CDC PUBLIC HEALTH GRAND ROUNDS

Dengue and Chikungunya in Our Backyard: Preventing *Aedes* Mosquito-Borne Diseases

Accessible version:  https://youtu.be/v0KaDZ6Zmuo

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Dengue, Chikungunya, and Other Aedes Mosquito-Borne Diseases

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## Viruses Transmitted by *Aedes aegypti* and *Aedes albopictus* Mosquitoes

<table>
<thead>
<tr>
<th>Virus</th>
<th><em>Aedes aegypti</em></th>
<th><em>Aedes albopictus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dengue 1–4</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Chikungunya</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Yellow fever</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Zika</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Weaver SC, Reisen WK. Antiviral Res 2010
Aedes aegypti and Aedes albopictus Mosquitoes

- **Aedes** (Stegomyia) subgenus
- Lay eggs in peridomestic water containers
- Live in and around households
- Peak feeding during daytime
- **Aedes aegypti** more efficient vector for humans

Schaffner F, Mathis A. Lancet Infect Dis 2014
Approximate Distribution of *Aedes aegypti* and *Aedes albopictus* Mosquitoes

*Aedes aegypti*

*Aedes albopictus*

Kraemer M. Unpublished data (global maps) and ArboNET reports (US maps)
Aedes Mosquito-Borne Virus Transmission Cycles

Sylvatic (jungle) cycle

Epidemic (urban) cycle

MMWR 2010;59(RR-7)
Sylvatic (Jungle) Transmission Cycle

Sylvatic (jungle) cycle
Epidemic (Urban) Transmission Cycle

Sylvatic (jungle) cycle

Epidemic (urban) cycle

MMWR 2010;59(RR-7)
Dengue Virus Types 1–4

- Four related viruses in genus *Flavivirus*
- *Aedes aegypti* is primary vector
  - *Aedes albopictus* also transmits dengue viruses
- Humans are primary amplifying host
  - Transmitted in epidemic (urban) cycle
  - Sylvatic cycle no longer needed to maintain virus

Weaver SC, Reisen WK. Antiviral Res 2010
Dengue Virus Types 1–4: Approximate Geographic Distribution

Dengue Virus Epidemiology

- Most important mosquito-borne viral disease
- 30-fold increase in incidence over past 50 years
- 25% of infected people develop clinical symptoms
  - Ranges from mild febrile illness to life threatening disease
- Estimated 96 million disease cases in 2010
  - 67 million cases in Asia
  - 16 million cases in Africa
  - 13 million cases in the Americas

Dengue Virus Disease and Outcomes

- **Acute febrile illness often with**
  - Headache, retro-orbital pain, myalgia, and arthralgia
  - Maculopapular rash
  - Minor bleeding

- **5–10% symptomatic patients develop severe disease**
  - Plasma leakage with shock or respiratory distress
  - Severe hemorrhage
  - Organ impairment

- **Subsequent infection with different type of dengue virus increases risk for severe disease**

- **Case fatality for severe dengue as high as 10%**
  - Proper case management reduces mortality to <1%

Chikungunya Virus

- **Genus *Alphavirus***

- **Aedes aegypti** primary vector
  - *Aedes albopictus* important in several recent outbreaks

- **Humans primary amplifying host during outbreaks**
  - Sylvatic transmission in non-human primates in Africa
  - Role of other animals in maintaining the virus not known

Chikungunya Virus:
Approximate Geographic Distribution

Available at http://www.cdc.gov/chikungunya
Chikungunya Virus: Approximate Geographic Distribution

Available at http://www.cdc.gov/chikungunya
Chikungunya Virus: Approximate Geographic Distribution

2013–2015

Available at http://www.cdc.gov/chikungunya
Chikungunya Virus Epidemiology

- Large outbreaks with high infection rates (≥30%)
- Majority (72%–97%) of infected people symptomatic
- Over 1 million suspected cases reported in 2014
  - Mostly in the Caribbean, and Central and South America

Chikungunya Virus Disease and Outcomes

- Primary clinical symptoms are fever and polyarthralgia
- Joint pain can be severe and debilitating
- Other common findings include headache, myalgia, arthritis, and maculopapular rash
- Acute symptoms typically resolve in 7–10 days
- Some have persistent rheumatologic symptoms
- Case-fatality is low (<1%) and mostly in older adults

