Real-Time Public Health Surveillance for Emergency Preparedness

Public health agencies conduct surveillance to identify and prioritize health issues and evaluate interventions. Recently, natural and deliberate epidemics have motivated supplementary approaches to traditional surveillance methods based on physician and laboratory reporting.

Fueled initially by post–September 11, 2001, bioterrorism-related funding, and more recently used for detecting natural outbreaks, these systems, many of which are called ''syndromic'' systems because they focus on syndromes recorded before the diagnosis, capture real-time health data and scan for anomalies suggesting an outbreak. Although these systems as typically implemented have often proven unreliable for detecting natural and simulated epidemics, real-time health-related data hold promise for public health.

If redesigned to reliably perform beyond outbreak detection, syndromic systems could demonstrate unprecedented capabilities in responding to public health emergencies. (*Am J Public Health*. 2009;99:1360–1363. doi:10.2105/AJPH.2008.133926)

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PUBLIC HEALTH AGENCIES conduct surveillance to identify and prioritize health issues and evaluate interventions. Marking a change from traditional surveillance approaches, in recent years, natural and deliberate epidemics have motivated supplementary approaches to traditional surveillance methods based on physician and laboratory reporting, which can be insensitive and slow. Systems that use automated procedures to capture near-real-time data on patient presentations or care-seeking behavior ("health indicators") and scan for anomalies suggesting an outbreak have proliferated in the United States[1] (see the box on the following page). Many are called "syndromic" surveillance systems because they monitor clinical syndromes recorded before definitive diagnosis. Following the attacks of September 11, 2001, early syndromic surveillance efforts focused on detecting bioterrorism attacks in large populations; more recently, sponsors, users, and researchers have commonly cited their potential for detecting naturally occurring epidemics as well (e.g., Henning[2]).

Assessments of health indicator surveillance have noted frequent false alarms[3–5] and the cost of a national system developed originally to detect bioterrorist attacks.[3] Although health indicator surveillance systems have not proven highly useful for detecting naturally occurring or simulated outbreaks, proponents are right that real-time availability of health-related data holds enormous promise for public health. The potential benefit extends to a broad range of health protection activities; here we focus specifically on response to public health emergencies.

LIMITS OF AUTOMATED OUTBREAK DETECTION

An assumption underlying many health indicator surveillance systems—that automated signal detection algorithms can identify disease outbreaks—is both innovative and problematic. Clinicians have provided early alerts of many novel epidemics. The investigation that first identified West Nile virus in the United States began after a physician reported 2 patients with unusual cases of viral encephalitis.[6] In 2001, a physician reported suspected inhalational anthrax, the first US case in 23 years, hours after the initial victim of the anthrax mail attacks reached the hospital.[7] Health indicator surveillance was in its infancy during these outbreaks, but the outbreaks suggested that it may be challenging for systems that attempt to detect outbreaks through statistical analysis of aggregated case data to improve on competent clinicians in detecting early-stage or small outbreaks.

As there have been no bioterrorist attacks since most health indicator surveillance systems were implemented, evaluations have used naturally occurring and simulated outbreaks. In a comprehensive review of evaluations, systems generally performed well in detecting large, naturally occurring outbreaks but missed small ones[8] (although caution is warranted in drawing broad conclusions from these evaluations because of the large variation in surveillance practice). Some simulation-based evaluations have shown high sensitivity and specificity for small outbreaks,[8] but even for large outbreaks, results are mixed. Nordin et al.[9] simulated anthrax release in a large shopping mall and used data from an active syndromic surveillance system covering 9% of the area population. Monitoring physician visits for respiratory complaints, the system had 20% detection probability 4 days after the release if 15% (approximately 19 000) of mall visitors were affected. By then, hospitals would have seen hundreds of patients with inhalational anthrax.[10]

Calibrating systems for high sensitivity incurs more frequent false alarms. Buckeridge et al.[11] compared clinical case identification based on laboratory diagnosis with automated outbreak detection by syndromic surveillance in a simulation study of an inhalational anthrax outbreak. Syndromic surveillance achieved earlier outbreak detection (by approximately 1 day) than did clinical case identification when the outbreak detection false alarm rate was set at 1 per 10 days. Clinical case identification usually alerted first when the outbreak detection false alarm rate was set at 1 per 40 days.

