Outbreak Preparedness and Integrated Vector Management

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Vector-Borne Disease Consulting, LLC
Vector-Borne Disease Outbreak Preparedness

• Response Plan Resources
  • Structure, common elements

• Surveillance and Phased Response
  • Evidence-Based Decisions
  • Action Thresholds
  • Reactive vs. Proactive Control
“Model Contingency Plan”

- Framework for developing a national contingency plan.
- Local adaptations.
- Considers structure of the health and vector control services, the availability of infrastructure and budget, and human resources.
- Diagrams, Checklists, Flowcharts.

WHO. 2016, Technical handbook for dengue surveillance, dengue outbreak prediction/detection and outbreak response (“model contingency plan”)
Good practices leading to effective outbreak management.

1. **Timely contingency planning**
   - National adapted contingency plan distinguishing between routine and outbreak interventions
   - Guarantee availability of plan, M&E, training on contingency planning
   - Ensure full implementation

2. **Surveillance system**
   - Use enhancement strategies: active, sentinel, syndromic and viral surveillance
   - Monitor alert signals
   - Ensure use of uniform case definition and classification

3. **Outbreak definition**
   - Context-dependent, simple, with an operational focus;
   - Identification of the early stages of an outbreak

4. **Alert algorithm**
   - Define alert algorithm based on thresholds of reported cases including syndromic surveillance based signals;
   - Consider staged alert scheme

5. **Managerial capacity**
   - Financial management
   - Capacity building
   - Risk communication
   - Intersectoral Cooperation
   - Outbreak investigation
   - Outbreak declaration

6. **Vector control**
   - Enhance community engagement
   - Focus on timely impact of interventions, considering multiple approaches
   - Differentiate between outbreak and seasonal interventions
   - Monitor insecticide resistance routinely
   - Focus on quality of vector interventions

7. **Clinical services**
   - Facilitate hospital contingency plans
   - Ensure regular timely training
   - Mortality reviews
   - Ensure timely alert of clinicians

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1. Timely contingency planning
National adapted contingency plan distinguishing between routine and outbreak interventions
Guarantee availability of plan, M&E, training on contingency planning
Ensure full implementation

Have a Plan.
Training, Monitoring and Evaluation.
2. Surveillance system

Use enhancement strategies: active, sentinel, syndromic and viral surveillance
Monitor alert signals
Ensure use of uniform case definition and classification

Obtain Quantitative Data.
Support Evidence-Based Decisions.
Develop risk indicators and action thresholds.

3. Outbreak definition
Context-dependent, simple, with an operational focus;
Identification of the early stages of an outbreak

4. Alert algorithm
Define alert algorithm based on thresholds of reported cases including threshold of syndromic surveillance based signals;
Consider staged alert scheme
 Defined roles and responsibilities.
Assure adequate resources.
6. Vector control
Enhance community engagement
Focus on timely impact of interventions, considering multiple approaches
Differentiate between outbreak and seasonal interventions
Monitor insecticide resistance routinely
Focus on quality of vector interventions

Appropriate interventions. Monitor Effectiveness.
7. Clinical services

Facilitate hospital contingency plans
Ensure regular timely training
Mortality reviews
Ensure timely alert of clinicians

Clinician awareness.
Diagnostic testing.
“PLANNING PREVENTS AN EMERGENCY FROM BECOMING A DISASTER”

Edwin Kent Gray
Chief, Emergency Preparedness and Response Branch
National Center for Environmental Health
Centers for Disease Control and Prevention
Retired
2. Surveillance system
Use enhancement strategies: active, sentinel, syndromic and viral surveillance
Monitor alert signals
Ensure use of uniform case definition and classification

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Context-dependent, simple, with an operational focus;
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5. Managerial capacity
Financial management
Capacity building
Risk communication
International cooperation
Outbreak investigation
Outbreak declaration

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Enhance community engagement
Focus on timely impact of interventions, considering multiple approaches
Differentiate between outbreak and seasonal interventions
Monitor insecticide resistance routinely
Focus on quality of vector interventions

1. Timely contingency planning
National adapted contingency plan distinguishing between routine and outbreak interventions
Guarantee availability of plan, M&E, training on contingency planning
Ensure full implementation

7. Clinical services
Facilitate hospital contingency plans
Ensure rapid on-time treatment
Mortality review
Ensure timely alert of clinicians

