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Report to Congressional Requesters

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WEST NILE VIRUS OUTBREAK

Lessons for Public Health Preparedness

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Contents

Abbreviations

APHIS	Animal and Plant Health Inspection Service
CDC	Centers for Disease Control and Prevention
DNA	deoxyribonucleic acid
ELISA	enzyme-linked immunoabsorbent assay
E. coli	*Escherichia coli*
FBI	Federal Bureau of Investigation
HHS	Department of Health and Human Services
NYC	New York City
NYS	New York State
PCR	polymerase chain reaction
ProMED	Program for Monitoring Emerging Diseases
RNA	ribonucleic acid
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

United States General Accounting Office
Washington, D.C. 20548

Health, Education,
and Human Services Division

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September 11, 2000

The Honorable Daniel Patrick Moynihan
The Honorable Charles E. Schumer
United States Senate

The Honorable Gary L. Ackerman
The Honorable Joseph Crowley
The Honorable Eliot L. Engel
The Honorable Vito J. Fossella, Jr.
The Honorable Carolyn B. Maloney
The Honorable Jerrold L. Nadler
The Honorable Major R. Owens
The Honorable Charles B. Rangel
The Honorable Jose E. Serrano
The Honorable Edolphus Towns
The Honorable Anthony D. Weiner
House of Representatives

In the fall of 1999 the mosquito-borne West Nile virus—a virus never before seen in this hemisphere—killed seven people in the New York City area and made dozens more very sick. It was initially misidentified as a different, related mosquito-borne virus often found in the United States. The incorrect diagnosis did not significantly affect the appropriateness of spraying and other mosquito control steps quickly begun in response. Even so, the outbreak can serve as a source of lessons about how public health officials can be better prepared in responding to potential crises involving uncertain causes. And although the outbreak is considered to have been a natural occurrence—possibly introduced by international travelers, migrating birds, or mosquitoes accidentally brought from abroad—it can also provide lessons about detecting and responding to an act of biological terrorism.

You asked us to review this outbreak and the response to it. We focused our efforts on the following:

- establishing a thorough chronological account of the significant events and communications that occurred, from doctors and others who first saw the symptoms and from the officials mounting a response, and

- identifying lessons learned for public health and bioterrorism preparedness.

We interviewed key officials, reviewed existing studies and reports, assembled a detailed chronology of what occurred, and discussed the implications of our findings with a wide range of agency and area officials. We asked officials to provide documentation to the extent possible for key decisions or events; however, to some extent the chronology of events is based on officials' recollections of the dates that particular events occurred. Appendix I describes our methodology in more detail. We conducted our work from May through August 2000 in accordance with generally accepted government auditing standards.

Results in Brief

The analysis of the West Nile virus outbreak began—and for several weeks continued—as two separate investigations: one of sick people, the other of dying birds. On the human side, the investigation began quickly after a physician at a local hospital reported the first cases, and the original diagnosis, while incorrect, led to prompt mosquito control actions by New York City officials. The ongoing investigation involved the combined efforts of many people in public health agencies and research laboratories at all levels of government. A consensus that the bird and human outbreaks were linked, which was a key to identifying the correct source, took time to develop and was initially dismissed by many involved in the investigation. When the bird and human investigations converged several weeks after the initial diagnosis, and after laboratory research was launched independently by several of the participants to explore other possible causes, the link was made and the virus was correctly identified.

Key lessons that emerge from the investigation and response to this outbreak are as follows:

- The local disease surveillance and response system is critical. In public health, surveillance is the ongoing collection, analysis, and interpretation of health-related data. In this outbreak, many aspects of the local surveillance system worked well, in that the outbreak was quickly spotted and immediately investigated. Assessments of the infrastructure for responding to outbreaks suggest that surveillance networks in many other locations may not be as well prepared.
- Better communication is needed among public health agencies. As the investigation grew, lines of communication and decision-making were often unclear, and efforts to keep everyone informed were awkward

(such as conference calls that lasted for hours and involved dozens of people). Many officials reported problems in this area.

- Links between public and animal health agencies are becoming more important. Many emerging diseases, including West Nile, affect both animals and humans. So do many viruses or other disease-causing agents that might be used in bioterrorist attacks. The length of time it took to connect the bird and human outbreaks of the West Nile virus signals a need for better coordination among public and animal health agencies.
- Ensuring adequate laboratory capabilities is essential. Even though this was a relatively small outbreak, it strained resources for several months. Officials said there is a need for broadening laboratory capabilities, ensuring adequate staffing and expertise, and improving the ability to deal with surges in testing needs. These concerns point out the importance of ensuring adequate networks between public health and other types of laboratories, and of completing assessments of what laboratory capacity is needed and what capacity is available.
- Because a bioterrorist event could look like a natural outbreak, bioterrorism preparedness rests in large part on public health preparedness. While the West Nile virus outbreak is considered by the Centers for Disease Control and Prevention (CDC) and others to have been a naturally occurring event, at one point there was speculation that it might have had an unnatural (bioterrorist) origin. The ensuing investigation and post-outbreak assessments illustrate the challenges in identifying the source of an outbreak, supporting public health officials' views that public health preparedness is a key element of bioterrorism preparedness.

Background

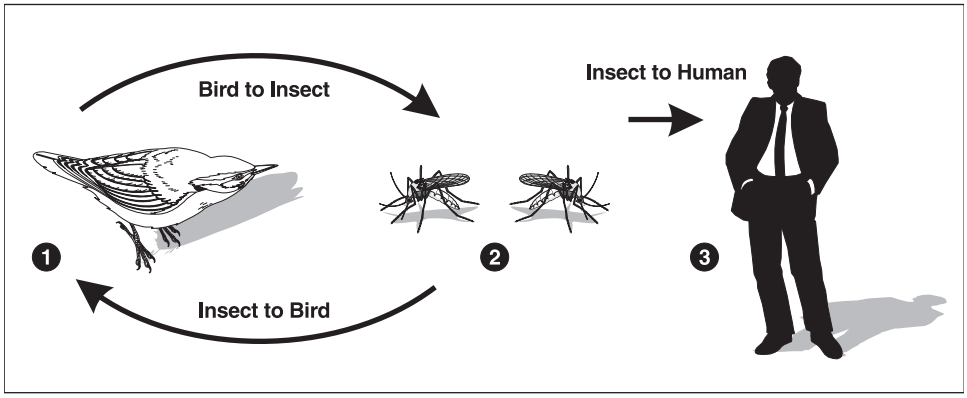
The Viruses: West Nile and St. Louis Encephalitis

Identified in 1937 and named after the Ugandan province where its discovery took place, West Nile virus has a widespread distribution in Africa, West Asia, and the Middle East, occasionally causing epidemics also in Europe. Many people infected with the virus do not become ill or show symptoms, and even when they do, symptoms may be limited to a headache, sore throat, backache, or fatigue. Because no effective antiviral drugs have been discovered, treatment for those who do become seriously ill can only attempt to address symptoms such as swelling of the brain (encephalitis) and other complications such as bacterial pneumonia.

Fatality rates—the percentage of people with confirmed infections who have died—have ranged from 3 to 15 percent for West Nile and are highest in the elderly.

The virus that was originally misidentified as the cause of the New York outbreak is called St. Louis virus. Both West Nile and St. Louis encephalitis viruses are in a group called "flaviviruses," and can be spread when mosquitoes bite birds (often a natural host for the virus), acquire the virus, and then pass it on to humans (see fig. 1). St. Louis encephalitis is found in nature through much of the lower 48 states and is the most common mosquito-borne virus causing outbreaks of human disease in the United States. About 30 confirmed cases occur on average each year during non-outbreak years. St. Louis encephalitis is also similar to West Nile in that most people infected with it show no symptoms, but for those who become seriously ill, no effective antiviral drugs are available. St. Louis encephalitis has a slightly higher fatality rate than West Nile, ranging from 3 to 30 percent of confirmed cases.

Figure 1: Transmission of St. Louis and West Nile Viruses



Overview of the Public Health Response Network

Rapid and accurate diagnosis of disease outbreaks is essential for many reasons. It can help contain an outbreak quickly by allowing health officials to implement appropriate control or prevention measures and provide the most effective treatment for those who are affected. Rapid and accurate diagnosis is essential not only for the public at large, but also for health care workers and others who work with patients and laboratory samples. Accurate diagnosis is also important in providing information that could

help determine whether the outbreak could have been deliberate—an act of bioterrorism. Public health officials use the term "surveillance" to denote the ongoing effort to collect, analyze, and interpret health-related data so that public health actions can be planned, implemented, and evaluated.

Local health personnel are likely to be the front line of response. Local and state health departments might be the first to recognize unusual patterns of illnesses. For example, an epidemiologist (a health official trained to investigate diseases of unknown origin) in a city health department might receive phone calls from nurses, doctors, or emergency room personnel about increasing numbers of patients with similar symptoms. If the problem is thought to be widespread or suspicious in origin, the local health department is likely to involve the state health department, which is responsible for statewide surveillance and investigations involving multiple locations. The local and state response may also involve emergency management personnel. Current protocols recommend that law enforcement officials be notified if a case or series of cases have a suspicious origin.

Local, state, and federal laboratories also play a vital role. Initially, this role may be to determine whether the unusual cases have the same pathogen (the specific causative agent for the disease), and if so, to identify it. Once an outbreak is established, laboratories may be called upon to test samples such as blood or spinal fluid from persons with similar symptoms, to determine who has the illness and the extent of the problem.

At the federal level, CDC, an agency of the Department of Health and Human Services (HHS), is available upon request to help state and local officials investigate the nature and origin of disease outbreaks. For example, CDC maintains several laboratories that identify unusual or exotic viruses and other pathogens when other laboratories are unable to do so. One such laboratory, at the Division of Vector-Borne Infectious Diseases in Fort Collins, Colorado, deals with viral and bacterial diseases transmitted by vectors such as mosquitoes and ticks. It is part of CDC's National Center for Infectious Diseases. Besides providing laboratory services, this division also develops ways to diagnose vector-borne pathogens more quickly and helps develop and evaluate approaches to preventing and controlling outbreaks.

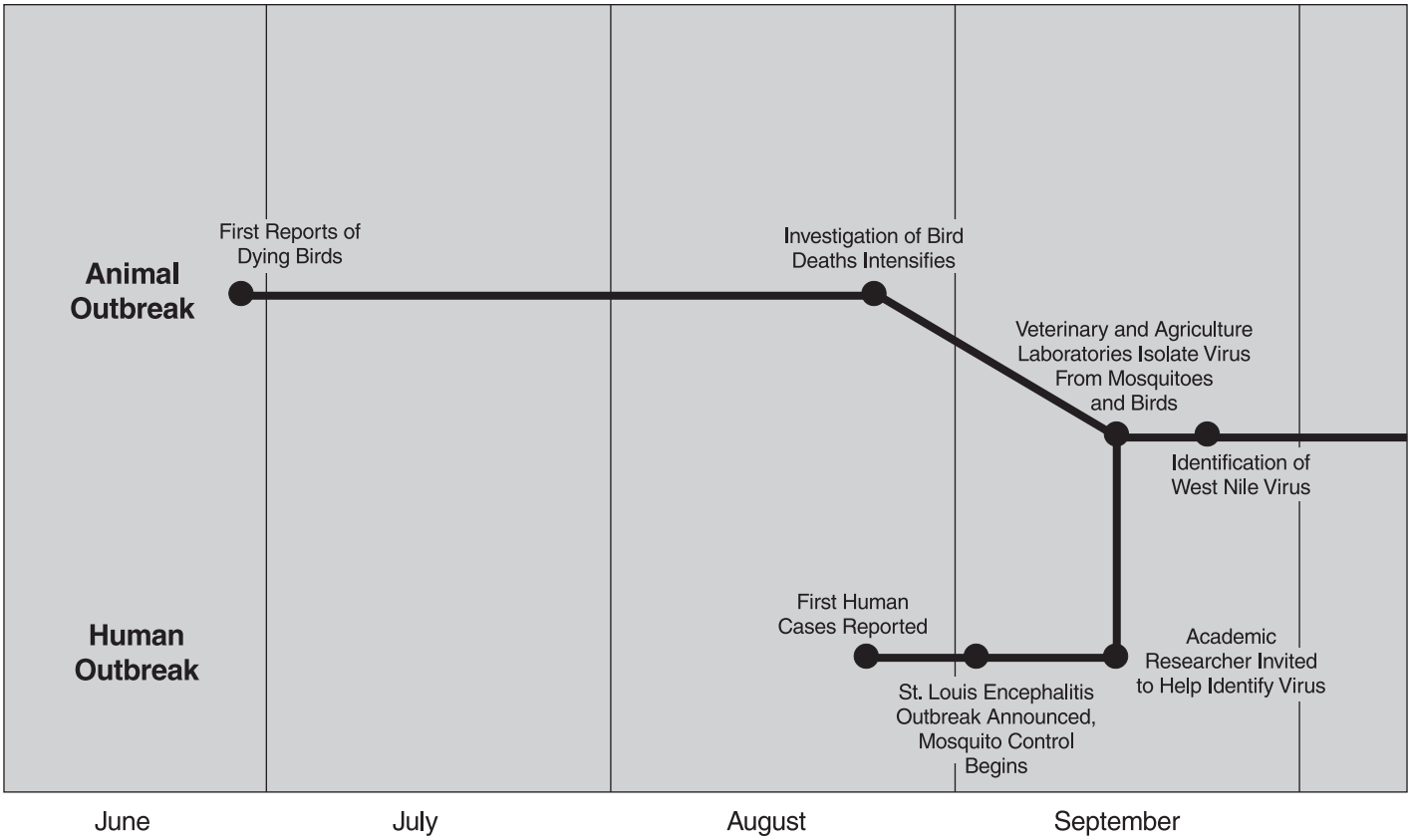
CDC is also the lead agency in HHS for bioterrorism preparedness. In recent years, the President and Congress have been increasingly concerned about the threat of terrorists using weapons of mass destruction, including biological agents.[1] Part of CDC's National Center for Infectious Diseases, the Bioterrorism Preparedness and Response Program is responsible for public health preparedness for potential acts of bioterrorism. In fiscal year 2000, HHS received $278 million of the $10.2 billion in counterterrorism monies allocated to federal agencies. Of the HHS funding, CDC received approximately $155 million for bioterrorism preparedness programs in fiscal year 2000, approximately $40 million of which is to be awarded to state and local health departments for surveillance, epidemiology, laboratory, and communications.

West Nile Identified After Separate Investigations Converge

During the first recognized outbreak of West Nile virus in the United States, infection of animals preceded the first human cases by at least 1 to 2 months. Large numbers of dying birds and an unusual cluster of human cases were at first viewed as separate events. Gradually, as an increasing number of laboratories became involved to conduct further testing on human, animal, and mosquito samples, the linkages became clear, resulting in the identification of the West Nile virus (see fig. 2). The scale of these efforts was substantial, involving participants around the country. Since the end of the outbreak, various local, state, and federal agencies have taken actions to address the potential ongoing consequences of the virus's introduction into North America.

[1]Although the chance that terrorists may use biological materials may increase over the next decade, conventional explosives and firearms continue to be the weapons of choice for terrorists. Terrorists face considerable obstacles in developing biological weapons. See *Combating Terrorism: Need for Comprehensive Threat and Risk Assessments of Chemical and Biological Attacks* (GAO/NSIAD-99-163, Sept. 1999) and *Combating Terrorism: Observations on the Threat of Chemical and Biological Terrorism* (GAO/T-NSIAD-00-50, Oct. 20, 1999).

