Before the Swarm

Guidelines for the Emergency Management of Vector-Borne Disease Outbreaks

Acknowledgements

The Association of State and Territorial Health Officials (ASTHO) sincerely thanks the members and consultants of the Vector Control Workgroup (VCW) for their dedication and indispensable contributions to the development of this document. Without their unique perspectives, diversified backgrounds, and incomparable technical expertise, this project would not have been possible.

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ASTHO is grateful for the financial support and technical assistance provided by the Centers for Disease Control and Prevention (CDC). The project received direct funding through the CDC Cooperative Agreement to Improve the Nation's Health Public Health Infrastructure with State Public Health Agencies/Systems, Award No.5U38HM000454-05. Ben Beard, chief of the Bacterial Diseases Branch at CDC' Roger Nasci, Chief, Arboviral Diseases Branch, Division of Vector-Borne Diseases at CDC; Renee Hutchens, Division of Vector-Borne Diseases at CDC; and Gino Marinucci, Climate and Health Program at CDC, provided key support, guidance, and feedback throughout the course of this project.

Jennifer Goodnight and Abraham Kulungara served as the coordinating ASTHO staff persons for the project. ASTHO staff member Kimberly Martin also provided important feedback and support during the project.

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Executive Summary

Vector-borne diseases pose a continual threat to the nation's health. Worldwide, vector-borne diseases, including malaria and dengue fever, affect more than 390 million people each year, approximately 40 percent of the world's population.[i] Many vector-borne diseases exist in the United States and other dangerous pathogens could be just a plane ride away from entering the country. In response to such a threat, *Before the Swarm* provides straightforward and realistic guidance to help state, territorial, and local agencies; nongovernmental organizations; and private industry groups prepare for the emergency management of vector-borne disease outbreaks.

This document addresses three trigger events—existing, endemic diseases, emerging or newly emerging exotic diseases and vectors, and natural disasters—that could necessitate an emergency response. Building on the solid foundation established by the Association of State and Territorial Health Officials (ASTHO) in the report *Public Health Confronts the Mosquito: Developing Sustainable State and Local Mosquito Control Programs*, this document provides analysis and recommendations for countering the threat of vector-borne disease outbreaks in six sections:[ii]

- ✓ **Plan Ahead**
- ✓ **Involve Others**
- ✓ **Use the Best Science and Data**
- ✓ **Inform the Public**
- ✓ **Responding to a Mosquito-Borne Disease Emergency**
- ✓ **Responding to Other Vector-Borne Diseases**

While emergencies can be extremely challenging, careful planning may avert many difficulties. As evidenced by recent events such as Hurricane Sandy in 2012, thorough, deliberate, and evidence-based preparation is essential for health departments that may be required to respond to a vector-borne emergency. However, since vector-borne disease funding is often limited, this document also provides recommendations for vector control and emergency preparation in areas with limited resources or a reduced response capacity.

The following two pages contain a checklist summary of recommendations. The recommendations are not designed to be all-encompassing, and they will not necessarily apply to every stakeholder involved in the fight against vector-borne diseases and nuisance vectors. Rather, the analysis and recommendations will assist policymakers and state and territorial health workers to make informed decisions on how best to prepare their respective jurisdictions for the dangerous threat vectors pose to human and animal health, economic prosperity, and overall quality of life.

Planning and Action Checklist

Plan Ahead

- ☐ Begin now to devise plans for potential emergencies
- ☐ Hold on-site training sessions with state epidemiologist and/or entomologist
- ☐ Send vector control and public health personnel to attend training sessions from specialized providers, if applicable
- ☐ Take advantage of online and printed training manuals and pesticide applicator certification materials
- ☐ Ensure that all persons with a direct role in emergency management activities receive the appropriate training in the National Incident Management System (NIMS) and Incident Command System (ICS)
- ☐ Ensure that all persons with a direct role in emergency management activities have a firm grasp of resource typing for the request for assistance agreements between jurisdictions
- ☐ Gather and prepare communications products in advance so that your messages are timely, concise, clear and adaptable for various audiences.

Involve Others

- ☐ Ensure continuity of communication between health agencies, private industry, academic, and other public sector response partners
- ☐ Designate one leader who can coordinate emergency vector control operations
- ☐ Involve entities such as schools, faith-based organizations and churches, community groups, and businesses as distribution pathways for relevant health information
- ☐ Coordinate with both elected and non-elected community leaders in the release of important public information
- ☐ Maintain a good working relationship with academic partners that permit the sharing of disease surveillance data and technical expertise

Use the Best Science and Data

- ☐ Ensure the continuity of surveillance efforts and data collection from a variety of immature mosquito, adult mosquito, equine, human, wild bird, and sentinel vertebrate sources
- ☐ Prepare cooperative, resource-sharing agreements with other jurisdictions for use in future emergencies
- ☐ Access agricultural extension agents and subject matter experts
- ☐ Contract private companies to conduct surveillance, if necessary
- ☐ Work with state agriculture and public health agencies to facilitate access to important surveillance data from veterinary diagnostic laboratories, zoos, and equine, falconry, and raptor rehabilitation organizations
- ☐ Analyze geographic distribution of telephone complaint calls and train volunteers, college interns, and employees to track mosquito landing rates as a last resort for a basic source of surveillance data

Inform the Public

- ☐ Organize risk communication campaigns that have accurate, clear and timely information to reduce public anxiety and give people practical and concrete steps to protect themselves
- ☐ Summarize important messages with phrases that are easy to remember-such as the "Five D's of Prevention"
- ☐ Repeat important vector control and public health messages on a routine basis even before an emergency starts
- ☐ Adapt routine messages with new information that explains any enhanced risk during an emergency
- ☐ Translate brochures, public service announcements, and other forms of communication into other languages to reach minority communities
- ☐ Develop and practice plans to ensure the distribution of important public information
- ☐ Route all public messages through the agency Public Information Officer (PIO) for a consistent message
- ☐ Maintain regular contact with media by periodically passing along relevant stories through the PIO
- ☐ Create a Joint Information System (JIS) in emergencies where more than one PIO or agency is involved
- ☐ Release important public information quickly as time can be of the essence in emergencies
- ☐ Work with the PIO to hold a town hall or participatory community meeting about the risks and benefits of using pesticides
- ☐ Hold the above public dialogue session(s) even before a disease outbreak occurs

Responding to a Vector-Borne Disease Emergency

- ☐ Collaborate with a variety of organizations that may conduct vector control operations, such as community groups, public works departments, and transportation agencies
- ☐ Establish shared service agreements, equipment pools, regional districts, and standard contracts for services with other, nearby jurisdictions before an emergency occurs
- ☐ Coordinate with public health laboratories for testing and surveillance services during an emergency
- ☐ Sign preemptive contingency agreements with private contractors for vector control services that stipulate that the businesses will respond within a given time period (i.e. 72 hours)
- ☐ Public health and vector control agencies should help prepare and regularly update county Pre- Disaster Mitigation Plans together with other emergency management offices
- ☐ Participate in regional vector control teams that could supply technical expertise in the event of an emergency
- ☐ Become familiar with federal response partners and their protocols for requesting assistance
- ☐ Make informed, evidence-based decisions regarding pesticide applications in the areas where the risk for vector-borne disease is highest
- ☐ Work with the public to eliminate possible vector habitats, if applicable
- ☐ Consider the costs and benefits when implementing 'pay for service' vector control initiatives
- ☐ Take advantage of GIS tools to track the status of pesticide applications, source reduction efforts and public education message coverage

(Note: These are summary recommendations that are explained in more detail throughout the document.)

