# CDC PUBLIC HEALTH GRAND ROUNDS

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

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

**May 19, 2015**

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

# Dengue, Chikungunya, and Other *Aedes* Mosquito-Borne Diseases





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

| **Virus** | ***Aedes aegypti*** | ***Aedes albopictus*** |
|---|---|---|
| Dengue 1–4 | X | X |
| Chikungunya | X | X |
| Yellow fever | X | |
| Zika | X | |

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**

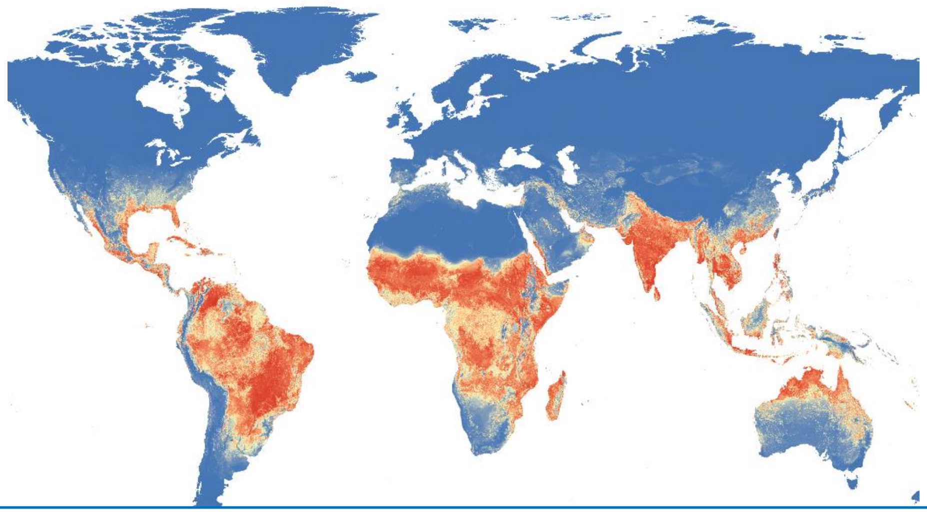
*Aedes aegypti*

*Aedes albopictus*

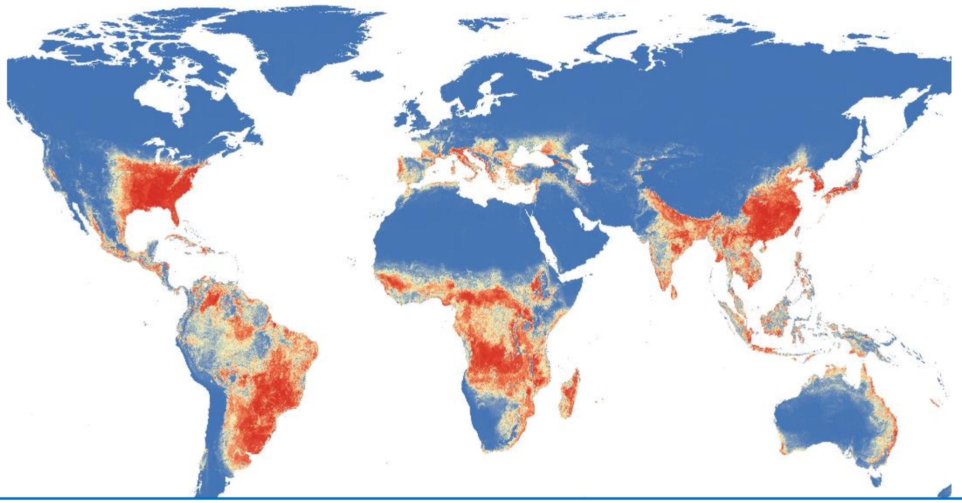
Schaffner F, Mathis A. Lancet Infect Dis 2014

# Approximate Distribution of *Aedes aegypti* and *Aedes albopictus* Mosquitoes

## *Aedes aegypti*

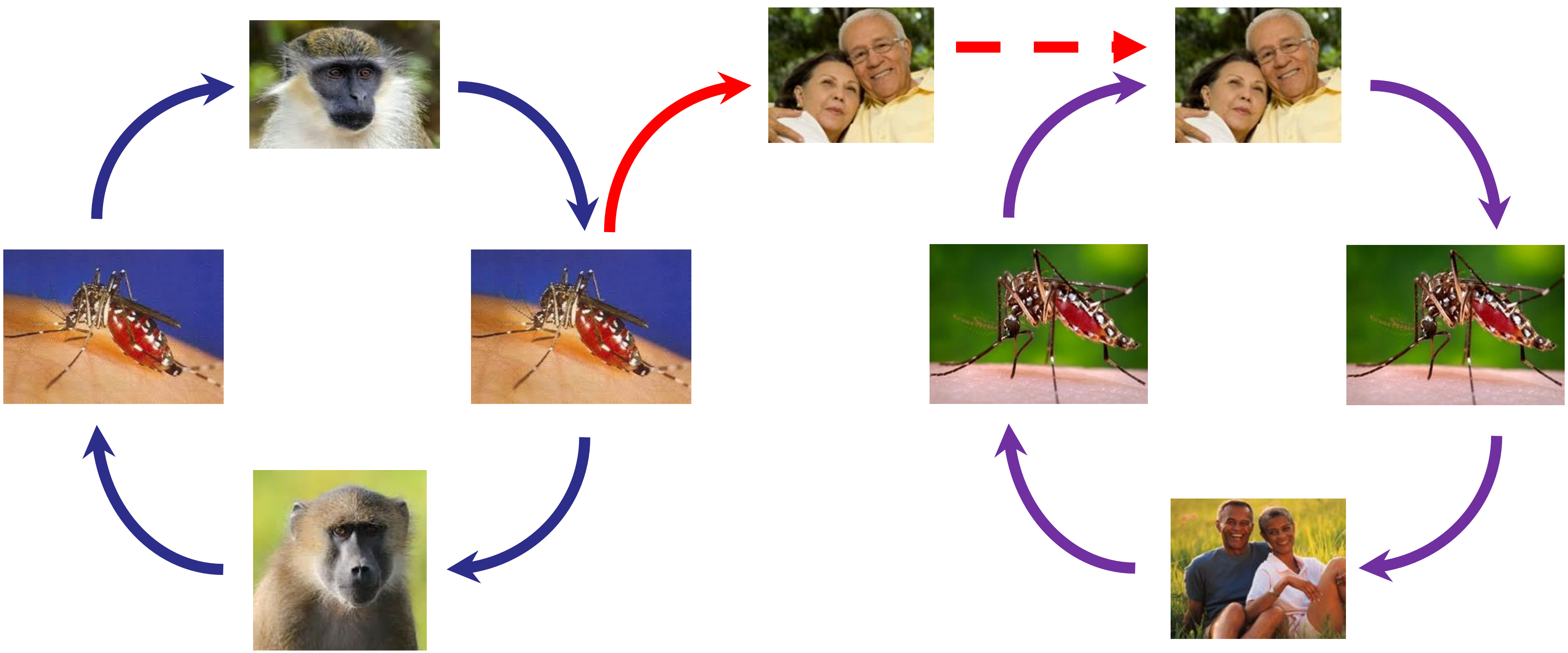


## *Aedes albopictus*



Kraemer M. Unpublished data (global maps) and ArboNET reports (US maps)

