

## **Is the U.S. Public Health System Ready for Bioterrorism? An Assessment of the U.S. Public Health Infrastructure and its Capacity for Infectious Disease Surveillance**

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Bioterrorism has become a household word. For years experts have warned of the potential of bioterrorist events, and today we have finally experienced the reality of this particular horror. As the nation garners resources to combat current and future bioterrorist activity, questions and debate arise as to the appropriate allocation of resources. Most funding appears targeted toward vaccines and medical supplies with little focus on the underlying public health infrastructure. However, it is the infrastructure—the organizations and people who comprise the nation’s public health system—that will ultimately determine the success of any efforts to fight the spread of infectious diseases, including those resulting from bioterrorism. Within the overarching infrastructure, it is the nation’s capacity to conduct infectious disease surveillance—detecting unusual disease patterns, investigating sources of outbreaks, and triggering control efforts—that will play the greatest role in our success or failure in combating infectious diseases.

In light of ongoing concerns about the nation’s public health infrastructure and infectious disease surveillance capacity, we undertook a study to identify gaps in the system and specific areas in need of improvement. We performed this study on behalf of the Assistant Secretary for Planning and Evaluation in the Department of Health and Human

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Services. Given recent events, we believe it is important not only to present the gaps in the system as identified by our study, but also to provide readers with a context and framework for discussing surveillance activities. This Commentary presents a discussion of the goals of infectious disease surveillance, a framework for understanding and discussing the U.S. public health infrastructure in which surveillance occurs, and the results of our analysis on gaps in the infectious disease surveillance system.

## I. BACKGROUND

Infectious diseases are the leading cause of death worldwide, and the third leading cause of death in the United States. In the twentieth century therapeutic advances, such as the introduction of antibiotics and the development of vaccines, have decreased the risks posed by infectious diseases. Dramatic medical successes led some experts in the 1960s and 1970s to proclaim that infections had been conquered in this country and were no longer a significant hazard. However, in the last twenty years, infectious diseases have once again become a threat.

### *A. Increasing Threat of Infectious Diseases*

As we move into the twenty-first century, biological, sociological, technological, and political factors have converged to promote the emergence of new infections, and renew anxiety about the possibility of bioterrorism and the resurgence of some conditions that were thought to have been conquered only a few decades ago.

Globalization of the world economy has increased the reach of pathogens. Rapid air travel allows a person who has early, minor, or misleading symptoms of a dangerous, highly contagious infection to expose hundreds of others in planes, in airports, and in hotels around the world. International businesses and rapid transportation create the possibility that food can be contaminated in one country, further contaminate large quantities of food in bulk processing plants in another country, and be shipped to yet additional countries where illness results.

Bioterrorism is also an increasing concern. Large quantities of highly communicable microorganisms can be grown inexpensively, transported inconspicuously, and released anonymously by terrorists to produce widespread panic, illness, and death.

Other infectious disease challenges are more subtle but represent an equal if not greater threat to the health of the public. Decades of use and misuse of antimicrobial agents are inducing antibiotic resistance in organisms once readily treated. Most physicians have limited clinical

experience with many significant infectious disease threats, and a large portion of the public have been protected from epidemic and endemic infections that were part of the day-to-day reality for their parents and grandparents. As a result, the public's responses to infectious disease threats are muted.

### *B. Role of Surveillance in Detecting Infectious Diseases*

Surveillance is widely regarded as the key to detecting new and emerging diseases, as well as tracking incidence and prevalence of established diseases. Surveillance data help detect unusual disease patterns and trigger control efforts. In 1963, Alexander Langmuir, organizer of the Epidemic Intelligence Service (EIS) at the Centers for Disease Control (CDC), coined the modern definition of public health surveillance, which was later endorsed by the World Health Organization (WHO). Langmuir defined public health surveillance as having three elements: (1) the systematic *collection* of pertinent data; (2) the orderly *consolidation* and *evaluation* of the data; and (3) the prompt *dissemination* of results to those who need to know (e.g., relevant health authorities).

The data referred to in the above definition include information such as the diagnosis of the disease, disease severity, geographic distribution of cases, and the route of transmission. The unit of analysis in surveillance is a *case*, which is an instance of a single individual with the disease.

The definition implies an ordered sequence of discrete activities or events that can be used both for circumscribing the surveillance process and for assessing what needs to be improved. Essential steps in the surveillance process include: (1) diagnosis of a health event by clinicians and laboratories; (2) reporting of health events and other disease information to local, state, and/or federal health agencies (reporting sources include clinicians, laboratories, hospitals, schools, and vital statistics records); and (3) management of health event data. Once information is reported, the data are collected, entered into a data management system, and edited. The information is then analyzed to establish baseline disease information and time trends. The data are examined for the identification and documentation of outbreaks. Reports are then generated and disseminated so that appropriate public health actions can be taken.