Outbreaks of Unknown Etiology

Charissa frowned at her PCR results. She was working as an emerging infectious diseases fellow in Tennessee, and it was her job to figure out why a man who had never left the state was showing symptoms of babesiosis – which had never been documented before in Tennessee.

No one believed that the black-legged tick carrying the Babesia parasite had moved that far south. Furthermore, Charissa couldn't find any trace of Babesia microti*—the most common strain of* Babesia *that infects humans in the United States—in the ticks she collected near the man's house. It had been quite an experience collecting those ticks, too; her team went rabbit hunting in the areas the patient frequented, dragging the collection cloth behind them and the 30 hunting beagles as they all traipsed excitedly around the area.*

The preliminary tests showed that the man wasn't positive for Babesia microti *but clinical analysis indicated babesiosis. Charissa's team thought that perhaps, given his affinity for hunting, he was infected with a different species of* Babesia. *Thus, Charissa was tasked with finding a way to detect whatever species of* Babesia, *if any, was present in the ticks she had collected. But in order to do this she had to cast a wide net, searching for as many species of* Babesia *as she could.*

She worked with colleagues in both government and academia to try to create a method of detecting rare and potentially unknown species of Babesia. *Since the day's results were not what she expected, she needed to try something new. She quickly tapped out an email to her colleagues in Massachusetts, Georgia, and within Tennessee. Perhaps they would be able to help her…*

Vector-borne diseases and outbreaks of previously unknown infections are on the rise. Nearly half of the world's population is infected with at least one type of vector-borne pathogen.[iii] Vector-borne disease outbreaks can occur suddenly, with little or no warning. It is impossible to predict if such an outbreak will occur after a drought in Texas, in the form of a previously unseen disease agent in California, or as a resurgence of an existing pathogen in Nebraska. In May 2014, the Puerto Rico Department of Health reported the first case of locally acquired chikungunya in Puerto Rico. This is the first time that local transmission of chikungunya has been reported in the United States.[iv]

While most areas in the United States do not confront exotic vector-borne diseases on a frequent basis, the lessons learned from recent outbreaks remain important today, and should be continually revisited to factor in human migration patterns and the potential impact of climate change on vector-borne disease incidence.[v,vi] If a new disease that is transmitted effectively is introduced to the existing mosquito populations, a devastating outbreak of human illnesses could occur quite rapidly.

The unpredictable nature and severity of vector-borne disease outbreaks demonstrates the urgent need for careful preparation and the incorporation of vector-control emergency-management activities into overall public health preparedness efforts. Since climate change is altering temperature and precipitation patterns across the country, it is critical that public health professionals also prepare for a potential increase in the geographic spread of existing vectors, such as *Aedes albopictus* or *Aedes aegypti*, and potentially for new vector-borne diseases.

The fact that the United States is already home to competent hosts and vectors for many of the world's most serious vector-borne diseases, including *Aedes albopictus* and *Aedes aegypti*, which can carry West Nile, yellow fever, dengue, and chikungunya viruses, underscores the fundamental importance of creating and sustaining vector-control programs.[vii] One key component of these programs is the ability to identify and mitigate vector-borne diseases that pose a substantial health threat to the public. More information on evaluating arboviral disease threat levels is available in Appendix B.

The following three trigger events could necessitate an emergency response and require extraordinary measures and resources to protect the public.

Existing Diseases
For the purpose of this document, existing diseases are defined as vector-borne diseases that appear regularly at varying levels of activity within the United States.

Mosquito-Transmitted Diseases: Examples of existing mosquito-borne diseases in the United States include West Nile fever, St. Louis encephalitis, eastern equine encephalitis, western equine encephalitis, the Jamestown canyon virus, and La Crosse encephalitis. Although these diseases do not routinely appear in every part of the U.S., they often occur in sporadic, focal outbreaks or are consistently present at low to moderate levels in certain geographic areas.

Tick-Transmitted Diseases: Multiple species of the *Rickettsia*, *Anaplasma*, *Borrelia bacteria*, and *Babesia* protozoa have long been known to cause illness in the United States through tick bites. Recently, additional tick-borne disease agents have been discovered to be endemic in various regions of the United States, including the Powassan virus, the Heartland virus, *Rickettsia philipii*, *Borrelia miyamotoi*, and a novel *Ehrlichia muris*-like species.

While new diseases receive greater media attention, existing diseases already threaten public health. While already problematic in many regions, these existing diseases could become more prevalent as human activity continues to expand into previously undeveloped areas and land use patterns shift from agriculture to suburban housing developments. The situation could be complicated further if these existing diseases appear in new regions of the United States or surge in endemic regions as a result of climate or other related changes.

Dengue in the Virgin Islands

In November 2012, 27 students in the Virgin Islands were found to have dengue fever. A subsequent investigation in December confirmed that Aedes aegypti mosquitoes, which transmit the dengue virus, were found in nine out of the ten schools in St. Croix. The investigation suggested that the territory had experienced an outbreak during the peak transmission period due to increased rains, and the schools were part of a larger island-wide outbreak that might not have been identified without the school report.

In response to the outbreak, the Virgin Islands Department of Health worked to improve dengue surveillance, reporting, and prevention. It improved the physician reporting form to make it more user friendly, used mosquito larvicides to treat containers with water that could not be eliminated, routinely inspected areas such as schools that are prone to having containers that accumulate water and produce mosquitoes, and sponsored training for healthcare providers.

Exotic Diseases and Vectors

As globalization and climate change increasingly become an aspect of daily life, so too may new, exotic and-re-emerging vectors and pathogens from around the world. Exotic vector-borne diseases such as Rift Valley fever, dengue, chikungunya fever, Japanese encephalitis, and Venezuelan equine encephalitis could enter the United States and its territories through a variety of avenues, including person-to-mosquito-to-person transmission from infected humans being transported across borders, or vector species migration due to temperature increases. For example, the redisplacement of *Aedes albopictus* by *Aedes aegypti* within the United States could portend an uptick in vector-borne disease in certain areas, as *Aedes aegypti* appears to be a more efficient vector of dengue.[viii] Other exotic diseases that are not currently found in the United States could be introduced to vectors that are already endemic and common. Some of these diseases could have a devastating effect not only on humans but also on animal populations. Mosquito-borne Rift Valley fever in particular could have a substantial economic impact if introduced to the United States because the virus can infect and cause fatal disease in cattle, sheep, and goats in addition to humans.