Figure 2: Timeline of 1999 West Nile Virus Outbreak



Detecting West Nile: An Overview

The identification of a newly emerging infectious disease[2] within a few months was due to the combined, considerable efforts of scores of individuals and several agencies in the animal and the human public health fields and in academia. Here is an overview of the key events that occurred. Appendix II contains a more detailed chronology.

The Animal Outbreak

No one is sure exactly when or how birds became infected. By late June a veterinarian at an animal health clinic in the New York City borough of

[2]Emerging infectious diseases include those whose incidence in humans has increased within the past two decades or threatens to increase in the near future.

Queens had examined and treated several birds that appeared to have nervous system disorders, releasing those that survived. Reports of dead birds increased through July and into August. By mid-August, dead birds were being sent to the wildlife pathologist at the New York State Department of Environmental Conservation. The wildlife pathologist was able to determine that the birds were not dying from any of several common problems, but he could not identify a clear cause. By late August, veterinarians at the Bronx and Queens zoos had joined the effort to identify the disease, after several wild and caged birds died on zoo property.

The Human Outbreak

Meanwhile, near the end of August, a specialist in infectious diseases in a community hospital in Queens noticed that the hospital had an abnormally large number of suspected cases of encephalitis or meningitis (diseases involving inflammation of the brain or spinal cord) and that several of the patients had developed an unusual pattern of muscle weakness. When the hospital's doctors were unable to find a clear cause or an effective treatment, the specialist called the Bureau of Communicable Disease within the New York City Department of Health.[3] After a quick but careful investigation, city health officials contacted the state health department and CDC for additional help. Blood and spinal fluid specimens from hospital patients were rapidly tested at state and CDC laboratories. On September 3, CDC announced that the test results were positive for St. Louis encephalitis, a virus known in the United States but never before known to occur in New York City. That same day, the city, assisted by the state and CDC, launched a massive campaign to prevent people from being bitten by mosquitoes and to determine the extent of the St. Louis encephalitis outbreak.

Within the next week, however, the State Department of Health obtained what appeared to be conflicting test results for St. Louis encephalitis, raising doubts among some health officials about whether the exact cause of the outbreak in humans had been determined. In addition, CDC officials were questioned by city and state health workers and the public as to whether the deaths of large numbers of birds and the human encephalitis cases might be connected. Because St. Louis encephalitis had not been known to kill its bird hosts, CDC officials said they considered the two

[3]According to a New York City Department of Health official, these patients were initially seen by different physicians, as commonly occurs in any hospital, and it was not until a single infectious disease consultant reviewed their cases that the opportunity to see these patients as part of a cluster presented itself.

outbreaks to be unrelated. The cause of the outbreak in birds remained unidentified, and, to help identify it, the zoo veterinarians and the state wildlife pathologist enlisted the help of federal veterinary laboratories at the U.S. Department of Agriculture (USDA) and the U.S. Geological Survey (USGS). By mid-September, both laboratories concluded that the bird disease was caused by a virus, that it did not appear to be any strain of St. Louis encephalitis or other avian virus they had previously tested, and that they had insufficient laboratory capabilities to identify it more specifically. The USDA veterinary laboratory sent its virus samples to the CDC laboratory for further analysis.

The Two Responses Converge and More Laboratories Become Involved

The test results in birds, along with repeated negative test results in human samples in the state health department laboratory, increased the doubts of some state health officials about whether the human disease agent had been correctly identified as St. Louis encephalitis. On September 15, they invited a visiting academic researcher from California to try out some new testing methods on tissue specimens from human patients. The following week, a Connecticut agricultural laboratory involved in that state's routine mosquito surveillance reported isolating St. Louis encephalitis virus from both a dead bird and mosquitoes collected near the outbreak area. This finding was significant in implying that, if the virus was St. Louis encephalitis, it was killing birds and possibly could be connected to the human outbreak.

At about the same time, CDC had begun testing and retesting mosquito, bird, and human specimens against a wider variety of flaviviruses in order to rule out the possibility of another closely related virus. Independently, the head pathologist at the Bronx Zoo gained agreement from the U.S. Army Medical Research Institute of Infectious Diseases to attempt to identify the virus in birds.

Beginning on September 23, the academic researcher and CDC came to the same general conclusion: the virus causing the outbreak was not St. Louis encephalitis but, rather, a virus that had never before appeared in the United States. By the week of September 27, CDC had confirmed that a "West Nile-like" virus was responsible for both the animal and the human outbreaks.

Workload Was Significant

The effort involved in addressing these outbreaks and identifying the cause was concentrated and considerable. Hundreds of reported potential human cases were investigated to determine whether West Nile was the infecting virus. By the end of the investigation, health officials confirmed 62 cases of West Nile virus, including 7 people who died. Thousands of bird deaths were similarly investigated by several state and federal laboratories and agencies, to determine how far the virus had spread. In addition to the laboratory investigations, state and local emergency management teams were mobilized to respond to public health concerns. They managed the coordination of conference calls and other communications, the establishment of hotlines to address the general public's concerns, and the procurement, distribution, and application of pesticides. The New York City and State Departments of Health also developed fact sheets for the public on each of the pesticides in 1999, and in 2000 they implemented a surveillance system for health effects from pesticides.[4] Table 1 shows some specific examples of the case surveillance and laboratory workload experienced by some of the involved agencies during and since the outbreak. Not all of the agencies involved have developed cost estimates for their efforts. As one indication of the cost, however, New York State officials estimated that the state, city, and four counties in the area spent more than $14 million on protective measures such as mosquito control from late August through October.

[4]The City Department of Health conducts surveillance for pesticide-related morbidity by monitoring calls to the Department's Poison Control Center.

Table 1: Examples of Surveillance and Laboratory Workload Experienced by Selected Involved Agencies During and Since the West Nile Outbreak

Agency	Time frame	Example of workload experienced during and since the outbreak
New York City Department of Health, New York City	August to December 1999	Human case surveillance: The city health department investigated 622 suspect hospitalized cases and 88 suspect outpatient cases that were reported. Case investigation included contacting physicians and hospitals, interviewing patients, and coordinating specimen collection and transport. Animal and mosquito surveillance: The city set up and maintained mosquito traps, established a hotline to receive dead bird reports, and triaged the collection of specimens and submission for testing to appropriate laboratories.
New York State Health Department (including counties outside of New York City and New York State Department of Agriculture and Markets)	August to December 1999	Human case surveillance: The state and local health departments (outside of NYC) investigated 229 suspect cases, of which 196 were hospitalized. Human sample testing workload: Polymerase chain reaction (PCR) tests for 13 viruses were performed on 198 specimens from 190 patients.[a] Serology tests were performed on almost 600 specimens. A laboratory official indicated that before the outbreak, the average number of requests for arbovirus tests was 40 to 50 per year. Animal and mosquito surveillance[b]: As many as 17,000 dead birds were reported by local health departments to the state (one-third were crows). The state health department coordinated submissions for testing, with 130 dead birds confirmed positive (at federal laboratories). Twenty-five horse cases were reported. Over 25,000 mosquitoes (in more than 1,500 pools) were collected, with 15 pools testing positive (at CDC).
New York Department of Environmental Conservation, Albany, N.Y.	1999 to June 2000[c]	Avian sample preparation and pathology investigations: The department received, catalogued, and performed necropsies (postmortem examinations) on 880 dead birds submitted from various parties across the state; prepared and mailed samples to various laboratories for testing.
CDC's Division of Vector-Borne Infectious Diseases, Fort Collins, Colo.	1999	Human sample testing workload: In 1999, CDC-Fort Collins received over 1,200 samples from New York alone for testing, representing more than 700 patients. In past years, CDC has received 10 to 20 specimens per year from the state. Avian sample testing workload: CDC tested approximately 1,000 avian tissue samples and 3,000 serum samples from all locations.
U.S. Geological Survey, National Wildlife Health Center, Madison, Wisc.	Fall 1999 to June 2000	Avian sample testing workload: The Center received almost 1,200 specimens from 22 states and local jurisdictions, including nearly 500 animal carcasses for necropsy and testing and 699 tissues for testing for West Nile virus from states such as New York and New Jersey. Live bird surveillance: The Center received almost 1,500 serum samples for West Nile testing from collaborative surveillance activities with USDA in 10 states and from zoos and endangered species in captivity. Collected over 1,000 blood samples from wild birds in New York City in October 1999 for expanded surveillance.
USDA National Veterinary Services Laboratories, Ames, Iowa	Fall 1999 to July 2000	Animal sample testing workload: The laboratory performed almost 120 virus isolation attempts and 640 serum sample tests.

Note: Several other state and private agencies experienced significant workloads. These examples represent New York City and State as well as federal government activities.

[a]PCR is a laboratory process in which a particular ribonucleic acid (RNA) or deoxyribonucleic acid (DNA) segment is rapidly replicated, producing a large, readily analyzed sample of a piece of RNA or DNA.

[b]In addition to laboratory testing, a large number of staff are involved for surveillance and control and to respond to public inquiries, set up mosquito traps, collect birds and mosquitoes for shipment, collect blood samples from horses, establish computerized databases, complete specimen and summary reports, prepare public information and maps, organize prevention and response programs, and so forth.

[c]Specimens from almost 20 crows stored in 1998 were sent for West Nile testing in the fall of 1999.

Many Federal, State, and Local Activities Have Continued Since the Initial Outbreak

While the first frost of the season signaled the end to the initial outbreak in 1999, activities at the national, state, and local levels have continued. In the first week of October 1999 the New York City Department of Health and CDC conducted a random survey of Queens residents to assess the overall infection rate associated with the outbreak. The results of this serosurvey (in which a blood test for West Nile antibodies is performed) revealed that between 1.2 and 4.1 percent of the population in the area surveyed had been infected with West Nile virus.

The change in diagnosis from St. Louis encephalitis to West Nile also caused public health agencies to evaluate whether aspects of their intervention response should be changed. While the West Nile and St. Louis encephalitis viruses are closely related and mosquito-borne, the change in diagnosis had some implications for the intervention approach. For example, past research had shown that different types of mosquitoes might carry the viruses. Both West Nile and St. Louis encephalitis are carried by a certain species of mosquito, *Culex pipiens*. However, West Nile is also carried by other species, including *Aedes vexans* and *Anopheles*. Some of these species have different habitat and activity patterns. For example, *Culex pipiens* breeds in polluted water and is active at night, while *A. vexans* has been found in natural areas and is active during the day.[5] Once the distinction between the viruses was made, the public health interventions were changed accordingly to reflect the other types of mosquitoes potentially carrying the West Nile. For example, local public health notices stated that the public should also avoid contact with mosquitoes active during the day. While these differences are not considered significant since the public health recommendations for mosquito control are appropriate in either case, they illustrate the potential significance of an accurate diagnosis in that even closely related viruses might require different responses.

[5]Due to increased surveillance since the initial outbreak, a new species of mosquito, *Aedes japonicus*, has been found to carry the virus.

Some of the activity since the initial outbreak has involved learning more about where the virus came from and when it arrived. Research into the origins of the virus found that it is most closely related to a strain isolated in a goose found in Israel in 1998. Testing of previously stored bird tissue samples at the Bronx Zoo was negative for West Nile virus, suggesting the virus was introduced in 1999.

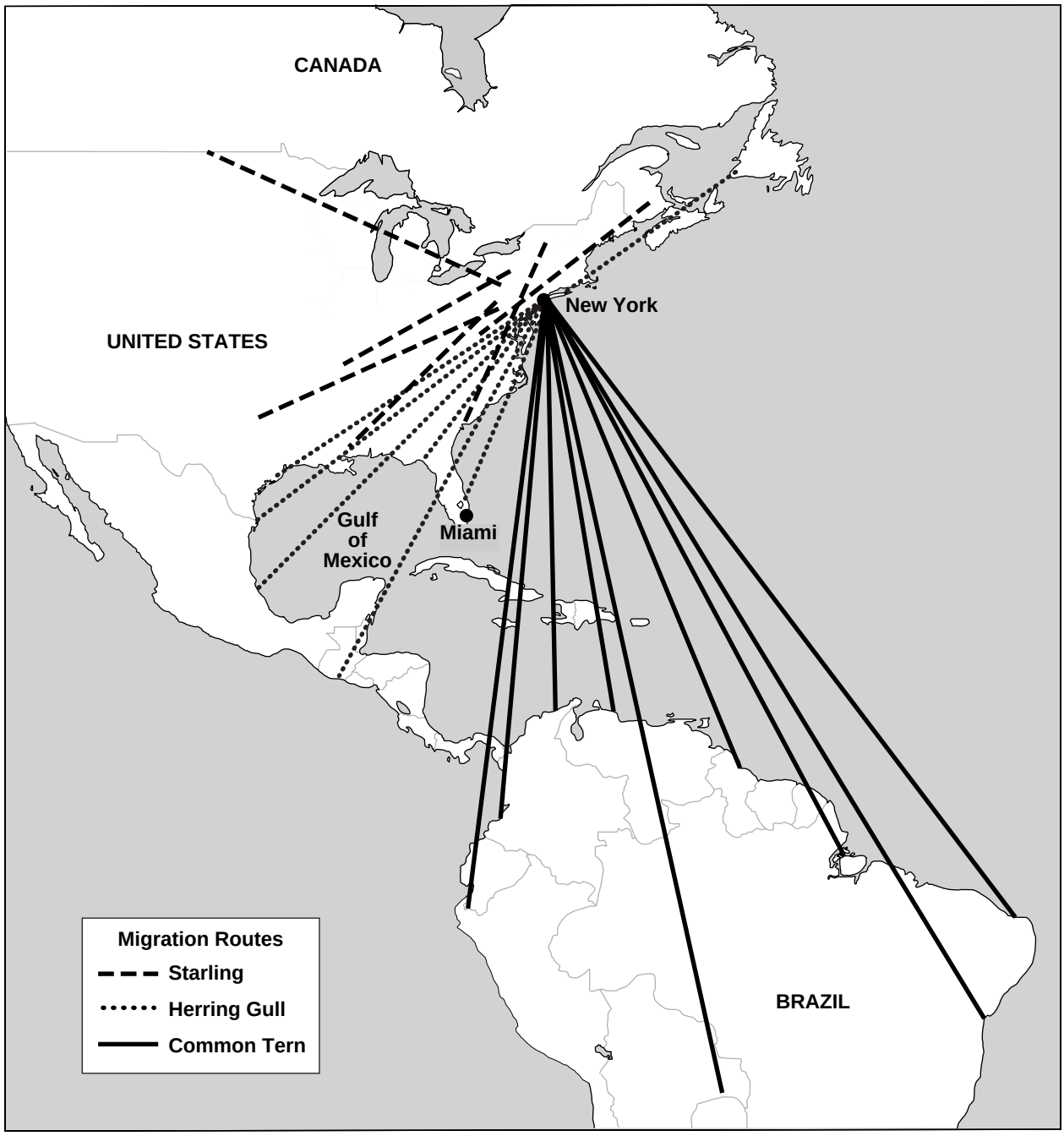
Much of the ongoing effort has been applied to determining whether West Nile will be an ongoing threat to animal and human health. The West Nile outbreak represents a potential problem stretching well beyond New York City, because the virus can spread through bird migrations. In fiscal year 2000, HHS and CDC will provide approximately $10 million for West Nile virus activities. This amount includes grants totaling $4.5 million available to 19 state and local health departments[6] along the Atlantic flyway of migratory birds for West Nile virus surveillance in humans, mosquitoes, and birds. An additional $2.7 million of the $10 million has been made available to 31 other state health departments to expand surveillance capabilities. As of August 2000, communities in at least seven eastern states[7] had undertaken active mosquito control programs, such as spraying, as well as public education campaigns and surveillance activities.