The New York City Department of Health and Mental Hygiene retrospectively evaluated 236

Data Sources for Health Indicator Surveillance

- Emergency department reason for visit
- Ambulatory care clinic reason for visit
- Hospital discharge diagnosis
- Medical call center data
- School nurse diagnosis
- Ambulance dispatch data
- School absenteeism
- Work absenteeism
- Pharmacy prescriptions
- Over-the-counter medicine and product sales
- Medical laboratory test orders and results
- Radiology results

gastrointestinal illness alerts from its syndromic surveillance system over 3 years, during which time the department investigated 49 gastrointestinal outbreaks. Alerts did not correspond to any real outbreaks. Balter et al. concluded,

> The primary problem with using syndromic surveillance to prospectively detect outbreaks is that analyses that are sensitive enough to detect smaller outbreaks signal falsely so often that they generate too many signals from which to distinguish genuine outbreaks.[12(p179)]

Some health departments set the system-alerting threshold at a level that allows investigation of all alerts. Experience with this approach has not been uniformly positive. For example, in a 4-state evaluation of ambulatory care–based syndromic surveillance alerts, only very strong signals in each syndromic category were investigated (once-per-year strength or greater).[13] After 8 months, none of the 10 alerts corresponded to events of concern to the respective health departments.

POTENTIAL FOR WIDER APPLICATIONS

Despite limited utility for outbreak detection, health indicator surveillance systems are popular among public health practitioners. In an International Society for Disease Surveillance ongoing survey of state and US territory health departments that conduct syndromic surveillance, 24 of 31 respondents indicated that it was highly or somewhat likely they would expand use of syndromic surveillance; none expected to use the systems less.[14]

Why do users like these systems? One reason is that outbreak alerts are more reliable when systems focus on specific syndromes that reflect high-probability events. For example, with heightened concern for pandemic influenza, many health departments use syndromic surveillance to identify influenza season onset. In Boston, syndromic surveillance consistently provides earlier notice than do other systems.[15]

Syndromic surveillance also may be useful in detecting outbreaks of noncommunicable diseases. For example, telephone calls to the National Health Service Direct[16] health line in Great Britain and ambulance dispatch calls in New York City[17] identified heat wave–related illnesses. Such systems could be useful in many cities, because urban heat waves are expected to occur more frequently and mortality can increase rapidly (e.g., a heat wave in France caused more than 14 800 deaths during 2 weeks in August 2003).[18] Syndromic surveillance could help target interventions for other environmental hazards as well, such as windstorms[19] and air pollution.[20]

Practitioners have found health indicator surveillance systems helpful for purposes beyond outbreak detection. These surveillance systems facilitate rapid investigation of situations detected through other means, such as querying emergency department data for food-related illness after recall of a contaminated product or using hospital arrival time data to identify contacts of infectious patients.[21] They suggest promising areas for research, such as identifying age groups that first manifest influenza activity, for which early vaccination may reduce community transmission.[22,23] Their development has advanced the science of public health surveillance by promoting collaboration among public health practitioners, computer scientists, statisticians, and others who previously were not as engaged in surveillance and by emphasizing rigorous system evaluation.

Such examples suggest a broad perspective on the potential utility of surveillance systems that operate in near-real time: by making health-related data available in useful form soon after the data are collected, near-real-time surveillance systems could enhance public health emergency preparedness in many ways (Table 1).[24]

BUILDING NEXT-GENERATION SYSTEMS

Designed primarily for early outbreak detection, health indicator surveillance systems are not optimized for wider applications. Fully realizing the benefits of real-time public health surveillance requires increased effort in 4 key areas.