Surveillance activities can recognize the occurrence of new or emerging infections and track the prevalence of infectious agents already established in human populations. Effective surveillance programs are able to detect unusual clusters of disease, document the geographic and demographic spread of an outbreak, and estimate the magnitude of an

infectious disease problem. In addition, effective surveillance helps identify the natural history of a disease and factors responsible for its emergence, facilitates laboratory and epidemiological research, and assesses the success of specific intervention efforts.

Poor surveillance leads to incomplete, non-representative, and untimely disease reporting. These gaps leave policy makers and medical personnel without a basis for setting policy to control the spread of infectious diseases and to mount an effective prevention and treatment campaign. For example, in the 1980s tuberculosis was no longer considered a significant problem, and surveillance of the disease declined. The reemergence of the disease in the early 1990s, particularly multi-drug-resistant strains, took the public health and medical communities by surprise.

### *C. Surveillance Challenges*

Changes in the systems to provide and pay for health care pose both an opportunity and a threat to surveillance of infectious diseases. Concerns over double-digit health care inflation in the 1980s made cost control a number one priority for both policy makers and the major payers for health care delivery, private employers. During the past two decades the U.S. population has rapidly moved into managed care. The promised focus of managed care—managing the health of a population—should bring the goals of the delivery system closer to those of public health. There is great potential for productive collaboration in prevention of illness and in using managed care databases to integrate patient data across the continuum of care.

On the other hand, concerns about costs have changed clinical and laboratory practices in ways that limit the availability and reduce the utility of information upon which infectious disease surveillance has traditionally been based. Intense competition and razor-thin profit margins among laboratories have driven the adoption of highly efficient processes that narrow the range of tests conducted on specimens. New technologies allow private labs to identify the nature of an individual patient's illness faster and cheaper so that growth and identification of the specific pathogen are sometimes not needed to recommend appropriate treatment. While this represents an advantage to efficiency and effectiveness of care for the individual patient, it obviates the clinical need for tests of public health significance.

Current capacity for infectious disease surveillance is a product of a century of piecemeal investments as the country has organized to respond to various biological threats. Much of the investment has been categorical,

resulting in uneven capacity depending on disease type and fragmentation of surveillance efforts across the spectrum of infectious disease threats. The CDC alone has literally hundreds of data collection systems and data sets.

Legal authority for surveillance rests with the states and localities, adding another dimension to the fragmentation noted above—not only is surveillance fragmented by disease type, it is also fragmented geographically. The presence of hundreds of jurisdictions makes it difficult and confusing for those required to report infectious diseases and can make it hard to identify and respond to threats that cross county and state boundaries. The lack of standards for data collection, storage, and transmission makes it hard for states and localities to work collaboratively to develop more effective interfaces with the private sector.

Differing authority and oversight also mean different levels of resources devoted to surveillance at both the state and local level. There is currently a lack of consensus or guidelines for what should be monitored, by whom, and in which populations. As such, capabilities vary substantially both within and across states. Despite expanding expectations for the scope and nature of surveillance efforts, resources devoted to surveillance have changed little at the local level, and in many places have actually declined.

Thus, as the threats of infectious diseases increase, it becomes crucial to re-examine the public health system in this country. Preparing a defense against bioterrorism, as well as naturally occurring infections, will require targeted interventions to ensure the presence of a strong and reliable public health infrastructure and surveillance system.

## II. METHODOLOGY

This study was based on an analysis of recent literature,<sup>1</sup> interviews with fifty-five surveillance experts in the field, and validation through direct observation of the capacity currently in place for surveillance in Baltimore, Oregon, and West Virginia.<sup>2</sup> Additionally, we received input from a blue ribbon panel drawn from state and local health departments, academe, private provider systems, laboratories, and the CDC. This study was conducted in 1999 and 2000, but given the tenacity and systemic nature of the issues identified by our study, we consider our results to remain highly relevant today.

We thoroughly reviewed the literature pertaining to infectious disease surveillance. This enabled us to synthesize current thinking on the topic and to pinpoint specific issues or gaps within the public health infrastructure and surveillance activities for which there is widespread

concern among published authors and researchers. The key issues identified through the literature review formed the basis of our subsequent interviews with surveillance experts.

After completing the literature review, we conducted detailed conversations with fifty-five surveillance experts around the country and in Canada. These surveillance experts represented local and state governments, the CDC, academic institutions, laboratories, private providers, managed care organizations, the military, and the Veterans Administration.

Using the literature review results as a starting point, we developed a conversation guide to structure our discussions.<sup>3</sup> As part of the interviews, we provided each surveillance expert with one of seven surveillance scenarios (Appendix) and asked each person to describe: How the infectious disease surveillance process should work in dealing with this scenario? Where would it be likely to breakdown? Where would you invest resources to improve capabilities to handle this scenario? And what would you hope to achieve from this investment?

We also asked the surveillance experts to provide their definition of surveillance; describe surveillance successes and failures in which they were personally involved to illustrate the current strengths and weaknesses of surveillance capacity; discuss the strengths and limitations of surveillance with regard to selected issues including education and training, staffing, technology, information flow, legal authority, the impact of managed care, and other topics; and identify the types of situations that represent the greatest threat to the population's health.