# *Aedes* Mosquito-Borne Virus Transmission Cycles

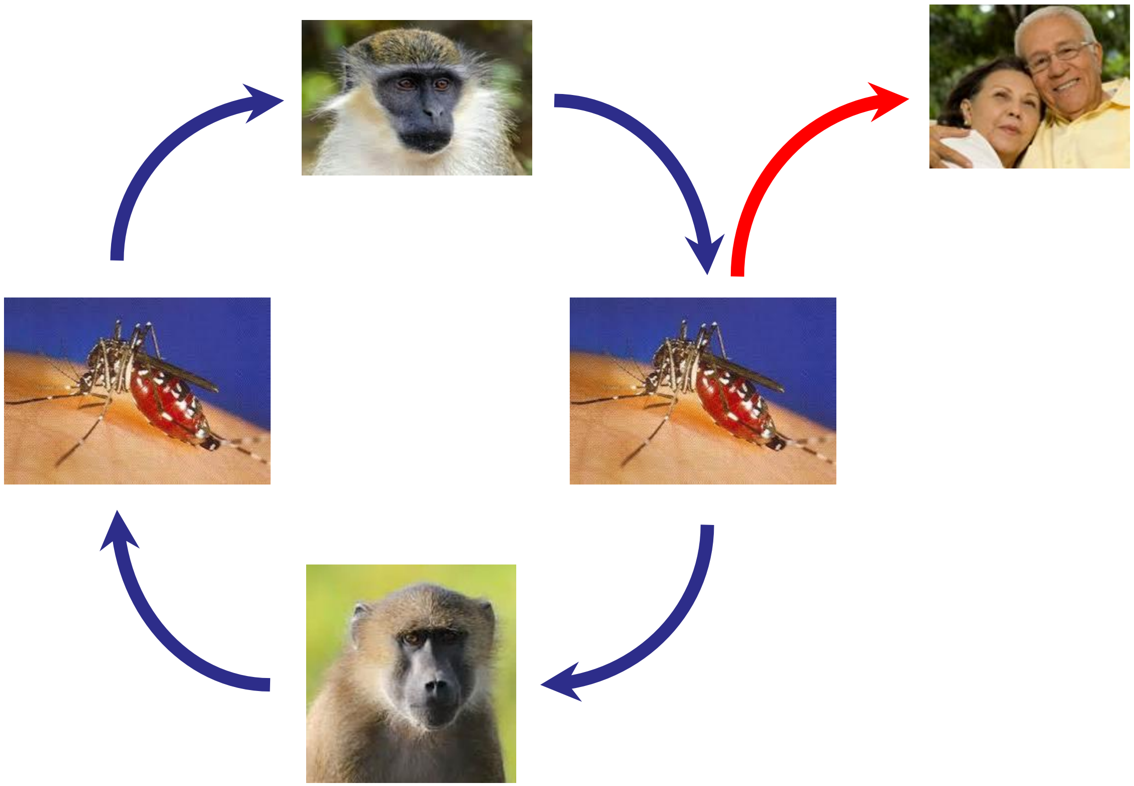


Sylvatic (jungle) cycle

Epidemic (urban) cycle

MMWR 2010;59(RR-7)

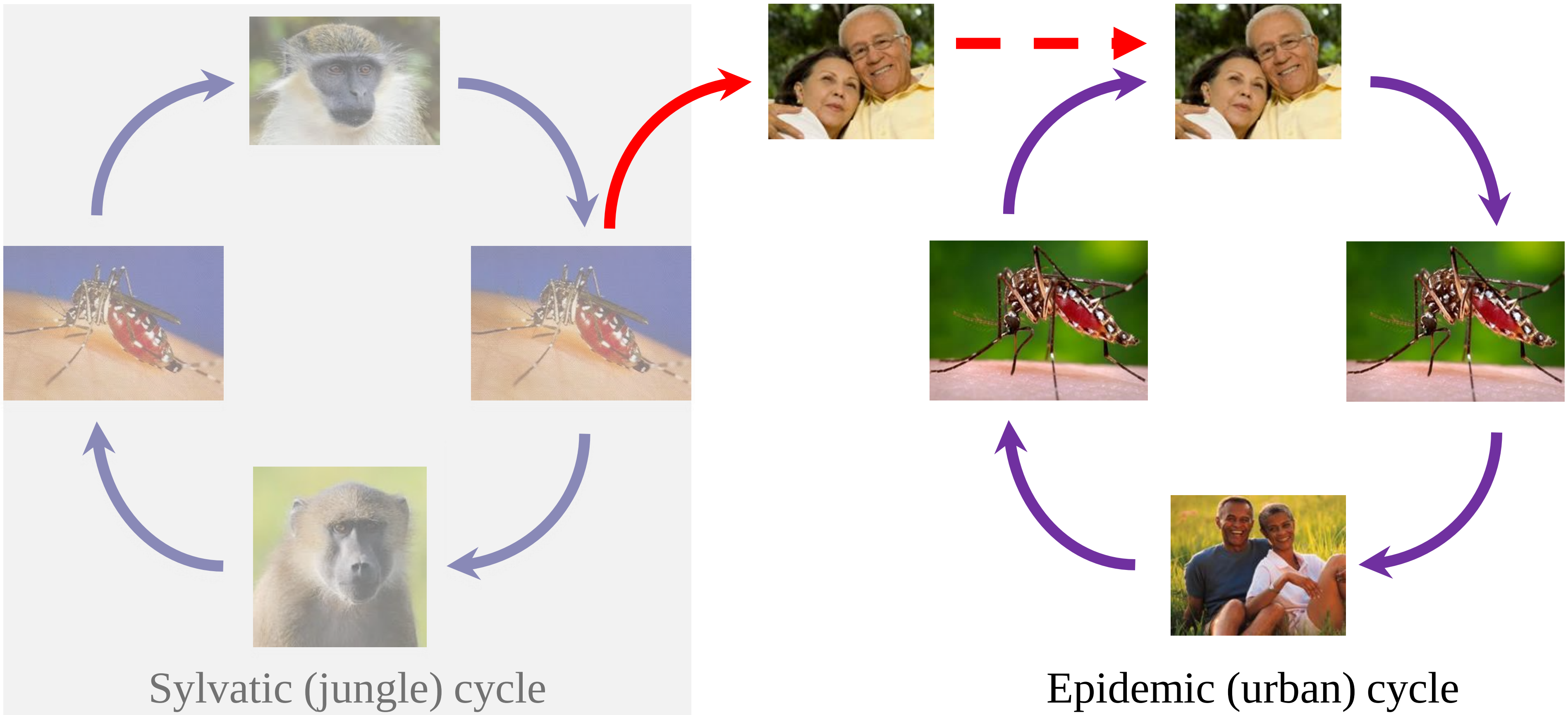
# Sylvatic (Jungle) Transmission Cycle



Sylvatic (jungle) cycle

MMWR 2010;59(RR-7)

# Epidemic (Urban) Transmission 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

Bhatt S, et al. Nature 2013

# 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

Bhatt S, et al. Nature 2013

# 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%

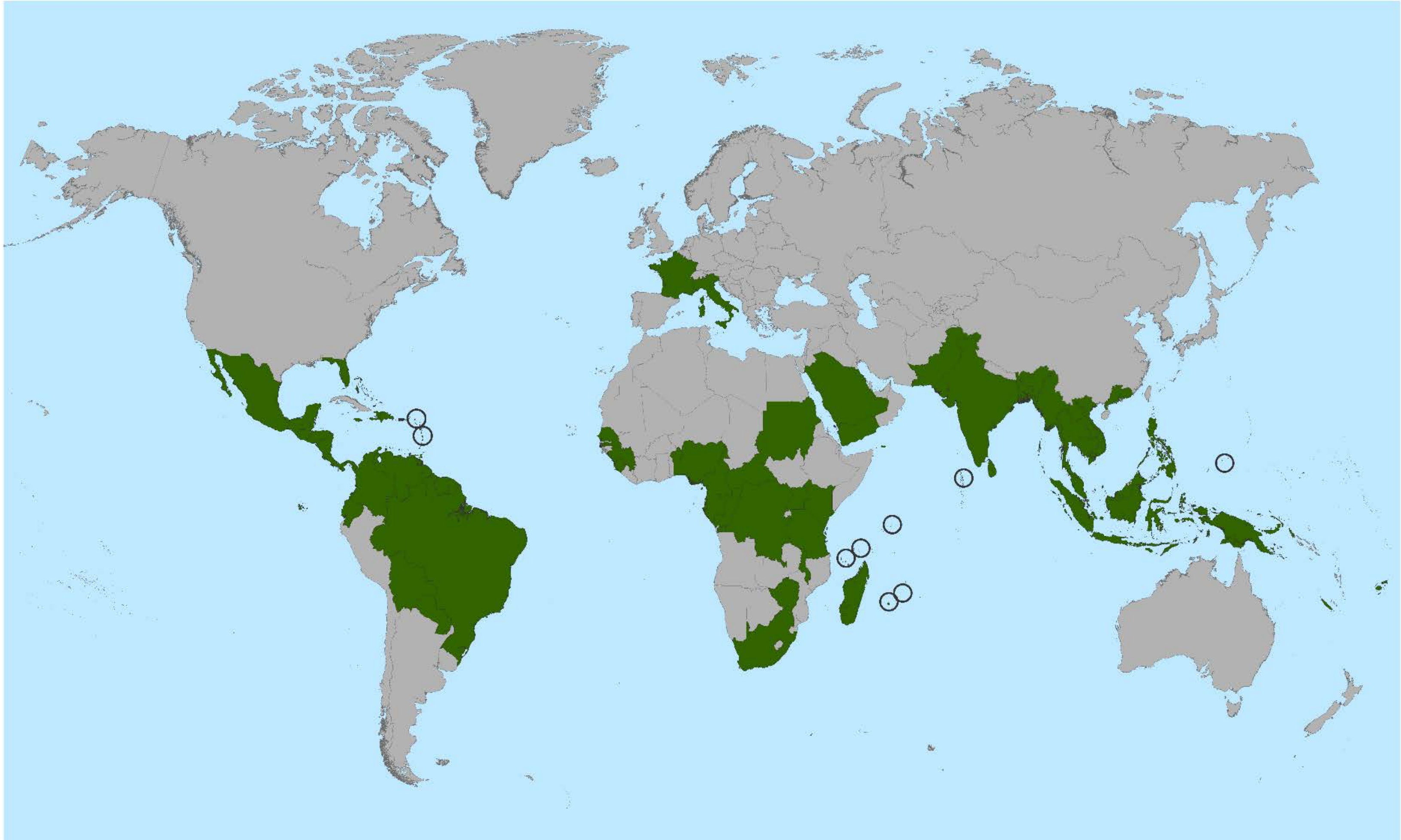
WHO 2009. http://whqlibdoc.who.int/publications/2009/9789241547871_eng.pdf