Warmer weather may increase the number of opportunities for exotic vector-borne diseases to enter and establish transmission in the United States by lengthening the transmission season. Realistically, due to the varied nature of exotic vectors and diseases, public health and mosquito control programs cannot expect that one methodology can provide a reliable one-size-fits-all response for all exotic diseases, especially since exotic disease agents could target several different hosts. The dead-bird-reporting system designed to track West Nile virus cases may work for exotic pathogens such as Japanese encephalitis but would not be useful when confronting other diseases such as Rift Valley fever, since this virus only affects mammals.[8] The success of a mosquito control program depends on its ability to use multiple surveillance methods to provide data on disease threats, including novel threats that may spread into the United States and become endemic.

The risk of exotic vector-borne diseases entering the United States and its territories and establishing sustained transmission of disease is unclear. However, West Nile virus is a good example of an international, exotic threat to the United States. After the first domestically acquired human cases of West Nile virus were reported in New York City in 1999, the virus spread westward and by 2005 had established itself in countries throughout the hemisphere, from central Canada to southern Argentina. Annual outbreaks of West Nile virus continue to occur in the United States, causing an estimated 3 million infections since 1999. A recent estimate by CDC found cases of West Nile Virus disease have cost a cumulative $778 million in healthcare expenditures and lost productivity over the last 14 years.[ix]

For this reason, it is crucial for the United States to maintain critical vector-borne surveillance and laboratory capacities at the federal and state level to quickly detect and respond to vector-borne disease threats. According to a 2012 surveillance assessment capacity report, surveillance capacity in state and large city and county health departments has decreased since 2004. The number of staff working at least half-time on West Nile Virus surveillance in states has decreased 41 percent. The percentage of states conducting mosquito surveillance has decreased from 96 percent to 80 percent. The percentage conducting avian mortality surveillance has dropped from 98 percent to 39 percent. More than half of states (58%) have reduced mosquito trapping activities, and 68 percent have reduced mosquito testing. Alarmingly, laboratory and mosquito environmental surveillance capacities for West Nile Virus have reached a tipping point, where further reductions in capacity will likely result in their loss entirely in some states.[x]

Natural Disasters
Natural disasters such as floods, severe storms, or hurricanes often cause great public concern about vector-borne disease outbreaks. Members of the public often assume that water-related natural disasters produce more pools of standing water, which lead to more mosquitoes and more cases of vector-borne disease. In reality, vector-borne disease outbreaks after natural disasters in the United States are fairly uncommon.[xi,xii] However, since the number and intensity of natural disasters is likely to increase due in part to climate change, it is especially important to understand what, if any, effects these disasters will have on vector-borne diseases.

Rain events and drought cycles could profoundly influence the spread of vector-borne disease in the United States, not only due to displacement of populations of humans and disease reservoirs, but in terms of vector abundance. Drought conditions could favor closer contact among vectors, reservoirs, and hosts, and thus facilitate transmission. Other areas could become too arid or too wet and may actually become inhospitable to vectors, thus possibly decreasing the overall risk of disease. However, warming temperatures could favor more rapid amplification and dissemination of viruses within both reservoirs and vectors. Higher temperatures have been correlated with increased incidence of disease at local, regional, and national scales.[xiii,xiv] West Nile virus outbreaks have also been associated on a local level with urban habitats in the Northeast, agricultural habitats in the Western United States, and rural irrigated landscapes.[xv,xvi] Since West Nile virus and other important vector-borne diseases of concern are still relatively new to many parts of the country, it is important to note that their full disease profiles remain uncertain. Thus, only the sustainable dedication of resources for vector control, surveillance, and personnel can help advance both understanding and capacity to respond to these diseases in a timely and effective fashion.

This document discusses the above factors and response recommendations for the emergency management of vector-borne disease outbreaks. These recommendations are based on the solid foundation established in the initial ASTHO report, *Public Health Confronts the Mosquito: Developing Sustainable State and Local Mosquito Control Programs*, and employ the same, easy-to-use format in four sections:

- ✓ **Plan Ahead**
- ✓ **Involve Others**
- ✓ **Use the Best Science and Data**
- ✓ **Inform the Public**

The additional segments, “Responding to a Mosquito-borne Disease Emergency” and “Responding to Other Vector-Borne Diseases,” discuss specific control measures.

Anaplasmosis and Babesiosis in New York

In 2001, the New York State Department of Health received word of five locally acquired babesiosis cases north of New York City—an area where the Babesia *parasite had never been found in the tick population.*

New York had already been ramping up its vector-borne disease surveillance efforts in response to West Nile virus, so health officials were able to quickly send personnel to the area of interest to collect ticks. When samples tested positive for Babesia microti*, the team decided to screen the ticks for the pathogens that cause Lyme disease and anaplasmosis as well.*

They found much higher rates of Anaplasma *infection in ticks than expected based on reported human case numbers, and were able to use this information in their updates to physicians on local vector-borne disease activity. New York continues to collect and analyze ticks from approximately 50 locations across the state twice per year and is currently expanding surveillance capacity to other emerging tick-borne pathogens and broadening research capacity in collaboration with other agencies and universities. Tick testing results are shared with local health departments, other state agencies, medical providers, veterinarians, and the general public in an effort to reduce disease occurrence and ensure timely diagnosis and appropriate treatment of tick-borne diseases in New York State*

Plan Ahead

It's never too early to begin planning for an emergency response. Emergency response measures alone cannot begin to provide the same level of response as an organized, established vector control program. Any emergency can strain an agency's staffing, equipment, and budget resources. State and local vector control programs cannot rely on federal agencies to supply timely financial aid or comprehensive emergency assistance when a disaster strikes. Rather, the ability of state and local actors to provide an effective emergency response depends on independent, well-prepared programs with integrated emergency functions in place. The efficient emergency management of vector-borne disease outbreaks, as is the case with any crisis response, requires thorough planning, practice, and implementation.

In addition to improving efficiency, sustainable vector control programs can save valuable local emergency response resources. Vector control programs are relatively inexpensive, costing approximately $3.67 per person, per year.[xvii] This figure pales in comparison to the costs associated with the emergency use of contractors, equipment, and pesticides. For example, the cost associated with a West Nile virus outbreak in Louisiana during an eight month period from 2002-2003 was $20.1 million and included $9.2 million for public health response, $4.4 million for medical costs, and $6.5 million for nonmedical costs.[xviii] Emergency costs can quickly drain an agency's budget.

Thorough planning also necessitates ongoing professional development for vector control staff. Some examples of professional enhancement activities include the following:

- **Training Sessions—**Many local vector control staff report that they find on-site training sessions with the state entomologist or epidemiologist to be extremely beneficial experiences. These training sessions can be mutually beneficial. State experts learn what is happening on the ground level, while local vector control authorities gain a better understanding about statewide patterns and best practices. Many vector control programs have also sent employees to attend training sessions from private firms. Information on training resources are available in Appendix A.

- **Training Manuals and Pesticide Applicator Certification—**In addition to training sessions, several states have produced printed materials and training manuals on safe and effective methods to apply pesticides. Links to these materials and opportunities are available in Appendix A.

- **National Incident Management System—**All persons with a direct role in emergency response measures must complete the relevant National Incident Management System (NIMS) training courses in order to be eligible to receive federal preparedness funding assistance.[xix] This training prepares public health and other response partners for the structured cooperation between public- and private-sector organizations during any major event. Moreover, a firm grasp of "resource typing" is critical to streamlining the assistance request process. Typing provides a common definition of resources that is standardized between jurisdictions and commensurate with the threat level. For example, a Type 1 response team provides a more robust response capability than a Type 4 unit. While not required for most vector control officials, an in-depth knowledge and familiarity with the Incident Command System (ICS) and NIMS will allow state and local programs to integrate themselves into general preparedness efforts. More information regarding NIMS, ICS, and resource typing is available in Appendix A.