The blue ribbon panel also met twice to provide input and guidance in this study. These meetings aimed to identify and prioritize opportunities to improve domestic surveillance of infectious diseases. In addition, for each opportunity area, the panel sought to identify minimal performance goals and objectives; to identify what core capacity needs to exist to meet these objectives; and to specify the interventions/investments that would be required to attain the core capacities and performance goals.

We also conducted a "goals and performance" exercise with the expert panelists. The exercise asked each panelist to rank the importance of eight goals of surveillance at each level of government on a five-point scale.<sup>4</sup> It then asked each panelist to rank system performance relative to each goal at each level of government. The resulting data was displayed in a matrix format to visually depict gaps in the system.

Following the first blue ribbon panel meeting, we conducted site visits to test these identified gaps against the priorities of surveillance systems that have taken, or are currently undertaking, efforts to improve their

surveillance capabilities. The site visits were conducted in January and February 2000.

### III. RESULTS AND DISCUSSION

#### A. *Goals of Infectious Disease Surveillance*

Based on a review of relevant literature and the advice of the expert panel, we identified eight goals for infectious disease surveillance. These include:

1. *Detecting Outbreaks of Infectious Diseases.* Infectious disease surveillance allows public health officials to differentiate between endemic and epidemic levels of disease by placing current incidence statistics in the perspective of normal levels. An epidemic, or outbreak, of a disease is its occurrence at an unexpectedly high frequency. Determination of whether the level of disease is higher than normal is only possible when the “usual” or baseline rate of the disease is known. Surveillance systems regularly monitor the health status of populations and therefore allow the identification of baseline levels of different diseases. For instance, surveillance efforts have shown that the endemic level of measles in the United States is extremely low. Nearly all new outbreaks can be attributed to imported measles cases. This type of information helps policy makers focus disease control efforts.

2. *Detecting Changes in the Epidemiology of Infection.* Patterns of infection change over time. For instance, a disease that at one time primarily affected young children may now have its greatest effect on young adults or the elderly. Many factors can account for changes in the epidemiology of infection, such as implementation of a vaccination campaign or mutations in the infectious agent. For example, after vaccination for measles became routine in the United States, the average age at which individuals became infected rose significantly, changing the health care needs of the affected population. Surveillance identifies these important trends.

3. *Providing Information to Prompt and Guide a Public Health Response at both the Individual and Population Level.* Without a firm understanding of who, where, and why people become infected and by what, the public health community would have no reasonable approach for tackling a problem caused by an infectious agent. Surveillance was instituted to enable society to deal with immediate communicable disease threats. Surveillance information is critical for making intelligent decisions to protect the health of the public both at the population and the individual level. Botulism and meningitis surveillance both illustrate the multiple roles of surveillance information. The purposes of reporting suspected

botulism are: (1) to aid clinicians in making the diagnosis of this rare disease; (2) to provide access to treatment, often available only through the public health service with the approval of state health officials; and (3) to identify the source of disease through a public health investigation. The source could be either a home-canned product, which generates one kind of public health response, or a commercial product, which generates a very different response. In the case of meningitis surveillance, the primary goal at the local level is to identify close family and child daycare contacts for prophylactic administration of rifampin within forty-eight hours to prevent other cases of disease.

4. *Assessing the Health Status of the Public.* A primary role of disease surveillance is the assessment of the overall health status of the public. Infectious disease surveillance provides descriptive information on the most frequent causes of morbidity and mortality in communities, the magnitude of health problems, and the demographic and geographic distribution of diseases.

5. *Evaluating Prevention and Control Interventions.* Prevention guidelines, screening, vaccination, efforts to change lifestyles, and other disease prevention and control interventions are designed to improve health outcomes. Surveillance systems enable the evaluation of these efforts by charting changes in health status before and after introduction of the intervention. For example, active surveillance of Group B Streptococcus, funded through the Emerging Infections Program, has monitored the burden of disease over time and has been crucial in measuring the uptake and impact of prevention measures. Likewise, the incidence of diseases for which vaccines are available can be used to assess the success of efforts to increase vaccination rates. Using surveillance data to evaluate prevention programs can improve program designs and better target public awareness campaigns.

6. *Aiding in Understanding the Etiology and Natural History of Diseases.* Disease surveillance data can be used to help understand the etiology (factors of causation) and natural history of diseases. Surveillance can provide information that helps determine the mode of disease transmission (e.g., vector-borne or water-borne); short- and long-term trends of disease (including the incidence, prevalence, and case fatality over time); risk factors for new and old diseases (e.g., age, gender, or comorbidities); and environmental factors related to diseases (e.g., warm climates or seasonal changes). However, undertaking surveillance exclusively for research purposes is uncommon since specific aspects of a disease are better investigated by more detailed data collection and tracking of cases (e.g., registries).

7. *Assisting in Health Planning.* Information obtained from surveillance systems can be used to guide health planning. For example, health departments can use surveillance information to help prioritize efforts to combat the most prevalent preventable diseases, set target goals (e.g., Healthy People 2010), and estimate resource needs.