Surveillance activities have already produced evidence that West Nile has spread to other areas. In October 1999 a dead crow carrying the virus was found in Baltimore, Maryland. In 2000, as of August, West Nile virus had been detected in birds in nearly all New York counties as well as in Massachusetts, Connecticut, Rhode Island, and New Jersey and in mosquito pools in several states. If West Nile is carried further south along bird migratory routes (see fig. 3 for examples), it could become permanently established in the Western Hemisphere.

[6]Massachusetts, Rhode Island, Connecticut, New York State, New York City, Pennsylvania, New Jersey, Delaware, Maryland, the District of Columbia, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas.

[7]Connecticut, Delaware, Maryland, Massachusetts, New York, New Jersey, and Rhode Island.

Figure 3: Examples of Migratory Patterns of Three Bird Species Susceptible to West Nile



Source: *New Scientist*, http://www.newscientist.com/nl/0708/birds.html.

The spread of the virus by birds and mosquitoes has significant implications for animal health as well. Animal health officials are concerned about the potential effects on wildlife and other animals, particularly those birds that are susceptible to fatal illness from the virus. The USGS, which conducts surveillance of wildlife health, has helped develop and maintain national maps showing the current wildlife surveillance data now submitted by states.[8] Economic concerns also have been raised. While wild birds were the primary carrier of West Nile in last year's outbreak, the disease was also detected in domestic livestock. Twenty-five cases were identified in horses on Long Island, nine of which died or were euthanized. Although there is no evidence that the virus can spread from infected horses to uninfected horses or other animals, countries from Argentina to the United Arab Emirates placed import restrictions on horses from affected areas.[9] In addition, the role of commercial poultry in maintaining or transmitting the virus is not thoroughly understood. CDC research has found that chickens can develop a short-lived infection without clinical signs.[10]

Several organizations, including CDC, USDA, the Wildlife Conservation Society, and Flushing Hospital, have organized conferences and workshops to review the West Nile virus outbreak. In December 1999, CDC issued guidelines for West Nile virus surveillance, prevention, and control. In the spring of 2000, HHS and USDA appointed West Nile coordinators to oversee efforts against the virus. See appendix III for a list of some key publications about or related to the virus outbreak.

[8]Developed in partnership with National Atlas of the United States, http://www.nationalatlas.gov.

[9]Horses are thought to be terminal or "dead-end" hosts, in that they can be infected with the virus, but the virus does not develop in their blood at sufficient quantities to reinfect mosquitoes.

[10]As of August 2000, no clinical signs of the virus had been reported in poultry in the United States, according to USDA.

Lessons Learned Center on Infrastructure and Communication

While many officials and experts we contacted believe aspects of the outbreak investigation went quickly and well, nearly all of them also believe there were lessons to be learned. These lessons may be especially relevant for acts of bioterrorism, where the outbreak of cases may be much more rapid and law enforcement agencies may need to be involved to prevent terrorists from releasing additional biological agents. The time available for decision-making and response may be compressed from days or weeks to a matter of hours. The lessons we identified related primarily to addressing possible needs in five areas:

- local surveillance and response capabilities,
- communication among public health agencies,
- coordination between public health and animal health efforts,
- capabilities of laboratories, and
- efforts to distinguish between natural and unnatural events.

The Local Disease Surveillance and Response System Is Critical

The West Nile outbreak provided a number of lessons about surveillance. We learned that many aspects of the surveillance network worked well, speeding the response to the outbreak. These positive lessons can serve as models for other communities that may have less substantial surveillance networks. However, while several of the lessons are positive, the outbreak also exposed some weaknesses.

Many Aspects of Surveillance and Response Worked Quickly and Well

The human outbreak of West Nile began with a few unusual cases. The potential that one or two persons' medical conditions could be an indication of some larger concern, such as an emerging infectious disease, may not be readily apparent to the health professionals involved. In many cases, such events might not be noticed until a number of physicians have reported the cases and the local health department identifies a cluster, or a number of victims seek care for similar conditions at the same location. Alert responses by the doctors and nurses who first see such victims are particularly crucial in alerting the public health community to the possibility of a wider problem.

In the West Nile outbreak, several actions were particularly important in providing this early alert, as well as in providing valuable evidence for the investigation. Among these actions are the following:

- The physician who encountered the first human cases at the local hospital in Queens reported the unusual cluster of illnesses to local

public health officials. Such occurrences could easily go unreported, if, for example, the physician does not consider the circumstances to be unusual enough to report or does not recognize a rare disease.

- Epidemiologists and staff at the New York City Department of Health took a number of actions that were essential to containing the outbreak. They quickly investigated and recognized the potential significance of the initial case reports. Their interviews with patients and families identified common features in how the patients were exposed out of doors, suggesting that a mosquito-borne disease might be involved. They canvassed all New York City area hospitals to identify potential cases, and throughout their investigation, they remained in daily touch with the many local, state, and federal officials who had quickly become involved. These staff members said previous planning for bioterrorism response in place at the city health department was key to the success of the Department's response.[11]
- Autopsies were performed on the victims. The New York City Department of Health and Office of Chief Medical Examiner worked together to ensure that autopsies were performed on any fatal case of encephalitis. Autopsies were performed on over 25 fatal cases who were initially suspected as having viral encephalitis, including all 4 fatal cases of West Nile encephalitis that occurred among city residents. According to one assessment of the response, information obtained from the autopsies pointed to a flavivirus as the cause and helped guide subsequent laboratory testing.[12] Autopsy rates nationally have been decreasing, at a time when public health officials believe they should increase to help detect infectious diseases. The decline has been influenced by such factors as costs and jurisdictional and authorization uncertainties.

[11]Officials indicated that most critical was the collaborative relationship in place between the health department and the Office of Emergency Management due to the bioterrorism planning efforts. This collaboration helped facilitate the rapid mobilization of emergency control measures, establishment of the public hotline, and rapid mobilization of staff over the holiday weekend to assist in canvassing local neighborhoods with educational materials.

[12]Wun-Ju Shieh, Jeannette Guarner, Marci Layton, Annie Fine, James Miller, Denis Nash, Grant L. Campbell, John T. Roehrig, Duane J. Gubler, and Sherif R. Zaki, "The Role of Pathology in an Investigation of an Outbreak of West Nile Encephalitis in New York, 1999," *Emerging Infectious Diseases*, Vol. 6, No. 4 (May-June 2000).

Uncertainty Exists About What to Report, When, and to Whom

While the West Nile outbreak was identified more quickly than otherwise might have been expected because an astute physician reported two unusual cases, it still provides evidence that the reporting system could be improved. The virus might have been identified earlier—perhaps by a week according to an involved official—if case reporting had been better and if good baseline data showing past trends of encephalitis and related diseases had been available. Similarly, a physician we interviewed who had treated West Nile patients said clinicians often do not know whom to call when a cluster of patients with a disease of unknown origin is noticed. Wildlife and zoo officials also indicated that within their fields there is a need for better information and guidance about whom to contact in the public health community when an outbreak is suspected.

These problems have been noted in other instances besides the West Nile outbreak. For example, a November 1998 workshop on public health systems and emerging infections sponsored by the Institute of Medicine—an organization chartered by the National Academy of Sciences to examine public health policy matters—reported that physicians are not sure when or where to report suspicious cases of infection. The workshop also reported that physicians are unaware of the need to collect and forward clinical specimens for laboratory analysis and may not be educated regarding the criteria used to launch a public health investigation. Unlike the case in New York City, where the health department had been actively communicating with physicians, the workshop found that there is often a lack of communication between public health agencies and community physicians.[13]

A 1999 assessment by the Institute found that disease surveillance systems in place at local, state, and federal levels rely on systems of disease reporting from health providers that are notorious for their poor sensitivity, lack of timeliness, and minimal coverage.[14] Because an effective medical response to a bioterrorist event would depend in part on the ability of individual clinicians to identify, accurately diagnose, and effectively treat diseases (including many that may be uncommon), the Institute reported

[13]Institute of Medicine, *Public Health Systems and Emerging Infections: Assessing the Capabilities of the Public and Private Sectors*, Workshop Summary (Washington D.C.: National Academy Press, November 2000), p. 5.

[14]Institute of Medicine and National Research Council, *Chemical and Biological Terrorism: Research and Development to Improve Civilian Medical Response* (Washington D.C.: National Academy Press, 1999), p. 66.

that education about the threat posed by bioterrorism and about the diagnosis and treatment of various agents deserves priority.

Some Inadequacies in Resources for Surveillance Were Exposed

Although this outbreak was relatively small in terms of the number of human cases, it taxed the resources of one of the nation's largest local health departments. The strain on resources is particularly noteworthy because local health departments in the United States have initiated nearly all the investigations that led to the recognition of infectious disease outbreaks. At the time of the West Nile outbreak, the New York City Department of Health had a unit of about eight people responsible for surveillance and case investigations related to over 50 reportable infectious diseases. Officials told us that having even this small number of trained staff available was critical to the quick response to the initial outbreak. Once the outbreak was identified, these and other staff assigned to help from other agencies and departments worked long hours, seven days a week.

We reported in 1999 that surveillance for important emerging infectious diseases is not comprehensive in all states, leaving gaps in the nation's surveillance network.[15] Many state epidemiologists reported inadequate staffing for generating and using laboratory data—often considered more reliable for case investigation purposes than physician-reported data—for performing infectious disease surveillance. The Institute of Medicine workshop reported that, in general, epidemiological investigations and surveillance efforts are challenged by a variety of factors. These include changes in the health care system and the continuing use of paper-based disease-reporting systems in many locations, where surveillance is consequently sporadic and inadequate.[16]

Better Communication Is Needed Among Public Health Agencies

Experts consider rapid and reliable communication among public health agencies to be essential to bioterrorism preparedness and coordination. Timely dissemination of information allows public health officials to make decisions with the most current information available. During the West Nile outbreak, however, officials indicated that the lack of leadership in the initial stages of the outbreak and the lack of sufficient and secure channels

[15] *Emerging Infectious Diseases: Consensus on Needed Laboratory Capacity Could Strengthen Surveillance* (GAO/HEHS-99-26, Feb. 1999), p. 2.

[16] *Public Health Systems and Emerging Infections*, p. 4.

for communication among the large number of agencies involved prevented them from sharing information efficiently.

Many officials interviewed pointed to the lack of clear reporting guidelines as one source of confusion. Knowing who was in charge or could act as an agency spokesperson, and which agency was responsible for what, would have allowed each agency to operate more effectively. Some officials suggested that each agency should have one "point person" overseeing operations and the flow of information.

During the outbreak, local, state, and federal officials held daily conference calls coordinated by the City or State Department of Health, or CDC. During these calls, officials received up-to-date information on such topics as the human and animal surveillance systems, test results from each laboratory, and schedules for mosquito spraying. While these calls were considered necessary to ensure that all parties heard the same information, they sometimes involved over 100 people and lasted 2 hours or more.[17] As a result, key officials had less time to investigate the outbreak in the laboratory and in the field. Additionally, veterinary health officials were concerned because they were not always included in these calls.

While a secure electronic communication network was in place at the time of the initial outbreak, not all involved agencies and officials were using it at the time. For example, because CDC's laboratory was not linked to the New York State network, the New York State Department of Health had to act as an intermediary in sharing CDC's laboratory test results with local health departments. CDC and the New York State Department of Health laboratory databases were not linked to the database in New York City, and laboratory results consequently had to be manually entered there. Physicians, local health departments, and laboratory officials indicated that during the outbreak, it was sometimes difficult to determine the status of patients' samples and of the laboratory results. During and since the outbreak, however, officials indicated that the use and utility of the network have improved for West Nile surveillance and information sharing. Using the network, the state has put together an interactive surveillance system for mosquito, bird, and human disease reports. Since the fall of 1999, access to the network has been provided to more health officials, including animal health agencies, for tracking West Nile in animals and

[17]An involved official indicated that these problems were improved with the implementation of a standard format and agenda for each call.

humans. The communication limitations during the outbreak, the resulting changes to the electronic network capabilities, and the increased reliance on the network for sharing information have increased awareness of the need for established electronic data-sharing mechanisms.

New York State officials told us that the state has invested heavily in its communication infrastructure and has created an advanced information system, but at a national level some local health departments still do not have access to modern communication technologies. A 1999 survey by the National Association of County and City Health Officials found that one-third of health departments serving fewer than 25,000 people did not have access to the Internet or electronic mail. Similarly, more than half the agencies surveyed had neither continuous, high-speed access to the Internet nor broadcast facsimile transmission capabilities.

Links Between Public and Animal Health Agencies Are Becoming More Important

The West Nile events illustrate the value of communication between public and animal health communities, the latter including those dealing with domestic animals, wildlife, and other animals such as zoo animals. Many infectious diseases, including West Nile, are zoonotic, that is, capable of infecting both animals and people. According to recent research, approximately three of every four emerging infectious diseases reach humans through animals.[18] Of over 1,700 known pathogens affecting humans, including viruses and bacteria, 49 percent are zoonotic. Of the 156 pathogens associated with emerging diseases, 73 percent are zoonotic. Many of the viruses or other pathogens considered most likely by CDC to be used in a bioterrorist incident are zoonotic, such as anthrax, plague, brucellosis, tularemia, and the equine encephalitic viruses. An official of the USGS National Wildlife Center noted that many zoonotic pathogens become established in wildlife before they are transmitted to humans and domestic animals. The November 1998 Institute of Medicine workshop reported that, because of their familiarity with a number of these biological agents, the veterinary medicine community should not be overlooked in surveillance efforts.[19] Moreover, veterinarians and veterinary laboratory workers are likely to have been vaccinated against many zoonotic diseases and are used to working with zoonotic pathogens.

[18]M. Enserink, "Origins of New, Booming Diseases," http://sciencenow.sciencemag.org/cgi/content/full/2000/717/1 (cited July 17, 2000).

[19]*Chemical and Biological Terrorism*, p. 68.

The West Nile outbreak shows how domestic, wild, and zoo animals can be considered "sentinels," providing an early warning device for diseases that can harm people. Even for a deliberate biological attack, animals may be the first victims, unintentionally or as part of an effort to avoid discovery, according to the Institute of Medicine and National Research Council.[20] In the case of the West Nile outbreak, USDA and USGS National Wildlife Center laboratories were involved in early or mid-September in testing bird samples prior to the identification of the West Nile virus. However, because these laboratories lacked reagents[21] for the virus, they were unable at the time to specifically identify it.

Experience with the West Nile outbreak also illustrates how links between the animal and public health communities were missing. For example,

- Some key public health officials, such as the city health department's Director of the Bureau of Communicable Disease, indicated that they were not aware of the similarities in the clinical symptoms occurring in the birds and humans until many days or weeks after the human outbreak began. Officials said they believe that communication was hindered even further because, even within the animal health community, there is fragmentation at the state and federal level in what agencies are responsible for different types of animals. For example, domestic animals, such as cats and dogs, are usually the responsibility of state and local health departments. Livestock, such as cattle and swine, are often the responsibility of state agricultural agencies. Wildlife, such as birds, are under the state environmental or wildlife agencies.
- When wildlife health officials approached the state public health laboratory to test the bird samples, they were told their samples should be tested at another laboratory, because the state laboratory did not have the reagents to perform animal (bird) testing. According to a New York State animal health official, not having adequate capacity within the state laboratory to test animal samples can create administrative and cost barriers to getting samples tested. For example, many veterinary laboratories will test samples only on a fee basis and not for public health purposes. In some areas of the country, such as the

[20] *Chemical and Biological Terrorism*, p. 72.

[21] Reagents are chemicals used in laboratory tests to indicate the presence of a virus or other substance.

Southwest, where zoonotic diseases such as hantavirus are endemic in the animal population, integration of the animal and public health communities is considered to be better.