Yellow Fever Virus

- Genus *Flavivirus*

- Most human infections occur as a result of sylvatic (jungle) transmission

- Urban outbreaks occur periodically, mostly in West Africa

- *Aedes aegypti* is primary vector during urban outbreaks
Yellow Fever Virus: Approximate Geographic Distribution

Yellow Fever Virus Epidemiology

- 30% of population infected during urban outbreaks
- 10%–20% infected people develop clinical disease
- Estimated 200,000 cases annually worldwide
- 85% of reported cases from sub-Saharan Africa

MMWR 2010;59(RR-7)
Yellow Fever Virus Disease and Outcomes

- Acute febrile illness often presenting with headache, myalgia, vomiting, and lumbosacral pain
- 15% of symptomatic patients develop severe disease with jaundice, hemorrhage, or multiorgan failure
- Hyperbilirubinemia usually peaks toward the end of the first week of illness
- 20%–50% case-fatality in patients with severe disease

MMWR 2010;59(RR-7)
Zika Virus

- **Genus Flavivirus**

- *Aedes aegypti* believed to be primary vector
  - Other *Aedes* (*Stegomyia*) mosquitoes have played important roles during recent Western Pacific outbreaks

- **Humans primary amplifying host during outbreaks**
  - Sylvatic transmission in non-human primates in Africa
  - Role of other animals in maintaining the virus not known

Hayes EB. Emerg Infect Dis 2009
Zika Virus: Approximate Geographic Distribution

Zika Virus Disease Epidemiology

- 2007 outbreak in Yap resulted in an estimated 900 cases (population 7,391)
- Estimated 73% of population infected in Yap
- 18% of infected people develop clinical disease
- In 2014–2015, more than 30,000 suspected cases reported from French Polynesia and other Pacific islands

Zika Virus Disease and Outcomes

- Mild acute illness with a diffuse rash, arthralgia, and conjunctivitis
- Fevers are low grade and 25%–35% of patients may be afebrile
- Symptoms typically resolve over 3–7 days
- Few reports of possible Guillain-Barré syndrome or other severe disease manifestations
- No deaths reported
Diagnostic Testing for Dengue, Chikungunya, Yellow Fever and Zika Viruses

- Viral RNA in blood within 3–7 days after onset

- IgM antibodies develop toward end of 1st week
  - Neutralizing antibody testing to confirm results and distinguish infection by closely-related viruses

- $\geq 4$-fold rise in virus-specific neutralizing antibodies on acute and convalescent specimens

- RT-PCR or immunohistochemical staining on autopsy tissues

RT-PCR: Reverse transcription-Polymerase chain reaction
Treatment for Dengue, Chikungunya, Yellow Fever and Zika Viruses

- No specific antiviral therapy; treatment is supportive
- Assess hydration and hemodynamic status
- Evaluate for other serious conditions and treat or manage appropriately
- Proper clinical management reduces mortality due to dengue
  - All suspected cases should be managed as if they have dengue until it has been ruled out

<table>
<thead>
<tr>
<th>Virus</th>
<th>Vaccine status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dengue</td>
<td>Phase 3 clinical trials</td>
</tr>
<tr>
<td>Chikungunya</td>
<td>Phase 1–2 clinical trials</td>
</tr>
<tr>
<td><strong>Yellow fever</strong></td>
<td><strong>Licensed and available</strong></td>
</tr>
<tr>
<td>Zika</td>
<td>None</td>
</tr>
</tbody>
</table>

Prevention and Control of Dengue, Chikungunya, Yellow Fever and Zika Viruses

- **Community-level control efforts**
  - Mosquito habitat control
  - Apply larvicide and adulticide
  - Difficult to sustain at effective levels

- **Personal protective measures**
  - Use air conditioning or window and door screens
  - Use mosquito repellents on exposed skin
  - Wear long-sleeved shirts and long pants

- **Protect infected people from further mosquito exposure during first week of illness**
Summary for Dengue, Chikungunya, Yellow Fever and Zika Viruses