# 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

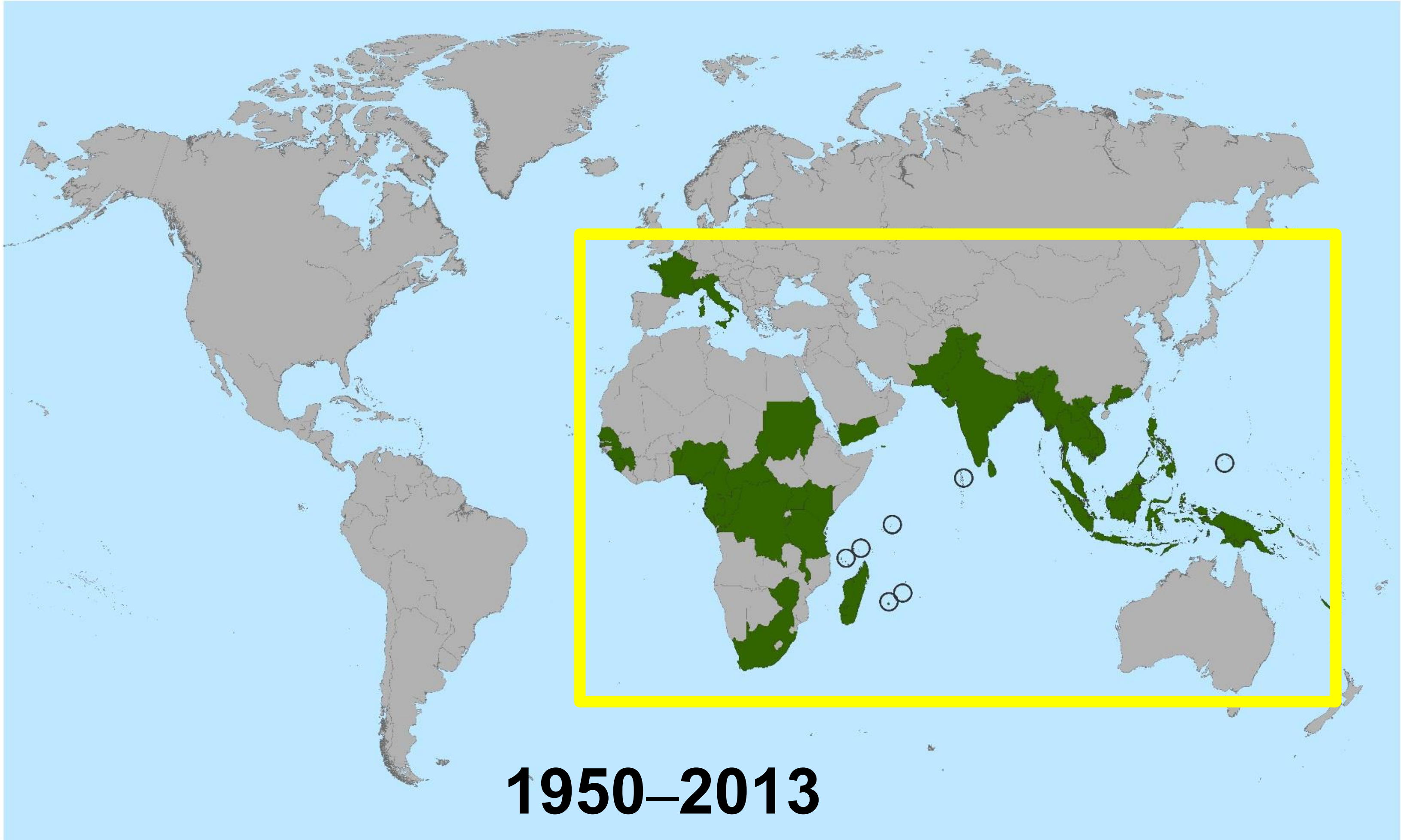
Thiberville SD, et al. Antiviral Res 2013

# Chikungunya Virus: Approximate Geographic Distribution



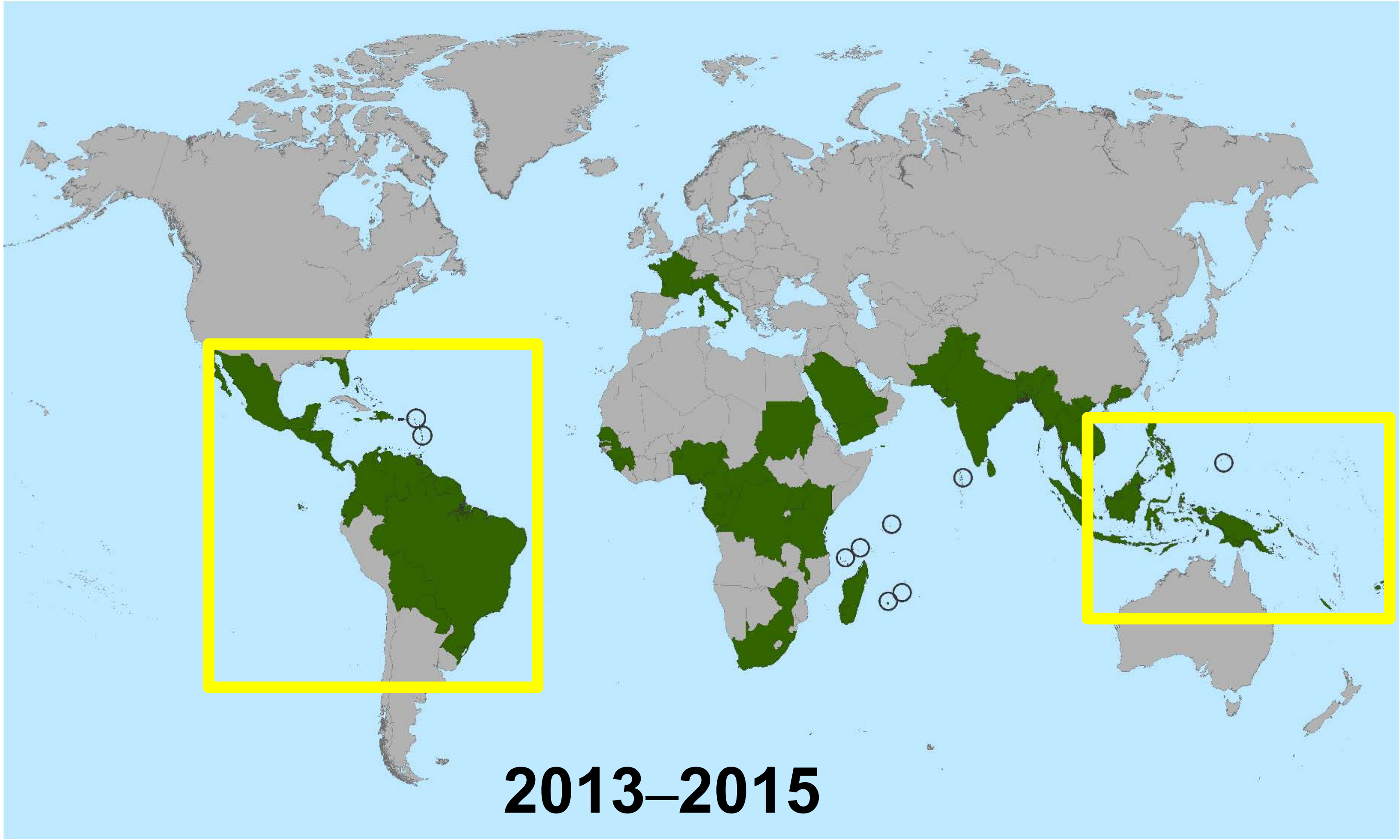
Available at http://www.cdc.gov/chikungunya