8. *Identifying Research Needs.* Disease surveillance can be used to identify gaps or unexplored areas of research. For example, surveillance data may reveal the emergence of a new antibiotic resistant strain of bacteria (e.g., penicillin-resistant strains of gonorrhea that required the development of new drugs for treatment). Additionally, surveillance may reveal that a certain disease has emerged in a previously unaffected population, thereby indicating the need for studies on possible reasons for this shift (e.g., socioeconomic changes or the influx of people from other communities).

### *B. Examining Surveillance Goals at Local, State, and CDC Levels*

Meeting these goals requires collecting data, translating that data into information to support decision-making, and communicating that information to those who need to take action or be informed. Performance relative to these goals varies widely across jurisdictions. While all of these surveillance goals are important, the prioritization of these goals differs among various surveillance entities. In assessing areas in the public health infrastructure and surveillance system for improvement, it is critical to ensure that investments target high priority goals for which the current level of performance is inadequate.

Based on the assessment of the expert panelists, a number of goals fall into a “low performance/high priority” category. At the local level there are five such target goals including: detecting outbreaks, detecting changes in the epidemiology of infection, assessing the health status of the public, evaluating prevention and control interventions, and assisting in health planning (figure 1).

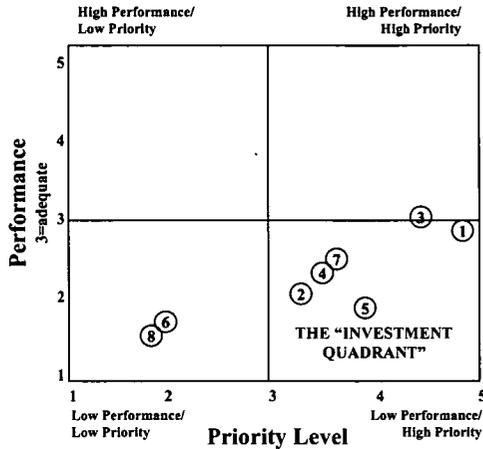
At the state level, the four goals that fall into the “low performance/high priority” category include: detecting changes in the epidemiology of infection, assessing the health status of the public, evaluating prevention and control interventions, and assisting in health planning (figure 2).

Finally, at the CDC level, only two goals fall into the “low performance/high priority” category: evaluating prevention and control interventions and assisting in health planning (figure 3).

In comparing the categorization of goals across the three levels of surveillance, the local level has the greatest number of target goals,

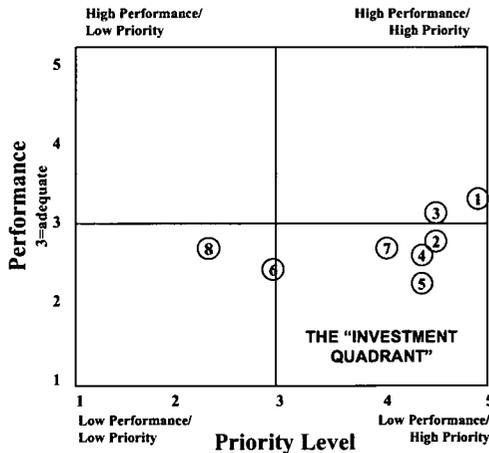
**Figure 1. Goals of Surveillance—Performance and Priorities at the Local Level**

- ✓1. Detecting outbreaks
- ✓2. Detecting changes in the epidemiology of infection
- 3. Providing information to prompt and guide a public health response
- ✓4. Assessing the health status of the public
- ✓5. Evaluating prevention and control interventions
- 6. Aiding in understanding the etiology and natural history of diseases
- ✓7. Assisting in health planning
- 8. Identifying research needs
  - ✓ = investment area

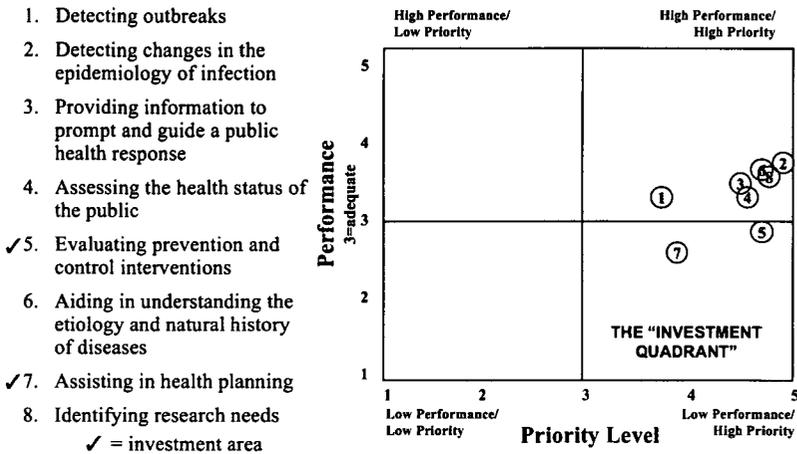


**Figure 2. Goals of Surveillance—Performance and Priorities at the State Level**

- 1. Detecting outbreaks
- ✓2. Detecting changes in the epidemiology of infection
- 3. Providing information to prompt and guide a public health response
- ✓4. Assessing the health status of the public
- ✓5. Evaluating prevention and control interventions
- 6. Aiding in understanding the etiology and natural history of diseases
- ✓7. Assisting in health planning
- 8. Identifying research needs
  - ✓ = investment area



followed by the state level, with the CDC level having the best perceived performance overall. Thus, not only should an effective plan to improve the core capacity for infectious disease surveillance target specific surveillance goals that fall into the “low performance/high priority” category, but it should also focus resources on improving performance at the local level, either through direct investment in local capacity, or through federal and state support and the development of new data flow arrangements.

