CHAPTER

8

Using Disease Surveillance for Early Warning

Public health officials have wanted to mine indirect early warning signs of an outbreak since 1993.

A rise in purchases of over the counter painkillers. An uptick in 911 calls for ambulances or in calls from parents alerting schools of children's absences. Together, those events could mean that an infectious disease outbreak is under way. Public health officials have wanted to mine these types of indirect early warning signs of an outbreak ever since 1993, when information about stores running out of antidiarrheal medications might have alerted Milwaukee health officials to an outbreak of waterborne disease *weeks* before a laboratory confirmed case.[281] Yet before "syndromic surveillance" began in earnest, such data were not always collected, organized, or reported, and they were not available to alert public health officials about emerging disease trends.

Syndromic surveillance gained ground after the 2001 anthrax attacks. Officials wanted early warning that a bioterrorist attack was in progress so medical countermeasures could be deployed. New syndromic surveillance systems were created, including the BioSense system mandated by the Public Health Security and Bioterrorism Preparedness and Response Act of 2002[282] and other systems in New York City and several large US cities.[283-285] These systems were put in place because, for public health purposes, it made intuitive sense to track such data as emergency room admission codes and pharmacy purchases, though at the time there was little evidence to suggest those efforts would lead to earlier and better public health decisions in mitigating an outbreak.[286]

Public health practitioners are using these systems to support "situational awareness" or near real time monitoring of a public health event.

In September 2002, the National Syndromic Surveillance Conference was hosted by the New York Academy of Medicine, the CDC, and the New York City Department of Health and Mental Hygiene (NYC DHMH), with generous support from the Sloan Foundation.[287] Two years later, Sloan awarded a grant to the Tufts Health Care Institute to provide administrative support for development of the International Society for Disease Surveillance (ISDS), "dedicated to the improvement of population health by advancing the field of disease surveillance."[287] The conference, now annual, has completed its tenth year and is still hosted by ISDS.[287]

The field of syndromic surveillance has supported monitoring for all hazards, which may include events such as the BP oil spill or increases in the incidence of chronic diseases, not just infectious disease outbreaks and bioterrorism. Most syndromic surveillance systems were initially designed to detect outbreaks rapidly, but public health practitioners are increasingly using these systems to support "situational awareness" or near real time monitoring of the evolution of a public health event. This evolution occurred because it was found that in the context of outbreak detection and management, syndromic surveillance is mainly useful for the characterization and management of a recognized outbreak.[288] David Buckeridge, president of ISDS, observed that the field is still evolving and growing: "The evidence base needs to continue to be built, and the knowledge needs to be translated into practice."[289] Farzad Mostashari, NYC DHMH assistant commissioner at the time, notes that syndromic surveillance has been useful for determining that cases of severe disease are not indicative of a large epidemic or an attack.[290]

ISDS continues to make significant contributions to public health surveillance of all types and to work toward ensuring that syndromic surveillance remains an effective tool for assessing the public's health. Recent efforts include strong advocacy to ensure that public health information is included in the electronic health record system called for in the Healthcare Reform Act of 2010 and development of the Distribute Project for influenza syndromic surveillance to provide comprehensive situational awareness of influenza like illness.[291,292]

Building a Flexible Platform for Syndromic Surveillance Software

The New York Academy of Medicine's SaTScan Program

In 2002, the Sloan Foundation awarded a grant to the New York Academy of Medicine (NYAM) to work with the NYC DHMH and the University of Connecticut to develop a syndromic surveillance software system for tracking potential disease outbreaks and to make the technology user friendly for state and local health departments. Farzad Mostashari, then NYC DHMH assistant commissioner, was principal investigator. (Mostashari is now national coordinator for health information technology at HHS.)

The software they developed, called SaTScan ("Software for the spatial, temporal, and space time scan statistics") was originally developed by Martin Kulldorff and Information Management Services, Inc., with support from the National Cancer Institute, to detect clusters of cancer. NYAM and NYC DHMH modified the statistical approach to conduct surveillance for West Nile virus, influenza, and bioterrorism. Their goal was to produce a flexible software platform on which to build a comprehensive system for outbreak detection and syndromic surveillance.

In 2002, NYC DHMH analyzed ambulance dispatch and emergency department visit data on every day of the year for spatial and temporal aberrations.[293] The department also analyzed data on subway worker absenteeism and sales of both prescription and over the counter medications.[294] In October 2002, a refined version of the software was released as a free downloadable program.[295] Today, the program can still be downloaded free of charge from the SaTScan website (http://www.satscan.org), and the NYC DHMH still maintains a link to the website.[296]

The outbreak detection software and analytic methods developed for SaTScan were used by leading practitioners and researchers in the field, including the Johns Hopkins University Applied Physics Laboratory and the University of Pittsburgh Real Time Outbreak Detection System (RODS) laboratory.[297] Sloan gave Mostashari a second grant in 2003 to refine the software's bioterrorism surveillance capability by incorporating data from pharmacy sales and BioWatch, the federal system of sensors and lab based analyses for detecting bioterrorism agents. Mostashari and his colleagues made the software easy to use for health departments that had never employed these methods and released an improved version in October 2003.[295] In December of that year, the NYAM launched a website that served as a "town hall" for the expanding international syndromic surveillance community.