# Chikungunya Virus: Approximate Geographic Distribution




Available at http://www.cdc.gov/chikungunya

# Chikungunya Virus: Approximate Geographic Distribution




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

Staples JE, Fischer M. N Engl J Med 2014

# 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

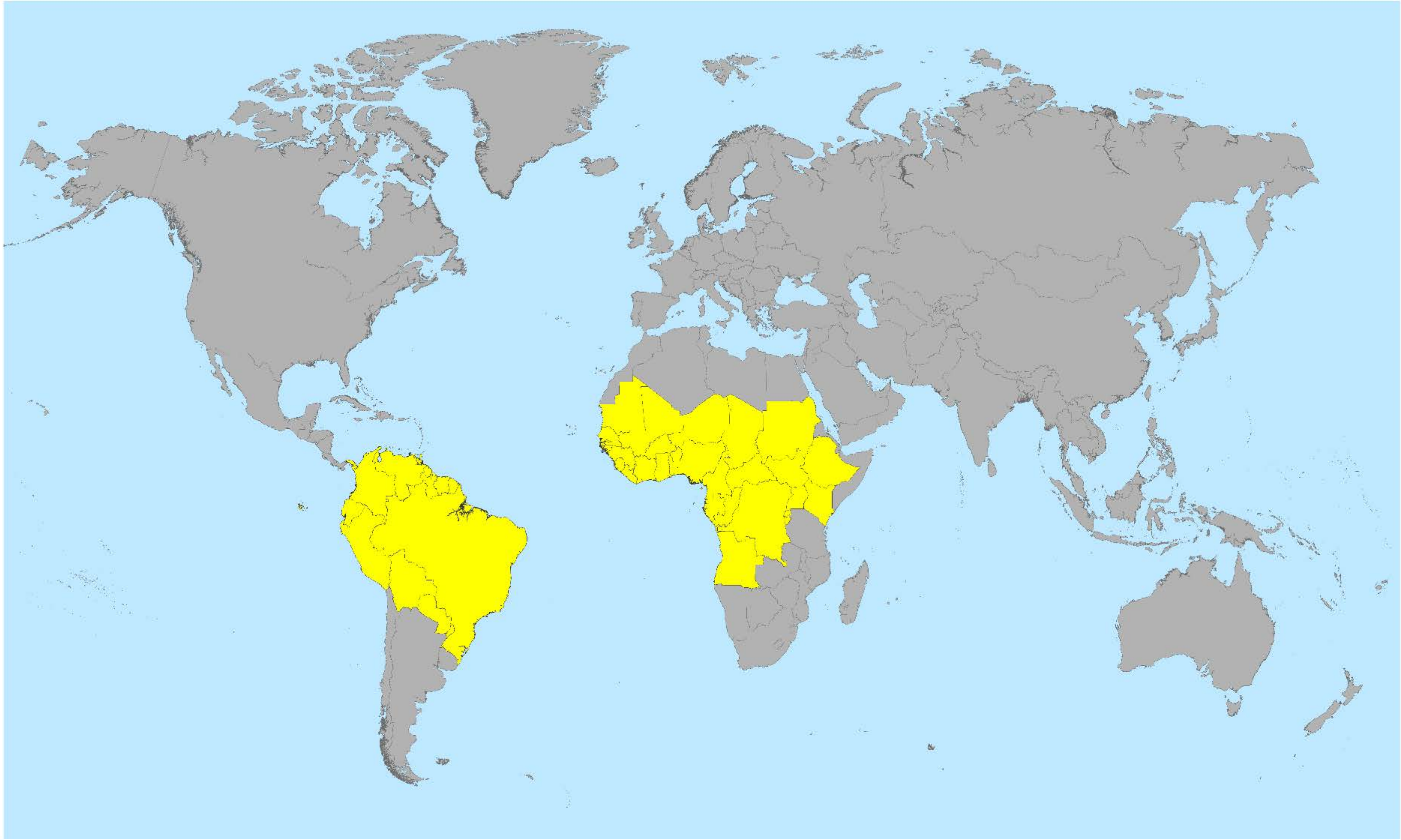
Thiberville SD, et al. Antiviral Res 2013

# 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

MMWR 2010;59(RR-7)

# Yellow Fever Virus: Approximate Geographic Distribution



Jentes ES, et al. Lancet Infect Dis 2011

# 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

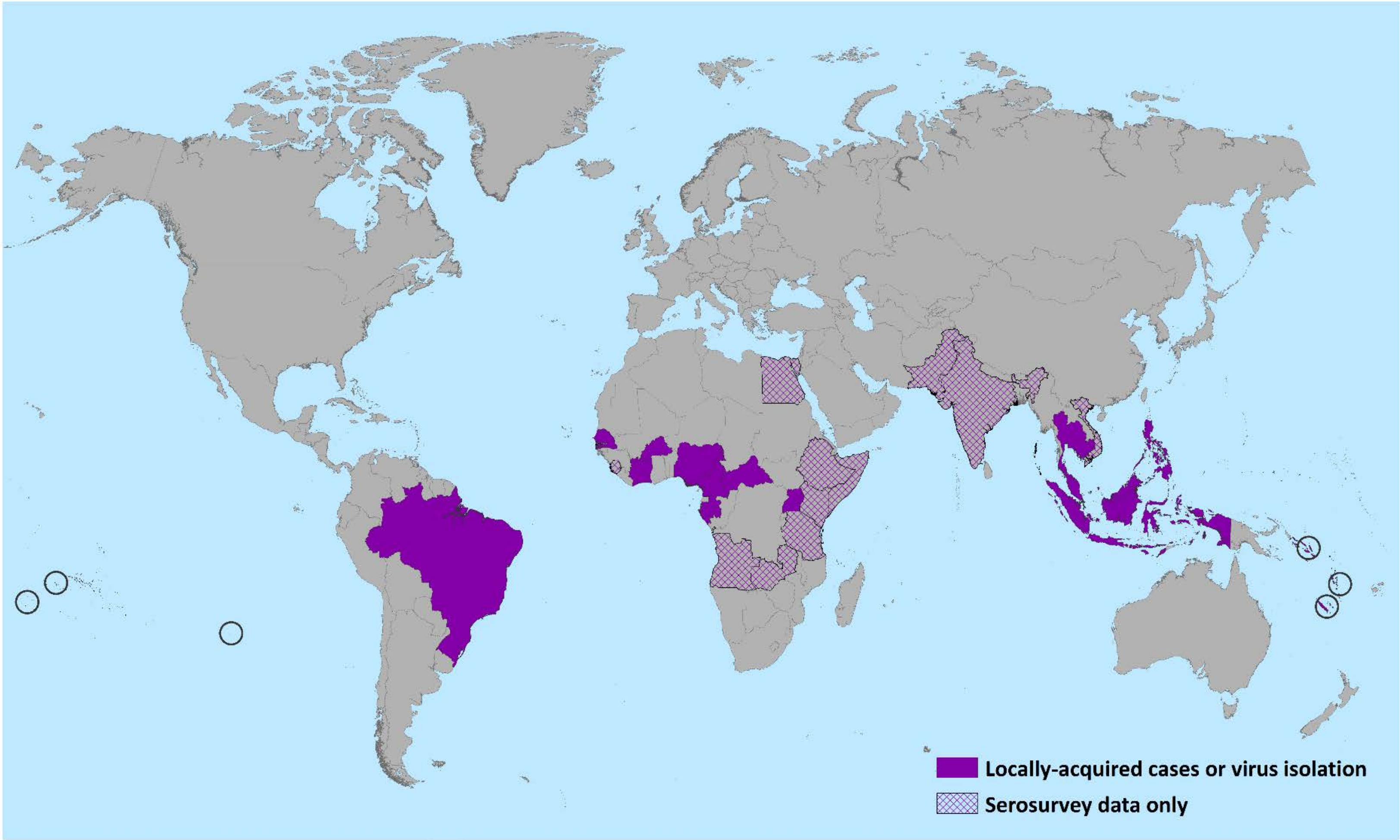
MMWR 2010;59(RR-7)