Involve Others

The emergency management of vector-borne disease outbreaks can quickly become an extremely complicated activity. A gap in communication often develops between the people with technical expertise in government and academia and the control agencies with logistical training and experience on the ground. Only proactive preparation and continuous interagency communication can ensure that all of these groups benefit from working together. All responsible parties must foster this interagency cooperation before a vector-borne disease occurs. In addition, while interagency cooperation is extremely important, vector control programs need a knowledgeable leader who can sit at the top of the chain of command and efficiently direct activities during an emergency. Vector control programs that wait until an emergency occurs to start forming cooperative interagency

Aedes aegypti *in California*

As of early 2013, Aedes aegypti*, or the yellow fever mosquito, had only rarely been spotted in California. But in June 2013,* Aedes aegypti *mosquitoes were found in multiple traps in two different counties, including within the cities of Clovis and Madera. Concerned that these day-biting mosquitoes could dramatically affect the quality of life, and potentially spark local transmission of yellow fever or Chikungunya, local vector control agencies worked with the California Department of Public Health and the CDC to implement Integrated pest management techniques, including source reduction, pesticide application, and education.* Aedes aegypti *has not yet been eradicated from the area, but surveillance and control efforts continue. The problem could be growing though, because in August of 2013,* Aedes aegypti *were also detected in San Mateo County in the San Francisco Bay Area.*[13]

relationships or designating leadership roles will find it difficult to conduct an efficient emergency management operation.

Vector control programs benefit from taking a broad view of important stakeholders in public education efforts. Organizations such as schools, faith-based organizations and churches, community groups, and businesses can serve as valuable distribution pathways for relevant health information. Vector control program staff can work with both elected and nonelected community leaders to coordinate the release of important public information. The maintenance of a good working relationship with academic and government partners and access to viral surveillance data at these institutions can help guide an appropriate response. The response partners listed in Appendix A are also helpful sources of information and cooperation.

Use the Best Science and Data

Effective surveillance is key to any effective response and integrated pest management (IPM) program, as it allows vector control programs to rapidly assess the scale of the emergency and determine the type and extent of proper response measures. In addition, the Federal Emergency Management Agency (FEMA) requires surveillance data to approve disaster assistance requests.[xx] Comprehensive vector control programs have access to surveillance data from a combination of immature mosquito, adult mosquito, wild bird, equine, and sentinel vertebrae sources. Ideally, public health and other government agencies will set up a system to coordinate and share information about human surveillance data. Conversely, vector control programs with limited surveillance capability will be hard-pressed to respond effectively. Figure 1 illustrates one example of how sentinel species in New York were used to measure West Nile virus activity.

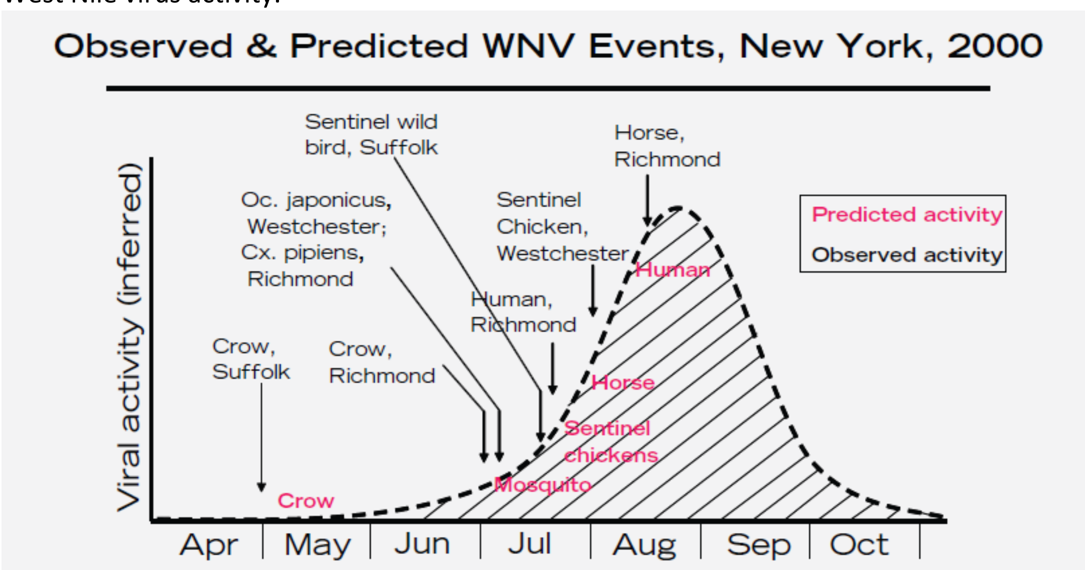


Figure 1 - A good surveillance program can provide early evidence of an impending epidemic, giving agencies a better chance of preventing human cases.[13]

Idea: Cooperative Agreements

As part of an agency's emergency planning, pursue cooperative agreements, such as equipment or human resource sharing, and information sharing agreements with neighboring jurisdictions.

Temporary solutions to the problem of a lack of surveillance resources can never substitute for in-house knowledge and human resources. However, in an emergency situation, vector control programs with limited or no funding still have options. In the past, these programs have successfully pursued cooperative relationships and information sharing with neighboring jurisdictions. While the requesting state still must pay for the use of borrowed resources, the Emergency Management Assistance Compact (EMAC) helps facilitate the process by which member states share equipment and human resources during emergencies. Successful examples in New York (West Nile virus, 1999) and Kansas (flooding, 2007) have helped to establish precedents for the sharing of resources for surveillance and/or vector control under EMAC. Such agreements between states are most effective when written before an emergency event occurs. State and local vector control programs may sign other agreements with neighboring jurisdictions for the sharing of data and information. While these agreements are valuable tools, however, they will be of limited assistance if neighboring areas are facing the same outbreak as the requesting agency.

Vector control programs with limited or no funding can work with universities or colleges to access experts and agricultural extension services provided through such institutions. State agriculture and public health departments may facilitate access to surveillance data from veterinary diagnostic laboratories, veterinary clinic networks, zoos, and equine, falconry, and raptor rehabilitation organizations. Additionally, vector control programs may contract with private companies or associations in order to conduct surveillance. Some vector-borne disease resources are listed in Appendix A. As a last resort, areas with little or no funding have analyzed geographic distributions of telephone complaint calls and trained volunteers, college interns, and employees to track landing rates as basic forms of surveillance data. This can be a dangerous practice if such individuals are exposed to mosquitoes carrying West Nile virus or other diseases, and may not be recommended. CDC recommends developing a phased response based on the existence of some form of West Nile virus monitoring data. Recommendations for a phased response to West Nile virus surveillance data can be found in Appendix B.