- *Aedes aegypti* most important vector during outbreaks
- Recent increased incidence and spread to new areas
- Overlapping geographic areas and clinical features
- No antiviral therapy but proper clinical management can reduce dengue mortality
- Yellow fever vaccine widely used; dengue and chikungunya vaccines in development
- Primary prevention is to reduce mosquito exposure but current vector-control options difficult to sustain
The Status and Frontiers of Vector Control

Thomas W. Scott, PhD
Professor and Director
Vector-Borne Disease Laboratory
Department of Entomology and Nematology
University of California, Davis
Environments That Favor More Mosquitoes

- *Aedes aegypti* is highly domesticated
- Stored water and discarded non-biodegradable items accumulate rain water, and create abundant mosquito development sites
Environments that Favor More Mosquitoes and Transmission of Diseases

- **Rapid urban growth**
  - Lack of adequate water supply
  - Lack of solid waste disposal
  - Substandard housing

- **High human density support high *Aedes aegypti* densities with close biting contact to humans**
  - High virus transmission potential
Ecology of Adult *Aedes aegypti*

- Adult females lay eggs on the sides of water holding containers
  - In about 1 week, eggs hatch & larvae develop into pupae
  - Two days later adults emerge
- **Adults rest inside houses**
  - Often in quiet, dark places like closets or clothes racks
- **Adults do not move far**
  - Often living their entire life in a single house or its neighbor
  - Seldom fly 100 meters from their initial resting site
Population of *Aedes aegypti*

- **Low population densities** (e.g., few numbers of mosquitoes per house)
- **Population tends to be focal and dynamic**
  - Number of mosquitoes per house changes over time
  - Geographical distribution of infested houses varies
Vector Host Relationship of *Aedes aegypti*

- **Only females feed on blood**
  - For egg development
  - Prefer human source of blood
- **“Day-biters”**
  - Bite during the day when people are active
- **Average ~ 1 bite per day**
- **Biting more often leads to**
  - Increased fitness of mosquitoes
    - Live longer and lay more eggs
  - Increased potential for virus transmission
Aedes aegypti Transmits Mosquito-Borne Diseases Efficiently

- **Biting a human host is required for virus transmission**
  - Low vertical virus transmission rate from females to their eggs
  - Less than 1:1,500

- **Biting patterns facilitate transmission**
  - Some people are bitten more than others, including visitors to homes
  - Frequent human biting helps explain explosive epidemics

- **Low entomologic transmission thresholds**
  - Epidemics can occur even when mosquitoes populations are low
  - They live, bite, and lay eggs close to humans
  - They feed frequently and preferentially on human blood
Vector Control to Stop the Spread of Mosquito-Borne Diseases

- Vector control measures reduce
  - Adult mosquito population density
  - Human biting rate
  - Infectious mosquitoes; i.e., mosquito survival through the virus incubation period
  - Target both larval and adult stages

- To be effective, vector control measures need to reduce mosquito populations
  - Target levels at or just below level required for virus transmission
  - Threshold density of the vector population

- They must also sustain those low levels
- Defining transmission thresholds has been difficult
Improving Measures of Entomological Risk

- Historical indices for immature mosquitoes do not predict human dengue infection risk
- Shift to pupae and adult mosquitoes indices requires understanding of complex interplay of many factors
  - Susceptibility of human population; i.e., herd immunity
  - Human biting rate
  - Human host density
  - Virus introduction
  - Weather
Existing Methods for *Aedes aegypti* Control – Immature Stage

- **Difficult to achieve and sustain epidemiologic impact with just larval control**
- **Major categories include**
  - **Containers**
    - Cleaning (bleach/wash/dump)
    - Manipulation (covers/treated covers)
    - Treatment (insecticide/bio-control)
  - **Social campaigns**
    - Education and source reduction
  - **Environmental management**
  - **Legislation**
    - Fines and penalties, if larva or pupae found

Existing Methods for \textit{Aedes aegypti} Control – Adult Stage

Major categories include
(1) Space spraying (indoor vs outdoor)
(2) Indoor residual spraying
(3) Personal protection

Interventions Currently Under Development

RIDL: Release of Insects Carrying a Dominant Lethal
Release of Insects Carrying a Dominant Lethal (RIDL) – Flightless Females