First, systems should enable rapid access to rich patient data. Although not all variables should be subject to routine analysis, availability of targeted queries would facilitate assessment of potential public health emergencies. For example, case definitions based on clinical and laboratory findings among initial patients could immediately be applied systemwide to determine the extent of an emerging epidemic. Efforts by the Centers for Disease Control

Table 1—Near-Real-Time Public Health Surveillance and Potential Applications to Emergency Planning and Response

Type of Application[a]	Examples
Detect events	Facilitate detailed patient record queries for suspected event
	Network professionals for signal assessment
Estimate event magnitude	Apply new case definition systemwide
	Monitor impact on health care system
Describe disease natural history	Establish case definition for novel disease
	Track changing disease severity
Evaluate event response	Assess changes in disease incidence
	Monitor vaccine or drug effectiveness
Monitor health practice	Assess management of patients meeting case definition
	Detect inappropriate therapeutic practices
Facilitate planning	Allocate resources where needed as event unfolds
	Direct patients to facilities with capacity as event unfolds
Improve risk communication	Support timely recommendations to population at risk
	Reduce panic and overreaction

[a]Modified from Thacker.[24]

and Prevention to link electronic data sources for rapid assessment of suspected cases reported by hospitals and to make electronic health records useful for public health applications[25] are promising. Consideration of privacy law is critical as systems incorporate detailed patient information.[26]

Second, systems should strive to enhance human judgment, not replace it. Many health indicator surveillance systems automate routine operations, such as data capture and signal detection, minimizing additional tasks for busy hospital and health department personnel. Next-generation systems should link computer capabilities with the intuition and contextual understanding of system operators. An example is a syndromic surveillance system in the Washington, DC, area that provides an Internet-based forum in which users comment on data and alerts.[27] Health departments across the region focus on data of concern to those who best understand the context, dismissing probable false alarms.

Third, better approaches to system evaluation are needed. Current evaluation methods,[28] although useful, often lead to excessive emphasis on outbreak-detection performance. A meaningful public health definition and measurement approach for "situational awareness,"[29] which is sometimes cited as a justification for health indicator surveillance systems, could help. Measuring and reporting system cost could help maintain political support, especially for state and local systems, which may not severely strain health department budgets (for example, in one of the few published attempts to assess direct costs for a syndromic surveillance system, a system covering all emergency departments in Boston was found to account for a small proportion of city health department surveillance costs[30]).

Fourth, new sources of useful surveillance data are needed. To date, syndromic surveillance system developers have been creative and effective in exploiting easily accessible data, which has been useful but sometimes problematic. For example, ascribing syndromes to residential zip codes may obscure workplace exposure, and selecting nonrepresentative sites may lead to incorrect inference. Sophisticated analytical approaches may still extract additional benefit from current data sources. But developers of next-generation systems should reach beyond the "low-hanging fruit" and consider the cost and potential benefit of new data sources, such as place of work in large metropolitan areas, to identify workplace exposures.

TIME FOR ACTION

There is an important opportunity to improve public health surveillance in the United States. In October 2007, the White House directed the Department of Health and Human Services to establish a national surveillance system based on electronic data that would facilitate response to previously unknown or emerging public health threats.[31] This is part of a broader directive to improve national public health and medical readiness for all health catastrophes, including pandemic influenza, bioterrorist attacks, and natural disasters.

Policymakers should consider the perspectives of users and developers of health indicator surveillance systems as this effort proceeds, especially practitioners at state and local health departments who have implemented useful syndromic surveillance systems at reasonable cost. There is potential for a next-generation surveillance system to provide important new capabilities in responding to public health emergencies. But there is also risk that unrealistic expectations and failure to learn from related efforts could lead to an expensive system with limited utility. ■

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Contributors

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