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The Sloan grant helped catapult syndromic surveillance from a cumbersome research method to a mainstream technology in public health. In 2008, Mostashari published findings from a survey of public health officials in fifty nine state, territorial, and selected large local jurisdictions in the United States indicating that 83 percent of the respondents conducted syndromic surveillance.[284] In a recent interview, he estimated that today, approximately 90 percent of state health departments rely on the technology. Emergency department visits are the most commonly used data source for surveillance, but others include clinic visits, calls to poison control centers, 911 emergency medical service calls, medication purchases, and school absenteeism. “It’s almost ubiquitous now,” Mostashari said, “but it wasn’t bioterrorism that made people engage with this; it was helping them solve daily problems like flu surveillance.”[290] Impressive as that progress may be, Mostashari thinks much more work is needed, especially in collecting clinical specimens for laboratory diagnosis once there is a signal that an outbreak is under way.

When syndromic surveillance was getting off the ground, some practitioners questioned whether high tech surveillance for bioterrorism was a public health priority, and Mostashari conceded that the early skepticism was justified: “The question is, are these tools useful daily. Because if they’re not useful daily, they won’t be useful for bioterrorism events.” In an ideal world, he added, “Routine clinical care would help provide an understanding of population patterns, and situational awareness of what’s happening in the community would in turn be fed back in to clinical care.”[290]

The Sloan grant allowed researchers to develop new science, not out of whole cloth, but by fostering connections between different fields. Future support of syndromic surveillance should also draw on that approach, Mostashari said. “What a philanthropic organization or government entity gives to a grantee is not just money. It’s support, visibility, and flexibility.”[290]

Applying the Language of Science to Problems in Biosecurity

DIMACS's Research Program on Computational and Mathematical Epidemiology

Interdisciplinary collaborations have become a hallmark of security oriented research, according to Fred S. Roberts, a mathematics professor at Rutgers and, since 1996, director of the Center for Discrete Mathematics and Theoretical Computer Science (DIMACS).[298] The problems are complex and evolving, and solving them requires many types of technical expertise. For example, persistent problems in biosecurity, such as modeling the potential spread of deliberately dispersed pathogens, developing successful vaccination strategies, and predicting the evolution of pathogens, require the expertise of biologists, epidemiologists, public health experts, mathematicians, and computational modelers.

Roberts described DIMACS as a center that tries "to get different people with different backgrounds talking to each other to do things that aren't traditional."[299] DIMACS itself is a collaboration among researchers from Rutgers, AT&T, Alcatel Lucent Bell Labs, IBM Research, Microsoft Research, and other academic and industrial centers. Roberts's efforts to apply mathematics, which he calls "the language of science,"[300] to complex problems in biosecurity and intelligence at DIMACS led to its designation as a Center for Excellence by DHS.[301]

In summer 2002, DIMACS brought together more than one hundred experts in epidemiology, infectious diseases, and mathematics for the first national conference on mathematical contributions to biodefense.[301] That Sloan funded conference, organized by Roberts and DIMACS colleague Simon Levin of Princeton University, kicked off a Special Focus on Computational and Mathematical Epidemiology research program. A major goal was to involve more mathematicians (especially graduate students and postdocs who might focus on this area in their careers) in work on public health problems, so the conference started with a tutorial on infectious diseases and how public health epidemiologists track disease spread.

This special focus research program began as a five year project and was extended to eight years, during which time it gave rise to working groups on such topics as the analogies between computer viruses and biological viruses, ways to use mathematical methods to more quickly detect adverse events caused by new medical countermeasures, spatiotemporal and network modeling of disease spread, and mathematical methods for comparing vaccination strategies. Working group members included experts from international academic centers, government, and private industry.

While important mathematical and security work for biodefense has continued, as has education for graduate students and postdocs, there are challenges ahead, mostly related to analyzing massive amounts of data and developing new tools for data analysis.[302] It is a complex task to ensure that false positives indicating the occurrence of a bioattack, for instance are avoided, while at the same time ensuring that false negatives do not slip by undetected. In the end, the goal of this effort is to devise new approaches to providing the most accurate information possible for leaders.

Disease Surveillance in Real Time

Expanded Data Collection Capacity for RODS

In 1999, two years before the anthrax attacks, Jeremy Espino, "Rich" Fu Chiang Tsui, and Michael Wagner started the Real Time Outbreak and Disease Surveillance (RODS) Laboratory "to investigate methods for real time detection and assessment of disease outbreaks."[303] This syndromic surveillance system collected data from emergency departments and hospitals in western Pennsylvania; the data included patients' symptoms, age, gender, address, and test results.[304] Started with funds from the National Library of Medicine, RODS aimed to make surveillance data collection automatic by eliminating reliance on care providers to fill out and submit forms by hand and to relieve hospitals of the burden of sending data manually to health departments. Their goal, explained Wagner, now director of RODS, was to be able "to analyze patterns and ask whether there is something unusual compared to the usual."[305]

Hours count, and detection has to occur early to allow time for response and treatment.

After the 2001 anthrax attacks, the RODS system was examined as a national model for syndromic surveillance; President Bush even visited the laboratory in February 2002.[306] The system was used in areas outside of Pennsylvania as well, including Salt Lake City, Utah, for the 2002 Winter Olympics, where it linked and gathered data from thirty hospitals and walk in clinics to monitor for a possible bioterrorist attack. Although RODS did not detect bioterrorism, it did catch an influenza outbreak in its data stream.[305,307]

In December 2002, the software was made publicly available at no cost to health departments nationwide. Now it is one of the most commonly used systems in the country, and it is used outside the United States as well.[308]

Sloan recognized the potential of this system, and in 2003, a Sloan funded project made the RODS system more powerful by allowing the researchers to expand pharmacy data collection from twenty three retailers to 33 percent of all product sales nationwide. "There's a torrent of information being collected routinely in real time. Over the counter sales of pharmaceuticals contain information very relevant to outbreaks of disease," explained Wagner.[305] For bioterrorism, "hours count, and detection needs to occur very early to allow time for response and treatment to occur."[309]