- **Flightless females**
  - Males carrying a female-acting transgene mate with wild-type females
  - Female offspring cannot fly
  - Female offspring are unable to mate (cannot reproduce) or bite human hosts (cannot transmit virus)
  - Heterozygote male offspring can mate and pass along transgene

Release of Insects Carrying a Dominant Lethal (RIDL) – Kills Larvae

- **Stage-specific killing**
  - Males carrying a transgene that causes late-acting lethality mate with wild-type females
  - Offspring die as pupae
  - Reduces population density

- **Successful safety testing and mosquito population reduction field trials**

- **Need to evaluate impact on human dengue outcomes**

Naturally Occurring Bacteria – *Wolbachia*

- *Wolbachia* is an endosymbiotic bacteria
  - Commonly infects many insects
- Female *Aedes aegypti* experimentally infected with *Wolbachia* can pass the bacteria to their offspring
- Adult female *Aedes aegypti* infected with *Wolbachia* have a 66%–75% reduced capacity to transmit dengue

[Link to Wikipedia article on Wolbachia](http://en.wikipedia.org/wiki/Wolbachia)
Vector Control Using *Wolbachia*

- Offspring from infected females are favored and spread *Wolbachia* through mosquito populations
- Field trials have successfully established *Wolbachia* in natural *Aedes aegypti* populations
- Field trials are testing the impact of releasing *Wolbachia* infected *Aedes aegypti* on human dengue infection and disease
CDC Autocidal Gravid Ovitrap (AGO) Trap

- **Population reduction**
  - Removes egg laying and older, potentially dengue infected females

- **Field trials in Puerto Rico**
  - Detected sustained reduction in *Aedes aegypti*

- **Enhance effectiveness**
  - By adding attractants
  - Removing natural egg laying sites

- **Merits further evaluation**

Working with Industrial Partners to Develop New Insecticides

- Three new active ingredients with novel modes of action available for vector control by 2020–2022
- Improvements in indoor residual spray and insecticide-treated materials
  - Long lasting, repurposed insecticides for areas of high insecticide resistance and dual-treated materials
- Outdoor biting protection
  - Supporting research on the prevention of pathogen transmission by mosquitoes that bite people outdoors

IVCC: Innovative Vector Control Consortium
Combining Vector Control with Vaccines to Reduce Dengue Risk at Community Level

- Vector control and vaccines should complement each other – resulting in a greater impact than either alone

- Vector control reduces each susceptible persons’ risk of being infected by reducing mosquito:
  - Population density
  - Human biting rate
  - Survival

- Vaccination artificially elevates and sustains herd immunity

- Details for how these various strategies can best be combined need to be determined
Summary and Implications

- *Aedes aegypti* is an efficient virus vector
  - Epidemics can occur even at low mosquitoes densities

- Lack of appropriate infrastructure in cities allows for increasing *Aedes aegypti* populations with high potential for virus transmission

- Indoor residual insecticides have the greatest potential for reducing human infection and disease

- Emerging insecticide resistance is a growing concern for chemically-based interventions
Steps Forward

- Need for epidemiologic assessment of interventions
- Insecticides
  - Insecticide resistance monitoring and management
  - New active ingredients and improving in indoor residual treatments
- Promising genetic-based strategies
  - Release of Insects Carrying a Dominant Lethal (RIDL)
  - *Wolbachia* infected mosquitoes
- Scaling-up and maintaining coverage to prevent dengue remains a major challenge
- Integrated interventions will require carefully designed combinations of vector control with vaccines
Prevention Strategies
Aedes Mosquito-Borne Diseases

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Chief, Dengue Branch
Division of Vector-Borne Diseases
National Center for Emerging and Zoonotic Infectious Diseases
Centers for Disease Control and Prevention
San Juan, Puerto Rico
Dengue Infection and Dengue Disease

- Dengue infection is largely asymptomatic for ~75%
- For the rest, “dengue fever” or “dengue disease”
  - Acute febrile illness
  - Can present like many other diseases
- Typical course is 4-5 d fever, then resolves
- For ~10% with dengue disease, “severe dengue” develops
Proper Case Management Critical to Survival

- **Severe dengue (WHO, 2009)**
  - Plasma leakage which results in compensated or decompensated shock
  - Includes a subset of individuals which develop
    - Dengue hemorrhagic fever
    - Dengue shock syndrome
  - Life threatening, requires critical, supportive care