Inform the Public

Keeping the public informed is a key public health function during an emergency response situation. Effective risk communication campaigns are successful because they provide accurate, clear, and timely information, which can reduce public anxiety and give people concrete steps to protect themselves. Health departments should continually communicate with physicians and other healthcare providers to ensure that all medical professionals who may be involved in diagnosing vector-borne disease patients are apprised of what the current vectors and diseases of concern are, including what environmental conditions may facilitate the spread of vector-borne disease, and what public health resources are available.

The keys to effective public health communication are reliable information, repeated regularly and rapidly.

Public Communication

The keys to effective public health communication are reliable information, repeated regularly and rapidly.

Repetition—An emergency risk communication program should complement concepts that are already familiar to the population from previous, routine messaging campaigns. For example, many mosquito programs summarize mosquito avoidance efforts by educating the public about the "5 D's of Prevention" (Dress, Drain, DEET*, Dusk, Dawn) in response to endemic disease prevention efforts. Repetition of core messages during an emergency can reduce anxiety, although the risk communication program should explain any enhanced risk during an emergency response to help people make informed risk calculations. Brochures, public service announcements, and other forms of communication in several languages can assist in efforts to reach minority communities. (** Note: DEET is currently one of several repellent products recommended by CDC.)*

Regularity—As natural disasters may interfere with normal media operations, vector control programs should develop and practice a plan to ensure the distribution of important public information. Where applicable, agencies should also routinely discuss important matters with the Public Information Officer (PIO) to ensure a consistent message. For the sake of consistency, all public messages should go through the PIO to prevent the mixing of messages and a decline in public confidence. Through the PIO, vector control programs should maintain regular contact with media outlets by periodically passing along relevant stories. When more than one responding agency is involved, a joint information system should be established through the Incident Command System to ensure a cohesive message is being delivered by all PIOs at different agencies and institutions. Continued contact will be of great value during emergencies when important public information requires timely distribution.

Rapidity—Water-related disasters underscore the importance of enacting a rapid risk communication strategy. Effective risk communication can decrease the danger of a potential vector-borne disease outbreak. For example, depending on the species, new mosquitoes may appear 5-10 days after a water-related natural disaster and increased mosquito activity may continue for several weeks thereafter.[xxi] Even without the presence of disease-carrying mosquitoes, large numbers of biting nuisance mosquitoes can seriously hamper power restoration activities, impede recovery efforts, and pose significant public health hazards. After Hurricane Katrina in 2005, researchers recorded landing rates (defined as "a count of the number of mosquitoes that land on a person in a given amount of time") of up to 100 per minute, which made life unbearable for recovery workers and regular citizens alike.[xxii,xxiii] Damage and destruction of homes, power outages, hot temperatures, and recovery work increased the amount of time people spend outdoors. Even mild damage to doors, windows, and screens allowed mosquitoes to enter homes. This increased exposure to mosquitoes emphasized the importance of disseminating protection messages and providing appropriate materials. However, quick and effective risk communication regarding risk and advised courses of action can protect vulnerable populations.

It is important to note, though, that the mere implementation of risk communication messages, even during an emergency, does not mean that the public will immediately accept the program's advice. The target audience must also see the recommended actions as practical and feasible. The public must also believe that the risk is substantial enough to take action. Several West Nile virus studies suggest that many people who ignore advice to wear repellent or adopt other preventive measures do so because they do not perceive the risk of contracting mosquito-borne disease to be high enough to warrant such actions. People most often report that they believe their time of exposure is too short for them to be bitten or that using repellents is inconvenient.

Some people have negative attitudes about mosquito repellent. Survey research indicates that some people do not like the way traditional mosquito repellents smell or feel on the skin; others have concerns about product safety. Recent public information campaigns have sought to address safety concerns and highlighted the newest generation of mosquito repellents, which may counter some of these concerns.

Effective risk communication is also crucial in engaging groups opposed to pesticide application. Wide-area pesticide use is controversial in some communities. As the Environmental Protection Agency indicates, "no pesticide is 100 percent safe and care must be

Flooding in Kansas

In June and July 2007, a powerful, slow-moving storm struck Arkansas, Oklahoma, Kansas and Missouri. Much of the area had been experiencing drought, and suddenly the storm released up to 20 inches of rain in a week.Extensive flooding resulted in a federal disaster declaration. In response to subsequent complaints about mosquitoes, a public health entomology team from North Carolina conducted a survey of mosquito species that were responsible for the complaints, and whether or not there was an increased risk of West Nile virus transmission by the key vector, Culex pipiens.

The team uncovered several hot spots, including one house with a leaking underground sewer pipe and an inch of water surrounding the house, which provided over half of the Cx. pipiens *mosquitoes trapped during the entire mission. In comparison with Hurricane Katrina, where the strong sustained winds likely swept away many of the birds and mosquitoes and none of the post-storm samples of mosquitoes were positive for West Nile, there were many positive West Nile samples in Kansas, where strong sustained winds did not occur. Luckily, all four counties in Kansas where the team worked had low human population densities or more West Nile cases would likely have resulted.*[31]

exercised in the use of any pesticide." [xxiv]Opponents of pesticides have used legal suits and other mechanisms to limit or even prevent mosquito control spraying efforts from taking place. This opposition can seriously affect an unprepared program's ability to respond quickly to mosquito-borne disease during emergencies.

Studies by the EPA, Karpati, Currier, and Peterson support the idea that the benefits of controlling the spread of vectors with pesticides, when conducted according to the directions on the label, outweigh the risks of potential harmful health or adverse environmental effects from pesticide spraying or common larvicidal treatments.[xxv,xxvi] To ensure that the public fully understands and embraces this risk/benefit consensus, vector control programs and PIOs are most successful when they initiate an ongoing dialogue with community members before a disease or a natural disaster occurs. Town hall and participatory community meetings have allowed members of the public and vector control programs to openly discuss the most current understanding of the health risks of pesticides. Vector control programs can use these meetings to discuss how the relative health risk of pesticide spraying is considerably lower than the risks posed by many vector-borne diseases, such as West Nile virus. A guide to holding productive dialogue sessions with communities is available in Appendix A.

Responding to a Mosquito-borne Disease Emergency

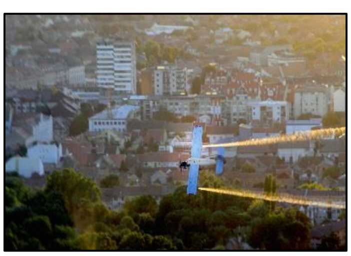
Emergencies affect multiple agencies within the community and demand timely, effective, and well-coordinated response measures. A detailed response matrix published by CDC is found in Appendix B. Many organizations, from community groups to public works departments to transportation agencies, conduct mosquito control operations, and all are valuable partners during emergencies. Mosquito control programs should use this matrix to help coordinate response measures. Several other key components are listed below:

- **Resource Sharing and Ability to Acquire Resources Quickly—**Rapid procurement of mosquito control resources can make a great difference in emergencies. During the 1999 experience with West Nile virus, New York City quickly purchased or borrowed (from Suffolk County) the necessary equipment, human resources, and pesticides. The establishment of shared services agreements, equipment pools, regional districts, and standard contracts for services can be extremely helpful to mosquito control programs with limited or no funding. Public health laboratories in other areas may assist with testing and surveillance during an emergency. Contractors can provide immediate help, but may be already committed elsewhere or prohibitively expensive for many communities. To ensure a timely response, mosquito control programs can preemptively sign contingency agreements that stipulate that contractors will respond in a given period, such as within 48 to 72 hours.