# 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




Haddow AD, et al. PLoS NTD 2012

# 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

Duffy MR, et al. N Engl J Med 2009

# 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

Hayes EB. Emerg Infect Dis 2009
Oehler E, et al. Euro surveillance 2014

# 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
- **≥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

WHO 2009. http://whqlibdoc.who.int/publications/2009/9789241547871_eng.pdf

# Vaccines for Dengue, Chikungunya, Yellow Fever and Zika Viruses

| Virus | Vaccine status |
|---|---|
| Dengue | Phase 3 clinical trials |
| Chikungunya | Phase 1–2 clinical trials |
| Yellow fever | Licensed and available |
| Zika | None |

Villar L, et al. N Engl J Med 2015
Chang LJ, et al. Lancet 2014
Garske T, et al. PLoS Med 2014

# 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

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U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

# 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

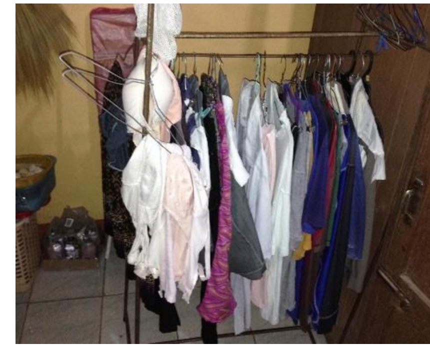
# Environments that Favor More Mosquitoes and Transmission of Diseases

- **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

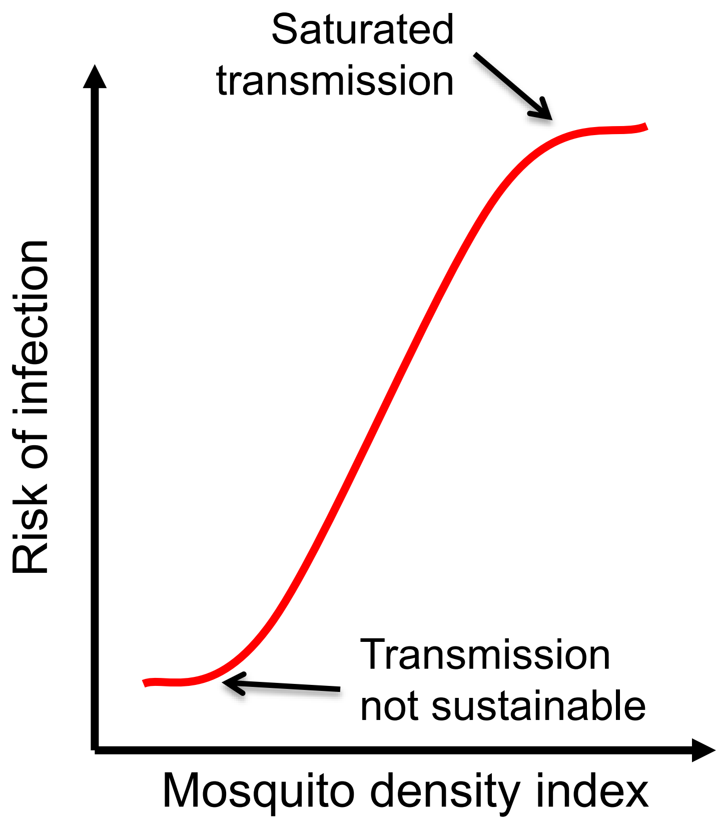
# Aedes aegypti Transmits Mosquito-Borne Diseases Efficiently

- **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**

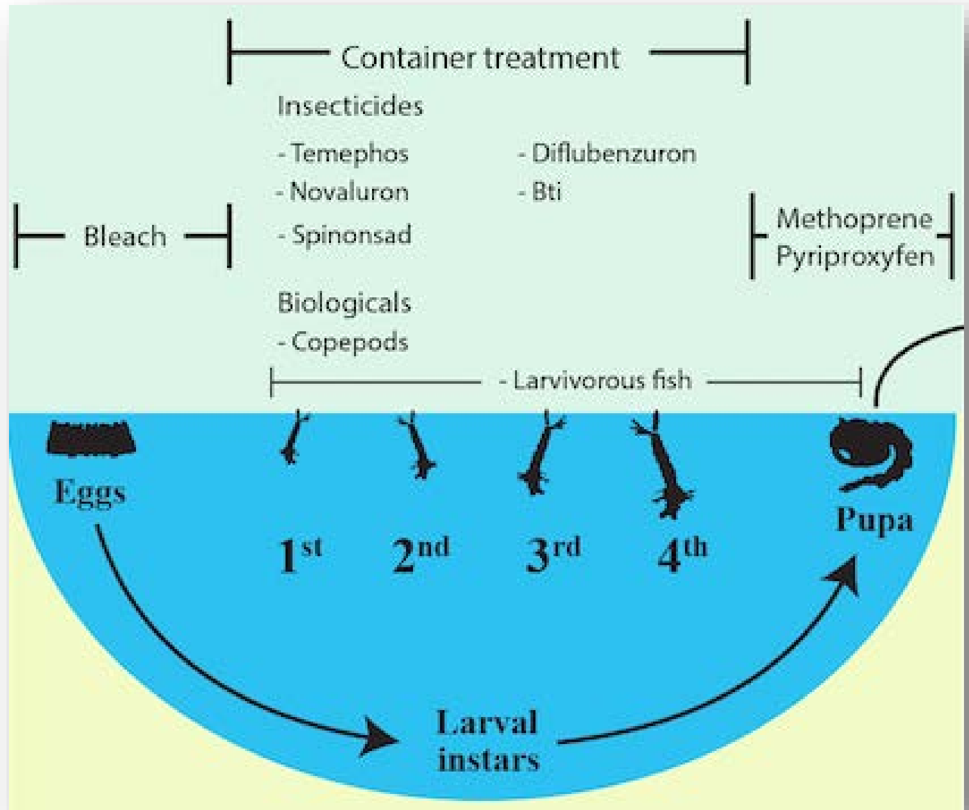
# Improving Measures of Entomological Risk




- **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

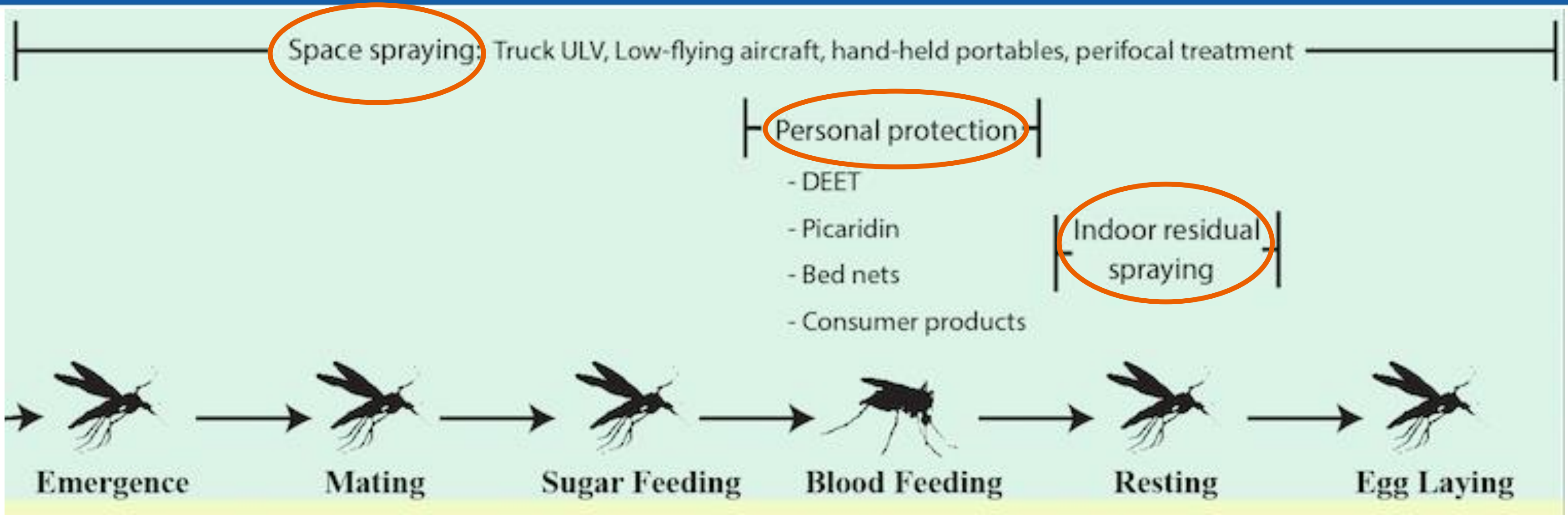
# Existing Methods for *Aedes aegypti* Control – Immature Stage