- **Timely diagnosis improves prognosis**

- **If properly managed, case fatality rate less than 1%**
  - Early recognition of plasma-leakage, and compensated or decompensated shock based on presence of “warning signs”
  - Proper fluid management and resuscitation of plasma-leakage
CDC Dengue Case Management E-Learning Course

- CDC Dengue Case Management Educational tool
  - Designed for healthcare providers
  - Includes case management steps recommended by WHO and incorporated in many dengue endemic countries

Free CME Training: cdc.gov/dengue/training/cme.html
Better Diagnostics Leads to Better Outcomes

- **Dengue is an acute febrile illness syndrome**
  - Similar presentation to chikungunya, leptospirosis, malaria, and other febrile illnesses

- **Clinical diagnosis often inconclusive**
  - Fever, rash, periorbital pain

- **Accurate diagnosis needed**
  - Patient case management
  - Public health surveillance

- **Lab tests depend on timing in course of illness**
  - Cases often present as viremia wanes
  - Both acute and convalescent needed for some serology
Sensitivity of Dengue Diagnostics Vary Over Course of Illness

- **Incubation Period**: Ave. 7 days
- **Dengue Febrile Phase**: Ave. 5 days
- **Critical Phase**: 1-2 days
- **Post Febrile Phase**:

  - **PCR for DENV Viremia**
  - **MAC ELISA IgM anti-DENV**

**Exposure**

**Onset Fever**

**Day Post Onset of Fever**

- **DENV**: Dengue virus
- **MAC**: M antibody capture
- **PCR**: Polymerase chain reaction

CDC unpublished data
# Dengue Diagnostics Algorithm

<table>
<thead>
<tr>
<th>Day Post Onset of Fever</th>
<th>Diagnostic Tests</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT-PCR</td>
<td>IgM anti-DENV</td>
</tr>
<tr>
<td>0–3</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>3–7</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>&gt;7</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

CDC unpublished data

DENV: Dengue virus
RT-PCR: Reverse transcription-Polymerase chain reaction
A Framework for Dengue Prevention

Integrated Vector Control

Case Management

Surveillance and Education

Vaccines

Diagnostics

**Prevention Through Personal Protection**

- **Repellents prevent all mosquito diseases, but...**
  - Must be reapplied
  - Compliance low

- **Several provide hours-long protection**
  - DEET, Picaridin (Icaridin), IR3535

- **Insecticide impregnated clothing (permethrin)**
  - Must be periodically reapplied
  - Impractical in endemic area

- **Do not provide community disease protection**

---

DEET: N,N-diethyl-m-toluamide
IR3535: 3-[N-Butyl-N-acetyl]-aminopropionic acid, ethyl ester
Why A Dengue Vaccine?

- Mosquito control works, but expensive and difficult to sustain at effective levels
- Vaccines protect the individual and community
- Efficacious *Flavivirus* vaccines exist
  - Yellow fever, Japanese encephalitis, tick-borne encephalitis
  - Technically feasible
- Challenge of dengue vaccine
  - Must protect against all 4 viruses
  - Implementation: 40% of world’s population at risk
## Dengue Vaccine Candidates

<table>
<thead>
<tr>
<th>Producer (developer)</th>
<th>Approach</th>
</tr>
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<tbody>
<tr>
<td>Sanofi Pasteur (Acambis)</td>
<td>Live attenuated chimeric vaccine</td>
</tr>
<tr>
<td>Takeda (CDC, InViragen)</td>
<td>Live attenuated chimeric vaccine</td>
</tr>
<tr>
<td>Butantan (NIAID)</td>
<td>Live attenuated, engineered mutations in 3 strains and chimeric in 2</td>
</tr>
<tr>
<td>GSK (WRAIR)</td>
<td>Cell culture derived inactivated vaccine</td>
</tr>
<tr>
<td>Merck (Hawaii Biotech)</td>
<td>Subunits of DENV envelop protein</td>
</tr>
</tbody>
</table>

GSK: GlaxoSmithKline  
NIAID: National Institute of Allergy and Infectious Diseases  
WRAIR: Walter Reed Army Institute of Research
## Dengue Vaccine Clinical Trial Phases