- Several persons involved in the outbreak commented that the zoo community is currently left out of the animal and public health paradigm, even though zoo animals may be useful sentinels. Zoo animals generally receive close attention from veterinarians, and in some cases pathologists track health care and disease causes, creating detailed health records and storing tissue samples for future analysis. Officials indicated that because zoo animals are not considered to be wildlife or domestic animals, they do not fall within the jurisdiction of animal health agencies such as the USGS, which tracks wildlife issues, or the USDA, which tracks concerns related to domestic animals. The Bronx Zoo pathologist tried many different channels in order to find laboratories willing to prioritize performing additional tests on the bird samples and to provide advice on needed safety precautions for zoo laboratory personnel working with the bird samples.[22]

Many officials provided other examples of where communication between public and animal health communities had not worked well and indicated that the West Nile events pointed to a need for better partnership between these communities. This opinion was voiced even by those who at first disregarded animal health officials' views and questions about the potential links between the animal and the human outbreaks. For example, in its own internal assessment of the West Nile events, CDC concluded that the relationships between public health agencies at the federal, state, and local levels and their counterparts in public and private agencies that monitor veterinary health should be strengthened. There are indications that some of this greater collaboration has begun. Since the outbreak, archived blood samples from zoo animals drawn in past years have been analyzed as part

[22]During the outbreak, one of the biggest concerns of the veterinary pathologist at the Bronx Zoo was the safety of laboratory workers at the zoo who were handling sick or dead birds. At one point before the virus was identified, a veterinarian who was euthanizing a dying flamingo stuck himself with a needle. Because the pathologist surmised that the animal and human outbreaks were related, this event heightened her concerns about identifying the virus.

of the ongoing investigation to determine when and how West Nile was introduced.[23]

Assessment of Laboratory Capacity and Improvement of Linkages Among Laboratories Are Needed

Another frequently cited lesson was the need for improved laboratory infrastructure and technologies for responding to outbreaks and newly emerging viruses. While the concerns were wide-ranging, three common themes emerged: broadening laboratory capabilities, ensuring adequate staffing and expertise, and improving ability to deal with work surges in testing needs. Since the extent to which public health and other laboratories across the country are capable of safely testing dangerous pathogens is unknown, a first step in addressing these concerns may be to complete assessments of inventory and core capacity needs. At the same time, lessons from the West Nile outbreak point to the need to improve current linkages among laboratories.

Broadening Laboratory Capabilities

The need for enhanced laboratory capabilities was frequently mentioned by officials involved in the West Nile outbreak, as well as in various assessments. Officials pointed out the need for more laboratory capacity for identifying and handling infectious agents of high concern to human health, particularly emerging or exotic ones. For example, they said that at the time of the outbreak, only two or three laboratories in the country had the reagents necessary to identify the West Nile virus. One of these was CDC's laboratory in Fort Collins, which did not initially use this reagent since the first test it had performed was consistent with the related St. Louis encephalitis virus.[24] Because New York State's laboratory was considered less equipped to perform the diagnostic testing on the human samples once the outbreak was identified, CDC performed the bulk of these tests. In this regard, the need to "expect the unexpected," a phrase frequently quoted in outbreak assessments, expresses the importance of developing a broader awareness within the laboratories of the potential for

[23]Specifically, according to information provided by a Wildlife Health Sciences, Wildlife Conservation Society researcher, a serologic survey of the Wildlife Conservation Society/Bronx Zoo collection was performed to confirm infection of clinical cases, assess the extent of West Nile exposure, and investigate when the virus was introduced to the collection.

[24]According to CDC, West Nile virus was not included in the original battery of antigens in the tests performed at this point because there are 30 possible antigens to include and West Nile had never before been seen in the Western Hemisphere. Other experts indicated that this was a reasonable conclusion at the time.

new agents to appear and, concurrent with such awareness, developing broader testing capacity. One federal laboratory official suggested, for example, that federal policy should consider a broader dissemination of methods for identifying more exotic pathogens—perhaps those pathogens that are more likely to be introduced to the country through international travel or otherwise.

Some bioterrorism and public health officials noted that, while expansion of laboratory capacity is vital to preparedness, efforts to identify more exotic agents may be beyond the scope of all but the largest health departments and therefore should be a regional or state-based activity. Consequently, some experts have suggested research into determining the utility of developing a network of regional laboratories capable of rapid diagnostic testing.[25] Determining current capacity will be a key first step in assessing the need for a regional network. Currently, the number of public health and other laboratories that can handle those viruses considered most harmful (those classified as requiring Biosafety Level-3 or Biosafety Level-4 equipment, trained staff, and safety procedures in place) is unknown.[26] CDC information indicates that most states lack the public health laboratory capacity to handle many of those viruses that CDC has classified as dangerous and identified as high priority because of risk to national security and public health. Specifically, in fiscal year 1999, less than half of the over 40 states and localities receiving funding for laboratory capacity through CDC's bioterrorism preparedness grant program reported having advanced capacity for rapid testing for at least four critical biologic agents.[27] Within the veterinary community, a USDA official told us that probably fewer than 20 veterinary laboratories across the country have the capacity to test for Biosafety Level-3 pathogens, and no veterinary laboratories have Biosafety Level-4 capacity.[28]

[25] *Chemical and Biological Terrorism*, p. 73.

[26] Biosafety Level-3 pathogens are considered serious or lethal with the potential for aerosol transmission. Biosafety Level-4 pathogens are dangerous, exotic agents posing high risk of life-threatening disease that also are transmitted through the air and with an unknown risk of transmission; Biosafety Level-4 pathogens have no vaccines or drugs available for treatment. Officials told us that three federal laboratories have Biosafety Level-4 capacity and that an inventory of Biosafety Level-3 laboratories is currently under way.

[27] Critical biologic agents are those considered by CDC to be of potential concern for bioterrorism and which must be registered with CDC when acquired or transported. CDC has classified laboratories based on their biosafety and containment capacities and other factors, level A, for example, representing those with low-level biosafety facilities and level D representing those with the highest-level containment and expertise in the diagnosis of rare and dangerous biological agents. CDC reported that in fiscal year 1999, 19 of 43 funded states or localities self-reported a level C laboratory capability for at least four of the critical biologic agents. According to CDC, level C capability requires a Biosafety Level-3 facility.

[28] Specifically, this official indicated that there are 9 Biosafety Level-3 veterinary laboratories that can study Biosafety Level-3 pathogen-infected animals, and fewer than 10 additional veterinary laboratories that have Biosafety Level-3 facilities for doing diagnostics or other nonanimal work.

Ensuring Adequate Staffing and Expertise

Several officials commented on the declining capacity and expertise within the federal and state public health laboratory infrastructure, particularly as it relates to zoonotic and vector-borne diseases. At the time of the outbreak the Fort Collins laboratory capacity was considered to be low, and many needed specialist positions had been eliminated or left vacant as experienced staff had left. Similarly, CDC reported that only a few states and even fewer local health departments have trained personnel or the resources to adequately address vector-borne diseases. According to CDC and other officials, the infrastructure of laboratories with the capacity to handle such diseases has deteriorated in recent decades. The number of laboratories and extent of capacity have dropped, and the staffing, physical plant, and financial support of many remaining laboratories have also been affected.

New York State, prior to the outbreak, lacked the capacity to address vector-borne diseases. A New York State laboratory official indicated that at one time the state had 5 or 6 staff to perform mosquito surveillance to track viruses. In recent years the laboratory's staff had been cut back as funding was diverted to other public health priorities. By contrast, Connecticut officials indicated that they had—after a similar encounter with eastern equine encephalitis, another mosquito-borne virus—instituted mosquito surveillance in 1997, at a cost of about $200,000.[29] Because of its ongoing surveillance program, the state was able to quickly respond to the outbreak, placing mosquito-monitoring devices in potentially infected areas and identifying the appropriate places to spray. According to a program official, having baseline data—for example, data on where most mosquitoes of concern resided in previous years—allowed the state to make informed decisions about where to spray.

[29]Officials told us that since the West Nile outbreak last fall, funding for these efforts in the state has increased.

Improving Ability to Deal With Surges in Testing Needs

Testing for West Nile taxed those parts of the laboratory system that were dealing with the outbreak—and in some ways, affected what some of these laboratories were normally expected to do. The New York laboratory that was testing samples for St. Louis encephalitis was also dealing with an outbreak of *Escherichia coli* O157:H7 at the same time.[30] Both the New York State and CDC Division of Vector-Borne Infectious Disease laboratories were quickly inundated with requests for tests, and because of the limited capacity at the New York laboratories, the CDC laboratory handled the bulk of the testing. CDC officials reported that nearly all the Fort Collins Arbovirus Disease Branch laboratory staff at one point was working on the response to the virus. Normally, the CDC laboratory functions as a reference laboratory for arboviruses, maintaining the technology and capability to accurately diagnose viruses of this type.[31] In this case, it was acting largely as a diagnostic laboratory, testing patient samples to determine who had the virus and who did not. Officials indicated that the CDC laboratory would have been unable to respond to another outbreak, had one occurred at the same time. Some officials also described what were considered to be unfortunate aspects of CDC's taking on the role of the diagnostic laboratory. Typically, the CDC laboratory's role would be to confirm test results rather than to perform diagnostic testing. In this case, in assisting the state in performing the diagnostic testing, CDC focused on determining whether individual patients had St. Louis encephalitis (and then West Nile) rather than identifying other possible causes of illness. This was considered by some to be unfortunate from the standpoint of the individual patients, whose diagnoses could therefore be delayed. Testing at the state laboratory from 95 patients with suspect viral infections found 16, or about 17 percent, of the patients positive for viruses other than West Nile.

[30]*E. coli* are normal bacterial inhabitants of the intestines of most animals, including humans, where they suppress the growth of harmful bacteria and synthesize vitamins. However, a minority of strains cause illness in humans. *E. coli* O157:H7, first identified as a human pathogen in 1982, is a strain that causes severe abdominal cramping and diarrhea that can become heavily bloody. Although people usually get well without treatment, the illness can be fatal.

[31]CDC's Division of Vector-Borne Infectious Diseases, Arbovirus Disease Branch, functions as a World Health Organization Collaborating Center for Reference and Research on Arboviruses.

Improving the laboratory network is key to improving the laboratory capacity to respond to surges in workload and to provide the new technologies, staff, and expertise to respond to outbreaks. Networks or linkages among federal, state, academic, and possibly private sector laboratories may also be needed, in part to clarify responsibilities for involved laboratories for providing surge capacity, diagnostic testing, and other critical roles in emergency situations. CDC's internal investigation concluded that the agency should enlist help from academic laboratories. The California researcher who conducted some of the diagnostic laboratory work on the West Nile outbreak was brought in by officials at New York State's Department of Health because they learned of the innovative research his laboratory was developing to quickly and accurately identify the viral causes of unexplained deaths from encephalitis.[32] Some involved officials indicated that the California laboratory's involvement was fortuitous in allowing a laboratory not consumed with diagnostic testing for the outbreak to focus on performing the types of tests required to eventually identify the virus. On the other hand, some officials also indicated that this laboratory's unplanned involvement contributed to confusion about which laboratories were performing tests and the types of tests being performed.

Those involved in responding to the West Nile outbreak have concluded that with a more formal network and clearer roles,

- necessary tests to accurately identify the virus could have been started sooner, and
- the resulting confusion about which federal and other laboratories were involved in the process and the tests each laboratory was performing could have been avoided or minimized.

[32]CDC officials from Atlanta were also involved in the discussion regarding involving the researcher. Because tests can take a considerable amount of time, a key state official involved in the decision indicated that test results were not expected for weeks or months. Consequently, officials did not inform the Fort Collins laboratory scientists that samples had been given to the California laboratory.

However, while many agree that more should be done to develop the laboratory network, the plans for such a network are still being developed. CDC's planned laboratory response network for bioterrorism—linking public health laboratories at the local, state, and federal levels—is still under development.[33] Private, veterinary, and USDA laboratories are not yet part of the network.

Assessment of the public health infrastructure by public health experts, and CDC's strategic plan for preventing emerging infectious diseases, also point out the need for defining and building the laboratory network. The Institute of Medicine workshop that assessed the capabilities of the public and private sectors for identifying emerging infections reported that surge capacity in response to an outbreak is an area in which the public health laboratory should define its core capability and standards, including the unique and complementary roles of the public and private sector laboratories.[34] CDC's strategic plan has a goal to strengthen the public health infrastructure in part by strengthening CDC's capacity to serve as the national and international reference laboratory for the diagnosis of infectious diseases.[35]

[33]The laboratory response network, which would link clinical laboratories to public health agencies, is discussed in a report containing recommendations of a CDC workgroup. See Centers for Disease Control and Prevention, "Biological and Chemical Terrorism: Strategic Plan for Preparedness and Response: Recommendations of the CDC Strategic Planning Workgroup," *Morbidity and Mortality Weekly*, Vol. 49, No. RR-4 (April 21, 2000).

[34]The workshop also concluded that specialized laboratory techniques in modern biology and the skilled personnel needed to perform those tests are usually too costly for most laboratories but could be obtained through the use of a regional system and private-public partnership. See *Public Health Systems and Emerging Infections*, p. 21.

[35]The plan similarly addresses goals and strategies related to other lessons learned discussed in this report, including improving disease surveillance and outbreak response; applied research to develop diagnostic tests, drugs, vaccines, and surveillance tools; public health infrastructure and training; and disease prevention and control. See Centers for Disease Control and Prevention, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century* (Atlanta, Ga.: U.S. Department of Health and Human Services, 1998).

Challenges in Distinguishing Between Natural and Unnatural Events Show Common Elements of Preparedness

Finally, the outbreak and surrounding events illustrate the challenges inherent in recognizing a bioterrorist event versus a natural outbreak. In October 1999 a media report suggested that the outbreak could have had an unnatural origin.[36] The Central Intelligence Agency examined the allegations and concluded that there was no evidence indicating that the outbreak was caused intentionally.

The report of the possibility of a bioterrorist event, and the difficulties in correctly identifying the virus and its source, highlight how hard it can be to determine whether an outbreak has an unnatural origin. While the actual response to the West Nile virus outbreak might not have been significantly different had it been considered a potential bioterrorist act, such an event would require the involvement of additional organizations to carry out a criminal investigation. CDC's current recommended protocols are to notify the Federal Bureau of Investigation and law enforcement officials, who would also seek to determine whether terrorists had targeted additional locations for release of the pathogen. The need to involve these agencies may not be evident at the start. An HHS Office of Emergency Preparedness official indicated that an investigation of a real bioterrorism attack may start as an emerging infectious disease outbreak investigation that finds that the cause was terrorism. It is difficult to establish specific criteria for reporting an outbreak as suspicious, but officials indicated that improved reporting criteria may be needed.

The West Nile investigation is not the only incident that has illustrated the difficulties of determining whether an outbreak was intentionally caused. According to the Federal Bureau of Investigation, there has been only one act of terrorism in the United States in which a biological agent was used, and in this case the deliberate cause was not known until long after the outbreak had passed. The event occurred in September 1984, when 751 persons in Oregon became ill with gastroenteritis, an inflammation of the stomach and intestines. The local health department, with assistance from CDC, discovered that food at salad bars had been contaminated with *Salmonella typhimurium*. More than a year later, the Federal Bureau of

[36] *The New Yorker* (Oct. 18 and 25, 1999), pp. 90-107.