**Figure 3. Goals of Surveillance—Performance and Priorities at the CDC Level**

### *C. Framework for Assessing the Public Health Infrastructure and Infectious Disease Surveillance System*

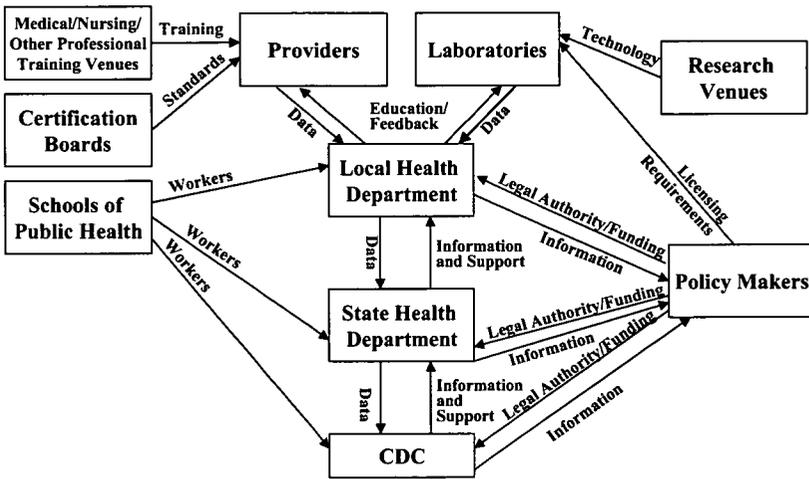
In accomplishing the goals described above, the core system for surveillance in this country involves a cascade of activities, with each step triggering a response from the next level of the system. As depicted in Figure 4, effective surveillance within the current hierarchical system requires a complex set of interactions and information flows among the clinical delivery system, public and private laboratories, and public health personnel at each level of government.

Laboratories and providers identify and report cases of infectious disease to the appropriate public health authorities. These data are used to guide an immediate public health response to individual reported cases of disease to (1) ensure correct diagnosis and treatment; (2) gather more detailed surveillance information such as risk factors; (3) identify, screen, and/or treat contacts who may also be at risk; and (4) determine the appropriate public health response (e.g., pulling contaminated food off the shelves). Moreover, public health officials translate these data into information to guide decision-making with respect to their broader role in protecting the public against infectious disease threats. These officials then provide data up the chain—local health officials provide data to state health officials who in turn provide data to the CDC. Each subsequent level of government conducts further analyses to understand the nature of biological threats and to develop strategies to address them. The information produced at each level in the system then

ideally flows back down the chain to each of the entities involved in surveillance.

This core system is supported by educational institutions that train clinical and public health professionals, accrediting and licensing bodies that set standards, a public and private research establishment that provides supporting technologies, and policy makers who provide the funding and legal framework for surveillance of infectious diseases.

**Figure 4. Interactions and Information Flows for Infectious Disease Surveillance**



*D. Critical Gaps in U.S. Infectious Disease Surveillance Capacity*

Our analyses assessed ways to improve this intricately linked hierarchical system for surveillance of infectious diseases as well as ways to reorganize the system to take advantage of advances in communications technology, and to respond to infectious disease threats that increasingly cross county and state boundaries. Military surveillance systems and the United States’ participation in global surveillance activities were beyond the scope of this project.

Below we identify a series of critical gaps that need to be addressed to ensure the population is adequately protected against infectious disease threats. We identified these gaps through the literature review and blue ribbon panel, and then validated them on the site visits.

1. *Gaps in the Core Capacity of the Key Entities Involved in Conducting Surveillance of Infectious Diseases.* This type of gap refers to the resources within state and local health departments, the CDC, public and private

laboratories, and provider systems that allow each entity to perform its role in meeting the goals of surveillance. Our study identified the following specific gaps:

*a. No clear standards exist that define the critical surveillance needs and associated capacity requirements at all levels of the system.* While some efforts have been made to define standards for public health laboratories and food-borne diseases, no comprehensive and systematic effort has been undertaken.

*b. Local capacity is not sufficient to ensure adequate performance across the eight goals of surveillance.* Staffing, skill levels, technological capability, and training are uneven across the country, leaving some populations not as well protected from infectious disease threats as others. Local-level public health officials need support from state health departments and the CDC to develop needed skills, to back up local-level staff during outbreaks, and to provide technological support and guidelines for how to handle various situations. For example, after the report of a case, public health staff often have to contact the provider and/or the affected individual to obtain complete information about the clinical picture, demographics and risks, treatment options, and contacts who may be at risk and who may require testing or prophylactic treatment.

