Infectious Disease Surveillance: A Crumbling Foundation

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Our ability to detect and monitor infectious disease threats to health is in jeopardy. False perceptions that such threats had dwindled or disappeared led to complacency and decreased vigilance regarding infectious diseases, resulting in a weakening of surveillance—the foundation for control of infectious diseases (*1*). However, such infectious diseases as acquired immunodeficiency syndrome (AIDS), influenza, and pneumonia are leading causes of death in the United States and the world. As microorganisms adapt to dramatic changes in our society and environment, we remain vulnerable to a wide array of new threats in the form of emerging, resurgent, and drug-resistant infections (Table 1) (*2, 3*).

Surveillance has served as the basis for important public health responses to new threats: identifying contaminated food or other products, determining the influenza virus strains to include in each year's vaccine, and monitoring the safety of our blood supply. Improved surveillance, including strengthened laboratories, is needed to assess the extent of illness and death associated with infectious diseases so that priorities can be assigned to control efforts. Surveillance is also critical in assessing the effectiveness of regulatory and advisory measures designed to safeguard public health, such as drinking water standards and guidelines for the prevention of infectious diseases in child care facilities.

Infectious disease surveillance in the United States relies heavily upon a national notifiable disease system. The legal authority for disease reporting rests with the states, which determine diseases or conditions to be reported by all physicians, laboratories, or others to local or state public health authorities (*4*). In turn, the states voluntarily report cases of more than 40 infectious diseases to the Centers for Disease Control and Prevention (CDC). Surveillance has encompassed not only the reporting and investigation of cases but also the submission of clinical specimens, when needed, for testing at local, state, or federal public health laboratories. This network has constituted the foundation for guiding communicable disease prevention and control activities. The system breaks down if any one step, such as appropriate diagnostic testing, reporting by physicians to public health agencies, or follow-up investigation, is not accomplished.

During the past decade, state and local support for infectious disease surveillance has diminished as a result of budget restrictions. In 12 states, for example, no personnel are dedicated to foodborne disease surveillance despite dramatic evidence that the spectrum of disease caused by microbiologically contaminated food is expanding and that foodborne disease outbreaks in this country may be increasing (*5, 6*). Moreover, there has been no federal financial support to states for the notifiable disease surveillance system and many state health laboratories receive no federal support (*7*).

Targeted federal programs for prevention and control of AIDS, tuberculosis (TB), sexually transmitted diseases, and childhood vaccine-preventable diseases have been unable to rely on data from this crippled surveillance network and have developed independent, federally supported, surveillance systems to obtain data for their prevention and control activities. As an example, approximately 20 million federal dollars are spent annually on AIDS surveillance in the United States, providing valuable information to public health professionals, health care providers, policy-makers, and others (*8*).

As AIDS surveillance was being established, other parts of the surveillance system for communicable disease were failing. For example, federal spending on TB control had declined and the surveillance system for multidrug-resistant (MDR) TB was discontinued in 1986. Consequently, a warning signal that prevention and control measures for MDR-TB needed to be enhanced or modified was absent in the late 1980s. This lack of early warning undoubtedly contributed to the more than $700 million in direct costs for TB treatment incurred in 1991 alone (*9*). Not until 1993, after MDR-TB became a public health crisis and federal dollars were allocated, was TB surveillance modified to reinstate collection of information on drug resistance.

A survey of public health agencies conducted in all states in 1993 documented that only skeletal staff exists in many state and local health departments to conduct surveillance for most infectious diseases, especially those not part of the specific programs noted above (*5*). In a survey to which 23 state laboratory directors responded, all except one reported a hiring freeze or loss of positions in 1992; nearly half indicated that privatization of some or all of their laboratory activities was under discussion (*7*). Public health agencies have been reluctant to add newly recognized diseases to their list of reportable diseases because their capacity to support the surveillance system, including collection, analysis, and response to the reports, is limited by lack of funds and personnel. Many of the currently reportable diseases are significantly underreported, and lack of public health staff in many areas results in limited follow-up of reported cases.

In 1993, a multistate outbreak of disease due to *Escherichia coli* strain O157:H7 occurred; cases were detected in Washington, Idaho, California, and Nevada (*10*). More than 600 cases, including 56 cases of acute kidney failure, and four deaths in children were identified. Epidemiologic investigation implicated hamburger served in fast-food restaurants as the source of the outbreak (*11*). The outbreak in Nevada was recognized only after the large Washington outbreak, despite the fact that most cases in Nevada occurred earlier than those in Washington. Of the 58 retrospectively identified cases of bloody diarrhea and acute kidney failure, none had been accurately diagnosed or reported to the health department (*12*). A system of passive reporting for *E. coli* O157:H7 that existed in Nevada at the time of the outbreak was ineffective because physicians and laboratories were not specifically testing for the pathogen.