Investigation learned through a former member of a religious cult that the cult had used the *Salmonella* to contaminate the food.[37]

The West Nile outbreak may also illustrate the importance of improving our understanding of the causes of unexplained deaths of previously healthy people. Currently, much is unknown about the specific pathogens that cause the deaths of Americans from suspected infectious diseases. Most of the specific causes of encephalitis are undiagnosed. From the point of view of improving surveillance for acts of bioterrorism, a key may be in improving the ability to identify the causative agent in any case where the disease is serious and unusual. One effort toward this end is CDC's unexplained death project. The project—the focus of the Albany conference at which the academic laboratory at the University of California at Irvine was asked to use innovative techniques to test the human samples—aims to improve CDC's capacity to rapidly identify the cause of unexplained deaths or critical illness, and to improve understanding of the causes of specific infectious disease syndromes for which a cause is often not found.[38]

[37]The cult's intent was to incapacitate people so they would be unable to vote in a local election. Because the crime was politically motivated, the Federal Bureau of Investigation subsequently considered the incident to be an act of terrorism. Two former members pleaded guilty to tampering with consumer products under the Federal Anti-Tampering Act of 1983. They were each sentenced to 4-1/2 years in prison. See *Food Safety: Agencies Should Further Test Plans for Responding to Deliberate Contamination* (GAO/RCED-00-3, Oct. 1999), pp. 3-4.

[38]In part, this project was initiated when researchers realized that what were thought to be new diseases or pathogens had actually been causing illness and deaths in past years. For example, after the serious outbreak of Legionnaire's disease in 1976 in Philadelphia, in which 221 people fell ill and 34 died, investigations identified cases in 1947 and an outbreak in 1957 that were previously unrecognized. Starting in 1995, under this project, surveillance for unexplained deaths and critical illnesses occurred first in four, and now in six states. This surveillance is considered to serve as an early warning system for dangerous microbes as well as a focal point for research on new tests.

Finally, the outbreak and surrounding events support public health officials' views that bioterrorism preparedness rests in large part on the soundness and preparedness of the public health infrastructure for detecting any disease and the causes of disease outbreaks. An important public health responsibility in any disease outbreak is to identify the agent and source of the disease as part of the process to determine how to prevent it from spreading further. From the public health standpoint, whether an outbreak is natural or artificial may be of little significance, although the political or legal ramifications may be large.[39] Bioterrorism preparedness officials aware of the West Nile outbreak and investigation indicated that because the local public health officials were taking appropriate steps to identify the spread and source of the disease, the proper steps were under way for determining whether the source or origin should be considered suspicious.

Appendix III contains a bibliography of selected assessments and reports that relate to the public health infrastructure and bioterrorism preparedness.

Conclusions

The sudden appearance of West Nile virus in this hemisphere is a clear illustration of the often-repeated need to "expect the unexpected." Much of the initial response was based on typical steps for identifying and responding to diseases that occasionally break out in the United States. From that standpoint, the correct public health agencies were involved and the response was timely and appropriate. But in this case, critical information and clues pointing to a newly emerging virus were discounted early on, but reemerged later. Persistence, coupled with the significant contributions of additional laboratories, investigators, and researchers, produced the additional evidence leading to the final identification of West Nile as the cause of the outbreak. However, as more agencies became involved, coordination with those already involved in the investigation was not always effective, and communication became more difficult.

[39]This point was emphasized in the report of the CDC Strategic Planning Workgroup. The report states that the epidemiologic skills, surveillance methods, diagnostic techniques, and physical resources required to detect and investigate unusual or unknown diseases are similar to those needed to identify and respond to an attack with a biological agent. See Centers for Disease Control and Prevention, "Biological and Chemical Terrorism," p. 4.

How can this incident be translated into increasing the likelihood that the public health network can detect similar threats and then identify and contain them more effectively in the future? The public health community is doing a great deal to respond—both to this particular outbreak, which continues to unfold, and to the larger set of concerns it raised. The lessons we identified are, to some extent, already part of that ongoing effort.

These lessons support the view of many that "an outbreak is an outbreak is an outbreak"—that is, whether an outbreak is intentional or natural, the public health response of determining the causes and containing its spread will be the same. Thus, policies and actions that improve the capabilities of the public health infrastructure—including those that improve the animal health infrastructure—do more than help the nation better prepare for a potential bioterrorist event. These same improvements will also increase our ability to detect and contain the more likely sort of outbreak that starts with a global traveler, a wayward mosquito, or a migrating bird.

We provided a copy of the draft report to CDC, USDA, and New York City and State Department of Health officials for comment. CDC and the New York City Department of Health provided written comments, which are provided in Appendices IV and V. USDA and the New York State Department of Health also provided comments, which are summarized below.

Generally, officials agreed with the lessons and conclusions drawn from experience that are presented in the report. The commenting agencies also offered several observations on various aspects of the report draft. CDC said that its strategic plans for emerging infectious diseases and bioterrorism should be mentioned in the report, and we have done so. CDC expressed a concern with the emphasis in the draft on those aspects that did not go as well as others. Because this report was designed to analyze the events of the fall of 1999 and identify lessons learned for the nation's preparedness, it necessarily focused on those things that were perceived as problems at that time. CDC also expressed a concern that the report overemphasized the role of the convergence of the human and animal investigations, because laboratory tests conducted by the California researcher and others on the human side were also showing that the virus was not the one initially identified as the cause at the same time as the animal tests. We agree that these contributions were significant, and we made clarifications to the text to recognize them. Nonetheless, we continue

to believe that the information from the animal investigations was critical to the timing of the final accurate diagnosis.

New York City Department of Health officials highlighted as important the points in the draft discussing the importance of effective disease surveillance, the need for better communication among public health agencies, and particularly the need for better communication within and among public and animal health communities.

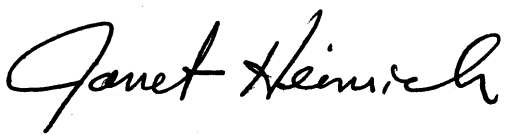
USDA officials indicated that increased emphasis is warranted on the importance not only of public health preparedness, but also of animal health preparedness. Several New York State Department of Health officials and all of the agencies mentioned above provided technical comments, which were incorporated where appropriate.

We also provided relevant excerpts of the draft report to officials from the Bronx Zoo, State of Connecticut, New York State Department of Environmental Conservation, USGS, and University of California at Irvine for technical review, and their comments were incorporated in the draft where appropriate.

We are sending copies of this letter to Donna E. Shalala, Secretary of Health and Human Services; Daniel R. Glickman, Secretary of Agriculture; Jeffrey Koplan, M.D., Director of CDC; and other interested officials.

This work was performed under the direction of Marcia Crosse, Assistant Director. Other major contributors are Rob Ball, Katherine Iritani, Anita Kay, Deborah Miller, and Stan Stenerson. Please contact me at (202) 512-7119 if you or your staff have any questions.

Sincerely yours,



Janet Heinrich
Associate Director, Health Financing
and Public Health Issues

Methodology

We interviewed officials in the public and private sectors at the national, state, and local levels, and, to the extent it was made available to us, we obtained relevant documentation from them. With this information, we developed a chronology and compiled a list of lessons learned from the West Nile virus outbreak. To some extent, the chronology was based on officials' recollections of the specific events occurring on particular dates. When information provided by agencies or officials was inconsistent, we assessed its relevance to our reporting objectives, sought any needed corroboration from other involved officials, and incorporated the information accordingly. Officials and agencies contacted included the following:

- U.S. Department of Health and Human Services, Office of Emergency Preparedness
- Centers for Disease Control and Prevention, National Center for Infectious Diseases, Division of Vector-Borne Infectious Diseases, Division of Viral and Rickettsial Diseases, Division of Bacterial and Mycotic Diseases
- Central Intelligence Agency
- U.S. Department of Agriculture, Animal and Plant Health Inspection Service
- U.S. Geological Survey, National Wildlife Health Center
- U.S. Army Medical Research Institute of Infectious Diseases
- New York State Department of Health
- New York State Department of Environmental Conservation
- New York City Department of Health
- New York City Commissioner's Office of Emergency Management
- Wildlife Conservation Society/Bronx Zoo
- Flushing Hospital Medical Center
- Connecticut Agricultural Experiment Station
- University of California at Irvine
- Association of Public Health Laboratories
- National Association of County and City Health Officials
- a ProMED moderator active during the initial outbreak

To gather background information and relevant literature on the West Nile outbreak, West Nile virus, and surveillance activities put in place since the outbreak, we searched academic journals and news media and performed an extensive review of publications related to the virus. We performed a similar review to identify reports and literature related to the preparedness of the public health infrastructure for a bioterrorist event.

We also reviewed assessments of the response to the West Nile outbreak prepared by various agencies. These assessments both describe the views of these agencies on lessons learned and outline the steps they have taken and policies they have implemented since the initial outbreak.

Timeline of Key Dates and Events in the West Nile Virus Outbreak, 1999

Time is of the essence in responding to an outbreak of an infectious disease. When the cause of an outbreak is unknown, it is much more difficult to respond quickly and effectively. As can be seen in the following chronological table of events, the key to rapidly identifying and responding to the West Nile virus outbreak lay in merging efforts and information from separate investigations of outbreaks in animals and humans. At the same time, as the number of participants increased, so did the complexity and difficulty of communication and coordination. Looking back on the outbreak of the fall of 1999 provides an opportunity not only to review the significant investigative and laboratory work of a myriad of participants and the contributions of each toward the final diagnosis of the virus, but also to analyze the communications and actions of the responding government agencies in order to improve the nation's preparedness for future outbreaks, including ones not due to natural causes. Table 2 provides a detailed chronology of significant actions and events.