- **County Pre-Disaster Mitigation Plan—**Each county in every state should prepare and regularly update a Pre-disaster Mitigation Plan. Public health and mosquito control officials should contact their Emergency Management or Disaster and Emergency Services offices and the State Health Department Emergency Preparedness and Response divisions in order to collaborate in the development of this important planning document. The completed plan should be shared with the state epidemiologist and the state emergency preparedness director. This accomplishes the following three objectives:
    1. Opens dialog and builds a relationship with the local emergency planner.
    2. Helps gain visibility for the issue so it is remembered during general county emergency planning.
    3. Qualifies your department for future predisaster mitigation funding from federal agencies.

- **Regional and Federal Response Partners—**Interested mosquito control programs can take the idea of cooperation one step further. Regional mosquito control teams of veteran experts could make themselves available for technical assistance in the event of a disease outbreak. Such teams would be able to complement the outbreak investigation work often conducted by CDC and remain available on a long-term basis.

  When the U.S. President declares an emergency, the Federal Emergency Management Agency may be able to provide reimbursement for mosquito control costs. However, this process can be time-consuming and FEMA will only reimburse mosquito control programs for eligible costs. More information about FEMA's reimbursement policy for mosquito control costs is available in Appendix A.



  Also in such emergencies, the military may provide aerial applications of insecticides. The U.S. Air Force Spray Flight has historically participated as part of FEMA-funded emergency response initiatives. Several aircraft are available for large area rapid mosquito control where such measures are warranted.

- **Rapid, Informed Deployment of Chemical Measures—**While biological controls, sanitation programs, and wetlands management are critical components of sustainable mosquito control programs, they are slow to take effect. Larval control measures have become a cornerstone of many mosquito control programs, but they also have some significant drawbacks in emergencies. If a natural disaster has created many potential habitats for mosquitoes, it will be difficult (both economically and logistically) to apply larvicides to huge areas of land. Larviciding after a natural disaster may also prove unnecessary if dry conditions prevent larvae from developing. Still, given these considerations, the use of larvicides and the targeted application of adulticides are important aspects of emergency management operations. Larvicides will help lessen the threat of a future outbreak. The use of adulticides can protect recovery workers, large public gatherings, and other exposed groups. As each species of mosquito has different activity patterns, control programs are most successful when they use surveillance data to determine the correct time, place, and frequency of pesticide application. In order to be most effective, mosquito control programs should prioritize pesticide application according to risk. Locations with high population densities, mosquito-borne disease activity, popular outdoor events (sports events, fairs, concerts, etc.), large numbers of recovery workers, homes without power, a high density of elderly population, and displaced individuals living in temporary housing or compromised shelters should receive priority attention. Control programs must also consider the geographic area of the outbreak and its corresponding weather and climate conditions.

- **Timely Source Reduction—**The effective emergency management of mosquito-borne disease outbreaks and nuisance mosquitoes often requires that response partners enlist the public in source-reduction efforts. For areas with limited or no funding, public service announcements and educational campaigns can be an inexpensive and effective way to get people to eliminate standing water. At the same time, large-scale elimination of standing water may not be feasible, especially in the wake of natural disasters. While members of the public can turn over empty pots or clean birdbaths, they cannot drain primary sources of mosquitoes such as rice fields or ditches. In addition, only timely, informed surveillance data can spur effective source-reduction efforts, as these activities depend greatly on the type of mosquito species present in the affected areas.

- **Pay for Service—**Several counties and communities have used pay-for-service models with some success in the past. Such systems charge communities for pesticide applications to control adult mosquitoes. While such initiatives may provide service for those areas willing to pay the fees, the environmental justice implications of such a model raise concerns that low-income areas would not receive the same treatment as wealthier communities. Furthermore, pay-for-service models do not take into account the short-lived nature of adulticide application or the fact that adult mosquitoes may migrate in from untreated, nonpaying areas.

- **Real Time Use of GIS Tools**—Computer-based geographic information systems (GIS) can provide mosquito-control programs with instantaneous mapping of target areas. Whenever possible, spray maps are most useful when prepared and updated regularly in advance of an emergency. GIS can greatly increase the efficiency of control measures, as it can supply a real-time map of the status of pesticide application, source reduction efforts, and public education messaging coverage. While some advanced GIS programs may be too expensive for many mosquito control programs, free Web-based services such as Google Earth can still be helpful.[xxvii]

Responding to Other Vector-Borne Diseases

In addition to mosquitos, other insects and animals can be vectors in the United States and its territories, including ticks. Ticks can feed on mammals, birds, reptiles, and amphibians. Most ticks prefer to have a different host animal at each stage of their life, and they can transmit pathogens that cause disease during the process of feeding. Some of the most common tick-borne diseases in the United States include Lyme disease, babesiosis, ehrlichiosis, Rocky Mountain Spotted Fever, anaplasmosis, Southern Tick-Associated Rash Illness, Tick-Borne Relapsing Fever, and tularemia.[xxviii]

Prevention of Tick-Borne Diseases
The risk of an individual becoming infected with a tick-borne pathogen depends on the likelihood of sustaining an infective tick bite. Reducing exposure to ticks is the best way to prevent tick-borne diseases. CDC's recommended steps for preventing tick bites are:[xxix]

1. Avoid direct contact with a ticks.
2. Repel ticks with pesticides such as DEET or Permethrin.
3. Find and remove ticks from your body.

Risk Communication
Consistent and effective information must be provided to the public that will motivate them to change their behavior and take preventive measures to minimize their contact with vectors for disease. It is essential that the public understands:

1) The types of tick-borne diseases.
2) How and where they may encounter ticks and different host animals.
3) The signs and symptoms of tick-borne disease.
4) Who is at risk in contracting tick-borne diseases.
5) Prevention and treatment options.

This kind of comprehensive communication plan requires a sustained, concerted effort on the part of public health departments. It also requires cooperation with physicians, nurses, and other local medical experts.

Powassan Virus in Minnesota

In 2008, a child in Minnesota presented with a severe central nervous system illness and a history of tick bite. All tests for endemic tick-borne pathogens in Minnesota were negative. The Minnesota Department of Health (MDH) suspected that the illness may have been due to Powassan (POW) virus, a tick-borne virus related to West Nile virus. Specimens were sent to the only two laboratories that could test for the virus – the New York Department of Health and the CDC. Both laboratories had positive results, marking the first known case of the virus in Minnesota. MDH then developed the capability to test human and tick specimens for POW virus and launched a field investigation in the areas where the child may have had tick exposure. Blacklegged ticks collected from near the child's house were positive for the deer tick virus lineage of the POW virus.