In contrast, in Washington, a well-functioning surveillance system that included appropriate diagnostic capability for *E. coli* O157:H7 was established in the 1980s. In addition, development and application of the new molecular technique of pulsed-field gel electrophoresis at CDC was critical to confirmation that patients carried the same outbreak strain as that found in the implicated ground beef. This surveillance system enabled a rapid response that resulted in recall of more than 250,000 contaminated hamburgers and termination of the outbreak.

In the spring of 1993, the largest waterborne disease outbreak recorded in U.S. history occurred in Milwaukee, Wisconsin,

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Table 1. Emerging infectious diseases.

Pathogen and year of emergence	Disease manifestations	Epidemiologic characteristics	Current surveillance	Comment
Drug-resistant pneumococci 1970s	Middle ear infections; pneumonia; meningitis	Person-to-person, especially large child care centers	Magnitude of problem unknown	In 1993, outbreaks of drug-resistant strains in communities in Tennessee and Kentucky
Cryptosporidium 1976	Prolonged watery diarrhea; life-threatening in immunosuppressed persons	Waterborne; person-to-person in child care centers	Reportable disease in two states	Since 1984, multiple outbreaks have been recognized involving municipal water supplies; in each outbreak, water met state or federal standards for quality
E. coli O157:H7 1982	Bloody diarrhea; acute kidney failure	Foodborne, especially ground beef; person-to-person spread in child care centers	National surveillance being initiated	Multiple outbreaks recognized since 1982; estimated 20,000 cases annually
Vancomycin-resistant enterococci 1988	Life-threatening bloodstream infections; surgical wound and urinary tract infections	Person-to-person spread in hospitals	Trends monitored by voluntary system of reporting to CDC by 166 hospitals	Since 1988, increasing number of outbreaks recognized in hospitals on east coast of U.S.
Hantavirus 1993	Hantavirus pulmonary syndrome; 60% mortality	Rodent reservoir; spread by inhalation of an aerosol of rodent urine, feces, or saliva	Case reports investigated by health departments and CDC; trapping and lab exam of rodents part of investigations	Confirmed to have caused deaths in previously healthy adults in the United States for more than a decade

with estimates of more than 400,000 persons ill for an average of 10 days with cryptosporidiosis, an illness characterized by profuse watery diarrhea. Approximately 44,000 persons visited health care facilities, and an estimated 4,400 persons were hospitalized (*13*). The source of the outbreak was traced to municipal water supplies contaminated with the parasite, *Cryptosporidium*. The outbreak was recognized as pharmacies sold out of anti-diarrheal medications, microbiology laboratories ran out of routine bacterial culture media for enteric pathogens, and emergency room visits for diarrheal illness increased. Cryptosporidiosis is currently a reportable disease in only two states; there is no national surveillance for human infections with *Cryptosporidium*.

That the United States in 1993 witnessed such severe epidemics as a result of these pathogens is not surprising. Both *E. coli* O157:H7 and *Cryptosporidium* were emerging as health threats while attention to public health functions required to detect and control infectious diseases was diminishing. Many factors were associated with the occurrence of each of these outbreaks; however, lack of prompt diagnosis and reporting likely contributed to morbidity, mortality, and economic costs. At the current level of disease surveillance, it may take thousands of cases for an outbreak causing diarrheal illness randomly in a large urban area to be detected by public health authorities. An even greater number of cases may be required for detection if a contaminated food product is widely dispersed across the United States.

In addition to strengthening domestic surveillance, it is necessary to establish effective global surveillance as international travel and commerce increase. The health of U.S. citizens is inextricably linked to the health of people in other parts of the world; microorganisms can and do cross borders easily and often without recognition. A survey conducted in 1993 by the World Health Organization (WHO) highlighted the urgent need for improving global surveillance capacity (*14*). The survey demonstrated that virology laboratories around the world are not fully prepared to recognize emerging viral diseases or to identify known viral pathogens not commonly occurring in their immediate geographic area. Only 56% of the 34 laboratories surveyed had the ability to diagnose yellow fever—a factor that likely contributed to delays in the recognition of a yellow fever outbreak in East Africa in 1992 to 1993. Fewer than half of the surveyed laboratories had the ability to diagnose Japanese encephalitis (47%), hantaviruses (44%), Rift Valley fever virus (41%), or California encephalitis (18%).