Table 2: Detailed Chronology of Events in the West Nile Virus Outbreak, 1999

Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Tuesday, 6/1/99	(Approx. date) Connecticut Agricultural Experiment Station begins annual mosquito surveillance.	
Mid-June to late July 1999	(Approx. dates) Veterinarian at Bayside veterinary clinic finds crows with signs of nervous system disorders, treats birds, and releases those that survive.	
Tuesday, 8/1/99 to Friday, 8/13/99	(Approx. date) New York State (NYS) Department of Environmental Conservation investigates bird poisonings in New York City (NYC) parks, obtains many reports and samples of dead birds, especially crows. (Approx. date) Veterinarian at Wildlife Conservation Center, Queens, treats several sick wild birds and releases those that survive; sends specimens to NYS Department of Environmental Conservation. (Approx. date) Zookeeper at Bronx Zoo tells zoo veterinarians he has heard reports about dead crows.	8/2/99: Earliest case of human infection with West Nile virus identified in retrospective study. Case was unreported and unknown until after identification of West Nile virus in late September.
Thursday, 8/12/99	Queens branch of Wildlife Conservation Society reports dead wild birds to the Bronx Zoo branch. Bronx Zoo branch of Wildlife Conservation Society sends dead bird samples to wildlife pathologist at NYS Department of Environmental Conservation.	Flushing Hospital in Queens admits an elderly patient who, after a few days, develops serious neurologic symptoms, including unusual pattern of muscle weakness.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Sunday, 8/15/99	(Approx. date) Nassau County, N.Y., highway crew brings in a bag of dead crows to NYS Department of Environmental Conservation.	Flushing Hospital admits an elderly patient with heart failure; after a few days he develops neurologic symptoms, including muscle weakness.
Monday, 8/16/99	ProMED (Internet bulletin board posting news of infectious disease outbreaks) posts news about bird poisonings in NYC, says NYS Department of Environmental Conservation is investigating.	
Tuesday, 8/17/99	(Approx. date) Wildlife pathologist at NYS Department of Environmental Conservation performs necropsies (postmortem examinations, or autopsies) of dead birds, examines for aspergillosis (fungal infection), poison, bacteria.	
Wednesday, 8/18/99		Flushing Hospital admits another elderly patient with symptoms similar to those of the 8/12/99 admission.
Thursday, 8/19/99	Article in local Queens newspaper quotes NYS Department of Environmental Conservation wildlife pathologist as saying he has received many dead bird reports from NYC and Buffalo; reports are being investigated intensively. Veterinary assistant from Bronx Zoo phones NYS Department of Environmental Conservation requesting laboratory results on zoo samples; informed that NYS Department of Environmental Conservation wildlife pathologist is finding several causes but “no common thread.”	
Friday, 8/20/99		Flushing Hospital admits a fourth elderly patient with possible viral symptoms, who, after a few days, develops neurologic symptoms. Flushing Hospital’s chief of infectious diseases recognizes that in the past 1 to 2 weeks, an unusually large number of spinal fluid samples have been drawn to test for meningitis or encephalitis (usually only two or three per year). Patients’ advanced age and pattern of muscle weakness also do not fit disease profile commonly seen at the hospital.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Monday, 8/23/99	(Approx. date) **NYS agricultural veterinarian informs state public health veterinarian that dead birds are being reported in the state. They discuss need for diagnostic laboratory testing and agree samples should be sent to the National Veterinary Services Laboratories in Ames, Iowa, operated by Animal and Plant Health Inspection Service (APHIS) of U.S. Department of Agriculture (USDA).**	Chief of infectious disease at Flushing Hospital phones director of Bureau of Communicable Disease, NYC Department of Health. Requests assistance in identifying disease causing encephalitis in elderly patients, discusses possible need to rule out botulism. Health bureau director does not think described symptoms fit botulism. She sends an epidemiologist to Flushing Hospital to review patient records and advises the chief of infectious disease to send cerebrospinal fluid samples to the virology laboratory at NYS Department of Health. Flushing Hospital admits a fifth patient with neurological and possible viral symptoms.
Wednesday, 8/25/99	Several birds in outdoor cage at Bronx Zoo die; necropsies performed in Bronx Zoo pathology laboratory.	
Friday, 8/27/99		Chief of infectious disease, Flushing Hospital, again phones director of NYC Department of Health, Bureau of Communicable Disease, discusses whether to try botulism antitoxin because patients are not responding to any other treatments. Flushing Hospital is having problems preparing and sending samples to NYS Department of Health; specimens need to be sent on dry ice, which hospital does not have. Flushing Hospital neurologist reports seeing another similar case during a visit to NYC Hospital–Queens. To address the Flushing physicians' concerns about botulism, the director of the city bureau of communicable disease contacts Centers for Disease Control and Prevention (CDC) Foodborne and Diarrheal Disease Program in Atlanta (oversees botulism surveillance). CDC experts agree that botulism is unlikely but that Flushing patients are unusual. Director of the city Bureau of Communicable Disease decides to visit Flushing Hospital the next day to gather more information. Sixth patient, elderly, admitted at Flushing Hospital with viral and possible encephalitis symptoms.
Saturday, 8/28/99		Director and epidemiologist from Bureau of Communicable Disease, NYC Department of Health, visit Flushing Hospital to review patients and patient records; they learn another patient with neurologic symptoms has just been admitted.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Sunday, 8/29/99		Epidemiologists from NYC Department of Health continue interviewing patients and families. They call hospitals in Queens and nearby Brooklyn and find three more suspected cases of encephalitis, in addition to five patients at Flushing Hospital and NYC Hospital, Queens. Director of city Bureau of Communicable Disease begins contacting health officials within CDC's Arboviral, Enteroviral, and Viral Special Pathogens Branches to request assistance with investigating a possible outbreak of unknown infectious disease in NYC. Also sends e-mail to NYS Department of Health, Connecticut Department of Health, and departments of health in surrounding counties.
Monday, 8/30/99 (approx.)	**Wildlife pathologist at NYS Department of Environmental Conservation contacts chief of virology laboratory for NYS Department of Health, requests testing of bird samples.** State laboratory does not have reagents to test for bird viruses. Laboratory chief suggests sending to Cornell University veterinary laboratory, who refers the wildlife pathologist to USDA/APHIS National Veterinary Services Laboratories.	Conference call between NYC Department of Health, NYS Department of Health, and individuals in CDC's Division of Vector-Borne Infectious Diseases, Bioterrorism Preparedness and Response Project, and Division of Viral and Rickettsial Disease. Decision is made to send patient specimens to NYS Department of Health for testing. State health department issues official invitation for CDC to assist with outbreak investigation. CDC Epidemic Intelligence Service officer already assigned to New York joins epidemiological investigation. NYC Department of Health begins active surveillance for patients with encephalitis at hospitals throughout the NYC area. Broadcast fax also is sent to alert NYC physicians about the Queens disease cluster and to ask that patients with similar symptoms be reported immediately. One of the elderly patients with serious neurologic symptoms dies at Flushing Hospital; autopsy is performed.
Tuesday, 8/31/99		Another elderly patient dies at Flushing Hospital of encephalitis; autopsy is performed. A seventh patient (young adult) is admitted with viral symptoms, rash, muscle weakness. (Approx. date) Human samples from Flushing Hospital are received by NYS Department of Health virology laboratory by way of NYC Department of Health. CDC Epidemic Intelligence Service officer from Atlanta joins epidemiological investigation in NYC. Evidence from the environmental field investigation suggests mosquito-borne disease as possible cause after numerous mosquito-breeding sites and mosquito larvae are found in patients' backyards and neighborhood.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Wednesday, 9/1/99	Head of pathology, Bronx Zoo, phones wildlife pathologist at NYS Department of Environmental Conservation, who says he has examined about 400 dead birds in August and is sending samples to the laboratory at USGS National Wildlife Health Center in Wisconsin.	State health department laboratory reports positive test results for flavivirus, further evidence of mosquito-borne disease agent. NYS Department of Health ships blood and spinal fluid samples from patients at Flushing Hospital to CDC Division of Vector-Borne Infectious Diseases, and informs CDC laboratory by e-mail of negative results for St. Louis encephalitis by polymerase chain reaction (PCR, or molecular biological) testing on the previous day. CDC Infectious Disease Pathology Activity laboratory (Atlanta) receives human brain tissue sample from autopsy of a Flushing patient.
Thursday, 9/2/99	NYS Department of Environmental Conservation wildlife pathologist contacts the USGS National Wildlife Health Center laboratory in Wisconsin to request help in testing bird samples. Instructed to wait until Tuesday, 9/7, to avoid having samples in transit over the long holiday weekend.	State health department laboratory reports to NYC health department that it has a strong reaction for St. Louis encephalitis in human specimens, using serological tests known to cross-react with similar viruses. NYC has never before had a documented, locally acquired human case of St. Louis encephalitis. NYC Department of Health has received reports of 30 to 40 suspected human cases in response to its health alerts and contacting infectious disease and neurology departments in local hospitals. CDC Division of Vector-Borne Infectious Diseases receives samples of Flushing Hospital patients from NYS Department of Health. Director of NYC Office of Emergency Management receives a call in late afternoon from head of NYC Department of Health, requesting assistance with cleanup of suspected mosquito-breeding site in Queens area and preparation for rapid implementation of mosquito control if CDC confirms mosquito-borne disease outbreak. Flushing Hospital admits eighth patient with possible viral symptoms, muscle weakness, rash.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Friday, 9/3/99		CDC Division of Vector-Borne Infectious Diseases announces it has positive results for St. Louis encephalitis in human samples by enzyme-linked immunoabsorbent assay testing (ELISA, a rapid test for virus antibodies), and it has ruled out several other viruses. NYC publishes news releases reporting that CDC has announced an outbreak of St. Louis encephalitis in New York City. CDC Division of Vector-Borne Infectious Diseases sends a third Epidemic Intelligence Service officer to NYC to assist. City Office of Emergency Management and NYC health department initiate mosquito control activities and start a public information hotline. Health department disseminates public information materials and sends sanitarians to assist with mosquito control and cleanup in Queens area. Office of Emergency Management provides interagency coordination and arranges emergency contracts for mosquito control. NYC Office of Emergency Management and city health department begin spraying for mosquitoes in non-residential areas. Commissioner of NYC Office of Emergency Management touches base with Federal Bureau of Investigation (FBI) about outbreak of unusual infectious disease in NYC so it can possibly evaluate for criminal (bioterrorist) involvement. City health officials also in contact with FBI.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Saturday, 9/4/99	**Over Labor Day weekend: Animal health officials become aware of human outbreak of St. Louis encephalitis through news releases, begin considering the possibility that outbreak of unknown infectious disease in birds might be linked.** **Connecticut Agricultural Experiment Station continues to trap mosquitoes and responds to announcement of St. Louis encephalitis in NYC by moving mosquito traps to areas near the NYC outbreak area.**	**Epidemiologist at NYC health department finds out about large numbers of dead birds from calls to public hotline and public comments at a news conference, considers possible connection between bird deaths and human outbreak of St. Louis encephalitis. She informs officials of the Office of Emergency Management, NYS health department, and CDC.** Director of NYS arthropod-borne disease program joins outbreak team in NYC. **At a mobile command unit, a member of the public brings in a dead bird. Director of NYS arthropod-borne disease program advises sending the bird to the wildlife pathologist at NYS Department of Environmental Conservation.** Researchers at CDC Infectious Disease Pathology Activity laboratory in Atlanta examine human specimens from NYC, observe evidence of viral encephalitis, obtain positive results for flavivirus in human brain sample by immunohistochemical testing (testing for chemical evidence of infection and immune system response).
Sunday, 9/5/99		(Labor Day weekend) Response to large outbreak of *Escherichia coli* O157:H7 at Washington County fair places large demand on NYS Department of Health resources. City health department begins daily alerts to area health officials. ProMED electronic mailing list posts announcement of outbreak of St. Louis encephalitis in NYC.
Monday, 9/6/99	Over Labor Day weekend, several more birds die at Bronx Zoo.	NYC Office of Emergency Management and health department do aerial survey, identifying stagnant water in swimming pools as possible mosquito-breeding sites. They begin door-to-door and call-in response to get pools drained.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Tuesday, 9/7/99	Wildlife pathologist at NYS Department of Environmental Conservation sends bird samples to USGS National Wildlife Health Center laboratory. **In cover letter requesting bird testing, he indicates NYC is experiencing the highly unusual event of a human outbreak of St. Louis encephalitis.** **(Approx. date) NYS public health veterinarian e-mails colleagues in other areas where St. Louis encephalitis has occurred to see if bird die-offs have been involved. All responses indicate bird die-offs have not been involved. NYS public health veterinarian reviews information on Rocio virus, known to cause bird die-offs along with human encephalitis outbreak in South America, but it does not seem a likely cause of the New York outbreak.**	City and state departments of health, NYC Office of Emergency Management, and CDC continue outbreak response, including telephone surveillance of hospitals for meningitis and encephalitis cases, weekly fax alerts to New York City medical community, daily public communication and response activities, and mosquito control.
Wednesday, 9/8/99	Wildlife pathologist at NYS Department of Environmental Conservation sends bird samples to USDA/APHIS National Veterinary Services Laboratories. **Indicates there is an outbreak of St. Louis encephalitis in humans in the same area where crows are dying.** Bronx Zoo head pathologist receives and examines slides from zoo birds that died in late August, compares to samples from birds that died over the holiday weekend, finds they have similar lesions indicating possible encephalitis. The National Wildlife Health Center laboratory in Wisconsin receives birds from NYS Department of Environmental Conservation. ProMED posts news that **Connecticut Agricultural Experiment Station is testing mosquitoes trapped near NYC area for both St. Louis encephalitis and eastern equine encephalitis,** and it will be 5 or 6 days before test results are available.	Entomologist from CDC Division of Vector-Borne Infectious Diseases arrives in NYC. Begins mosquito collection in Queens area to study extent of outbreak. Health officials confirm first positive human case in Brooklyn (outside of Queens area). Based on this case and increasing reports of suspected cases throughout the city, the city health department and Office of Emergency Management begin citywide mosquito control. Laboratory at CDC Division of Vector-Borne Infectious Diseases begins testing serum samples from New York patients using virus-specific neutralization assays (tests used to detect parts of a specific virus) for St. Louis encephalitis.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Thursday, 9/9/99	Wildlife pathologist at NYS Department of Environmental Conservation sends more crow samples to USGS National Wildlife Health Center laboratory in Wisconsin, indicates he has observed “gliosis” in brain tissue (evidence of degenerative lesion, possible encephalitis). USDA National Veterinary Services Laboratories in Iowa receives samples sent on 9/8/99 by NYS Department of Environmental Conservation. Bronx Zoo head pathologist starts doing necropsies on all birds that have died, preserving samples. **She calls CDC in Atlanta; referred to CDC Division of Vector-Borne Infectious Diseases in Fort Collins, Colo.** **Bronx Zoo head pathologist phones chief of the epidemiology and ecology section at Division of Vector-Borne Infectious Diseases, who says the division’s laboratory is not the appropriate one to test exotic bird specimens. Suggests specimens be sent to USDA/APHIS National Veterinary Services Laboratories for testing. They also discuss possible human exposure at the Bronx Zoo (needle-stick injury of veterinary assistant). Bronx Zoo head pathologist makes a second phone call to Division of Vector-Borne Infectious Diseases, speaks to the secretary and requests forms for submitting samples.** Secretary sends e-mail to chief of epidemiology and ecology section and to section medical officer regarding contact from the Bronx Zoo and asking whether approval is given for sending samples. **Medical officer forwards the e-mail to vertebrate ecologist, who responds he is willing to look at the bird samples.** **Bronx Zoo head pathologist prepares and ships bird tissue samples to National Veterinary Services Laboratories; in a cover letter, she indicates possible connection with St. Louis encephalitis outbreak in humans and her concern about needle-stick injuries among laboratory workers. She also sends a serum specimen from a Bronx Zoo employee who suffered a needle-stick injury and a plasma specimen from a flamingo to CDC Division of Vector-Borne Infectious Diseases.** Meeting held at Bronx Zoo, update on bird deaths and possible diseases. Zoo officials decide to get an outside consultant to help with mosquito control.	Third patient dies from viral encephalitis.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Friday, 9/10/99	Medical officer, CDC Division of Vector-Borne Infectious Diseases, responds to vertebrate ecologist by e-mail that he talked to the head pathologist at Bronx Zoo this morning, learned that the chief of epidemiology and ecology section had already told her that the Division of Vector-Borne Infectious Diseases was not the right place to send bird specimens. The medical officer advised the vertebrate ecologist to talk with the section chief before proceeding further. National Veterinary Services Laboratories in Iowa receives Guanay cormorant, bald eagle, flamingo, and tragopan (pheasant) samples from Bronx Zoo. **Head pathologist at Bronx Zoo is still concerned about human safety in the laboratory while performing bird necropsies.** Contacts the NYS agricultural veterinarian to get permission to send samples to National Veterinary Services Laboratories. Calls Cornell veterinary college; they suggest National Veterinary Services Laboratories. Calls head veterinary medical officer, National Veterinary Services Laboratories, asks if he would look at samples sent directly from the Bronx Zoo. Head veterinary medical officer says he has ruled out Newcastle disease in samples already received through NYS Department of Environmental Conservation; preparing to test for avian influenza.	**Assistant to NYC health department epidemiologists sends an e-mail to the team of epidemiologists investigating the outbreak. E-mail indicates receiving a call from the head veterinarian at the Bronx Zoo saying that many birds are dying** and they have not been able to determine the cause. NYC health department also has been contacted by Bayside Historical Society in Queens about dead birds. Assistant suggests passing the information on to the CDC Epidemic Intelligence Service veterinarian, who should let the CDC vertebrate ecologist know when he arrives, because he **"may want to contact the zoo for samples and perform a battery of tests for alphaviruses, and perhaps even St. Louis encephalitis, on these birds."** **NYC Department of Health epidemiologists ask CDC vertebrate ecologist if bird deaths and human disease could be related.** He responds that bird die-offs can be caused by many things and the two outbreaks probably are coincidental.
Saturday, 9/11/99	Head veterinary medical officer for National Veterinary Services Laboratories phones Bronx Zoo head pathologist. Results of serology testing are negative for eastern, western, and Venezuelan equine encephalitis. Now waiting for virus isolation.	Vertebrate ecologist from CDC Division of Vector-Borne Infectious Diseases arrives in NYC to conduct the bird serosurvey (taking and testing samples of blood from live birds).
Sunday, 9/12/99		**NYC Department of Health e-mails message about Bronx Zoo's request to look at bird die-offs to CDC vertebrate ecologist. He responds that he hopes to meet with head veterinarian of the Bronx Zoo the next day.** (Approx. date) In the past 1 to 2 weeks, NYS Department of Health's virology laboratory has conducted numerous tests for St. Louis encephalitis using PCR, all with negative results.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Monday, 9/13/99	**Connecticut Agricultural Experiment Station obtains an encephalitic dead crow from Westport area (near NYC outbreak area), will attempt to isolate virus from its brain tissue.**	**CDC vertebrate ecologist visits head veterinarian, Bronx Zoo, and asks to gather blood samples from live birds in the zoo. Bronx Zoo head veterinarian refuses because birds have been dying in the zoo and they do not want to expose them to additional stress or infection. Asks if the CDC vertebrate ecologist would like to test samples from dead birds and he responds that he is unable to because he is currently doing live-bird testing in investigating the human outbreak.** In Albany, NYS Department of Health and CDC are hosting a meeting of a work group on encephalitis cases of unknown etiology, associated with CDC's unexplained deaths project. Includes researchers from CDC Atlanta, NYS health department, and academic researchers, including one from University of California at Irvine.
Tuesday, 9/14/99	National Veterinary Services Laboratories isolates a virus from bird samples from Bronx Zoo and NYS Department of Environmental Conservation and begins attempting to identify it. Bronx Zoo head pathologist attempts to phone CDC Division of Vector-Borne Infectious Diseases to ask about results on specimens she has sent directly to them. (Approx. date) National Wildlife Health Center laboratory in Wisconsin isolates virus from bird samples, obtains negative results in testing for St. Louis encephalitis and eastern equine encephalitis using reagents they have on hand. **National Wildlife Health Center virologists discuss the possibility of a new strain of St. Louis encephalitis or an exotic disease.**	NYS Department of Health/CDC conference continues on encephalitis cases of unknown etiology.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Wednesday, 9/15/99	National Veterinary Services Laboratories observes, by electron microscopy, a "flavi/toga-like virus, 40 nanometers in diameter." Serum-based tests indicated negative results for eastern, western, or Venezuelan equine encephalitis viruses, or St. Louis encephalitis virus. **Researchers consider possibility of a new strain or virus.** National Veterinary Services Laboratories informs head pathologist at Bronx Zoo about latest test results. Bronx Zoo head pathologist sends paired plasma samples (well and sick) from birds to National Veterinary Services Laboratories. (Approx. date) Director of National Wildlife Health Center talks with CDC Division of Vector-Borne Infectious Diseases, branch chief of arbovirus diseases. They discuss what virus could be killing birds in New York.	NYS Department of Health's *E. coli* outbreak response is gearing down. Participants in the conference on encephalitis cases (including officials from CDC Atlanta) hear that USDA National Veterinary Services Laboratories isolated a virus it is unable to identify, from dead birds from New York. **Conference participants suggest sending human tissue samples to the University of California researcher's laboratory so he can attempt to identify virus with rapid PCR testing methods. State health officials decide to do so both to test the California researcher's testing methods and also because, although CDC is reporting positive serologies on human samples, the NYS Department of Health has failed to obtain positive results for St. Louis encephalitis by PCR testing after many attempts.**
Thursday, 9/16/99	**CDC Division of Vector-Borne Infectious Diseases medical officer calls back Bronx Zoo head pathologist, suggests discontinuing bird necropsies until human safety factors are determined. Suggests sending existing samples to NYS Department of Health's laboratory for faster testing than Division of Vector-Borne Infectious Diseases would do at this time on animal samples.** **USDA National Veterinary Services Laboratories contacts the CDC liaison officer at Veterinary Services at USDA/APHIS because of unusual properties of the virus it has isolated and its lack of reagents to identify whether the virus could be a human pathogen. Liaison officer contacts CDC. CDC contacts head veterinary medical officer at National Veterinary Services Laboratories and asks for virus isolate to be sent to the Division of Vector-Borne Infectious Diseases in Fort Collins.** CDC recommends waiting until Monday, 9/20/99, to ship the isolate to avoid having it in transit over the weekend.	Staff of virology laboratory, NYS Department of Health, sends human brain tissue samples from several patients to researcher at University of California at Irvine.