Integrated Vector Management
Integrated Vector Management Core Tactics

1. Surveillance, rational setting of action thresholds, and mapping
2. Physical control through manipulation of mosquito habitat
3. Larval source reduction and adult mosquito control
4. Monitoring for insecticide efficacy and resistance
West Nile Virus in the United States: Guidelines for Surveillance, Prevention, and Control

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
Division of Vector-Borne Diseases
Fort Collins, Colorado

4th Revision
June 14, 2013

FLORIDA MOSQUITO CONTROL
2018

The state of the mission as defined by mosquito controllers, regulators, and environmental managers

CALIFORNIA MOSQUITO-BORNE VIRUS SURVEILLANCE & RESPONSE PLAN

Edmund G. Brown Jr., Governor

California Department of Public Health
Mosquito & Vector Control Association of California
University of California

May 2018

Florida Coordinating Council on Mosquito Control

Commonwealth of Pennsylvania
West Nile Virus and other Arboviral Diseases: Surveillance, Prevention and Control Plan

Revision Date: May 10, 2017
Integrated Vector Management Core Tactics

1. Surveillance, rational setting of action thresholds, and mapping
2. Physical control through manipulation of mosquito habitat
3. Larval source reduction and adult mosquito control
4. Monitoring for insecticide efficacy and resistance

Outbreak-Producing Mosquito-Transmitted Pathogens

• Zoonoses - Domestic
  • West Nile
  • St. Louis Encephalitis
  • Eastern Equine Encephalitis
  • Western Equine Encephalitis
  • LaCrosse
  • Jamestown Canyon

• Zoonoses – Exotic
  • Rift Valley Fever
  • Mayaro
  • Usutu
  • Venezuelan Equine Encephalitis
  • Japanese Encephalitis
  • Ross River
  • Murray Valley
Surveillance Objective = Accurate Indicators of Risk

Vector and environmental surveillance

• Presence and abundance of vector mosquito species
  • Characterize sources
  • Relative abundance
• Presence and relative incidence of pathogen in vectors and vertebrate hosts
  • Infection Rate, Vector Index
  • Dead birds
  • Sentinel Chickens
  • Veterinary Cases
• Weather factors that influence vector activities and transmission patterns

Epidemiological surveillance

• Human Case incidence and distribution
Arbovirus Transmission Activity

- Epidemic Transmission Levels
  - Human Cases
- Enzootic Transmission Levels
- Interventions Implemented
Number of Arboviral Disease Cases by Week of onset

Timing of intervention critical
- Infection precedes onset by up to 2 weeks
- Control must anticipate risk
- Requires sensitive, index

Date of Infection
Number of Arboviral Disease Cases by Week of onset

Timing of intervention critical
- Infection precedes onset by up to 2 weeks
- Control must anticipate risk
- Requires sensitive, index
### Risk Categories and Phased Response

- **Structured activities.**
- **Escalate relative to increasing risk level.**

#### Before The Swarm

**Table: Risk Categories and Phased Response**

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Probability of human outbreak</th>
<th>Definition</th>
<th>Recommended activities and responses</th>
</tr>
</thead>
</table>
| 0               | None                          | - No adult mosquito biting activity (vector species).                       | - Develop and review West Nile virus (WNV) response plan.  
                                             |                  | - Escalate relative to increasing risk level.                      | - 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).                        | - Response as in category 0, plus:  
                                             |                  | - Epizootic activity expected based on onset of transmission in prior years. | - Conduct integrated vector management program to monitor and reduce vector mosquito abundance. |
                                             |                  | - Limited or sporadic epizootic activity in birds or mosquitoes.         | - 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.                 | - Response as in category 1 plus:  
                                             |                  | - Horse cases reported.                                               | - Intensify and expand adult mosquito control in areas using ground and/or aerial applications where surveillance indicates human risk.  
                                             |                  | - Human case or viremic blood donor reported.                          | - 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)  
                                             |                  | - 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. |
CALIFORNIA MOSQUITO-BORNE VIRUS SURVEILLANCE & RESPONSE PLAN

Factors
- Environmental Conditions
- Vector abundance
- Infection rate
- Sentinel Chickens
- Dead Birds
- Human Cases

Assigned Value (historical importance)