At one of the sites visited, a school bus driver was diagnosed with tuberculosis, requiring public health officials to identify and test more than one hundred children who may have been exposed. This investigative activity is a key, very labor intensive part of the surveillance process that often falls through the cracks because of a lack of local capacity. Without it, public health response to individual cases is difficult, and most case reports will be missing key information that make the data less useful for analysis at higher levels in the system.

*c. Staff capacity at the state and large local level (cities and metropolitan areas) is frequently not adequate to support ongoing collection and analysis of surveillance data to detect changes in the epidemiology of infection, to evaluate surveillance efforts, to plan interventions, and to set priorities.* For example, lack of staff capacity to conduct mosquito surveillance in New York City contributed to the delayed recognition of the West Nile Virus. Site visits confirmed reports that capacity varies widely both across states and localities, as well as across programs within a public health agency.

*d. Computerized decision and analytic support tools have not been developed to their fullest potential to support infectious disease surveillance activities.* For example, the military currently has the capability to collect patient data electronically on a real-time basis from field personnel. This data is fed into computer software that can detect when the occurrence of disease is

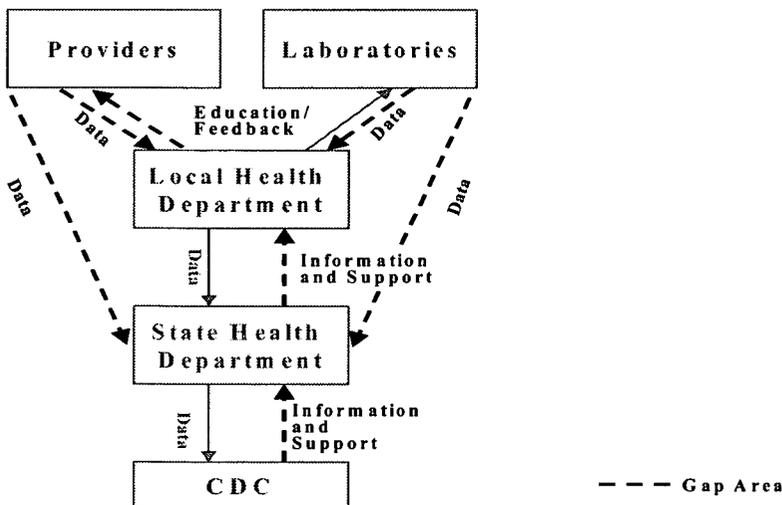
outside its expected frequency. While this system is not currently applicable to public health on a broad scale, it illustrates the potential utility of electronic medical record data for surveillance within defined populations.

*e. The public and private laboratory capacity supporting surveillance has eroded.* Public health laboratories are perceived to be behind the private sector in terms of technology development, dissemination, and adoption. Meanwhile, private laboratories, which focus on clinical rather than broader public health needs, face cost pressures that have encouraged fewer and less specific tests. Private laboratory consolidation into large regional or national facilities has made the current practice of reporting separately to each jurisdiction cumbersome and impractical.

**2. Gaps in the Flow of Data and Information Among the Entities Involved in Surveillance of Infectious Diseases.** As outlined above, surveillance of infectious diseases involves a series of data and information flows among the numerous entities involved in surveillance. Our analysis identified a number of critical gaps in these flows (figure 5):

*a. Provider and laboratory reporting of infectious diseases is incomplete and not timely.* Case reporting is a critical foundation for infectious disease surveillance; full participation from the provider community is a necessary component of a functional surveillance system under current data flow arrangements. Estimates of completeness of reporting range from 6% to 90% for many of the common notifiable diseases. Reasons given by providers for not reporting include: assumed that the case would be

**Figure 5. Gaps in Flows Among Entities**



reported by someone else; unaware that disease reporting was required; do not have notifiable disease reporting form or telephone number; do not know how to report notifiable diseases; do not have the list of notifiable diseases; concerned about confidentiality; concerned about violation of doctor-patient relationship; reporting is too time-consuming; and absence of incentives to report.

*b. A great deal of data flows through the system, but feedback and analyses need to be more effectively packaged and disseminated from the CDC to states and locals, from states to locals, and from public health venues to the clinical delivery system. Better feedback would help to engage the delivery system in infectious disease surveillance.*