Since then, MDH has issued electronic health alerts to physicians and infectious disease experts, encouraging them to submit samples for testing as necessary. Through extensive disease surveillance, 21 more cases were identified from 2008 to 2012. Further tick collection efforts indicated that POW virus-infected ticks were widespread across Minnesota. This virus may have been responsible for some of the viral encephalitis and meningitis cases of unknown etiology that were previously reported to MDH. MDH continues to encourage testing of suspect cases. Their efforts in responding to the disease enabled clinicians to more easily identify cases and learn about the clinical spectrum and risk factors associated with the it.

Hantavirus in Yosemite

In July 2012, the California Department of Public Health (CDPH) was informed that a tourist who had slept in one of the "signature" tent cabins in Yosemite National Park in June had fallen ill with hantavirus. Subsequently, another tourist who stayed in the same tent complex died of hantavirus.

Usually hantavirus cases are isolated, but in this case, since the second patient had slept in similar cabins as the first, CDPH suspected a possible environmental link. Working in collaboration with the CDC and the National Park Service, CDPH immediately launched an investigation to find any other cases of hantavirus in visitors to Yosemite and to make recommendations on control and prevention. In the course of the investigation health officials found deer mice nesting in the insulation between the canvas tent exterior and hard inner wall. These mice shed the virus that causes hantavirus and were likely responsible for the outbreak.

Eight more cases of hantavirus were discovered in people who had visited Yosemite between June and July, and two of these victims died. CDPH ensured that Yosemite closed the cabins and provided guidance on rodent control. The National Park Service launched an education campaign for visitors to Yosemite. The story was picked up by the media, and health officials had to react quickly in order to assure the public that the park was safe.

Communicating with Medical Experts

For all vector-borne diseases, prevention starts with effective public health messaging. In order for vector-borne disease prevention programs to be most effective at reducing the burden of vector-borne disease, health departments should collaborate and communicate frequently with physicians and other medical professionals. A communication plan can ensure that local medical professionals understand not only the diagnosis and treatment protocols for the various vector-borne diseases, including novel ones, but also that they are able to communicate accurate and coordinated prevention information to their patients. Health departments should also ensure that physicians understand when and where they should send samples for laboratory confirmation of a clinical diagnosis.

Some health departments use electronic health alert or notification systems to notify known medical providers of the discovery of new vector-borne pathogens or an increased risk of infection with endemic vector-borne pathogens. Health alerts can also be used to notify medical professions about what diseases are expected to appear in patients during a particular season. These notification systems can be particularly effective when they target physicians through large insurance networks or hospitals. Alert systems that can quickly notify the public about vector-borne disease conditions and outbreaks can also be extremely helpful, as communication is particularly critical in emergency vector-borne disease conditions. Having a communication system established before an emergency starts ensures that both the public and members of the medical community know where to obtain up-to-date, accurate information.

Conclusion

Vector control, public health, and emergency response programs face constant challenges. Increased global travel, natural disasters, changing climates, and the movement of vectors and pathogens are just a few of the issues that contribute to the complicated threat of vector-borne disease outbreaks. While the exact location, scope, and severity of the next vector-borne disease outbreak remains unclear, one thing is certain: Jurisdictions that begin to prepare and practice now for future vector-borne disease threats will find themselves in the best position to protect public health when an outbreak occurs.

Appendix A
Annotated Vector Control Resources

Associations

American Mosquito Control Association (AMCA) (http://www.mosquito.org/)
A national organization that works on mosquito control issues and related health policy and provides excellent general information and resources. AMCA publishes the Journal of the American Mosquito Control Association.

American Public Works Association (APWA) (http://www.apwa.net/)
The national and international professional and educational association of public works agencies. While mosquito control resources on this website are limited, APWA does have many active members who work on relevant mosquito control issues.

Association of Public Health Laboratories (APHL) (http://www.aphl.org/)
A national organization that provides support to the nation's public health laboratories through the promotion of effective programs and public policy.

Association of State and Territorial Health Officials (ASTHO) (http://www.astho.org/)
A national organization representing the state and territorial public health agencies of the United States, the U.S. Territories, and the District of Columbia. The ASTHO vector control page is available at http://www.astho.org/index.php?template=mosquito_control.html.

Council of State and Territorial Epidemiologists (CSTE) (http://www.cste.org)
A national organization of member states and territories representing public health epidemiologists. CSTE works on advancing public health policy and epidemiologic capacity and serves as the professional home for applied epidemiologists representing multiple levels of public health practice.

Mid-Atlantic Mosquito Control Association (http://www.mamca.org/)
A regional network of mosquito control actors from eight Mid-Atlantic States.

National Association of County and City Health Officials (NACCHO) (http://naccho.org/)
A national organization representing the local health departments of the United States. The NACCHO mosquito control page is available at http://www.naccho.org/topics/environmental/mosquitocontrol.cfm.

National Emergency Management Association (http://www.nemaweb.org/)
The professional association of state emergency management directors.

Northeastern Mosquito Control Association (http://www.nmca.org/)
A regional association of several Northeastern states.

Northwest Mosquito and Vector Control Association (http://www.nwmvca.org/)
A regional organization of five Northwestern states and three Canadian provinces.

Society for Vector Ecology (SOVE) (http://www.sove.org/Home.html)
The professional organization of vector biology and control experts. Also publishes the Journal of Vector Ecology*.*

West Central Mosquito and Vector Control Association (http://www.westcentralmosquitoandvector.org/)
A regional network of eight Great Plains and Rocky Mountain states.

Federal Agencies

Centers for Disease Control and Prevention (CDC) Division of Vector Borne Infectious Diseases (DVBID) (http://www.cdc.gov/ncidod/dvbid/index.htm)
A federal and international reference center for mosquito-borne and vector-borne diseases.

Federal Emergency Management Agency (FEMA) (www.fema.gov)
A federal agency that may reimburse jurisdictions for mosquito control costs during an emergency declared by the U.S. President. FEMA's guidelines for the funds disbursement are available at http://www.fema.gov/government/grant/pa/9523_10.shtm.

U.S. Air Force Medical Entomology (http://www.afpmb.org/military_entomology/usafento/af.htm)
The network of medical entomologists responsible for the protection of Air Force personnel from vector-borne and other disease threats.

U.S. Air Force Reserve Aerial Spray Flight (http://www.youngstown.afrc.af.mil/units/aerialspraysquadron/index.asp)
A wing of the Air Force Reserve that has some limited capacity to conduct pesticide application during emergencies.

U.S. Army Medical Entomology (http://www.afpmb.org/military_entomology/usarmyento/army.htm)
The network of medical entomologists responsible for the protection of Army personnel from vector-borne and other disease threats.

U.S. Army Environmental Command (http://aec.army.mil/usaec/pest/links00.html)
Provides information and training on vector-borne disease control to Army personnel.

U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) (http://www.aphis.usda.gov/)
A branch of the U.S. Department of Agriculture that specializes in the protection of agricultural resources, plants, and animals from various threats, including vector-borne diseases.

U.S. Environmental Protection Agency (EPA) Mosquito Control
(http://www.epa.gov/pesticides/health/mosquitoes/index.htm)
Provides information on mosquito control strategies and pesticides.

Grants

Epi and Lab Capacity Program Grant Information (http://www.cdc.gov/ncidod/osr/site/epi_lab/)
Offers a primer on the CDC's ELC grant program.