Score = Risk Level = Response
- Normal Season
- Emergency Planning
- Epidemic

<table>
<thead>
<tr>
<th>WNV Surveillance Factor</th>
<th>Assessment Value</th>
<th>Benchmark</th>
<th>Assigned Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Environmental Conditions</td>
<td>1. Average daily temperature during prior 2 weeks ≤ 50°F</td>
<td>Avg. daily temperature during prior 2 weeks ≥ 55°F</td>
<td>1. Normal Season</td>
</tr>
<tr>
<td></td>
<td>2. Average daily temperature during prior 2 weeks 55-65°F</td>
<td>Avg. daily temperature during prior 2 weeks 65-75°F</td>
<td>2. Normal Season</td>
</tr>
<tr>
<td></td>
<td>3. Average daily temperature during prior 2 weeks 66-72°F</td>
<td>Avg. daily temperature during prior 2 weeks 75-80°F</td>
<td>3. Normal Season</td>
</tr>
<tr>
<td></td>
<td>4. Average daily temperature during prior 2 weeks 80°F</td>
<td>Avg. daily temperature during prior 2 weeks &gt; 80°F</td>
<td>4. Normal Season</td>
</tr>
<tr>
<td>2. Relative abundance of adult female Culex tarsalis and Cx. pipiens complex mosquitoes</td>
<td>1. Vector abundance below average (≤ 50%)</td>
<td>Avg. vector abundance 50-100%</td>
<td>1. Normal Season</td>
</tr>
<tr>
<td></td>
<td>2. Vector abundance below average (51-90%)</td>
<td>Avg. vector abundance 91-150%</td>
<td>2. Normal Season</td>
</tr>
<tr>
<td></td>
<td>3. Vector abundance above average (151-300%)</td>
<td>Avg. vector abundance &gt; 300%</td>
<td>3. Normal Season</td>
</tr>
<tr>
<td></td>
<td>4. Vector abundance above average (&gt; 300%)</td>
<td>Avg. vector abundance &gt; 300%</td>
<td>4. Normal Season</td>
</tr>
<tr>
<td>3. Virus infection rate in Cx. tarsalis and Cx. pipiens complex mosquitoes</td>
<td>1. MIR = 0</td>
<td>Avg. MIR &lt; 1</td>
<td>1. Normal Season</td>
</tr>
<tr>
<td></td>
<td>2. MIR = 1-1.9</td>
<td>Avg. MIR 1-2</td>
<td>2. Normal Season</td>
</tr>
<tr>
<td></td>
<td>3. MIR = 2-2.9</td>
<td>Avg. MIR 2-3</td>
<td>3. Normal Season</td>
</tr>
<tr>
<td></td>
<td>4. MIR = 3-5</td>
<td>Avg. MIR &gt; 5</td>
<td>4. Normal Season</td>
</tr>
<tr>
<td></td>
<td>5. MIR &gt; 5</td>
<td>Avg. MIR &gt; 5</td>
<td>5. Normal Season</td>
</tr>
<tr>
<td>4. Sentinel chicken seroconversion</td>
<td>1. No seroconversions in flock</td>
<td>Average flock seroconversion rate ≤ 10%</td>
<td>1. Normal Season</td>
</tr>
<tr>
<td></td>
<td>2. One or more seroconversions in flock</td>
<td>Average flock seroconversion rate &gt; 10%</td>
<td>2. Normal Season</td>
</tr>
<tr>
<td></td>
<td>3. One or more seroconversions in a single flock in specific region</td>
<td>Average flock seroconversion rate &gt; 10%</td>
<td>3. Normal Season</td>
</tr>
<tr>
<td></td>
<td>4. More than two seroconversions in a single flock or two flocks with one or two seroconversions in specific region</td>
<td>Average flock seroconversion rate &gt; 10%</td>
<td>4. Normal Season</td>
</tr>
<tr>
<td></td>
<td>5. More than two seroconversions per flock in multiple flocks in specific region</td>
<td>Average flock seroconversion rate &gt; 10%</td>
<td>5. Normal Season</td>
</tr>
<tr>
<td>5. Dead bird infection</td>
<td>1. No positive dead birds in flock</td>
<td>Average number of dead birds ≤ 1</td>
<td>1. Normal Season</td>
</tr>
<tr>
<td></td>
<td>2. One or more positive dead birds in flock</td>
<td>Average number of dead birds &gt; 1</td>
<td>2. Normal Season</td>
</tr>
<tr>
<td></td>
<td>3. One positive dead bird in specific region</td>
<td>Average number of dead birds &gt; 1</td>
<td>3. Normal Season</td>
</tr>
<tr>
<td></td>
<td>4. Two to five positive dead birds in specific region</td>
<td>Average number of dead birds &gt; 1</td>
<td>4. Normal Season</td>
</tr>
<tr>
<td></td>
<td>5. More than five positive dead birds in specific region</td>
<td>Average number of dead birds &gt; 1</td>
<td>5. Normal Season</td>
</tr>
<tr>
<td>6. Human cases</td>
<td>1. No human cases in specific region</td>
<td>Average number of human cases ≤ 0</td>
<td>1. Normal Season</td>
</tr>
<tr>
<td></td>
<td>2. One or more human cases in specific region</td>
<td>Average number of human cases &gt; 0</td>
<td>2. Normal Season</td>
</tr>
<tr>
<td></td>
<td>3. One human case in specific region</td>
<td>Average number of human cases &gt; 0</td>
<td>3. Normal Season</td>
</tr>
<tr>
<td></td>
<td>4. One human case in specific region</td>
<td>Average number of human cases &gt; 0</td>
<td>4. Normal Season</td>
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<tr>
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<td>5. More than one human case in specific region</td>
<td>Average number of human cases &gt; 0</td>
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<tr>
<td>1. Environmental Conditions</td>
<td>1</td>
<td>Avg. daily temperature during prior 2 weeks ≤ 56°F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Avg. daily temperature during prior 2 weeks 57–65°F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Avg. daily temperature during prior 2 weeks 66–72°F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Avg. daily temperature during prior 2 weeks 73–79°F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Avg. daily temperature during prior 2 weeks &gt; 79°F</td>
<td></td>
</tr>
<tr>
<td>3. Virus infection rate in Cx. tarsalis and Cx. pipiens complex mosquitoes*</td>
<td>1</td>
<td>MIR = 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>MIR = 0.1–1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>MIR = 1.1–2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>MIR = 2.1–5.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>MIR &gt; 5.0</td>
<td></td>
</tr>
<tr>
<td>6. Human cases</td>
<td>3</td>
<td>One or more human infections in broad region</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>One human infection in specific region</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>More than one human infection in specific region</td>
<td></td>
</tr>
</tbody>
</table>
Level 2: Emergency Planning