- **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




Achee NL, et al. PLoS NTD 2015

# Existing Methods for *Aedes aegypti* Control – Adult Stage




**Major categories include**

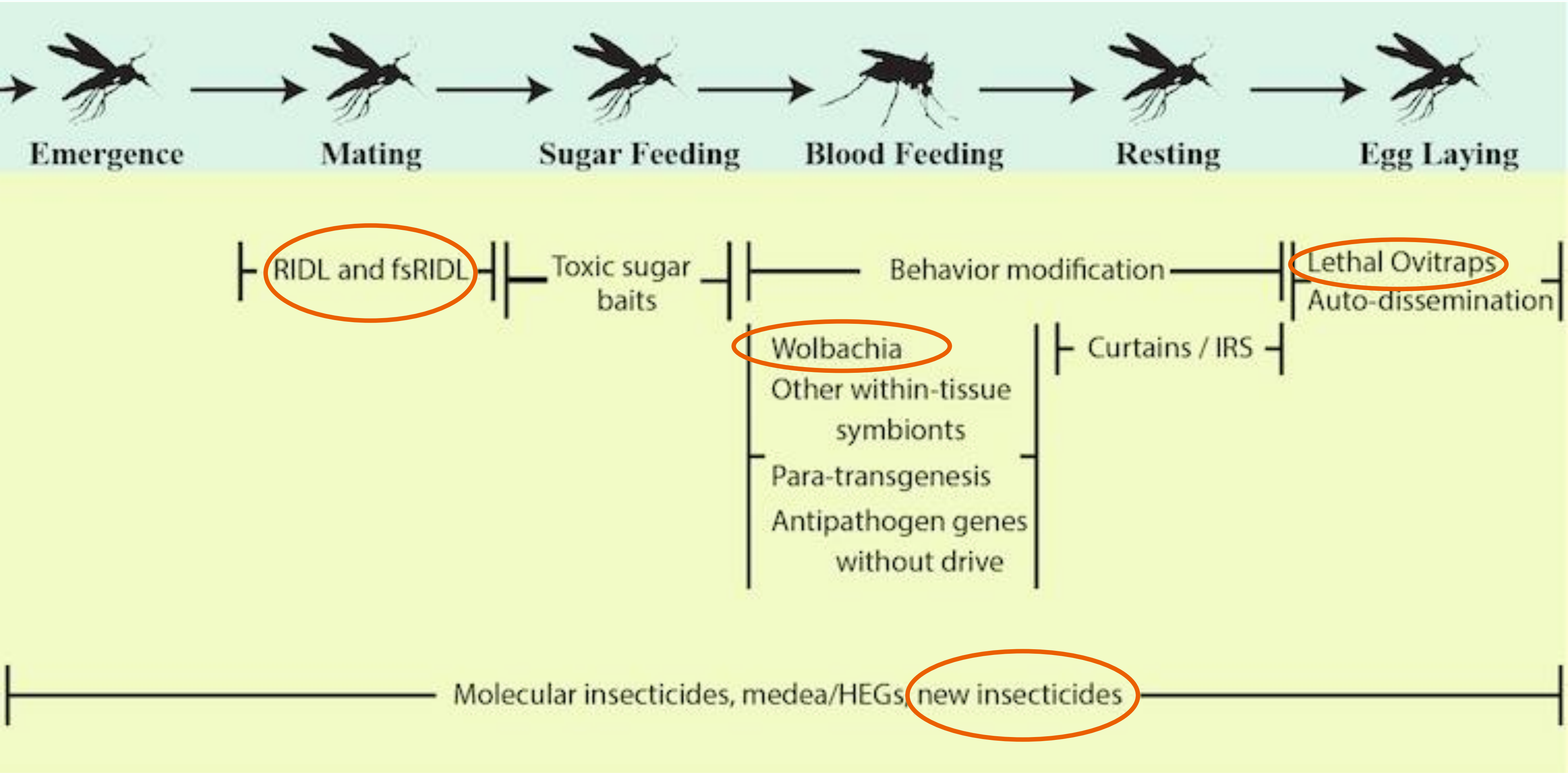
(1) Space spraying (indoor vs outdoor)

(2) Indoor residual spraying

(3) Personal protection

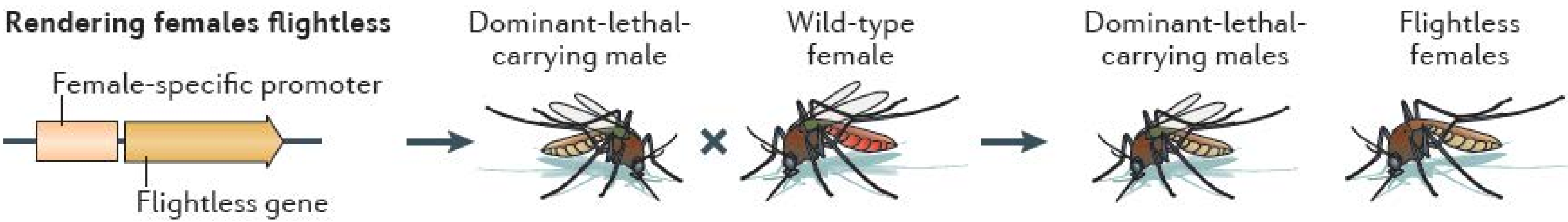
Achee NL, et al. PLoS NTD 2015

# Interventions Currently Under Development




Achee NL, et al. PLoS NTD 2015
RIDL: Release of Insects Carrying a Dominant Lethal

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

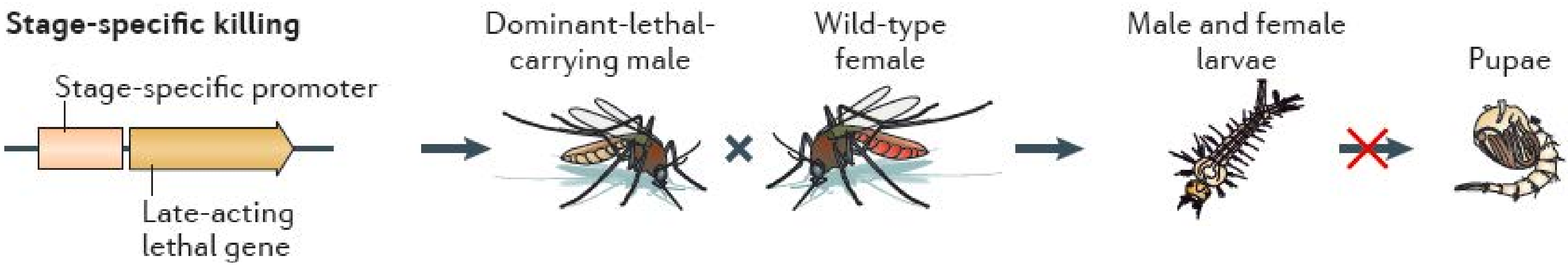



## ❑ Flightless females

- ➢ 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

McGraw & O'Neill Nat Rev Micro 2013

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

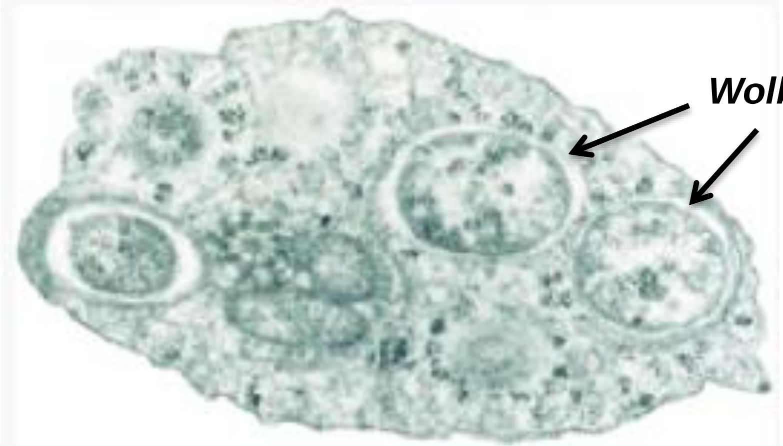



- **Stage-specific killing**
  - Males carrying a transgene that causes late-acting lethality mate with wild-type females
  - Offspring die as pupae
  - Reduces population density
- **Successful safety testing and mosquito population reduction field trials**
- **Need to evaluate impact on human dengue outcomes**