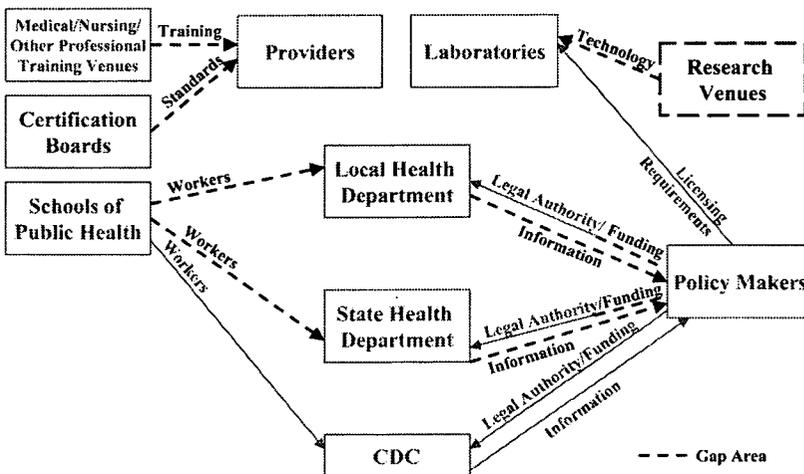
**3. Gaps in the Structures that Support Surveillance.** As described above, the core system is supported by educational institutions, accrediting and licensing agencies, the public and private research establishment, and policy makers. Figure 6 depicts gaps pertaining to these structures. Gaps identified with respect to these supporting structures include:

*a. Public health workers specifically trained to do infectious disease surveillance are perceived to be in short supply.*

*b. Training programs do not adequately educate clinical health professionals on their role in surveillance.*

*c. Research and development of new laboratory technology is focused on clinical rather than public health applications. Advanced laboratory technology that is available to support surveillance needs to be disseminated and adopted more rapidly.*

**Figure 6. Gaps in Structures that Support Surveillance**



*d. Public health misses opportunities to communicate the importance of surveillance to policy makers and the media.* A better understanding of surveillance among these constituencies would help ensure adequate funding and a rational legal framework to support it.

#### *E. Other Issues for Consideration*

In addition to these specific gaps in the system, we identified a number of cross-cutting issues that need to be addressed. These include:

*1. Information Technology.* Information technology offers opportunity for improvement across many areas, but significant obstacles exist to its widespread deployment. Support is lacking for existing technologies and current capabilities are uneven across states, localities, and disease areas. Lack of data standards and issues of privacy, confidentiality, and security must be resolved before systemic solutions can be implemented.

*2. Widespread Innovation but Limited Sharing.* States, localities, and disease areas within the CDC are developing multiple solutions to the same problems around data capture, analysis, and transmission. For example, many states are developing their own systems to integrate data across disease areas. There is a missed opportunity to share information and capture and disseminate lessons learned.

*3. Categorical Funding.* The historic patterns of categorical funding have impeded the development of a basic surveillance infrastructure capable of meeting the most critical disease threats. The surveillance infrastructure is fragmented and focused on specific diseases rather than on the broad range of threats that face a given population. This fragmentation is both a function of how Congress has funded the CDC and how the CDC allocates money to states and localities. As a result, data systems are incompatible and capacity is uneven across disease areas. The flexibility of federal funding for emerging infections and bioterrorism has been widely praised for its contribution to core capacity, but critical gaps still remain.

#### CONCLUSION

Numerous gaps in U.S. capabilities for conducting infectious disease surveillance leave the health of the public susceptible to a wide array of threats. The current categorical system is unprepared to deal with some of the most urgent concerns facing the public health system. Specifically, the experts who contributed to our research identified four potential threats, as detailed below.

### *A. Bioterrorism*

Well before the anthrax bioterrorist event, the concept of bioterrorism received a great deal of attention by legislators, government officials, and the press. It is defined as the deliberate spread of infectious diseases. Bioterrorism events can be potentially devastating—they are unpredictable, and their effects could easily overwhelm our medical care system. Strong surveillance is needed to identify these events at the earliest sign in order to trigger an immediate response. Bioterrorism falls outside the scope of most of our current surveillance efforts in that resulting infectious illness cannot be defined in categorical terms.

The framework and gap analysis presented in this paper can inform policy-makers as they develop an investment plan to strengthen the public health system to identify and respond to bioterrorist attacks. The recent anthrax attacks serve to highlight the importance of strengthening key components of our nation's core capacity for infectious disease surveillance, including: staff investigative and response capacity; communication channels between providers and public health officials to ensure individual cases are recognized and treated; and laboratory capacity to identify cases and areas of contamination.

### *B. Emerging Infections*

These include new or resurgent infectious diseases. New Variant Creutzfeldt-Jakob disease (the human disease associated with bovine spongiform encephalopathy or “mad cow” disease) is one recent example. These infections often take providers and public health officials by surprise, leaving the medical and health care communities unarmed to defend against them in the short term. Rigorous surveillance is needed to identify and control such diseases before they become widespread.

### *C. Drug Resistance*

Many infectious pathogens are renowned for their ability to mutate to accommodate changes in the environment. One particularly devastating type of mutation enables pathogens to become resistant to antibiotics—for example, drug resistant tuberculosis has emerged as a major problem around the world. When this situation occurs, pathogens can thrive despite medical treatment. Surveillance is critical to identifying changes in pathogens so that drug development can keep pace with evolving pathogens.

*D. Pandemic Influenza*

Experts fear the antigenic shift to a new pandemic strain of influenza, such as occurred in 1957 with the introduction of the Asian strain and in 1968 with the introduction of the Hong Kong strain. In each of these instances there was a significant increase in illness and deaths. The essential role of surveillance is to recognize the antigenic shift as quickly as possible so that the new strain can be incorporated into the vaccine.