Risk rating: 2.6 to 4.0

CONDITIONS

- Temperature above average (66–79°F)
- Adult *Culex* mosquito abundance greater than 5-year average (150% to 300% above normal)
- One or more virus infections detected in *Culex* mosquitoes (MIR < 5 per 1,000 tested)
- One or more seroconversions in single flock or one to two seroconversions in multiple flocks in specific region
- One to five recently infected WNV-positive dead birds in specific region
- One human case in broad or specific region
- WEEV detected in small towns or suburban area

RESPONSE

- Review epidemic response plan
- Enhance public education (include messages on the signs and symptoms of encephalitis; seek medical care if needed; inform public about pesticide applications if appropriate)
- Enhance information to public health providers
- Conduct epidemiological investigations of cases of equine or human disease
- Increase surveillance and control of mosquito larvae
- Increase adult mosquito surveillance
- Increase number of mosquito pools tested for virus
- Conduct or increase localized chemical control of adult mosquitoes as appropriate
- Contact commercial applicators in anticipation of large-scale adulticiding
- Review candidate pesticides for availability and susceptibility of vector mosquito species
- Ensure notification of key agencies of presence of viral activity, including the local office of emergency services

• Conditions well defined

• Response lacks specific targets
The 2012 West Nile Encephalitis Epidemic in Dallas, Texas

Outbreak-Producing Mosquito-Transmitted Pathogens

- Anthroponoses – Sporadic introductions
  - Dengue
  - Chikungunya
  - Zika
  - Yellow Fever
  - Malaria
Surveillance Objective = Accurate Indicators of Risk

Vector and environmental surveillance
- Presence and abundance of vector mosquito species
  - Characterize sources
  - Relative abundance
- Presence and relative incidence of pathogen in vectors and vertebrate hosts
  - Infection Rate, Vector Index
  - Dead birds
  - Sentinel Chickens
  - Veterinary Cases
- Weather factors that influence vector activities and transmission patterns

Epidemiological surveillance
- Human Case incidence and distribution
Describes 4 Zika Outbreak Situations
• Travel-Related Infections
• Locally-Acquired Infections
• Wide-Spread Locally-Acquired Infections in a Single County
• Widespread Local Transmission in Multiple Counties

• Details operational objectives for each level of response

Florida Dept. of Health (2017) Florida’s Zika Incident Response Playbook –
Risk Situation = Locally-acquired infections

- Response describes operational activities in detail
- Lacks specific targets

### Phase 2: Return of Locally-Acquired Infections in 2017

These activities represent lessons learned from 2016 Zika response.