In 1992, the Institute of Medicine published a report that highlighted the need to improve our ability to detect and respond to infectious diseases both domestically and globally; many of the recommendations were targeted at CDC (3). In the past year, CDC, in collaboration with numerous public health and infectious disease experts at community, national, and international levels, has developed a prevention strategy to address threats to health from infectious diseases (*15*). The plan emphasizes modification of the existing infectious disease reporting system at local, state, and federal levels to facilitate early detection of new, resurgent, and drug-resistant pathogens; enhancement of communications between health care providers and public health professionals; and provision of training to expedite responses to infectious disease threats. Increased innovation and efficiency are needed, such as automated reporting from laboratories to public health programs.

Surveillance needs may vary with the disease being monitored. Factors such as the frequency of the disease, the accuracy of diagnosis, the need for a rapid response, and the severity of the disease often determine what type of surveillance is most effective and efficient. Hence, the CDC strategy for improved surveillance emphasizes four complementary approaches to monitoring infectious diseases: (i) strengthening the national notifiable disease system, (ii) establishing sentinel surveillance networks, (iii) establishing population-based centers focused on epidemiology and prevention of emerging infections, and (iv) developing a system for enhanced global surveillance.

For diseases that require prompt reporting and investigation of every case (such as botulism and meningococcal meningitis), a national notifiable disease system works best. To improve this system in the United States, federal support to state and territorial health departments is needed. With greater financial and technical assistance, health departments will have more flexibility to modify surveillance for reportable diseases to include newer problems, such as

E. coli O157:H7–associated hemolytic uremic syndrome, hantavirus pulmonary syndrome, or multidrug resistance in common pathogens (such as pneumococci).

For other diseases, reporting of all cases is unnecessary. Sentinel networks, linking groups of health care providers or laboratories to a central data receiving and processing center, may be particularly helpful in such situations (*16*). For example, reporting of cases of influenza by approximately 150 primary care physicians located across the United States (with specimen submission from a subgroup of these physicians to public health laboratories) has been an efficient means to monitor this common respiratory illness. CDC proposes to establish a series of electronically linked Sentinel Surveillance Networks to help detect and monitor conditions such as unexplained adult respiratory distress syndrome and childhood illnesses characterized by fever and rash. Individual networks may consist of infectious disease specialists, clinical microbiology laboratories, emergency-medicine physicians, family practitioners, and pediatricians.

In addition to sentinel networks, comprehensive surveillance within well-defined populations (such as counties) is another useful approach. For example, population-based data from one county recently showed that hepatitis C is the leading cause of chronic liver disease and cirrhosis in that locale (*17*). CDC proposes to establish 10 strategically located population-based Emerging Infections Epidemiology and Prevention Centers to complement local and regional efforts in emerging infectious diseases, including antimicrobial drug–resistant, foodborne, opportunistic, and potentially vaccine-preventable infectious diseases. Priority activities in the centers will include: (i) conducting active population-based surveillance projects to obtain detailed information about selected diseases or syndromes for which adequate information is unavailable, (ii) evaluating new diagnostic tests, and (iii) implementing and evaluating pilot prevention/intervention projects. These centers will forge strong links with local medical and public health personnel as well as community representatives to conduct a variety of special surveillance, epidemiologic, and prevention research projects relevant to emerging infections. The centers will also provide opportunities for training public health professionals.

In addition to improvements in domestic surveillance, effective public health communication between countries may limit the extent of outbreaks and promote effective prevention strategies across borders (*18*). To further improve our capacity for international surveillance, CDC proposes to work with WHO and others to strengthen and link existing international biomedical research facilities to form a global consortium that will promote the detection, monitoring, and investigation of emerging infections. A global consortium would operate under the direction of an international steering committee, with representatives from national and international organizations.

The debate concerning health care reform is intensely focused on providing individual medical care; the debate has not adequately addressed the equally important topic of public health. Assuring effective surveillance has become even more important as new pathogens are recognized, as some diseases thought conquered reemerge, and as antibiotics become less effective. History has shown us repeatedly, in terms of both human suffering and economic loss, that the costs of preparedness through vigilance are far lower than those needed to respond to unanticipated public health crises.

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