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Date	Phase 1: Animal Outbreak	Phase 2: Human Outbreak
Friday, 9/17/99	Bronx Zoo head pathologist phones NYS Department of Environmental Conservation wildlife pathologist, who reports having sent bird samples to USGS National Wildlife Health Center laboratory. Bronx Zoo head pathologist leaves message for and receives message from acting section chief of Diagnostic and Reference, CDC Division of Vector-Borne Infectious Diseases. He expects Bronx Zoo samples from National Veterinary Services Laboratories to arrive on 9/21/99. Bronx Zoo head pathologist attempts to establish contact with the U.S. Army Medical Research Institute of Infectious Diseases. **Bronx Zoo head pathologist calls chief of the virology laboratory for the NYS Department of Health. The laboratory chief requests samples of virus isolates from National Veterinary Services Laboratories and advises on use of laboratory hoods for increasing human safety in the zoo pathology laboratory.**	University of California researcher receives brain samples sent the previous day by NYS Department of Health. He contacts officials at CDC's Division of Viral and Rickettsial Disease in Atlanta, informs them he has been invited by NYS health department to assist in testing human samples. He obtains information from chief of the CDC Infectious Disease Pathology Activity laboratory about his previous findings from immunohistochemical testing of brain tissue from NY patient. At CDC Division of Vector-Borne Infectious Diseases, results of testing for St. Louis encephalitis in human serum specimens are inconclusive.
Saturday, 9/18/99		CDC entomologist returns to CDC Division of Vector-Borne Infectious Diseases from NYC, begins assembling data from mosquito survey.
Monday, 9/20/99	**Bronx Zoo head pathologist contacts National Veterinary Services Laboratories, provides address for the virology laboratory at the NYS Department of Health, requests that virus isolate samples of Bronx Zoo birds be sent there.** National Veterinary Services Laboratories ships virus isolates to the Division of Vector-Borne Infectious Diseases. Virus isolates shipped were made from tissues of birds originally submitted by NYS Department of Environmental Conservation and the Bronx Zoo.	University of California researcher's laboratory purifies RNA from human brain samples and synthesizes reagents in preparation for PCR testing.

Date	Phase 3: Convergence
Tuesday, 9/21/99	Connecticut Agricultural Experiment Station reports isolating virus from brain tissue of a dead crow and from mosquitoes; they appear to be the same virus. Possible implication: If the virus is St. Louis encephalitis, it can kill and is killing birds; human and bird outbreaks may be related. Chief of arbovirus diseases branch at CDC Division of Vector-Borne Infectious Diseases contacts Connecticut Agricultural Experiment Station, determines testing protocols were not specific for St. Louis encephalitis. CDC requests that Connecticut Agricultural Experiment Station send virus isolates to the laboratory at CDC Division of Vector-Borne Infectious Diseases for confirmation. Vertebrate ecologist, CDC Division of Vector-Borne Infectious Diseases, returns to Fort Collins laboratory from NYC. CDC Division of Vector-Borne Infectious Diseases receives virus isolates from head veterinary medical officer at National Veterinary Services Laboratories and begins testing for several related viruses. Veterinary pathologists at U.S. Army Medical Research Institute of Infectious Diseases respond to contact from the head pathologist at the Bronx Zoo, agree to test bird samples. University of California researcher initiates genomic sequence studies on human brain samples.
Wednesday, 9/22/99	Director of Bureau of Communicable Disease, NYC Department of Health, hears for the first time that the wildlife pathologist at NYS Department of Environmental Conservation had been finding encephalitis in dead birds. Calls CDC. The city health department begins helping to collect dead birds. NYS public health veterinarian establishes surveillance system and database for ill and dead birds. Vertebrate ecologist at CDC Division of Vector-Borne Infectious Diseases begins testing samples obtained through bird serosurvey, hears about news from Connecticut Agricultural Experiment Station, sets up tests for other flaviviruses besides St. Louis encephalitis. CDC Division of Vector-Borne Infectious Diseases obtains positive test result for flavivirus in bird specimens from National Veterinary Services Laboratories. Bronx Zoo head pathologist phones U.S. Army Medical Research Institute of Infectious Diseases, learns that it has negative test results on Bronx Zoo bird samples for eastern, western, and Venezuelan equine encephalitis. Bronx Zoo head pathologist ships more samples to U.S. Army Medical Research Institute of Infectious Diseases. Bronx Zoo head pathologist talks with director of virology laboratory at NYS Department of Health, learns Connecticut Agricultural Experiment Station laboratory has isolated virus in both birds and mosquitoes. Bronx Zoo head pathologist contacts CDC Division of Vector-Borne Infectious Diseases, informs them of results from U.S. Army Medical Research Institute of Infectious Diseases. Late evening: Using PCR technique, University of California researcher finds genetic patterns of a flavivirus in brain samples of three New York patients.

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Date	Phase 3: Convergence
Thursday, 9/23/99	University of California researcher phones virologist at NYS Department of Health laboratory, reports he has found genetic evidence of flavivirus in brain samples of three human patients. Begins comparing flavivirus genomes from two patients to genome patterns available in GenBank (a national database of genetic information on disease agents). CDC Division of Vector-Borne Diseases again contacts Connecticut Agricultural Experiment Station. The Station is shipping virus isolates. CDC Division of Vector-Borne Infectious Diseases completes retesting of four human specimens previously tested for St. Louis encephalitis. Now testing for St. Louis encephalitis, West Nile, Japanese encephalitis, Powassan, dengue, and yellow fever viruses to rule out possibility of infection by a closely related virus. Retesting produces high reactivity with West Nile virus. Retesting commences on 24 more specimens. Strong reaction for West Nile virus in human body fluid samples using enzyme-linked immunoabsorbent assay (ELISA). Informs CDC Atlanta. CDC laboratory designs PCR test for West Nile virus and identifies “West Nile-like” virus in birds from virus isolates from USDA/APHIS National Veterinary Services Laboratories. Bronx Zoo head pathologist hears from veterinary pathologists at U.S. Army Medical Research Institute of Infectious Diseases that they have preliminary identification of St. Louis encephalitis or a related virus; requesting normal control samples for flamingo and tragopan. Bronx Zoo head pathologist phones head veterinary medical officer at National Veterinary Services Laboratories, asks why virus isolate samples were not sent to the NYS Department of Health laboratory as requested. National Veterinary Services Laboratories will ship isolates to NYS Department of Health on September 27 because of the need to send samples with adequate virus titer and to avoid shipping over the weekend. Mid-afternoon: Teleconference between Bronx Zoo head pathologist and Division of Vector-Borne Infectious Diseases, who report they have tested isolates from National Veterinary Services Laboratories and have obtained positive results for flavivirus. Bronx Zoo head pathologist sends more samples to Division of Vector-Borne Infectious Diseases.

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Date	Phase 3: Convergence
Friday, 9/24/99	NYS Department of Health gets phone and fax messages from University of California researcher. From samples from NYS Department of Health, he has determined virus is not St. Louis encephalitis but appears most closely related to Kunjin virus and West Nile virus. Researcher also informs others at University of California at Irvine. Director of virology laboratory at NYS Department of Health calls chief of arbovirus diseases branch, CDC Division of Vector-Borne Infectious Diseases; informs him of the University of California researcher's results. State laboratory officials inform NYS Health Commissioner. Division of Vector-Borne Infectious Diseases completes retesting of 24 human specimens, results show high reactivity with West Nile virus. Amplifies ribonucleic acid of virus from human brain tissue for PCR testing. Conference call including officials from CDC Division of Vector-Borne Infectious Diseases, CDC Atlanta, NYS Department of Health, NYC Department of Health, Connecticut Department of Health, and Connecticut Agricultural Experiment Station, and Bronx Zoo head pathologist. CDC announces West Nile virus in birds, does not want to announce publicly that West Nile virus has been found in humans until genome sequencing is completed and diagnosis is confirmed, expected early the following week. CDC publishes news release on West Nile virus found in birds. Head veterinary medical officer at National Veterinary Services Laboratories contacts headquarters for Veterinary Services at USDA Animal and Plant Health Inspection Service and also the office of the veterinarian-in-charge for the New York area; informs them of CDC's finding of West Nile-like virus in birds. Friday evening: University of California researcher informs deputy director of Division of Viral and Rickettsial Diseases, CDC Atlanta, of finding virus related to Kunjin virus or West Nile virus in humans by genomic sequencing.
Saturday, 9/25/99	Partial genome sequencing of human specimens at CDC Division of Vector-Borne Infectious Diseases indicates probable final diagnosis of West Nile virus in humans. Continuing analysis of samples from the bird serosurvey produces evidence of West Nile virus-neutralizing antibodies in healthy birds. West Nile virus confirmed in specimens obtained from the Connecticut Agricultural Experiment Station. CDC Division of Vector-Borne Infectious Diseases contacts researcher at University of California at Irvine. They compare their findings and discuss plans for public announcements and publications. Connecticut Agricultural Experiment Station obtains a live Cooper's hawk with neurologic symptoms; bird dies the next day and is tested for viral identification. News media breaks story, West Nile virus in birds and West Nile virus or Kunjin virus in people, explains CDC at first misidentified the virus as St. Louis encephalitis. ProMED reports a 75-year-old resident of Toronto, Canada, has St. Louis encephalitis after visiting New York City.
Sunday, 9/26/99	CDC Division of Vector-Borne Infectious Diseases expands dead bird surveillance, soliciting bird samples in affected states and asking that samples be submitted through state wildlife pathologists.

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Date	Phase 3: Convergence
Monday, 9/27/99	Chief of epidemiology section, bacterial zoonoses branch, at CDC Division of Vector-Borne Infectious Diseases goes to NYC to help the NYC health department conduct a human serosurvey (collection of blood samples from random sample of humans in the outbreak area). Researcher at Pasteur Institute, Paris, posts an offer on ProMED to assist scientists studying the New York outbreak by providing West Nile virus genome sequence patterns that have not yet been published. Researchers at CDC Division of Vector-Borne Infectious Diseases talk to foreign researchers to establish a collaboration. Evening: University of California researcher responds on ProMED to offer of assistance from researcher at Pasteur Institute; gives detailed report on his work to date in identifying "Kunjin/West Nile virus" in humans. USDA Animal and Plant Health Inspection Service is officially notified by CDC that "West Nile-like virus," rather than St. Louis encephalitis, is responsible for the human encephalitis outbreak in New York. CDC announces it has established that human outbreak in New York is due to West Nile-like virus. Involved agencies receive a large number of news media contacts and requests for information from the public.
Tuesday, 9/28/99	Human serosurvey (collection of blood samples) in NYC area begins, supported by six Epidemic Intelligence Service (EIS) officers from CDC and over 100 personnel from the NYC health department. (Approx. date) Preliminary results from bird serosurvey indicate an infection rate greater than 50 percent for birds in northeast Queens, providing further evidence of where outbreak may have originated. Daily conference calls are initiated among agencies participating in the outbreak response. USDA/APHIS veterinary services headquarters notifies others in APHIS and the Secretary's Advisory Committee on Foreign Animal and Poultry Diseases about West Nile-like virus outbreak in NY area. (Approx. date) CDC and international scientists find a link between the NYC strain of West Nile virus and a recent strain from Israel.
Wednesday, 9/29/99	Briefing of staff for New York and Connecticut congressional representatives by CDC's acting deputy director for science and public health. USDA Animal and Plant Health Inspection Service (APHIS) coordinates with state officials and cooperating federal agencies to address impact of West Nile virus outbreak on agricultural industry.
Thursday, 9/30/99	USDA receives reports of a horse on Long Island possibly infected with West Nile virus. Division of Vector-Borne Infectious Diseases isolates virus from *Culex* mosquitoes collected in Queens on September 12 and 13, identifies West Nile virus.
Friday, 10/1/99	USDA Animal and Plant Health Inspection Service plans diagnostic testing, inoculation studies, surveillance. Foreign animal disease diagnostician at USDA Animal and Plant Health Inspection Service investigates a suspicious horse death on eastern Long Island and submits tissue samples to APHIS National Veterinary Services Laboratories for diagnosis.
Saturday, 10/2/99	CDC identifies West Nile virus in infected birds submitted from New Jersey.
Sunday, 10/3/99	(Approx. date) Sixth human death from West Nile virus (Nassau County resident).
Tuesday, 10/5/99	National Veterinary Services Laboratories receives samples from Long Island horse; begins virus isolation. ProMED posting: Birds found positive for West Nile virus in New Jersey.

(Continued From Previous Page)

Date	Phase 3: Convergence
Wednesday, 10/6/99	(Approx. date) USGS National Wildlife Health Center laboratory in Wisconsin sends virus isolates from testing of birds begun in early to mid-September to CDC Division of Vector-Borne Infectious Diseases. CDC laboratory confirms West Nile virus in the samples. The human serosurvey conducted by the NYC health department and CDC is completed.
Thursday, 10/7/99	USDA Animal and Plant Health Inspection Service distributes guidelines for investigating suspected West Nile virus cases in livestock and poultry.
Saturday, 10/9/99	Tissues, including brain tissue, from a second horse from Long Island are received at National Veterinary Services Laboratories, duplicates also sent to CDC.
Sunday, 10/10/99	CDC and other federal agencies provide information about West Nile virus outbreak in relation to bioterrorism, in anticipation of a story to be released the following day in *The New Yorker* that indicates possible connection between outbreak and bioterrorist activities by Iraq. USDA Animal and Plant Health Inspection Service sends early response team, including veterinary pathologist, epidemiologist, and foreign animal disease diagnostician, to investigate reports of several horse deaths on Long Island. At the request of NYS animal health officials, the APHIS team works with state personnel, a local veterinarian, and horse owners to conduct an epidemiological investigation and examine affected animals. Eight horse deaths and 18 affected animals are identified.
Monday, 10/11/99	Article published in *The New Yorker* suggesting West Nile virus outbreak could have been deliberately introduced by Iraq. More news media and public response.
Tuesday, 10/12/99	National Veterinary Services Laboratories isolates virus from horse samples from Long Island, sends to CDC Division of Vector-Borne Infectious Diseases for identification.
Wednesday, 10/13/99	(Approx. date) USGS National Wildlife Health Center laboratory receives reagents from CDC so it can test for West Nile virus in wildlife. ProMED posting, University of California researcher responds to requests for West Nile virus primers and protocols for RT-PCR test, publishes protocol on ProMED.
Thursday, 10/14/99	CDC examines isolates of West Nile virus from horse samples sent by National Veterinary Services Laboratories. Initially obtains negative results by PCR testing but later confirms National Veterinary Services Laboratories' isolation of virus.
Friday, 10/15/99	U.S. Army Medical Research Institute of Infectious Diseases agrees to provide laboratory support for National Veterinary Services Laboratories and animal health investigations.
Saturday, 10/16/99	National Veterinary Services Laboratories completes PCR testing of virus isolated from two Long Island horses, using genetic sequence provided by CDC. Both horses test positive for West Nile virus.
Monday, 10/18/99	U.S. Army Medical Research Institute of Infectious Diseases provides Vickers Unit (portable biosafety level 3 laboratory), requested and paid for by USDA Animal and Plant Health Inspection Service, to Bronx Zoo so it can safely perform necropsies and prepare samples for testing.
Tuesday, 10/19/99	CDC Division of Vector-Borne Infectious Diseases reports serologic evidence of West Nile virus in horses. NYS agricultural commissioner issues a press release reporting that horse deaths and illnesses in Long Island area were likely due to West Nile-like virus.
Wednesday, 10/20/99	Memo from NYS agricultural veterinarian and NYS public health veterinarian summarizing confirmed cases of West Nile virus in horses, birds, and humans (56 confirmed cases with seven deaths). USDA Animal and Plant Health Inspection Service notifies agricultural commissioners and state veterinarians along the East Coast that West Nile virus has been found in horses on Long Island, NY.