<table>
<thead>
<tr>
<th>Operational Objective</th>
<th>Procedure and/or IMT Point of Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Continue activities from Phase 1.</td>
<td>Operations Chief Aaron Otis Public Health Advisor <a href="mailto:Aaron.Otis@flhealth.gov">Aaron.Otis@flhealth.gov</a> 850-445-1360</td>
</tr>
</tbody>
</table>
| 2. Consider active case finding (among others potentially exposed including family members, neighbors and business associates). For case clusters, consider doing active surveillance (including testing) using dengue cluster investigation protocols.  
  a. Conduct field sampling (e.g., urosurvey) to establish areas of local transmission  
  b. Implement surveillance to identify potential health effects post mosquito control efforts (for example, aerial spraying) utilizing ESSENCE-FL ED and FPICN data | Lead: Local Mosquito Control and Department of Agriculture Lisa Conti Deputy Commissioner and Chief Science Officer Lisa.Conti@myflorida.com 850-617-7703  
DOH Point of Contact: Liaison Officer Carissa Blackmore Acting Director Division of Disease Control Carissa.Blackmore@flhealth.gov 850-528-1595 |
| 3. In coordination with local health offices, local mosquito control and FDACS request that enhanced mosquito surveillance and integrated mosquito control measures be implemented within 12 hours according to CDC guidance.  
http://www.cdc.gov/chikungunya/resources/vector-control.html  
  a. Focus mosquito control efforts to high risk mosquito populations and areas, commensurate with arbovirus indicators for risk (i.e. larviciding, adulticiding hot spots); door to door outreach with possible use of Zika Kits as appropriate (from CDC or local resources)  
  b. Consider novel mosquito control efforts including new technology options.  
  c. Consider mosquito pool virus testing as appropriate to determine the vector responsible. (FDACS Bronson Animal Disease Diagnostic Laboratory has expanded capacity to conduct these assays.) | Lead: Local Mosquito Control and Department of Agriculture Lisa Conti Deputy Commissioner and Chief Science Officer Lisa.Conti@myflorida.com 850-617-7703  
DOH Point of Contact: Liaison Officer Carissa Blackmore Acting Director Division of Disease Control Carissa.Blackmore@flhealth.gov 850-528-1595 |
| 4. Shift public messaging strategies based on local transmission.  
  a. Focus messaging on personal protection from mosquito bites and routinely draining standing water from property after each rain or at least weekly.  
  b. Secure advertisements to educate the public on bite prevention and mosquito control in impacted community; consider distribution of Zika kits prioritizing pregnant women.  
  c. Disseminate messaging on how to prevent spread of Zika from infected persons  
  d. Disseminate messaging for women who are pregnant or trying to become pregnant within the impacted county.  
  e. Disseminate messaging regarding Florida travel safety for visitors | Public Information Officer Mara Gambineri Communications Director Mara.Gambineri@flhealth.gov 850-245-4111 |
Integrated Vector Management Core Tactics

1. Surveillance, rational setting of action thresholds, and mapping
2. Physical control through manipulation of mosquito habitat
3. Larval source reduction and adult mosquito control
4. Monitoring for insecticide efficacy and resistance

Problem

• Surveillance indicators often don’t give sufficient lead time to prevent outbreaks
• Results in REACTIVE control.
• Need surveillance indicators and thresholds that are more predictive - ACTIONABLE INFORMATION.
• Provide targets for outbreak prevention.
• Allow effective PRO-ACTIVE control.
Surveillance: 
*Culex pipiens-restuans / WNV* 

- 19 Gravid traps 
- 7 days/week
WNV Surveillance Indices
Calculated weekly

• **Abundance:**
  – # collected per trap night

• **Infection rate:**
  – proportion of adult mosquitoes carrying WNV

• **Vector Index:**
  – Number of WNV-infected mosquitoes collected per trap night
  – Associated with human risk
Risk Thresholds based on WNV Outbreak Indicators

- Keep abundance < 45/trap night until week 28
- Keep Infection Rate < 5 until week 32
- Keep Vector Index < 1 until week 34
WNV Surveillance

Vector Index

3 Human Cases in 2016
WNV Surveillance
Vector Index

4 Human Cases in 2017
WNV Surveillance
Vector Index

7 Human Cases in 2018
Culex pipiens
Northern House Mosquito