<table>
<thead>
<tr>
<th>Producer</th>
<th>Clinical Trial</th>
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<tbody>
<tr>
<td></td>
<td>Phase I</td>
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<tr>
<td>Sanofi Pasteur</td>
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<tr>
<td>Takeda</td>
<td></td>
</tr>
<tr>
<td>Butantan</td>
<td></td>
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<tr>
<td>GSK</td>
<td></td>
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<tr>
<td>Merck</td>
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</tbody>
</table>

GSK: GlaxoSmithKline
Sanofi Dengue Vaccine Efficacy Trials

- Random, blinded, placebo-controlled (2:1)
- Ages: 2-16 years (highest disease incidence)
- 3 doses: given at 0, 6 & 12 months
  - Vaccine – tetravalent, live, attenuated
  - Placebo – normal saline vaccine diluent
- End point: Symptomatic, confirmed dengue fever
  - Clinical acute febrile illness + PCR-detected viremia
- Follow-up: 25 months total (13 months after last dose)
- Longer-term follow-up: 48 months

Guidelines for the clinical evaluation of dengue vaccines in endemic areas
## Results of Efficacy Trials

### Sanofi Vaccine (per protocol results)

<table>
<thead>
<tr>
<th>DENV Types</th>
<th>Phase IIIB–Thailand Ages 4–11, N= 4,002</th>
<th>Phase III–Asia Ages 2–14, N= 10,275</th>
<th>Phase III–Latin America Ages 9–16, N= 20,869</th>
</tr>
</thead>
<tbody>
<tr>
<td>All DENV’s</td>
<td><strong>30.2</strong> -13–57</td>
<td><strong>56.5</strong> 44–66</td>
<td><strong>60.8</strong> 52–68</td>
</tr>
<tr>
<td>DENV 1</td>
<td>55.6 22–84</td>
<td>50.0 25–67</td>
<td>50.3 29–65</td>
</tr>
<tr>
<td>DENV 2</td>
<td>9.2 -75–51</td>
<td>35.0 -9–61</td>
<td>42.3 14–61</td>
</tr>
<tr>
<td>DENV 3</td>
<td>75.3 -38–100</td>
<td>78.4 53–91</td>
<td>74.0 62–82</td>
</tr>
<tr>
<td>DENV 4</td>
<td>100 25–100</td>
<td>75.3 55–87</td>
<td>77.7 60–88</td>
</tr>
</tbody>
</table>

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DENV: Dengue virus

Villar L, et al. NEJM 2015
Sanofi Vaccine Trials Conclusions

- **Sanofi vaccine offers only partial protection**
  - DENV 2: 9%–42% efficacy
  - DENV 1: about 50% efficacy

- **Current data have not shown any vaccine safety issues**

- **Long-term follow-up needed to evaluate immune cross reactivity from vaccination**
  - Natural immunity to one type of dengue can result in more severe course with subsequent infections with other types of dengue, whether this holds true for vaccine-derived immunity needs to be evaluated

Villar L, et al. NEJM 2015

DENV: Dengue virus
Dengue Summary

- For 40% of the world’s population, dengue remains a threat
- Proper case management of severe dengue decreases mortality from ~ 10% to less than 1%
- Lab diagnostics depend on stage of illness
- Vector control and vaccine research holds promise
- Until a safe and effective vaccine is available, enhanced surveillance, rapid diagnosis, and personal protection are still the best methods for preventing dengue
Future Directions

- Model to evaluate the best way to implement vaccines
  - Identification of target populations

- Develop new vector control options and ways to implement them at community level

- Improve diagnostic tests
  - Needed for mosquito-borne viruses
  - Point-of-care, rapid diagnostic tests

- Increase universal dengue case management training

- Further our understanding of global burden of mosquito-borne diseases
We Can Reduce the Global Burden of Mosquito-Borne Diseases

- Timely diagnosis and proper case management can save lives
- Safe and effective vaccines are needed
- Surveillance needs to be enhanced
- Vector control measures should be improved and sustained
- Coordination of all of these components will increase the impact of these efforts
Dengue and Chikungunya in Our Backyard: Preventing Aedes Mosquito-Borne Diseases