While these examples represent those threats of greatest concern to surveillance experts, a myriad of smaller-scale, every day threats also persist that can only be addressed through strengthened surveillance capacity.

As the United States faces its first major bioterrorist attack, lawmakers are debating how to improve the nation's capacity to protect the public from what has long been feared, but is now a reality. While bolstering the nation's supply of vaccines and pharmaceuticals is important, it is even more critical to shore up the public health infrastructure—the people, systems, and linkages that work to detect unusual patterns of disease—to investigate sources of outbreaks and to take measures to protect the health of the public. Substantial investment will be critical to ensure sufficient resources are in place at the federal, state, and local levels so that we are prepared for all types of biological threats.

## APPENDIX

**Scenario 1:** The challenge is to recognize a new respiratory illness. It can have multiple sources, including liquid aerosols. It is transmitted by the airborne route and from person-to-person. The attack rate for exposed individuals is about 30%. Most who have symptoms see physicians. To an experienced clinician, it does not look like typical influenza or other common infections although less experienced clinicians may be misled. It is very debilitating for about a week, but only a small portion of victims require hospitalization, and even fewer die.

**Scenario 2:** The challenge is to recognize a major change in antimicrobial drug resistance. The organism affected is not one commonly associated with multiple drug resistance and is not thought of as causing major infections in hospitalized or debilitated patients. It is a common cause of mild urinary tract infections, especially affecting young women—so called honeymoon cystitis. It can transmit its unique mechanism of drug resistance to a wide variety of other organisms.

**Scenario 3:** The challenge is to recognize a serious infection that does not fit the case definitions of any of the major reportable diseases and causes severe debilitation, but not death. This infection's source can be contaminated food or water. The incubation period is approximately 2 to 5 days, and the attack rate is about 30%. Its symptoms include a very unusual and severe headache, severe fatigue, and minor diarrhea. It is very debilitating—people are “wiped out” for at least a week—but physicians typically do not admit patients to the hospital. Few die from it, and the occasional deaths are due to a variety of complications.

**Scenario 4:** The challenge is to recognize importation of a highly contagious and quite serious viral hemorrhagic fever. The source is an infected individual who travels through several states using a series of crowded common carriers. With this condition, spread occurs during a relatively prolonged period—4 to 7 days—before the infected individual becomes quite ill. Attack rates are moderately high, and deaths are very common among those infected.

**Scenario 5:** The challenge is to recognize an important epidemic involving a common, community-acquired infection. Here, a processor of nationally distributed consumer foods changes its production processes, which leads to ongoing contamination of non-perishable foods with a *Salmonella* strain. The foods are typically used in restaurants and homes. A food item may be ingested within a week, or as long as six or more months, after production. The contaminated foods

have neither a different taste nor appearance, but depending on the way the food is handled at the point of use, it may cause illness in 5% to 30% of people.

**Scenario 6:** The challenge is to recognize an important change in the epidemiology of an enteroviral pathogen. Imagine that a new purification system for potable and swimming pool water becomes available that produces water with much greater customer satisfaction at much lower cost. As a result, this system is adopted by municipal systems and pool operators relatively quickly over a 1 to 2 year period. Even though the mechanism is unclear, some strains of enteroviruses are not inactivated by this process, and outbreaks of aseptic meningitis and other typical enteroviral illnesses occur sporadically across the nation.

**Scenario 7:** The challenge is to recognize a change in the epidemiology of sexually transmitted diseases caused by *Chlamydia* that result from changes in sexual practices. The use of a readily available commercial product is widely touted on the Internet and elsewhere as greatly enhancing sexual enjoyment for men and women. Since this product was not intended to be used for this purpose, it has never undergone any relevant testing. Unknown to anyone, use of the product greatly enhances the ease of *Chlamydia* transmission and also seems to increase the seriousness of resulting infections.

## References

1. The literature search entailed a review of articles published primarily between 1990 and 1999. Key terms that guided our search included: surveillance; infectious disease surveillance; disease reporting; disease detection; surveillance and technology; epidemics; laboratory surveillance; surveillance and geographic information systems; and disease outbreaks. On-line searches were conducted in three main databases (MEDLINE, HealthSTAR, and HSRProj) and the World Wide Web. Relevance was assessed according to each article's ability to inform the following questions: (1) What is disease surveillance? (2) What are the key characteristics of infectious disease surveillance? and (3) What are the key characteristics of the current domestic surveillance system?

2. These sites were chosen in order to capture a range of characteristics. For example, Oregon is widely perceived as a "best practice" site; West Virginia has recently implemented a number of model initiatives and is predominantly rural; and Baltimore is a large city region and functions independently from the state in which it is located.

3. The conversation guide was designed such that each surveillance expert responded to a somewhat different set of questions. Questions for a particular respondent were chosen based on a combination of the background of each surveillance expert and randomization.

4. These eight goals were identified based on our literature review as well as input from the blue ribbon panel.