(Continued From Previous Page)

Date	Phase 3: Convergence
Thursday, 10/21/99	USDA Animal and Plant Health Inspection Service notifies representatives of the horse industry that West Nile virus has been found in Long Island horses, provides informational materials. Many postings on ProMED about whether transcontinental airplanes are sprayed for mosquitoes.
Friday, 10/22/99	CDC Division of Vector-Borne Infectious Diseases and co-authors submit article for publication in *Science*, linking NYC virus strain to a strain of West Nile virus from Israel. Later published in 12/17/99 issue, along with paper from Connecticut Agricultural Experiment Station research group on its isolation of West Nile virus in Cooper's hawk and other species. ProMED posts update from CDC, West Nile virus has been identified in a variety of birds, no human cases were reported after 9/22/99. Posting stating that China has placed an import ban on U.S. horses.
Saturday, 10/23/99	(Approx. date) Researchers from USGS National Wildlife Health Center obtain a blood sample from a migrating bird in the Bronx. CDC later isolates West Nile virus from this sample, providing evidence that migratory birds might transport the virus.
Monday, 10/25/99	City department of health and Office of Emergency Management end the public hotline. Approximately 150,000 calls have been processed since it began on 9/3/99.
Thursday, 10/28/99	The Division of Vector-Borne Infectious Diseases reports that a dead crow infected with West Nile virus has been collected from Baltimore, Md. (submitted by the Maryland Department of Health through the USGS National Wildlife Health Center).
Friday, 10/29/99	European Union notifies USDA Animal and Plant Health Inspection Service of import restrictions on horses from New York, New Jersey, and Connecticut. USDA Animal and Plant Health Inspection Service notified that Mexico will not accept live poultry from areas affected by West Nile virus.
Monday, 11/8/99 – Tuesday, 11/9/99	Workshop co-sponsored by Department of Health and Human Services, CDC, and USDA held in Fort Collins, Colo. Participants include most agencies and individuals involved in outbreak response.

Note: Events involving crossover between animal and health outbreaks before convergence phase are represented in **bold type**.

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Comments From the Centers for Disease Control and Prevention

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
and Prevention (CDC)
Atlanta GA 30333

AUG 31 2000

Janet Heinrich
Associate Director, Health Financing and Public Health Issues
Health, Education, and Human Services Division
U.S. General Accounting Office
Washington, DC 20548

Dear Ms. Heinrich:

Thank you for the opportunity to review the GAO draft report, "West Nile Virus Outbreak: Lessons for Public Health Preparedness" (GAO/HEHS-00-180). The Centers for Disease Control and Prevention (CDC) concurs with the conclusion that the West Nile outbreak holds important lessons for response to public health emergencies involving uncertain causes whether intentional or unintentional. The finding that bioterrorism preparedness rests in large part on public health preparedness, and that surveillance, epidemiologic, laboratory, and communications capacity at local, state, and federal levels must be enhanced to ensure this preparedness is particularly noteworthy.

In 1994, CDC issued a strategic plan, *Addressing Emerging Infectious Disease Threats: a Prevention Strategy for the United States,* which launched a major effort to rebuild the component of the U.S. public health system that protects U.S. citizens against infectious diseases. In 1998, CDC issued the second phase of this plan, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century*, which builds upon the first report to combat today's emerging diseases and prevent those of tomorrow. Both plans focus on four goals, each of which has direct relevance to preparedness for bioterrorism: disease surveillance and outbreak response; applied research to develop diagnostic tests, drugs, vaccines, and surveillance tools; public health infrastructure and training; and disease prevention and control. The 1998 plan emphasizes the need to be prepared for the unexpected--whether it be a naturally occurring outbreak of West Nile virus or the deliberate release of anthrax by a terrorist.

Likewise, in April 2000, CDC issued the executive summary of *Biological and Chemical Terrorism: Strategic Plan of Preparedness and Response - Recommendations of the CDC Strategic Planning Workgroup* in the Morbidity and Mortality Weekly Report (MMWR). This report outlines steps for strengthening public health and health-care capacity to protect the nation against these threats, and it reinforces the work CDC has been contributing to this effort and lays a framework from which to enhance public health infrastructure. Five key focus areas have been identified which provide the foundation for local, state, and federal planning efforts: Preparedness and Prevention, Detection and Surveillance, Diagnosis and Characterization of Biological and Chemical Agents, Response, and Communication. These areas capture the goals of CDC's Bioterrorism Preparedness and Response Program.

Page 2 - Janet Heinrich

We believe that both the emerging infections documents and the bioterrorism strategic plan should be acknowledged in the GAO report, since they have direct relevance to the findings and recommendations of the West Nile investigation. In addition, many of the resources directed toward the states and localities involved in the West Nile investigation resulted from funding provided by Congress for incremental implementation of the CDC plans.

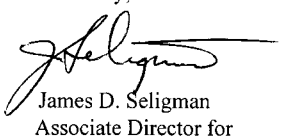
As the draft report mentions, several aspects of the 1999 WNV investigation went quite well; however, the emphasis of the draft report on those aspects which were not perceived to go well may not give a balanced appraisal of the response. There have been substantial improvements in capacity in the New York metropolitan region. These improvements can be attributed to a number of factors, at least some of which are CDC's support in both the emerging infections and bioterrorism arenas.

It is repeatedly stated in the draft report that the correct agent and cause of the illness were only identified once the human and animal investigations converged. This assertion is open to question. Even if the animal outbreak had not been linked to the human outbreak, the virus would have been definitively identified as WNV at essentially the same time as it otherwise was. Investigators at both CDC and New York state knew the serologic and molecular findings were atypical for St. Louis outbreaks, which led to the studies on human specimens by the California researcher which revealed a West Nile complex genetic sequence. Nevertheless, the point about the need for better surveillance of animal health problems is valid because of the potential for such diseases to have important implications for humans.

The draft report rightly emphasizes the lack of coordination between the human health and animal health communities, a valid observation that needs to be overcome. However, the report should also address the general lack of coordination within the animal health community, where there does not appear to be any unified surveillance effort in place.

CDC feels that this report is a thorough presentation of the challenges faced during the 1999 investigation, but that addressing these additional issues could strengthen the final product. In addition to these concerns, specific technical comments and suggestions follow this letter.

Sincerely,



James D. Seligman
Associate Director for
Program Services

Enclosure (1)

Comments From the New York City Department of Health

THE CITY OF NEW YORK
DEPARTMENT OF HEALTH

Rudolph W. Giuliani
Mayor

Neal L. Cohen, M.D.
Commissioner

August 30, 2000

Katherine Iritani
Senior Evaluator
United States General Accounting Office
701 Fifth Avenue, Suite 2700
Seattle, WA 98104

Dear Ms. Iritani,

We appreciated the opportunity to review the draft report entitled West Nile Virus Outbreak: Lessons for Public Health Preparedness. Overall, this is an extremely thorough account of the events of last year and provides an overview of the major lessons learned with respect to emerging infectious disease and bioterrorism preparedness. We strongly support your conclusions that the most important preparations for responding to a bioterrorist event require enhancing the existing public health surveillance and laboratory infrastructure for infectious diseases. These efforts will have the benefit of enhancing the nation's ability to respond to any infectious disease threat, whether natural or intentional.

We had the following general comments on the current draft report:

1 - Importance of effective disease surveillance at the local level:

Effective infectious disease surveillance at the local level has two primary components as mandated by local and state public health regulations: (a) reporting of specific diseases (*e.g, tuberculosis, malaria*) by healthcare providers and laboratories, and (b) reporting of any unusual disease manifestations or clusters of illness. The first component allows the tracking of individual diseases to monitor for changing trends in disease incidence, and for implementing and evaluating control measures, as needed. However, it is the latter component that is essential to the recognition of outbreaks or new infectious disease threats, whether natural or intentional.

For public health surveillance to promptly recognize a bioterrorist attack, the following need to be in place: (a) the clinical community needs to be aware of the clinical aspects of the likely bioterrorist agents, and know who to call if they suspect an unusual disease or cluster of illness, and (b) as importantly, there needs to be an effective public health infrastructure, with

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epidemiologic, infectious disease and laboratory expertise to promptly respond to these reports. In New York City (NYC), the Department of Health has recognized the importance of physician reporting and continues to work on improving outreach to the healthcare community to ensure that they know what, when and how to report unusual disease occurrences. This is an ongoing effort and works best when communication is bidirectional, with constant feedback to the medical community on surveillance findings.

The initial recognition of West Nile encephalitis among humans in New York City was solely due to the report of a single physician who rapidly communicated her concerns to the NYC Department of Health. We recognize that many local and state health departments may not have the staff resources in place to improve communications with their local medical communities and to effectively triage and investigate these initial reports of unusual disease clusters, when they occur. We urge you to emphasize that there is a need to continue to enhance this infrastructure at the state and local levels to ensure that there are sufficient and appropriately-trained staff with an understanding of clinical infectious disease, surveillance, epidemiology and laboratory diagnostics to respond to potential outbreaks.

2 - Need for better communication between public health agencies

We recognize that communication became more difficult as the number of agencies involved increased over the course of the West Nile virus outbreak investigation. Although cumbersome, telephone conference calls are often the most effective way to ensure that everyone involved is updated regularly, to coordinate the investigation and to allow discussion of the current issues and concerns. During the 1996 multi-state investigation of the foodborne outbreak of *Cyclospora cayetensis,* the daily conference calls chaired by the CDC were well-organized and were an effective means of coordinating the public health response. This outbreak involved over 20 different state, provincial and local health departments and several federal agencies. Part of the problem during the West Nile calls last year was the initial lack of leadership to ensure that the discussion remained focused. However, this did improve significantly with the implementation of a standard format and agenda for each call.

Although electronic discussion forums can be valuable, the West Nile virus forums have not been regularly utilized on either the CDC or NY State Department of Health's Website this year and the telephone conference calls have remained the most effective way for sharing information.

Decision-making during a multi-jurisdictional outbreak can be difficult to address and the draft report does not acknowledge that the authority to make the final decisions with respect to implementation of mosquito control measures was at the local, and not the federal, level. The CDC and the state health departments involved provided guidance and recommendations, but each local health department had the final responsibility to decide and implement their public health response.

3 - Improving linkages with animal health agencies:

We also recognize that this is one of the most important lessons learned from the West Nile virus outbreak last year. However, it is essential to note, that the monitoring of veterinary public health issues is multidisciplinary with several different agencies responsible for different

types of animals: (a) domestic animals, such as dogs and cats, are usually the responsibility of state and local health departments, (b) livestock, such as cattle and swine, are usually the responsibility of state agricultural agencies, and (c) wildlife, such as birds, are under the state environmental or wildlife agencies. This division also occurs at the federal level, and hinders effective communication and coordination during investigations that involve multiple animal species.

The early investigation of the avian outbreak was slow and the common pathologic finding of encephalitis among the affected birds was not reported until almost two months after the first reports of a bird die-off in the NYC area. In early to mid-August 1999, there were numerous articles on the avian outbreak in the local community papers that reported that no common pathology or etiology was identified despite multiple submission of dead birds for pathologic examination.

It was not until the media announcements reporting the human outbreak of St. Louis encephalitis, that the veterinary pathologists began to more intensively investigate the cause of the bird deaths. Although there was reportedly concern among these veterinarians and wildlife specialists that the avian outbreak was related to the human outbreak, there was never an attempt to communicate this directly to the NYC Department of Health, which was the lead agency investigating the human outbreak – especially regarding the key finding that most of these birds also had evidence of viral encephalitis.

As documented in the report, local health officials at the NYC Department of Health had been accurately informed by arboviral experts at CDC and elsewhere that the avian die-offs were likely unrelated to the human outbreak as flaviviruses do not normally kill their avian host reservoirs, and simultaneous avian and human arboviral encephalitis outbreaks have never been reported previously for SLE, or other flaviviruses such as West Nile virus. Bird die-offs due to various causes are not unexpected during the fall migration, but the finding that the majority of these birds, especially crows, had autopsy evidence suggesting viral encephalitis was an important clue that these outbreaks were indeed related, and this information could have been more rapidly and effectively shared with the epidemiologists investigating the human outbreak.

4 - Recognition of unusual clusters of human illness - Among the five patients that were admitted to the community hospital in Queens during August, at least three of them did not initially present with "unusual symptoms". Three of the four earliest cases did not develop symptoms of encephalitis with muscle weakness until almost a week into their hospital stay. Also, as commonly occurs in any hospital, these patients were initially seen by different physicians, and it was not until there was a single infectious disease consultant reviewing their cases that the opportunity to recognize that these patients were part of a cluster or outbreak presented itself. Therefore, the ability to recognize these patients as an unusual cluster was not possible until the third week in August.

There is a need for hospitals to ensure the capacity to detect clusters of unusual illnesses among their patient populations, so that the local and state health departments can be notified of any suspect outbreaks, even before a diagnosis is made. Infection control practitioners, infectious disease consultants or chief medical and pediatric residents may be in the best position to recognize unusual patterns of illness in their institutions and local and state health departments

should make special efforts to partner with these specialities.

It is important to note that both the NYC Department of Health and the Office of Chief Medical Examiner took an active role in ensuring that autopsies were performed on any fatal case of encephalitis. On a daily basis, Department staff contacted the hospitals to check on the status of all critically ill cases – both those that were laboratory-positive and those for whom the diagnosis was still pending. If a patient expired, the Department's medical epidemiologists contacted the patient's physician and family to explain the importance of obtaining an autopsy to determine the diagnosis. Autopsies were performed on over 25 fatal cases who were initially suspected as having viral encephalitis, including all four fatal cases of West Nile encephalitis that occurred among NYC residents. This active effort to ensure that autopsies were obtained was an essential component of the epidemiologic investigation on the part of the NYC Department of Health.

5 - Value of bioterrorism preparedness in improving public health capacity for responding to infectious disease outbreaks: The ongoing planning for bioterrorism response that has been in place at the NYC Department of Health since 1996 was key to the success of the Department's response. Most critical, was the collaborative relationship that existed between the Health Department and the Mayor's Office of Emergency Management. Our joint bioterrorism planning efforts facilitated the rapid mobilization of emergency mosquito control measures, establishment of the public hotline, coordination of the daily communications with the media and the rapid mobilization of Health Department staff over Labor Day weekend to assist with canvassing the Northen Queens neighborhood with educational materials and implementing active surveillance and epidemiologic investigations citywide

As your report demonstrates, the public health response to the West Nile virus was in most regards a success thanks to the tremendous efforts of staff in numerous federal agencies, especially at the Centers for Disease Control and Prevention, along with the many local and state public health officials who worked long hours during the 2 ½ month investigation. Again, we appreciated the opportunity to comment on this draft report. Please contact me directly if you have any questions.

Sincerely,

Marcelle Layton MD

Marcelle Layton, MD
Assistant Commissioner
Communicable Disease Program
New York City Department of Health

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