McGraw & O'Neill Nat Rev Micro 2013

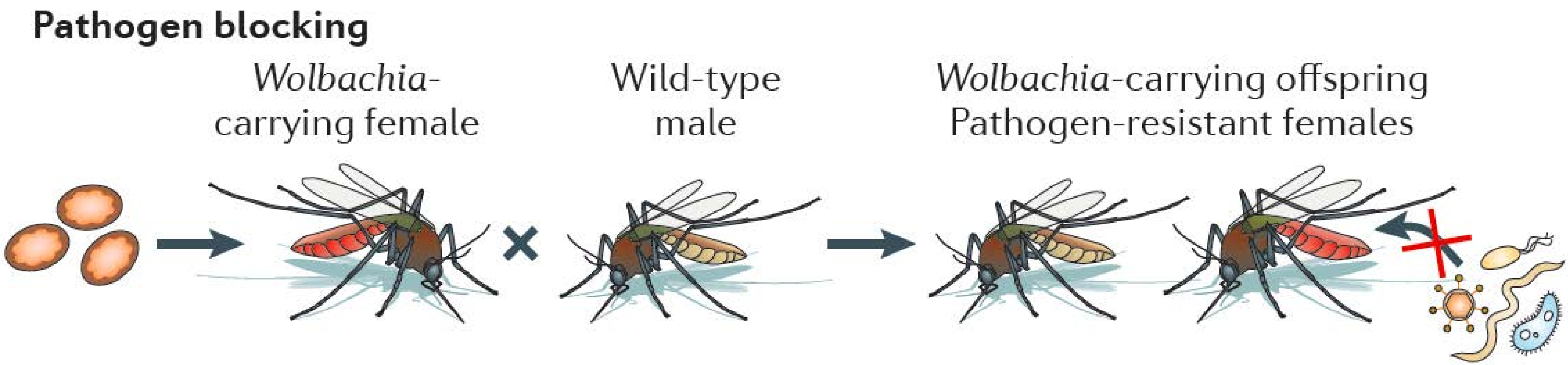
# Naturally Occurring Bacteria – *Wolbachia*

- ***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**




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**

McGraw & O'Neill Nat Rev Micro 2013

# 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**

Barrera et al. J Med Ent 2014

# 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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# 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

Dengue: Guidelines for Diagnosis, Treatment, Prevention and Control. New Edition. WHO, 2009

# CDC Dengue Case Management E-Learning Course

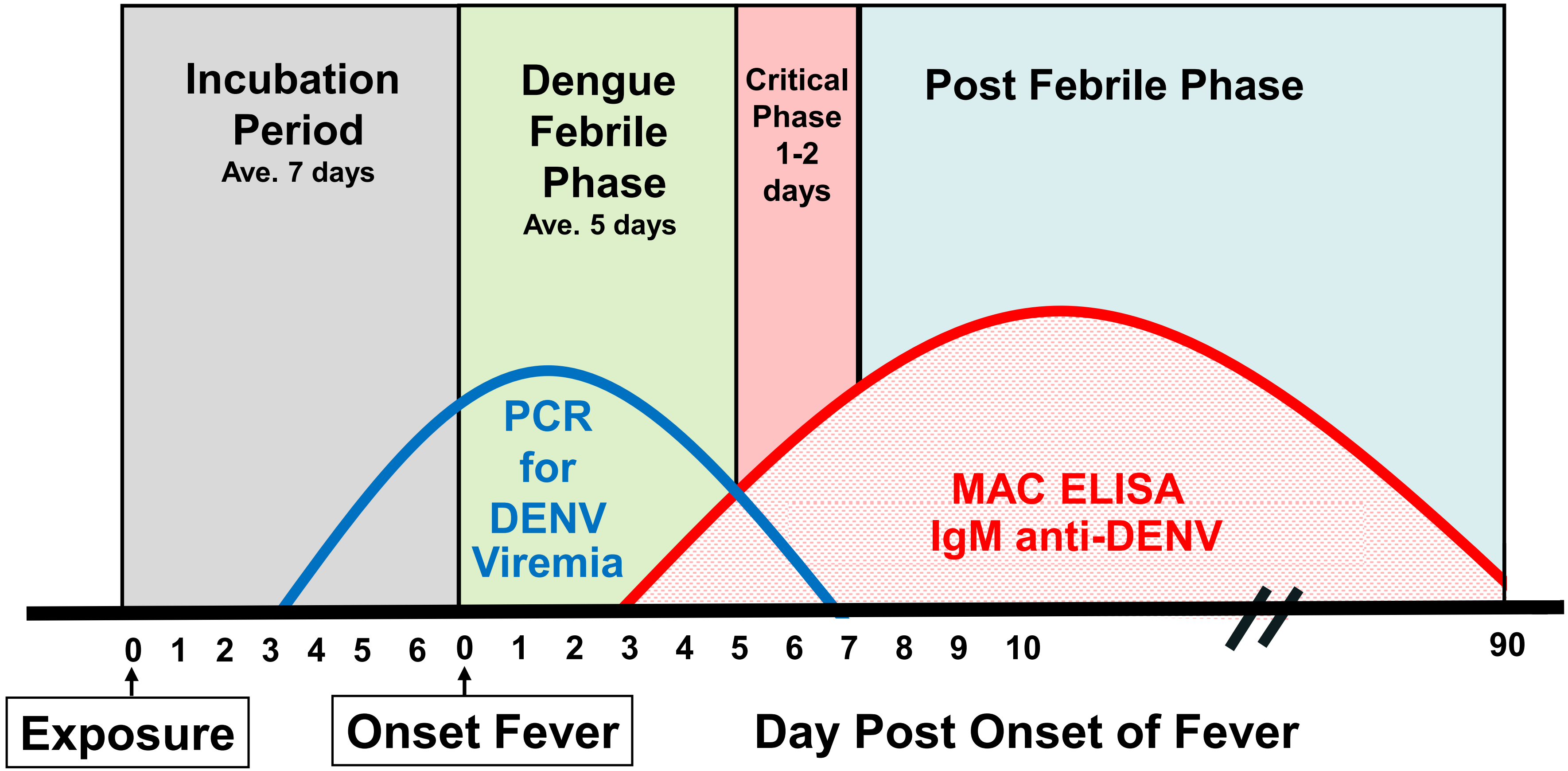
- **CDC Dengue Case Management Educational tool**
  - Designed for healthcare providers
  - Includes case management steps recommended by WHO and incorporated in many dengue endemic countries


**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




Peeling RW, et al. Nat Rev Microbiol 2010
Santiago GA, et al. PLoS NTD 2013
CDC unpublished data