Risk Communication

Agency for Toxic Substances and Disease Registry (ATSDR) (http://www.atsdr.cdc.gov/)
A guide to holding productive dialogue sessions with the community is available at http://www.atsdr.cdc.gov/risk/riskprimer/index.html.

Training Materials

American Association of Pesticide Safety Educators (AAPSE) (http://www.aapse.org/)
A national organization providing pesticide education and applicator certification information for each state. Specific information for each state is available under the 'Pesticide Safety Programs' link at http://pep.wsu.edu/psp/.

Association of American Pesticide Control Officials (AAPCO) (www.aapco.org)
A national organization that offers pesticide regulation information.

American Mosquito Control Association (AMCA) (http://www.mosquito.org/resources/links.aspx
Provides links to training websites and information.

Centers for Disease Control and Prevention (CDC) (http://www.cdc.gov/westnile/index.html#training).
Provides taxonomic guides for mosquito identification and training materials.

Federal Emergency Management Agency (FEMA) (www.fema.gov)
Information on the National Incident Management System (NIMS) and the Incident Command System (ICS) is available at http://www.fema.gov/emergency/nims/nims_training.shtm. More information on resource typing is available at http://www.fema.gov/pdf/emergency/nims/resource_typing_qadoc.pdf.

Appendix B

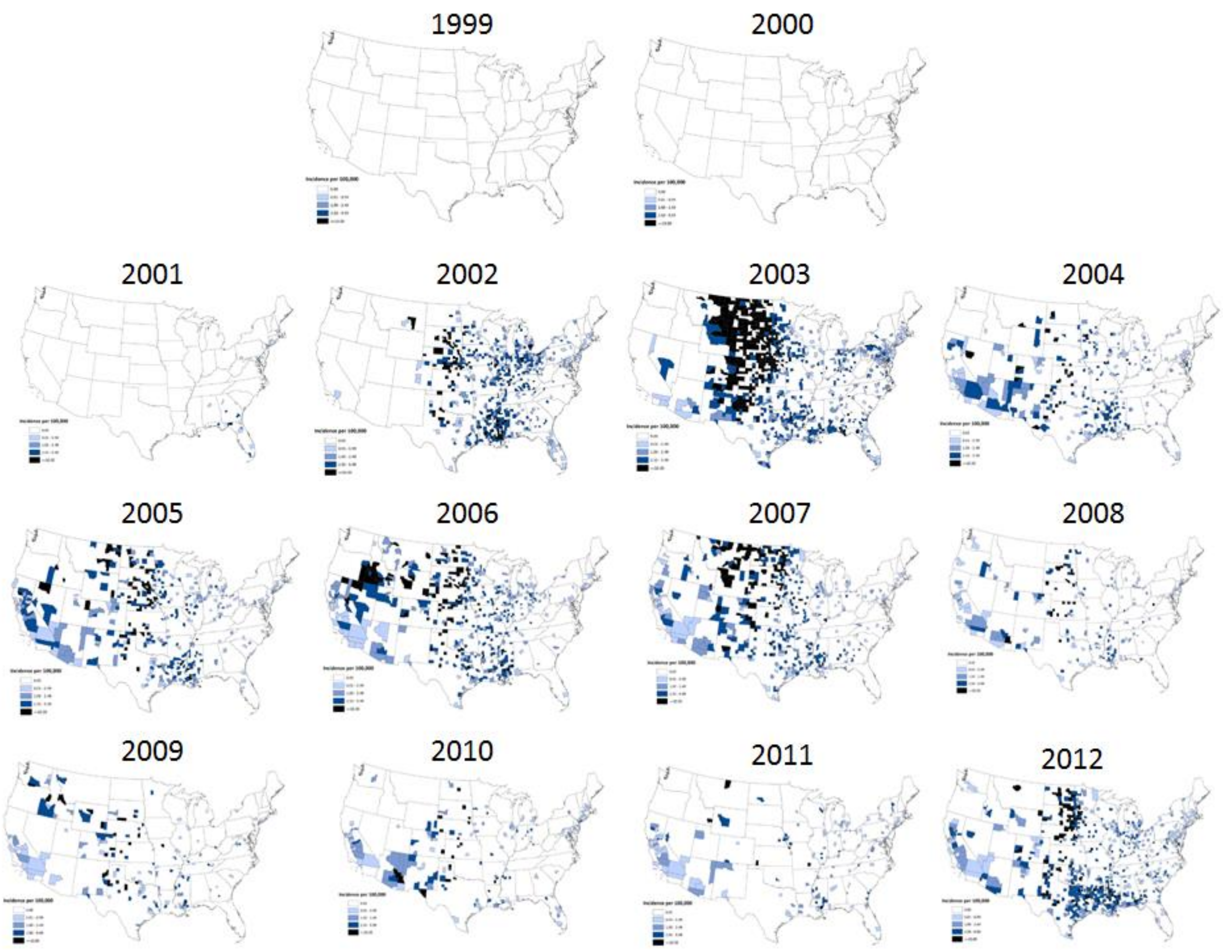
Arboviral Disease Outbreak Risk Categories[xxx]

Risk Category	Probability of human outbreak	Definition	Recommended activities and responses
0	None	• No adult mosquito biting activity (vector species).	• Develop and review West Nile virus (WNV) response plan. • Review mosquito control program. • Maintain source reduction projects. • Secure surveillance and control resources necessary to enable emergency response. • Review and update community outreach and public education programs.
1	Low	• Biting adult mosquitoes active (vector species). -or- • Epizootic activity expected based on onset of transmission in prior years. -or- • Limited or sporadic epizootic activity in birds or mosquitoes.	• Response as in category 0, plus: • Conduct integrated vector management program to monitor and reduce vector mosquito abundance. • Conduct environmental surveillance to monitor virus activity (mosquitoes, sentinel chickens, avian mortality, etc.). • Initiate community outreach and public education programs focused on personal protection and residential source reduction.
2	High	• Sustained transmission activity in mosquitoes or birds. -or- • Horse cases reported. -or- • Human case or viremic blood donor reported.	• Response as in category 1 plus: • Intensify and expand adult mosquito control in areas using ground and/or aerial applications where surveillance indicates human risk. • Intensify visible activities in community to increase attention to WNV transmission risk and personal protection measures. • Work with collaborators to address high-risk populations. • Intensify and expand surveillance for human cases.
3	Outbreak in progress	• Conditions favor continued transmission to humans (i.e., persistent high infection rate in mosquitoes, continued avian mortality, seasonal mosquito population decreases not anticipated for weeks) -or- • Multiple confirmed human cases or viremic blood donors.	• Response as in category 2 plus: • Intensify emergency adult mosquito control program repeating applications as necessary to achieve adequate control. • Monitor effectiveness of vector control efforts • Emphasize urgency of personal protection, including use of repellents, through community leaders and media.

Appendix C

West Nile Virus Human Neuroinvasive Disease Incidence in the U.S., 1999-2012

The following disease maps show how the initial outbreak of West Nile virus in New York City in 1999 spreads to every state in the continental United States by 2006. This rapid spread foreshadows the ease by which an even more destructive virus could spread throughout the United States, and illustrates the inherent unpredictability of annual disease risk.



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