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

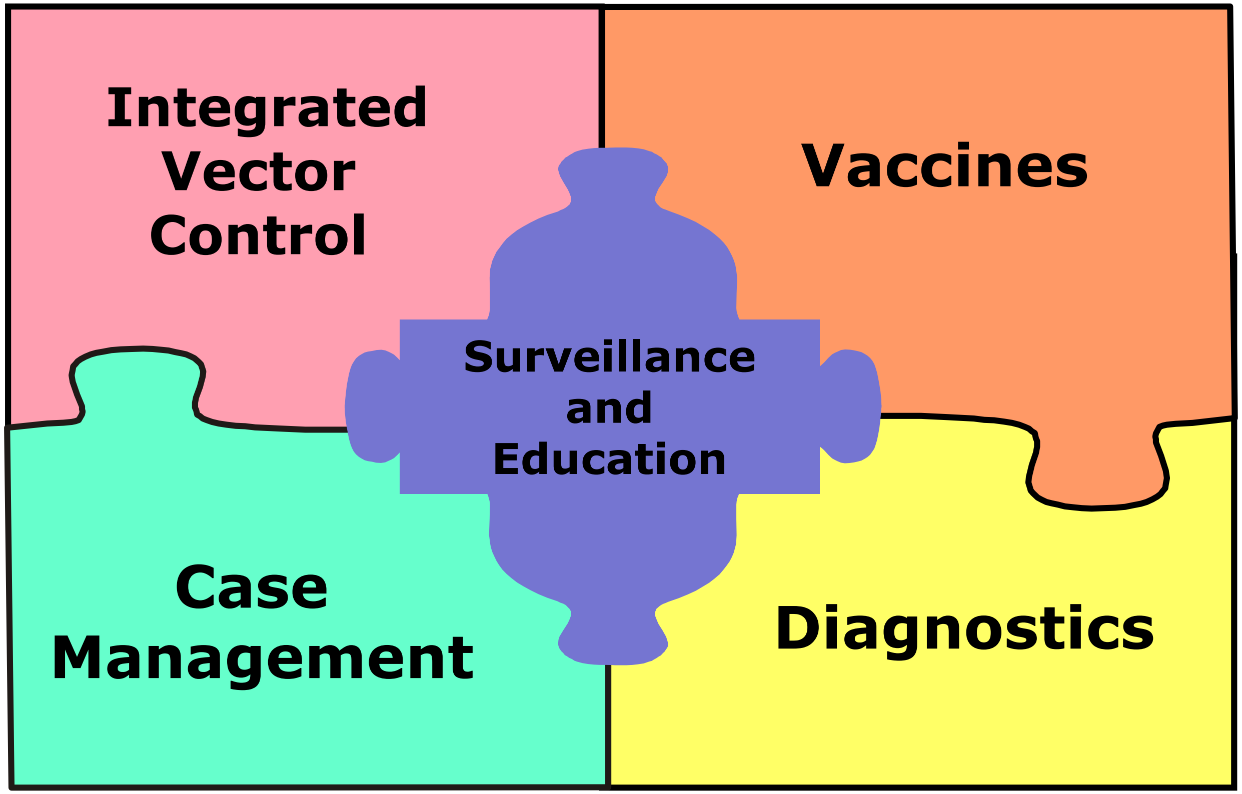
# Dengue Diagnostics Algorithm

| Day Post Onset of Fever | Diagnostic Tests | | Reliability |
|---|---|---|---|
| | RT-PCR | IgM anti-DENV | |
| 0–3 | + | - | ~90% |
| 3–7 | + | + | ~90% |
| >7 | - | + | ~90% |

Peeling RW, et al. Nat Rev Microbiol 2010
Santiago GA, et al. PLoS NTD 2013
CDC unpublished data

DENV: Dengue virus
RT-PCR: : Reverse transcription-Polymerase chain reaction

# A Framework for Dengue Prevention




Adapted from: Dengue: Guidelines for Diagnosis, Treatment, Prevention and Control. New Edition. WHO, 2009
Global Strategy for Dengue Prevention and Control 2012-2020. WHO, 2012

# 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?

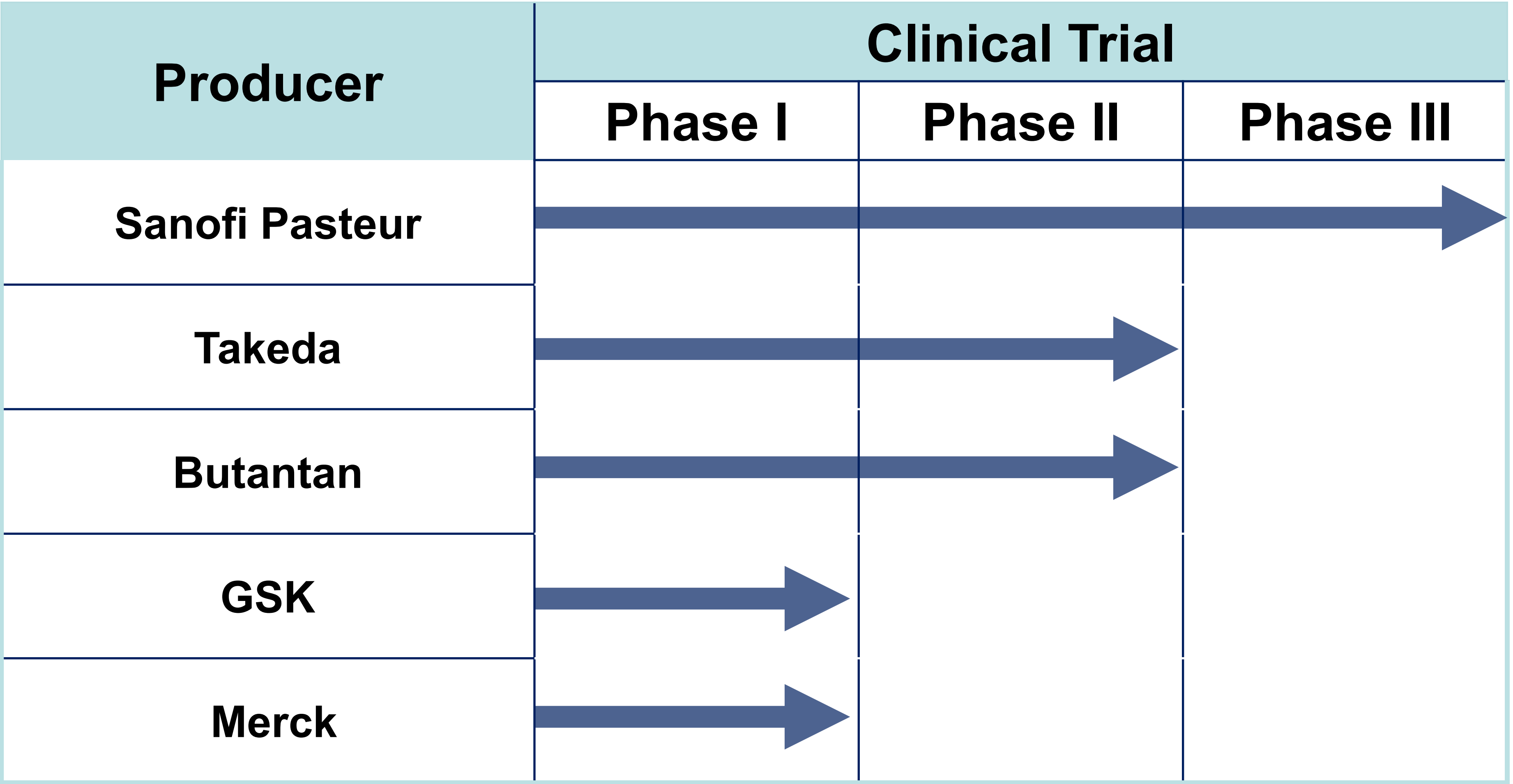
- **Mosquito control works, but expensive and difficult to sustain at effective levels**
- **Vaccines protect the individual and community**
- **Efficacious *Flavivirus* vaccines exist**
  - Yellow fever, Japanese encephalitis, tick-borne encephalitis
  - Technically feasible
- **Challenge of dengue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

# Dengue Vaccine Candidates

| Producer (developer) | Approach |
|---|---|
| **Sanofi Pasteur (Acambis)** | Live attenuated chimeric vaccine |
| **Takeda (CDC, InViragen)** | Live attenuated chimeric vaccine |
| **Butantan (NIAID)** | Live attenuated , engineered mutations in 3 strains and chimeric in 2 |
| **GSK (WRAIR)** | Cell culture derived inactivated vaccine |
| **Merck (Hawaii Biotech)** | Subunits of DENV envelop protein |

GSK: GlaxoSmithKline
NIAID: National Institute of Allergy and Infectious Diseases
WRAIR: Walter Reed Army Institute of Research

# Dengue Vaccine Clinical Trial Phases




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
http://www.who.int/immunization/documents/WHO_IVB_08.12/en/
Capeding MR, et al. Lancet 2014

PCR: Polymerase chain reaction

# Results of Efficacy Trials
# Sanofi Vaccine (per protocol results)

| DENV Types | Phase IIB–Thailand Ages 4–11, N= 4,002 | | Phase III–Asia Ages 2–14, N= 10,275 | | Phase III–Latin America Ages 9–16, N= 20,869 | |
|---|---|---|---|---|---|---|
| | Efficacy | 95% CI | Efficacy | 95% CI | Efficacy | 95% CI |
| All DENV's | **30.2** | -13–57 | **56.5** | 44–66 | **60.8** | 52–68 |
| DENV 1 | **55.6** | 22–84 | **50.0** | 25–67 | **50.3** | 29–65 |
| DENV 2 | **9.2** | -75–51 | **35.0** | -9–61 | **42.3** | 14–61 |
| DENV 3 | 75.3 | -38–100 | 78.4 | 53–91 | 74.0 | 62–82 |
| DENV 4 | 100 | 25–100 | 75.3 | 55–87 | 77.7 | 60–88 |

Sabchareon A, et al. Lancet 2012
Capeding MR, et al. Lancet 2014
Villar L, et al. NEJM 2015

DENV: Dengue virus

# 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

Sabchareon A, et al. Lancet 2012
Capeding MR, et al. Lancet 2014
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

# CDC PUBLIC HEALTH GRAND ROUNDS

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




**May 19, 2015**

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention