Zika: Responding to the Challenges of an Emerging Infection

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Presenter Disclosure Information
Alfred DeMaria, Jr., M.D.

Consultant	**No relevant conflicts of interest to declare**
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Speaker's Bureau	**No relevant conflicts of interest to declare**
Major Stockholder	**No relevant conflicts of interest to declare**
Other Financial or Material Interest	**No relevant conflicts of interest to declare**

Why Zika?

Why Does Zika Virus Epitomize Lessons Learned About Emerging Infection in the Past 25 Years?

TRANSACTIONS OF THE ROYAL SOCIETY OF
TROPICAL MEDICINE AND HYGIENE.
Vol. 46. No. 5. September, 1952.

COMMUNICATIONS

ZIKA VIRUS

(I). ISOLATIONS AND SEROLOGICAL SPECIFICITY

BY

G. W. A. DICK,

The National Institute for Medical Research, London

S. F. KITCHEN,

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(*From the Virus Research Institute, Entebbe, Uganda.*)

The isolation of filterable viruses from mosquitoes taken in Uganda has already been recorded on several occasions. Two of the agents so recovered, although well known, had not previously been identified by isolation from mosquitoes in Uganda, viz. yellow fever virus (MAHAFFY et al., 1942 ; SMITHBURN and HADDOW, 1946 ; SMITHBURN et al., 1949) and Rift Valley fever virus (SMITHBURN et al., 1948). A third which was called Mengo encephalomyelitis (DICK et al., 1948) (now known to be identical with Columbia SK,MM and encephalomyocarditis viruses (DICK, 1949 ; WARREN et al., 1949), has been isolated on several occasions from *Taeniorhynchus* spp. (DICK et al., loc. cit., DICK and HADDOW, (unpublished)). GILLETT and DICK (unpublished) have, however, failed to transmit this agent in the laboratory by three species of *Taeniorhynchus*. The isolation of three hitherto unknown, filterable viruses secured from wild mosquitoes in Uganda has been described,

TRANSACTIONS OF THE ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE.
Vol. 48. No. 2. March, 1954.

ZIKA VIRUS : A REPORT ON THREE CASES OF HUMAN INFECTION DURING AN EPIDEMIC OF JAUNDICE IN NIGERIA

BY

F. N. MACNAMARA*

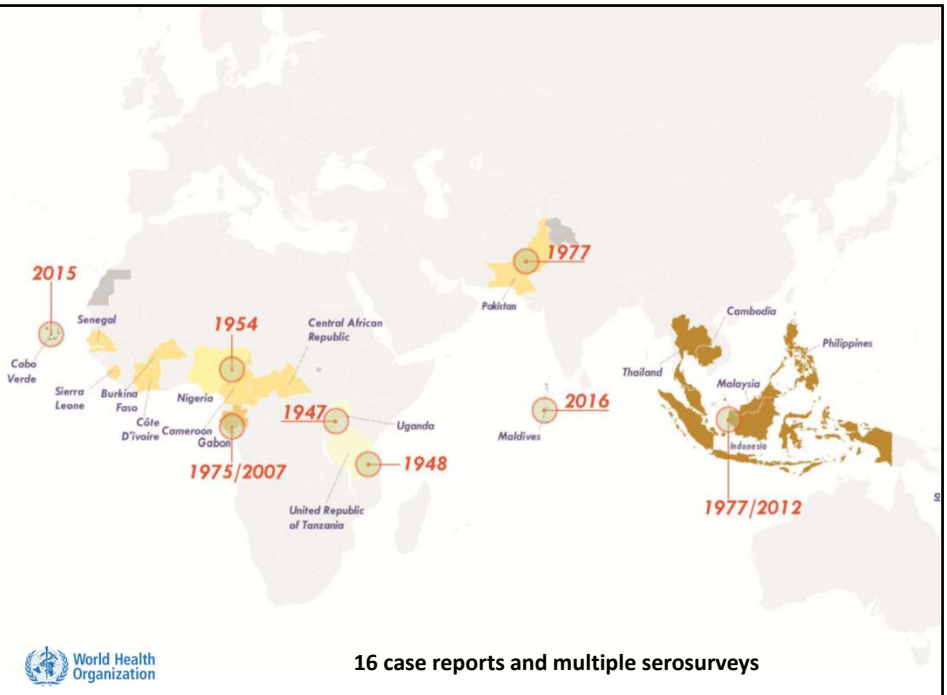
Acting Director, Virus Research Institute, Yaba, Nigeria

Zika virus was first isolated from a captive rhesus monkey stationed in the forest of Zika near Entebbe, Uganda, during the course of research into the epidemiology of yellow fever (DICK et al., 1952). Later it was isolated from a batch of wild-caught mosquitoes.

This virus was known by serological surveys to infect man in Uganda and Nigeria (DICK, 1952; MACNAMARA, 1952) yet nothing was known of the clinical manifestations of the infection.

During the investigation in Afikpo Division, Eastern Nigeria, of an outbreak of jaundice suspected of being yellow fever, Zika virus was isolated from one patient, and two other patients exhibited a rise in titre of serum antibodies against this virus.

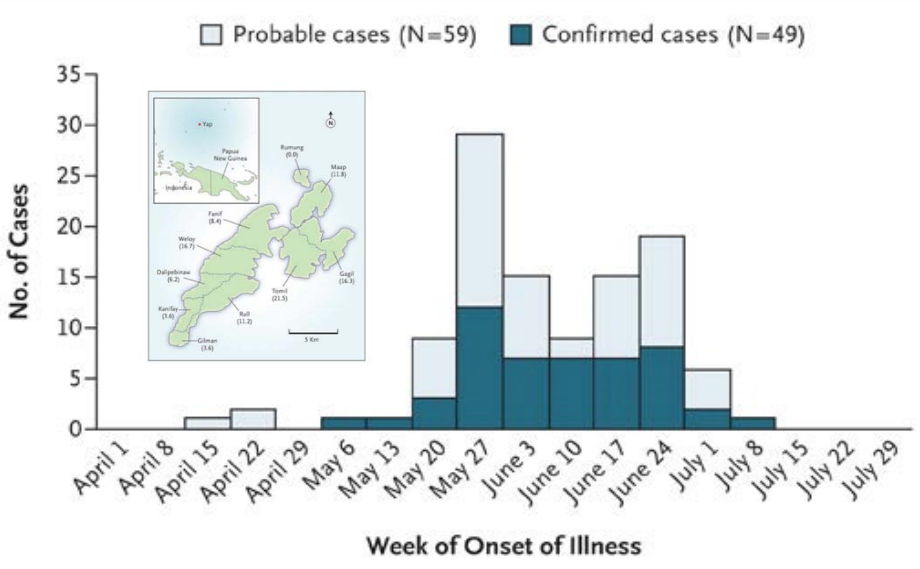
Serological examination of specimens taken from other patients was made in an attempt to evaluate the relationship between the occurrence of jaundice and Zika virus.



World Health Organization

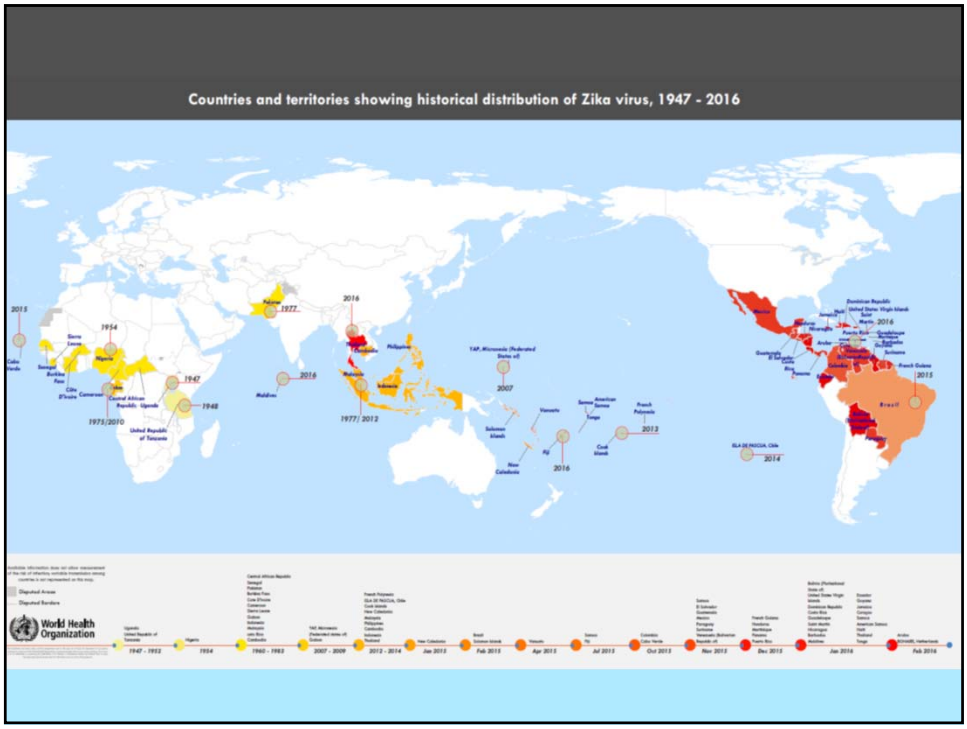
16 case reports and multiple serosurveys

Confirmed and Probable Cases of Zika Virus Disease on Yap among Persons Seeking Health Care, According to Week of Onset of Illness during the Period from April through July 2007



Duffy MR et al. N Engl J Med 2009;360:2536-2543.

The NEW ENGLAND JOURNAL of MEDICINE



ProMED mail

Published Date: 2015-05-01 10:36:31
Subject: PRO/AH/EDR> Undiagnosed illness - Brazil: (Northeast, RJ) Zika virus susp, RFI
Archive Number: 20150501.3334749

UNDIAGNOSED ILLNESS - BRAZIL: (NORTHEAST, RIO DE JANEIRO) ZIKA VIRUS SUSPECTED, REQUEST FOR INFORMATION

A ProMED-mail post
http://www.promedmail.org
ProMED-mail is a program of the
International Society for Infectious Diseases
http://www.isid.org

In this posting:
[1] Brazil: (Northeast) official information
[2] Brazil: (Rio de Janeiro) RFI

******
[1] Brazil: (Northeast) official information
Date: Wed 29 Apr 2015
Source: Secretariat of Health Surveillance, Ministry of Health of Brazil [in Portuguese, trans. Mod.JW, edited]
http://portalsaude.saude.gov.br/index.php/o-ministerio/principal/secretarias/svs/noticias-svs/17524-svs-monitora-casos-de-doenca-exantematica-no-nordeste

SVS (Secretariat of Health Surveillance) monitors cases of rash illness in the Northeast

SVS communicates that since the end of February [2015] it has been monitoring reported cases of a rash illness in the Northeast. According to reports shared by the Health Departments of the states of Bahia, Maranhao, Pernambuco, Rio Grande do Norte, Paraiba, and Sergipe, all cases have a benign course with spontaneous recovery, even without treatment. According to information passed to the Ministry of Health, 6807 cases of rash illness so far have been identified in the region. It is noteworthy that there have been no serious cases or deaths.

The most common signs and symptoms are rash (red spots) and pruritus (itching). To a lesser extent, cases with low-grade fever or no fever, with or without headache, pain or swelling in the joints, and muscle pain. The age group 20-40 years was the most affected. But there are reports of a patients 4 months old and another 98 years old.

According to the clinical features, the main assumptions in the investigations are: dengue, rubella, parvovirus B19, chikungunya, and measles, and other arboviruses and enteroviruses. So far, among 425 samples collected and tested, approximately 13 percent were positive for dengue. However, the clinical features available for now are not only characteristic of dengue cases. However, some samples tested for measles, rubella, chikungunya, and parvovirus were negative.

Pan American Health Organization
World Health Organization
Americas

Epidemiological Alert

Zika virus infection

7 May 2015

The Pan American Health Organization (PAHO) / World Health Organization (WHO) recommends its Member States establish and maintain the capacity for Zika virus infection detection, clinical management and an effective public communication strategy to reduce the presence of the mosquito that transmits this disease, particularly in areas where the vector is present.

Situation summary

The Zika virus was first isolated in 1947 in Zika Forest (Uganda), in a Rhesus monkey during a study of the transmission of wild yellow fever. It was first isolated in humans in 1952 (Uganda, Tanzania).[1,2] In 1968 the virus was detected in human samples in Nigeria. [3,4]

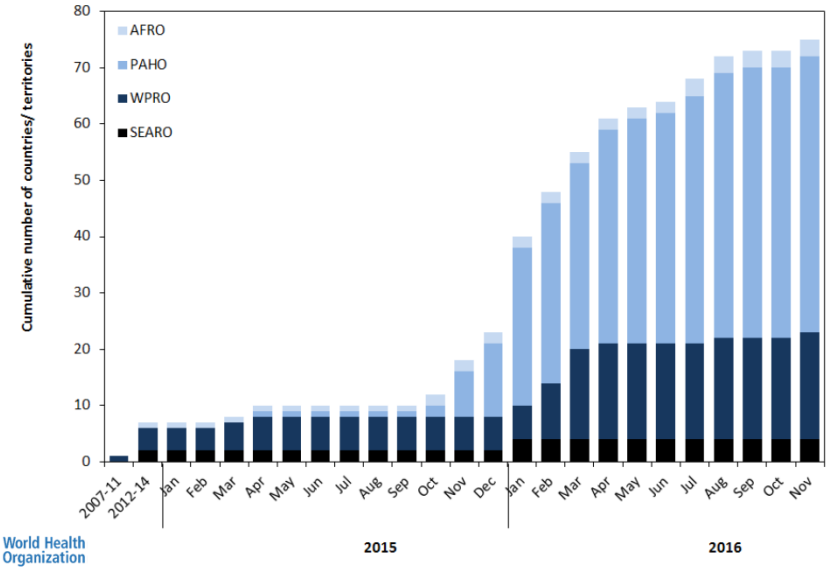
In 2007 the first major outbreak of Zika virus fever occurred on the island of Yap (Micronesia) where 185 suspected cases were reported, of which 49 were confirmed and 59 were considered probable. The

Zika virus infection

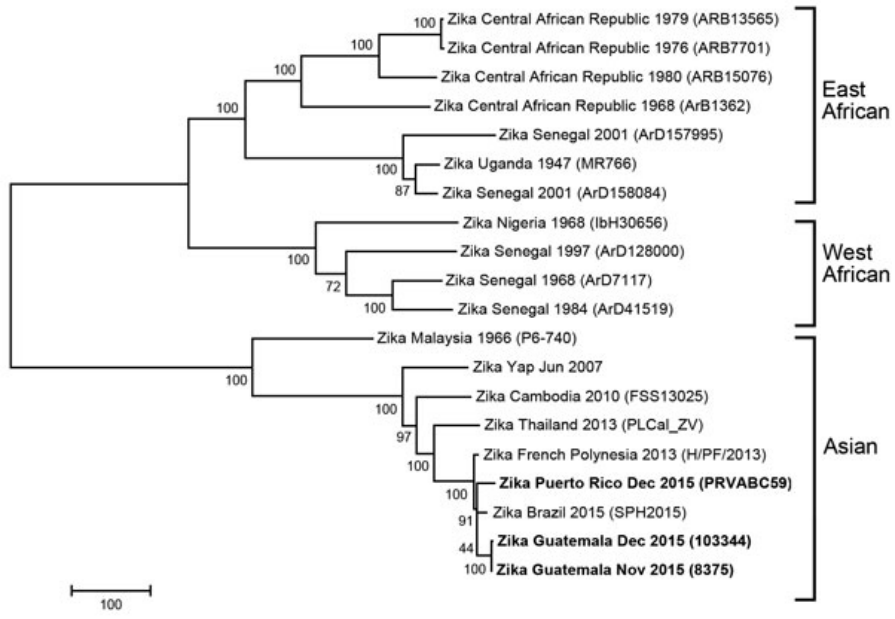
This is a disease caused by the Zika virus (ZIKAV), an arbovirus the flavivirus genus (family Flaviviridae), very close phylogenetically to viruses such as dengue, yellow fever, Japanese encephalitis, or West Nile virus.

The Zika virus is transmitted by mosquitoes of the genus Aedes, in urban areas (*A. aegypti*) as well as in the wild.

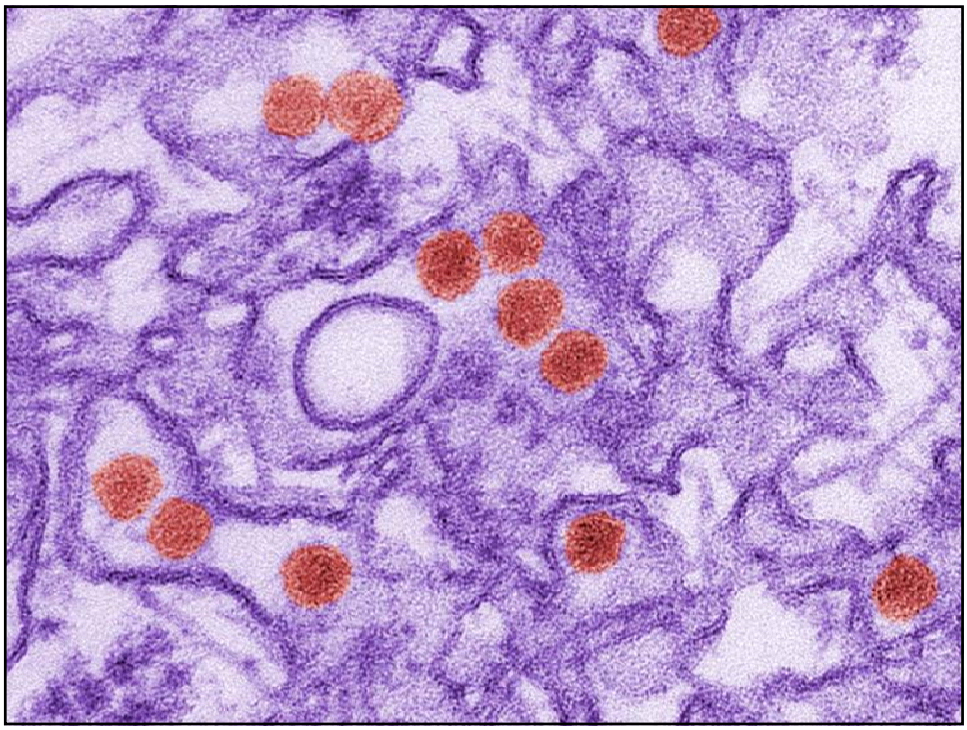
Cumulative number of countries and territories by WHO region reporting mosquito-borne Zika virus transmission for the first time in years (2007–2014), and monthly from 1 January 2015 to 16 November 2016



World Health Organization



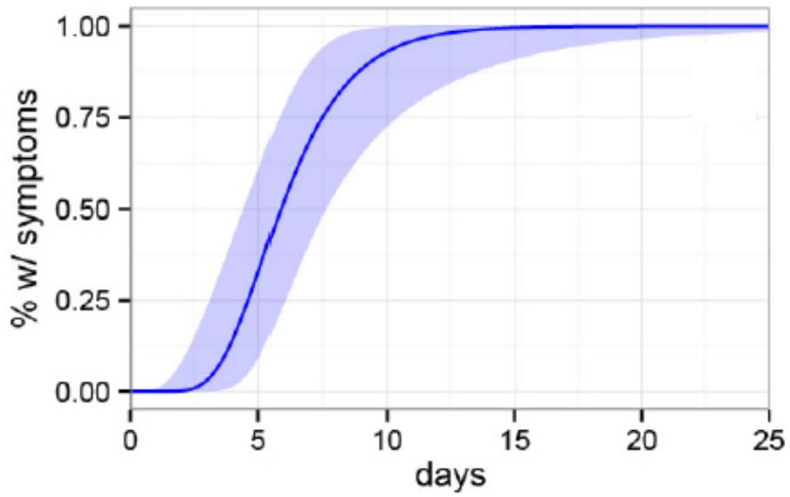
Lanciotti RS, et al. Emerg Infect Dis. 2016 May. http://dx.doi.org/10.3201/eid2205.160065



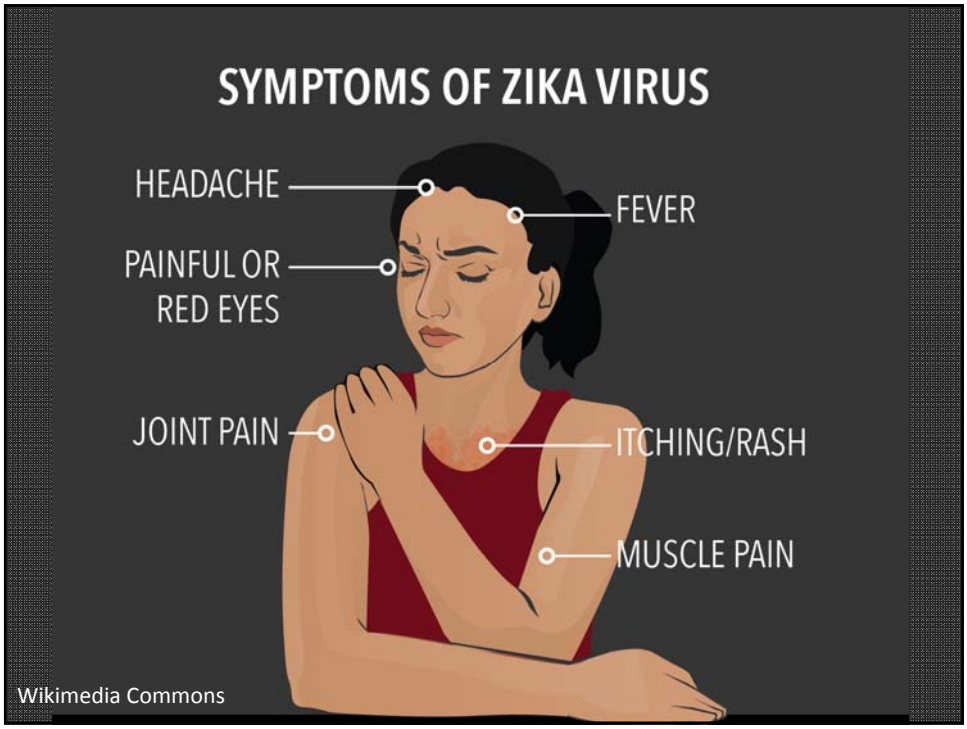
Zika Virus

- ❖Flavivirus, family *Flaviviridae*
- ❖Positive sense, single-stranded RNA virus
- ❖3 structural and 7 nonstructural proteins, expressed as a single polyprotein that undergoes cleavage
- ❖Closest relative Spondweni virus
- ❖African and Asian lineages
- ❖Enters skin cells at bite wound and travels to lymphatics and bloodstream
- ❖Neurotropic

Incubation Period from Exposure to Onset of Symptoms among Reported Zika Cases with Symptoms



Bull World Health Organ E-pub: 1 Apr 2016. doi: http://dx.doi.org/10.2471/BLT.16.174540


SYMPTOMS OF ZIKA VIRUS
HEADACHE
FEVER
PAINFUL OR
RED EYES
JOINT PAIN
ITCHING/RASH
MUSCLE PAIN
Wikimedia Commons

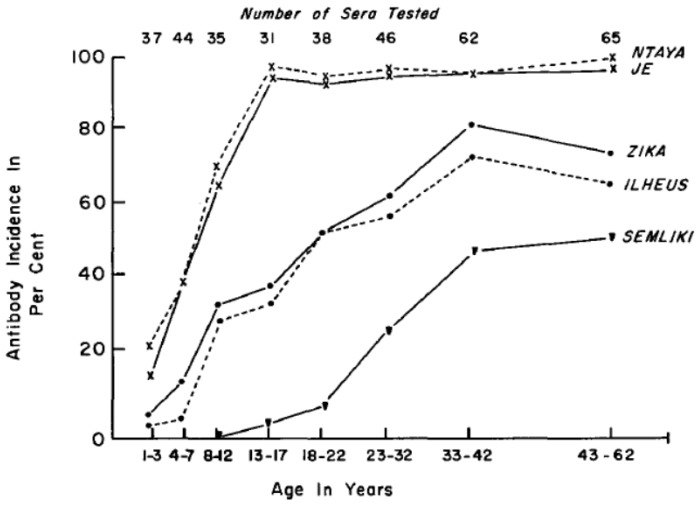
Differential Diagnosis

- ❖ Dengue
- ❖ Chikungunya
- ❖ Leptospirosis
- ❖ Malaria
- ❖ Rickettsial infection
- ❖ Parvovirus
- ❖ Group A streptococci
- ❖ Rubella
- ❖ Measles
- ❖ Adenovirus
- ❖ Enterovirus

Seropositivity Rates (%) for Anti-Zika Antibody

Country	Years	Children	Adults	Total
Uganda	1945-52	11.3	12.7	11.9
Tanzania	1945-52	13.3	19.0	16.7
Nigeria	1955			55.1
Angola	1960	15.9	38.7	27.0
Central African Republic	1961-62			48.8
Nigeria	1966-67	0.0	5.1	1.8
Kenya	1968	2.4	11.2	7.8
Nigeria	1969-71, 1972	52.3	71.7	64.0
Senegal	1972, 1975			58.3
Uganda	1984			6.1
Malaya	1953-54			75.0
Vietnam	1954			4.0
Indonesia	1983			12.7
Borneo	1996-97			44.1
Yap	2007			74.3
French Polynesia	2011-13			0.8
French Polynesia	2014	66.0		50.0

Musso D, Gubler DJ. Clin Microbiol Rev. 2016 Jul;29(3):487-524.



FIGURE

Incidence of Malayan residents with neutralizing antibodies against five arthropod-borne viruses.

Pond WL. Trans R Soc Trop Med Hyg. 1963 Sep;57:364-71

Why Zika?


CDC

Pan American Health Organization
World Health Organization
Americas

Epidemiological Alert

Increase of microcephaly in the northeast of Brazil

17 November 2015

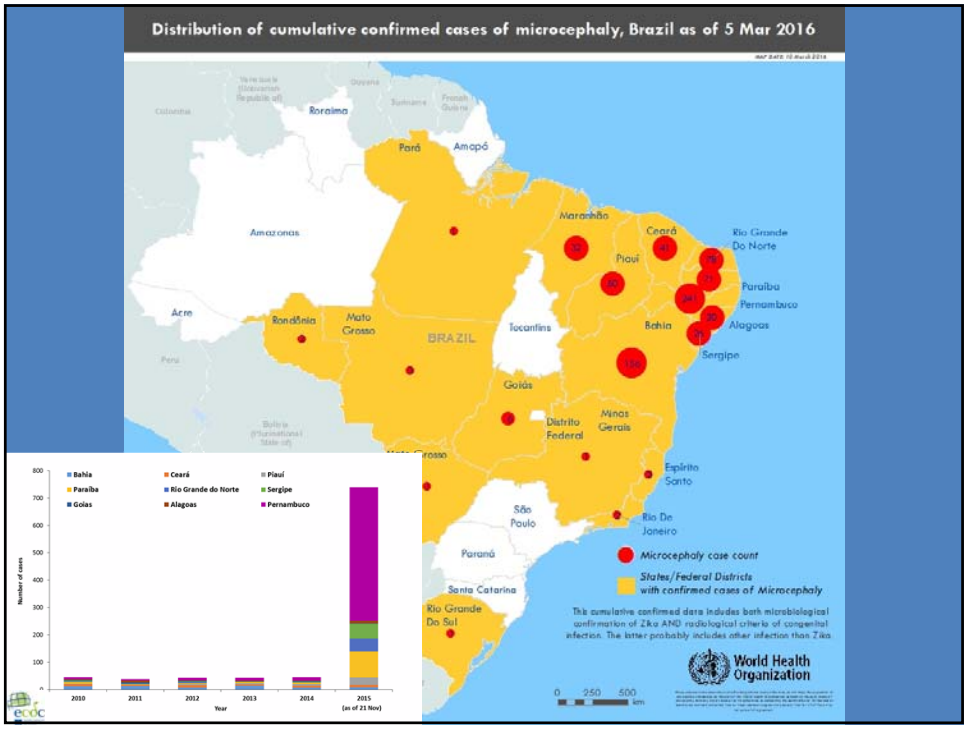
Given the unusual increase in cases of microcephaly in some northeast states of Brazil, the Pan American Health Organization (PAHO) / World Health Organization (WHO) calls upon Member States to remain alert to the occurrence of similar events in their territories and to notify its occurrence through the channels established under the International Health Regulations (IHR).

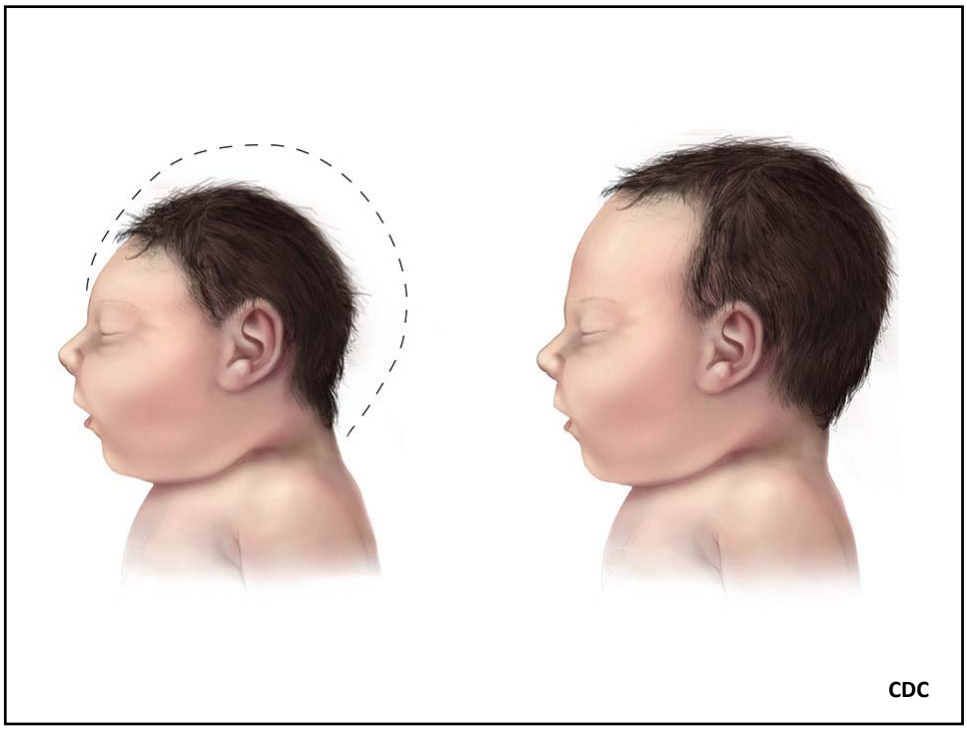
Situation summary

In October 2015 the Brazil Ministry of Health reported an unusual increase in cases of microcephaly in the state of Pernambuco, located in the northeast of Brazil. On average, the state of Pernambuco registered 10 cases of

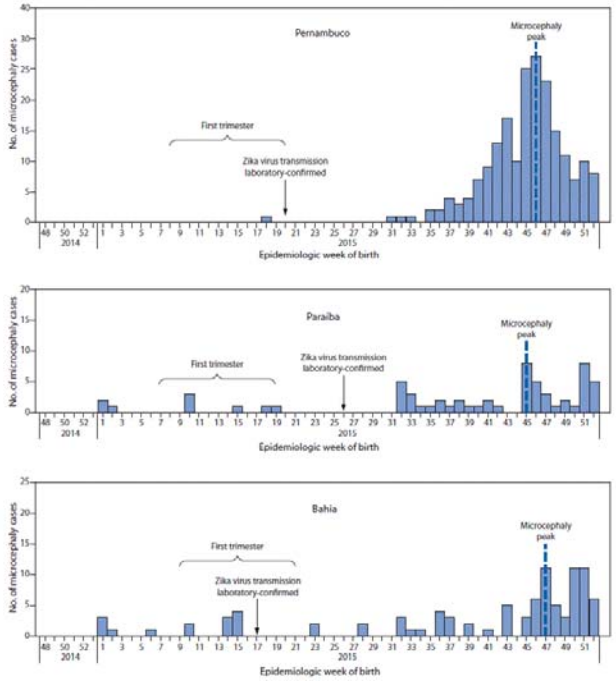
Microcephaly CIE-10: **Q02**

Microcephaly is a neurological disorder in which the occipitofrontal circumference is smaller than that


Distribution of cumulative confirmed cases of microcephaly, Brazil as of 5 Mar 2016
Roraima
Pará
Amapá
Amazonas
Maranhão
Ceará
Rio Grande Do Norte
Piauí
Paraíba
Pernambuco
Alagoas
Sergipe
Acre
Rondônia
Mato Grosso
BRAZIL
Tocantins
Bahia
Goiás
Distrito Federal
Minas Gerais
Espírito Santo
São Paulo
Rio De Janeiro
Paraná
Santa Catarina
Rio Grande Do Sul
Microcephaly case count
States/Federal Districts with confirmed cases of Microcephaly
This cumulative confirmed data includes both microbiological confirmation of Zika AND radiological criteria of congenital infection. The latter probably includes other infection than Zika.
World Health Organization
0 250 500 km
Bahia
Ceará
Piauí
Paraiba
Rio Grande do Norte
Sergipe
Goias
Alagoas
Pernambuco
Number of cases
Year
2010
2011
2012
2013
2014
2015 (as of 21 Nov)


CDC

Number of reported cases of microcephaly in full-term newborns following laboratory-confirmed Zika virus transmission — Pernambuco, Paraíba, and Bahia states, Brazil, 2015



MMWR/ March 11, 2016 / 65(9);242–247

Known Causes of Microcephaly

- **Genetic mutations**
- **Exposure to alcohol, drugs or toxic chemicals during pregnancy**
- **Malnutrition during pregnancy**
- **Infections, such as rubella, during pregnancy**
- **Lack of blood supply to the fetal brain**

Factors in Zika Virus Infection in Pregnancy

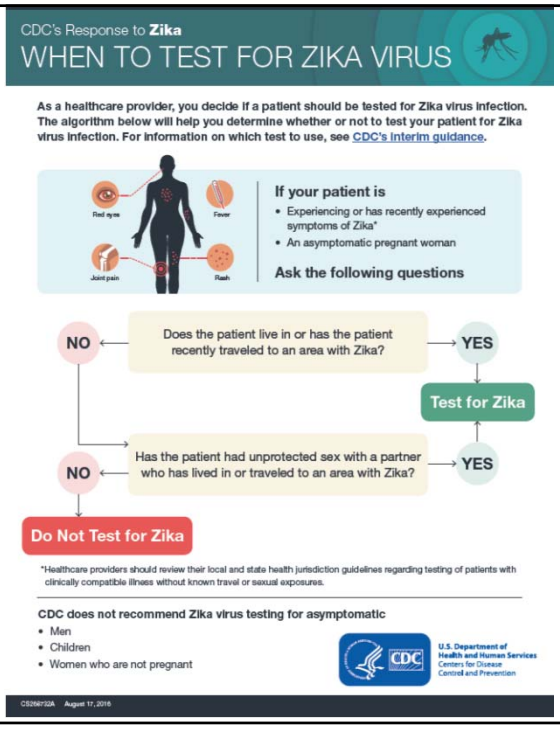
- Viremia
- Gestational age
- Transplacental transmission
- Placental infection
- Congenital infection
- Antibody – specific and cross-reactive

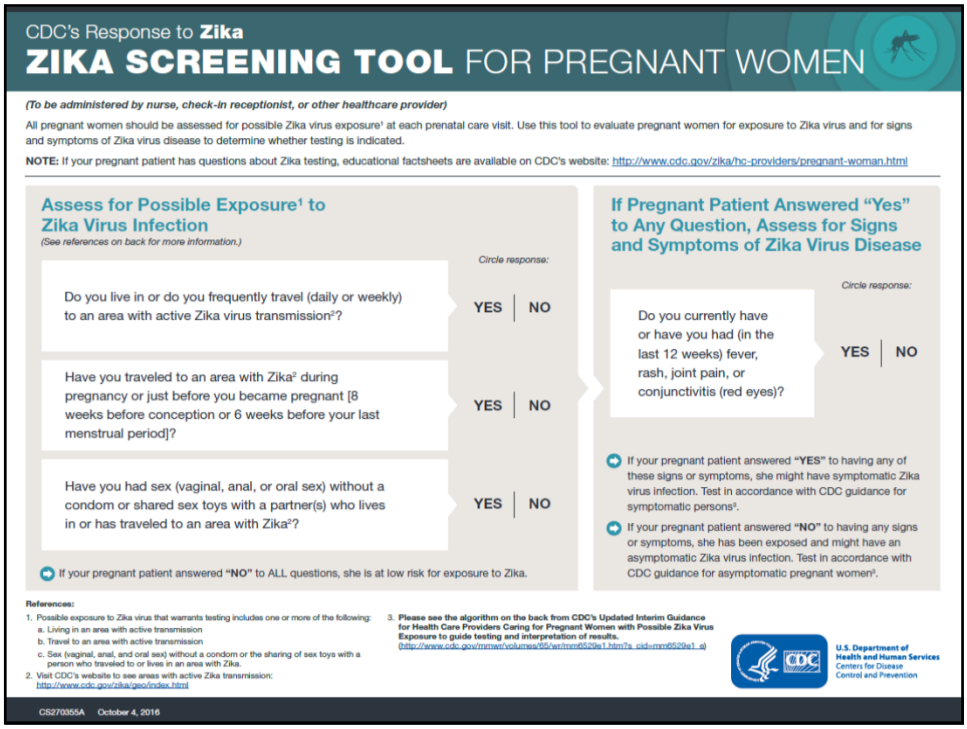
Why Microcephaly? Why Now?

- Not noticed before
- Immunity acquired in childhood
- Interaction with other factor
  - Infection due to related viruses
- Change in the virus

More Than Microcephaly

- ❖Retinal lesions
- ❖Sensorineural hearing loss
- ❖Arthrogryposis
- ❖Neuropsychomotor developmental delay
- ❖Hydrops fetalis
- ❖Fetal demise, miscarriage





CDC's Response to **Zika**

ZIKA SCREENING TOOL FOR PREGNANT WOMEN

(To be administered by nurse, check-in receptionist, or other healthcare provider)

All pregnant women should be assessed for possible Zika virus exposure[1] at each prenatal care visit. Use this tool to evaluate pregnant women for exposure to Zika virus and for signs and symptoms of Zika virus disease to determine whether testing is indicated.

NOTE: If your pregnant patient has questions about Zika testing, educational factsheets are available on CDC's website: http://www.cdc.gov/zika/hc-providers/pregnant-woman.html

Assess for Possible Exposure[1] to Zika Virus Infection

(See references on back for more information.)

Circle response:

Do you live in or do you frequently travel (daily or weekly) to an area with active Zika virus transmission[2]?	YES | NO
Have you traveled to an area with Zika[2] during pregnancy or just before you became pregnant [8 weeks before conception or 6 weeks before your last menstrual period]?	YES | NO
Have you had sex (vaginal, anal, or oral sex) without a condom or shared sex toys with a partner(s) who lives in or has traveled to an area with Zika[2]?	YES | NO

➡ If your pregnant patient answered **"NO"** to ALL questions, she is at low risk for exposure to Zika.

If Pregnant Patient Answered "Yes" to Any Question, Assess for Signs and Symptoms of Zika Virus Disease

Circle response:

Do you currently have or have you had (in the last 12 weeks) fever, rash, joint pain, or conjunctivitis (red eyes)?	YES | NO

➡ If your pregnant patient answered **"YES"** to having any of these signs or symptoms, she might have symptomatic Zika virus infection. Test in accordance with CDC guidance for symptomatic persons[3].

➡ If your pregnant patient answered **"NO"** to having any signs or symptoms, she has been exposed and might have an asymptomatic Zika virus infection. Test in accordance with CDC guidance for asymptomatic pregnant women[3].

References:

1. Possible exposure to Zika virus that warrants testing includes one or more of the following:
   a. Living in an area with active transmission
   b. Travel to an area with active transmission
   c. Sex (vaginal, anal, and oral sex) without a condom or the sharing of sex toys with a person who traveled to or lives in an area with Zika.
2. Visit CDC's website to see areas with active Zika transmission: http://www.cdc.gov/zika/geo/index.html
3. **Please see the algorithm on the back from CDC's Updated Interim Guidance for Health Care Providers Caring for Pregnant Women with Possible Zika Virus Exposure to guide testing and interpretation of results.** (http://www.cdc.gov/mmwr/volumes/65/wr/mm6529e1.htm?s_cid=mm6529e1_e)

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

CS270355A October 4, 2016

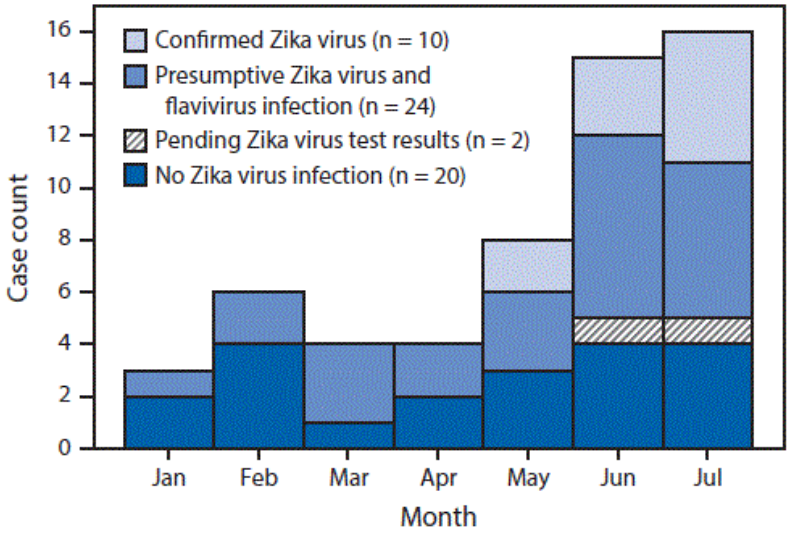
Suggested timeframe to wait before trying to get pregnant		
Possible exposure via recent travel or sex without a condom with a partner infected with Zika		
Women		**Men**
Wait at least 8 weeks after symptoms start or last possible exposure		Wait at least 6 months after symptoms start or last possible exposure
People living in or frequently traveling to areas with Zika		
	Women	**Men**
Positive Zika test	Wait at least 8 weeks after symptoms start	Wait at least 6 months after symptoms start
No testing performed or negative test	Talk with doctor or healthcare provider	Talk with doctor or healthcare provider

Zika Prevention Kit for Pregnant Women

- **A** - Permethrin spray repellent for treating clothing
- **B** - Treatment tabs for preventing mosquitoes from breeding in standing water
- **C** - EPA-registered insect repellent
- **D** - Condoms to prevent sexual transmission of Zika
- **E** - Mosquito bed Net
- **F** - Educational materials in English and Spanish

Reported cases of confirmed and suspected Guillain-Barré syndrome (n = 56), by Zika virus laboratory result and month of onset of neurologic signs — Puerto Rico, January 1–July 31, 2016

(MMWR/Early Release/August 26, 2016/65)



Guillain Barré Syndrome

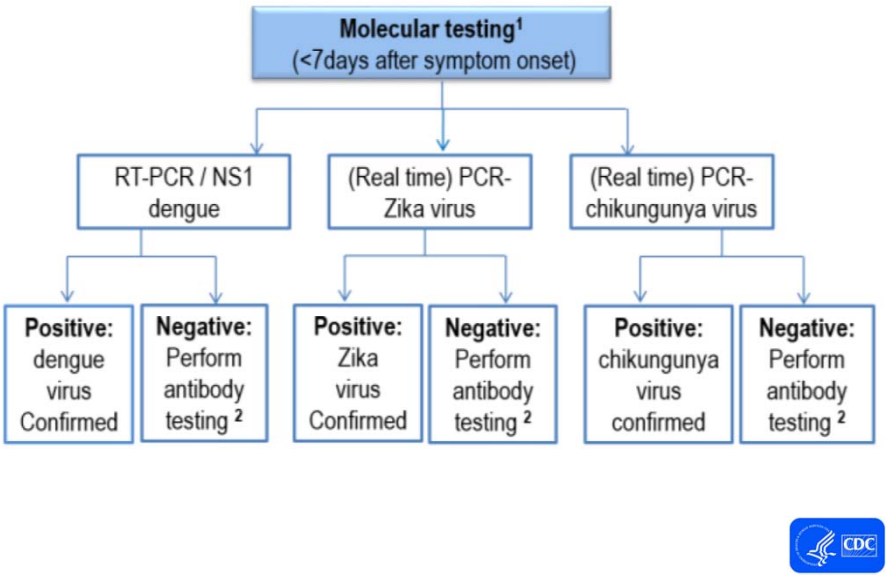
- Acute inflammatory demyelinating polyneuropathy (AIDP)
  - AIDP with secondary degeneration
- Acute motor axonal neuropathy (AMAN)
  - Acute motor sensory axonal neuropathy (AMSAN)
- Miller Fisher syndrome
  - Cranial nerve involvement, ataxia

Guillain-Barré Disability Scale

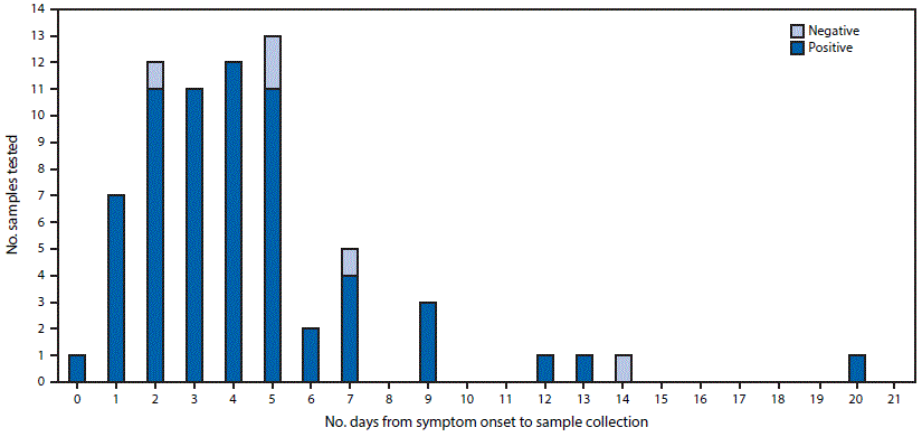
0	Healthy
1	Minor symptoms or signs of neuropathy but capable of manual work/capable of running
2	Able to walk without support of a stick (5 m across an open space) but incapable of manual work/running
3	Able to walk with a stick, appliance of support (5 m across an open space)
4	Confined to bed or chair bound
5	Requiring assisted ventilation (for any part of the day or night)
6	Death

Zika Virus Infection

- Asymptomatic (80%)
- Symptomatic (20%)
  - Fever, rash, conjunctivitis
  - Congenital infection
  - Guillain Barré syndrome
  - Uveitis
  - Encephalitis
  - Thrombocytopenia



Results of RT-PCR testing for Zika virus RNA in urine specimens of 70 persons with travel-associated Zika virus disease, by number of days after onset of symptoms — Florida, 2016

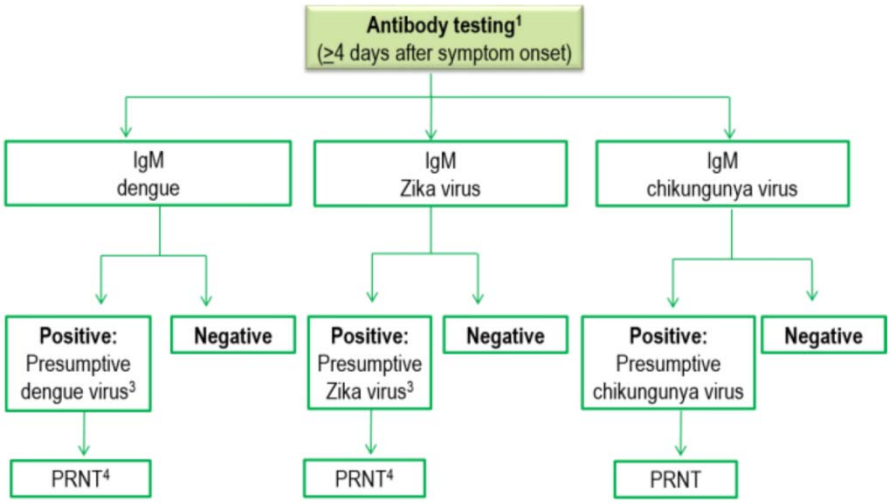


MMWR Morb Mortal Wkly Rep 2016; 65

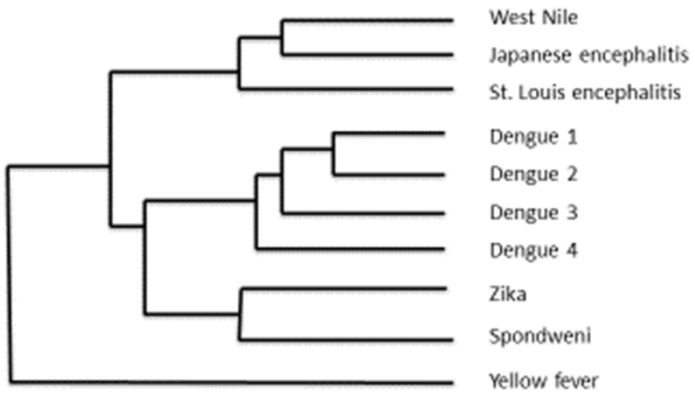
CDC

Prolonged Zika Viral Detection (PCR) (as of 11/22/2016)

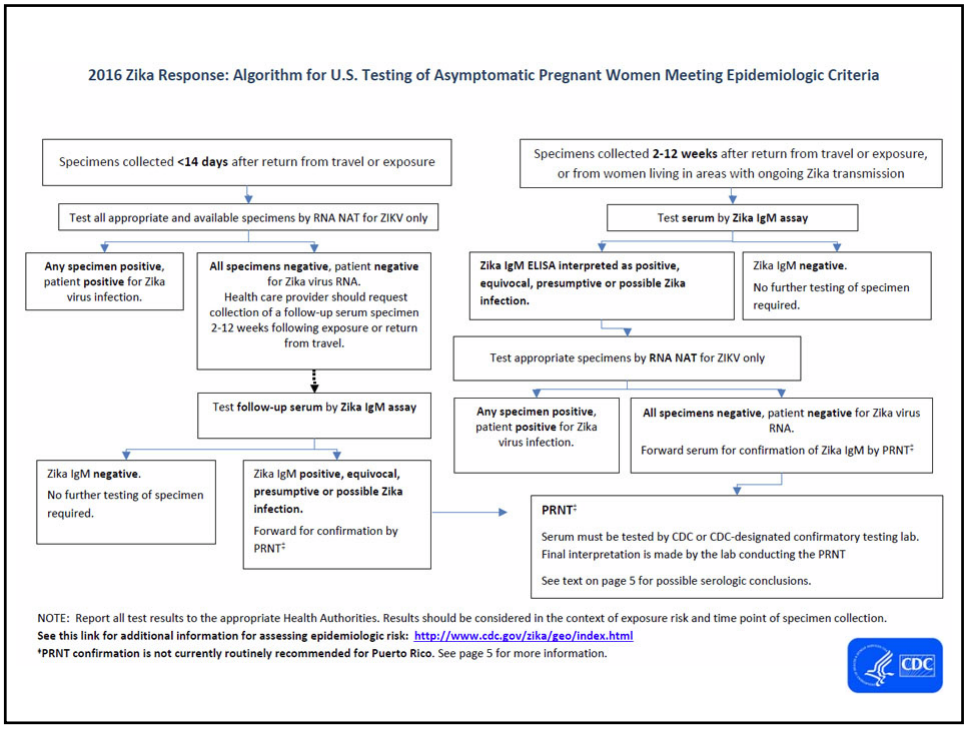
- Serum (7-14 days)
- Whole blood - RBCs (58-81 days)
- Viremia in pregnant women (53 days)
- Newborn (54 days)
- Semen (62-188 days)
- Vaginal fluid (14 days)
- Saliva (91 days)
- Urine (91 days)
- Breast milk (4 days)



Phlogenetic Tree of Mosquitoborne Flaviviruses



After Lazear and Diamond, 2016



Interpretation of results of antibody testing for suspected Zika virus infection - United States, 2016			
Zika virus and dengue virus IgM ELISA	**Zika virus PRNT**	**Dengue virus PRNT**	**Interpretation**
Positive or equivocal (either assay)	≥10	<10	Recent Zika virus infection
Positive or equivocal (either assay)	<10	≥10	Recent dengue virus infection
Positive or equivocal (either assay)	≥10	≥10	Recent flavivirus infection; specific virus cannot be identified
Any result (either or both assays)	<10	<10	No evidence of Zika virus or dengue virus infection
Inconclusive in one assay AND inconclusive or negative in the other	≥10	<10	Evidence of Zika virus infection; timing cannot be determined
Inconclusive in one assay AND inconclusive or negative in the other	<10	≥10	Evidence of dengue virus infection; timing cannot be determined
Inconclusive in one assay AND inconclusive or negative in the other	≥10	≥10	Evidence of flavivirus infection; specific virus and timing cannot be determined

Zika Virus Modes of Transmission

- **Established**
  - **Mosquitoborne**
  - **Transplacental**
  - **Intrapartum**
  - **Sexual - male to female, male to male, female to male**
  - **Blood and body fluid – laboratory needlestick, caregiver**
  - **Transfusion**
- **Theoretical**
  - **Organ or tissue transplantation**
  - **Breast milk**

Revised Recommendations for Reducing the Risk of Zika Virus Transmission by Blood and Blood Components

Guidance for Industry

This guidance is for immediate implementation.

FDA is issuing this guidance for immediate implementation in accordance with 21 CFR 10.115(g)(2) without initially seeking prior comment because the agency has determined that prior public participation is not feasible or appropriate.

FDA invites comments on this guidance. Submit one set of either electronic or written comments on this guidance at any time. Submit electronic comments to http://www.regulations.gov. Submit written comments to the Division of Dockets Management (HFA-305), Food and Drug Administration, 5630 Fishers Lane, Rm. 1061, Rockville, MD 20852. You should identify all comments with the docket number listed in the notice of availability that publishes in the *Federal Register*. FDA will review any comments we receive and revise the guidance when appropriate.

Additional copies of this guidance are available from the Office of Communication, Outreach and Development (OCOD), 10903 New Hampshire Ave., Bldg. 71, Rm. 3128, Silver Spring, MD 20993-0002, or by calling 1-800-835-4709 or 240-402-8010, or email ocod@fda.hhs.gov, or from the Internet at http://www.fda.gov/BiologicsBloodVaccines/GuidanceComplianceRegulatoryInformation/Guidances/default.htm.

For questions on the content of this guidance, contact OCOD at the phone numbers or email address listed above.

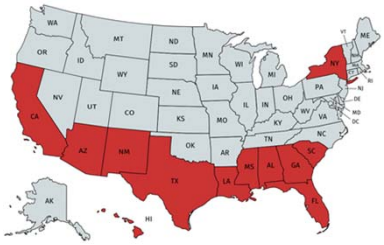
U.S. Department of Health and Human Services
Food and Drug Administration
Center for Biologics Evaluation and Research
August 2016

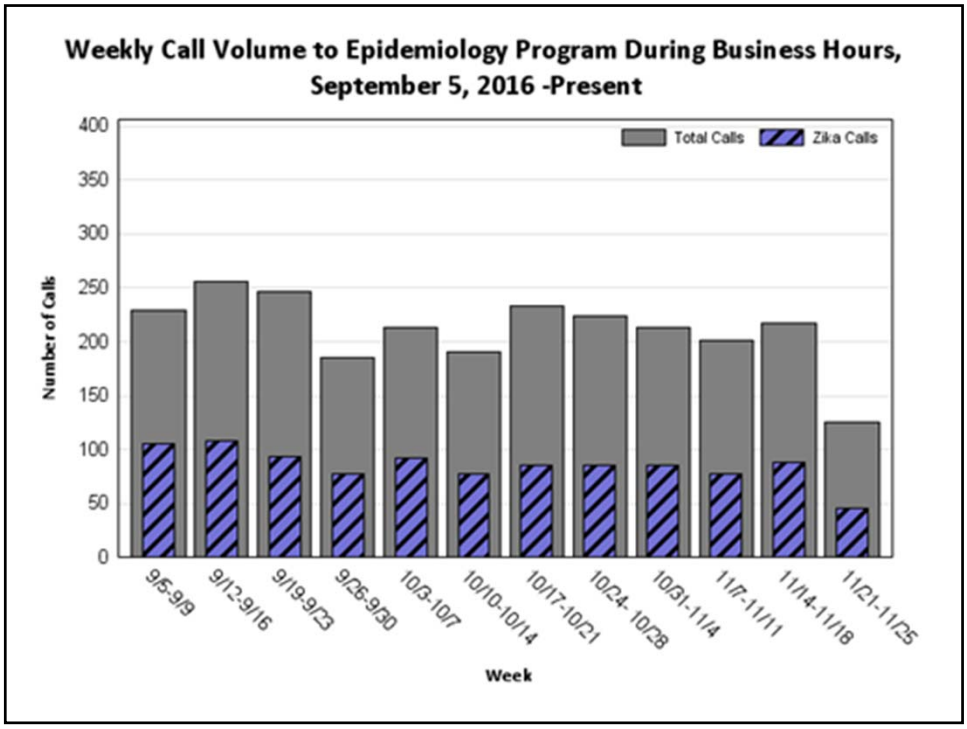
Individual donor NAT

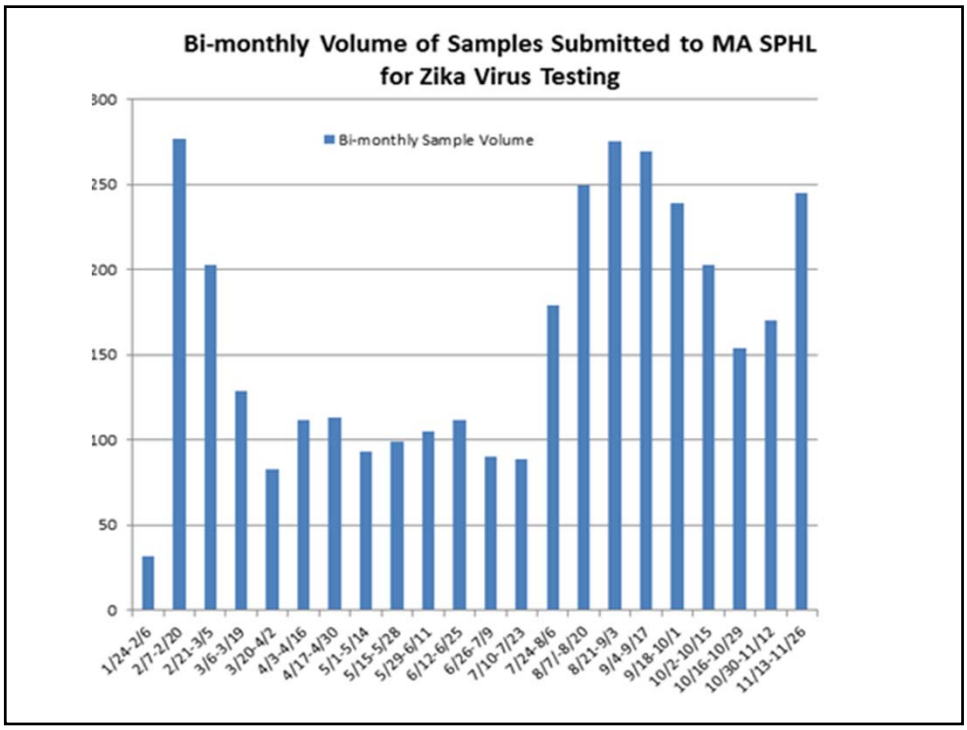
Phase in Florida, Puerto Rico and in 11 other states in 4 weeks and all by 12 weeks

120 day deferral and "look-back"

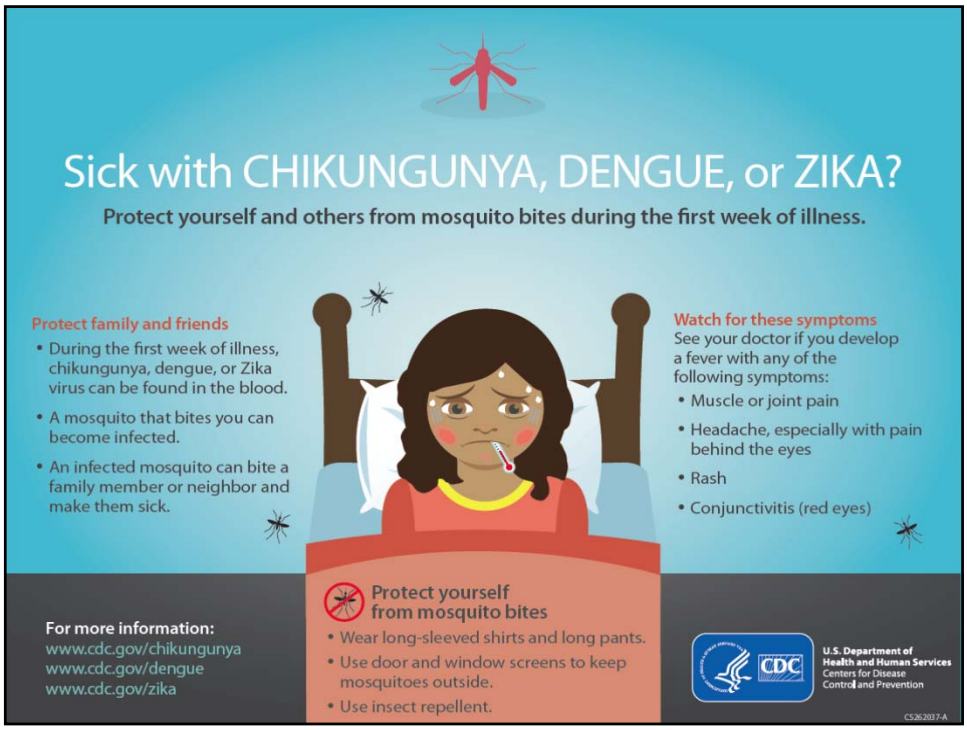
No travel screen with ID NAT

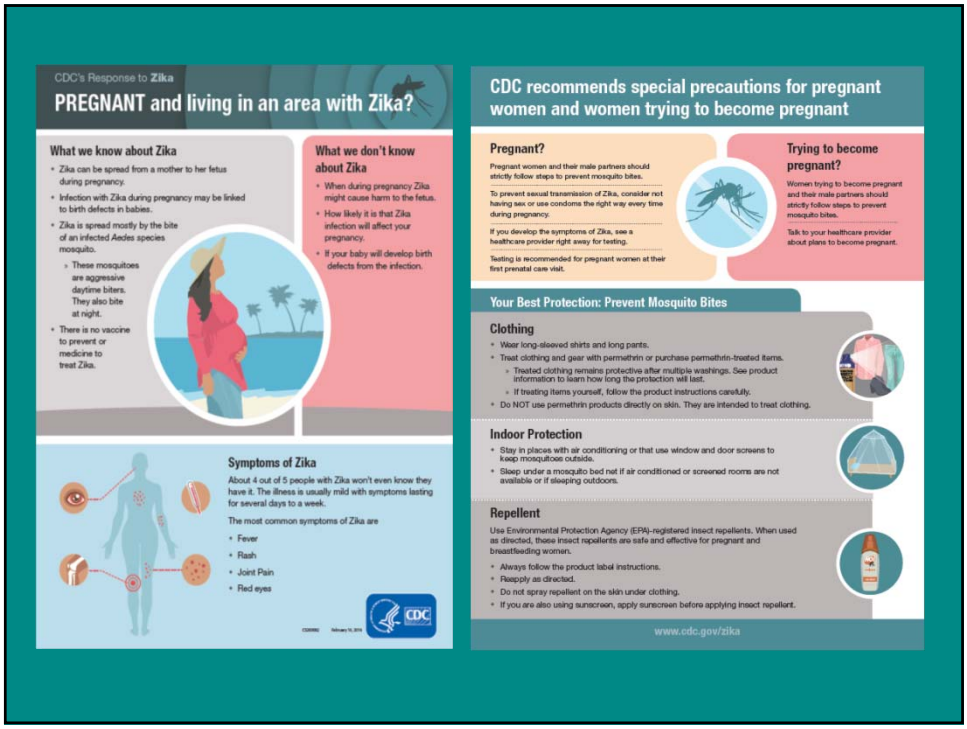



Weekly Call Volume to Epidemiology Program During Business Hours, September 5, 2016 -Present
Total Calls
Zika Calls
Number of Calls
400
350
300
250
200
150
100
50
0
9/5-9/9
9/12-9/16
9/19-9/23
9/26-9/30
10/3-10/7
10/10-10/14
10/17-10/21
10/24- 10/28
10/31-11/4
11/7-11/11
11/14-11/18
11/21-11/25
Week

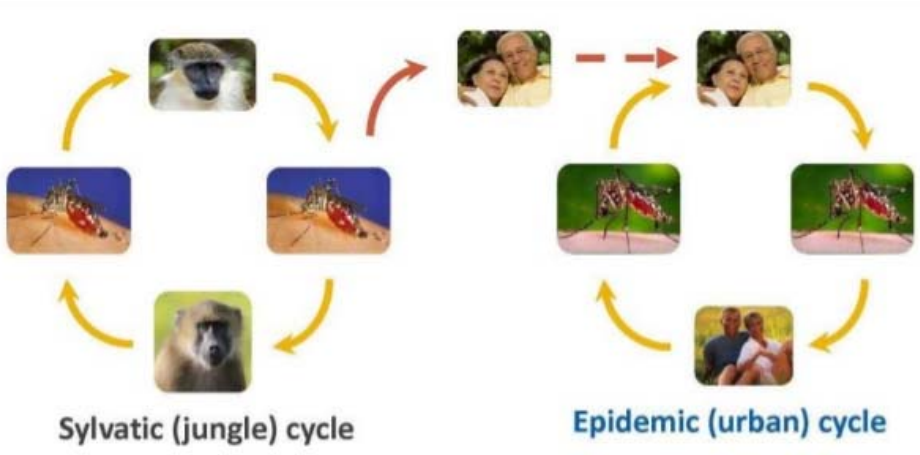

Bi-monthly Volume of Samples Submitted to MA SPHL for Zika Virus Testing
Bi-monthly Sample Volume
300
250
200
150
100
50
0
1/24-2/6
2/7-2/20
2/21-3/5
3/6-3/19
3/20-4/2
4/3-4/16
4/17-4/30
5/1-5/14
5/15-5/28
5/29-6/11
6/12-6/25
6/26-7/9
7/10-7/23
7/24-8/6
8/7/-8/20
8/21-9/3
9/4-9/17
9/18-10/1
10/2-10/15
10/16-10/29
10/30-11/12
11/13-11/26


PROTECT YOURSELF from MOSQUITO BITES
Mosquitoes spread chikungunya, dengue, and Zika viruses.
Mosquitoes that spread chikungunya, dengue, and Zika are aggressive daytime biters.
Use insect repellent.
Look for the following active ingredients:
• DEET • PICARIDIN • IR3535
• OIL of LEMON EUCALYPTUS
• PARA-MENTHANE-DIOL
Wear long-sleeved shirts and long pants or use insect repellent. For extra protection, treat clothing with permethrin.

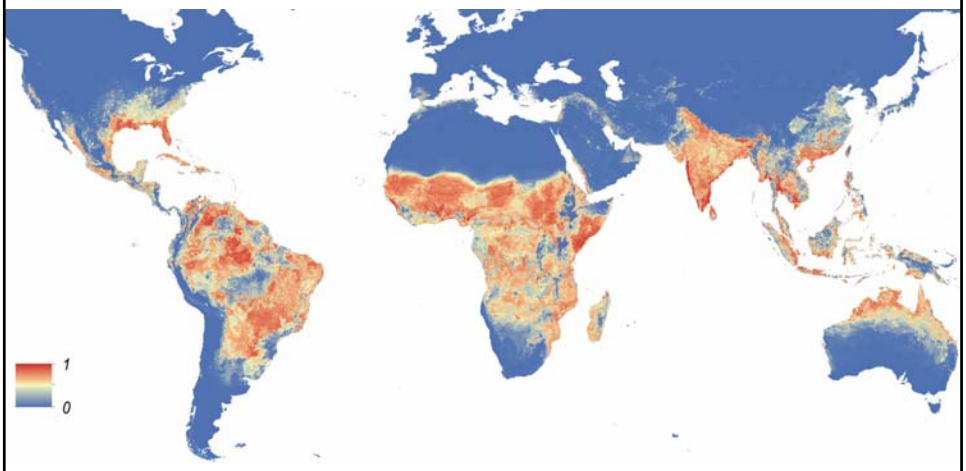

Sick with CHIKUNGUNYA, DENGUE, or ZIKA?
Protect yourself and others from mosquito bites during the first week of illness.
Protect family and friends
• During the first week of illness, chikungunya, dengue, or Zika virus can be found in the blood.
• A mosquito that bites you can become infected.
• An infected mosquito can bite a family member or neighbor and make them sick.
Watch for these symptoms
See your doctor if you develop a fever with any of the following symptoms:
• Muscle or joint pain
• Headache, especially with pain behind the eyes
• Rash
• Conjunctivitis (red eyes)
Protect yourself from mosquito bites
• Wear long-sleeved shirts and long pants.
• Use door and window screens to keep mosquitoes outside.
• Use insect repellent.
For more information:
www.cdc.gov/chikungunya
www.cdc.gov/dengue
www.cdc.gov/zika
CDC
U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
CS262037-A



Zika Virus Transmission Cycle



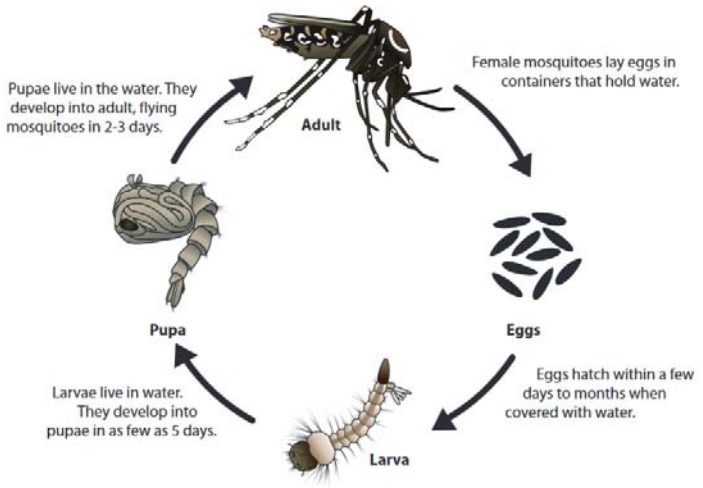
Global Distribution of *Aedes aegypti*



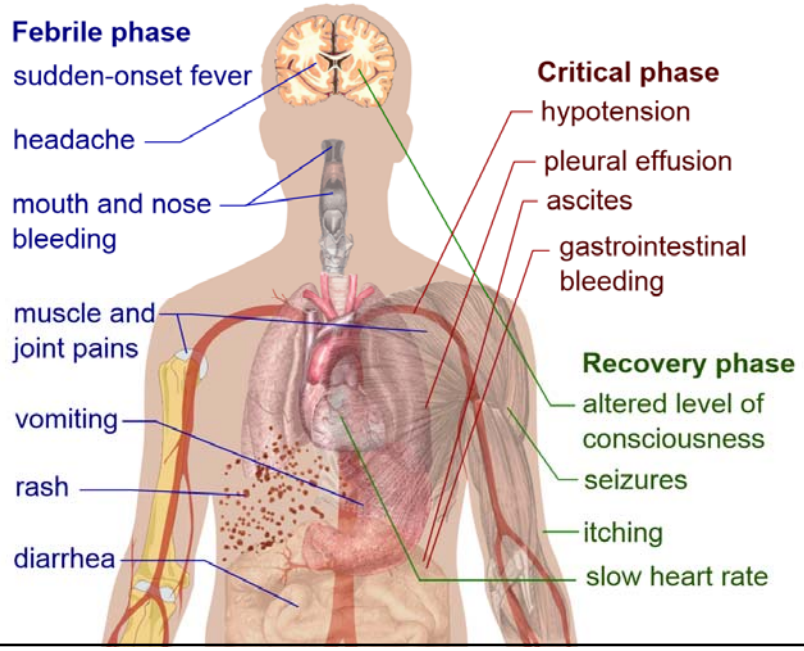
Kraemer et al. eLife 2015;4:e08347. DOI: 10.7554/eLife.08347

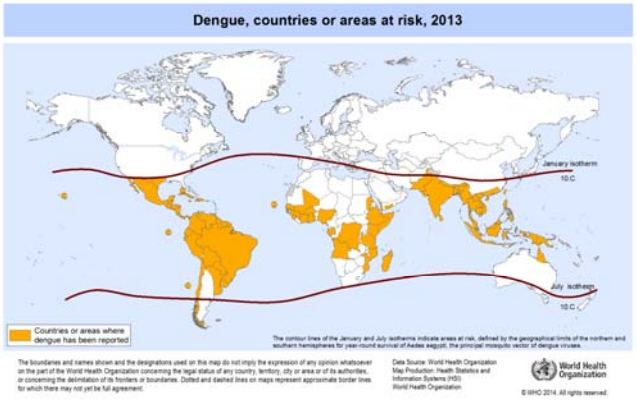
Aedes aegypti

It takes about 7-10 days for an egg to develop into an adult mosquito.

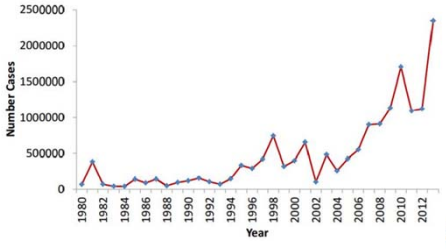


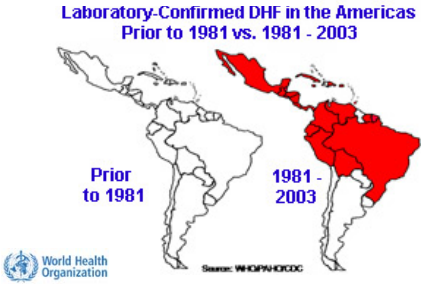
Dengue fever



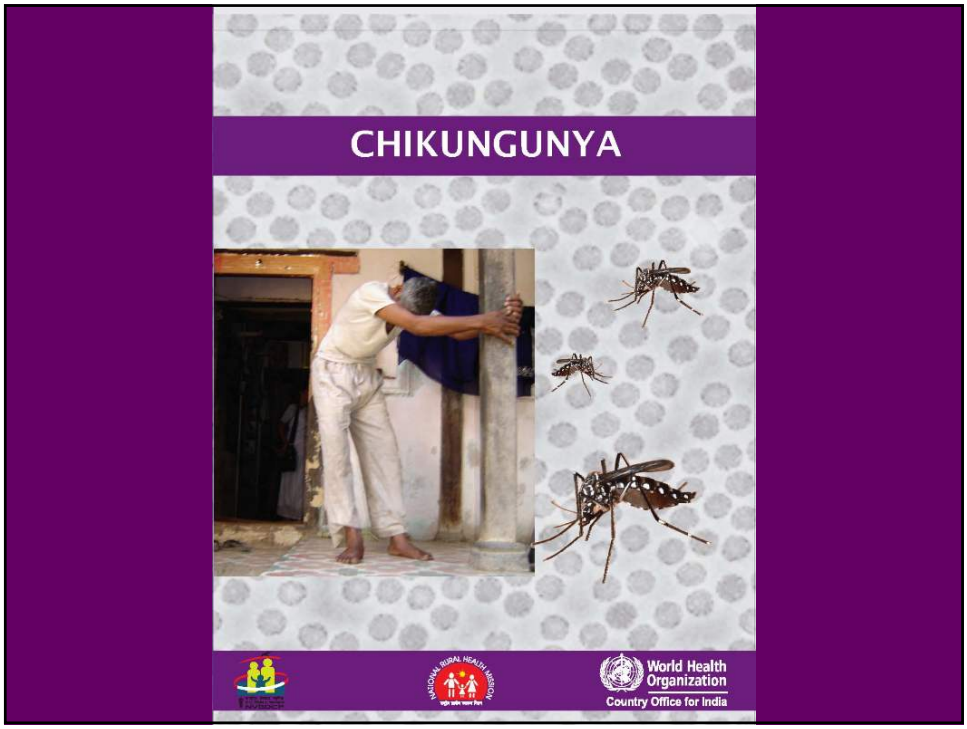


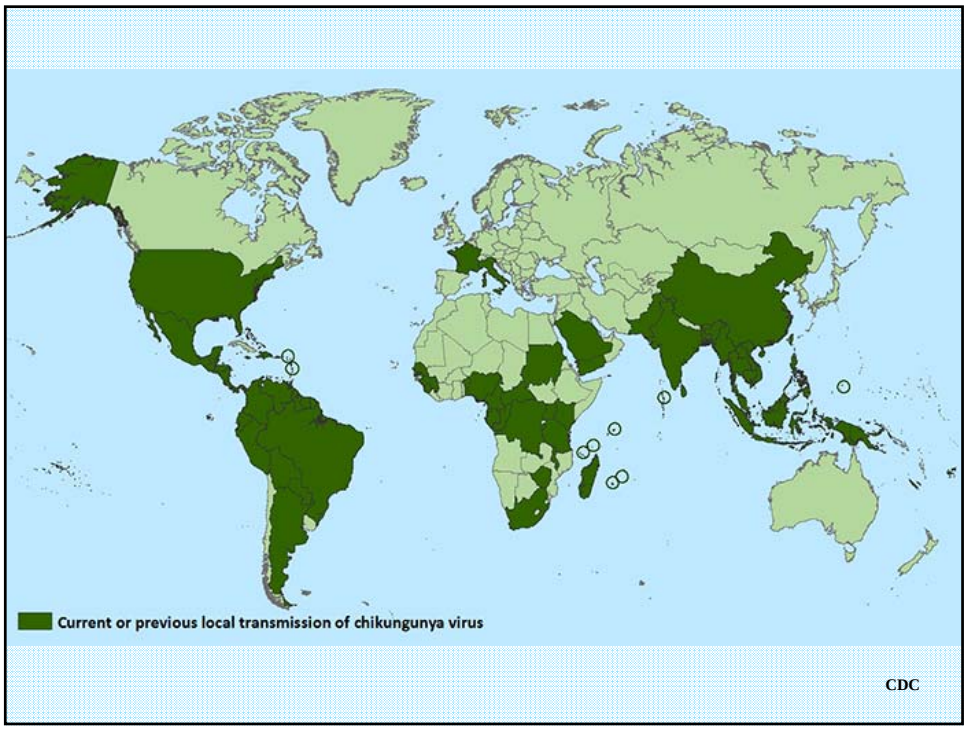
Dengue Virus Disease Incidence in the Americas

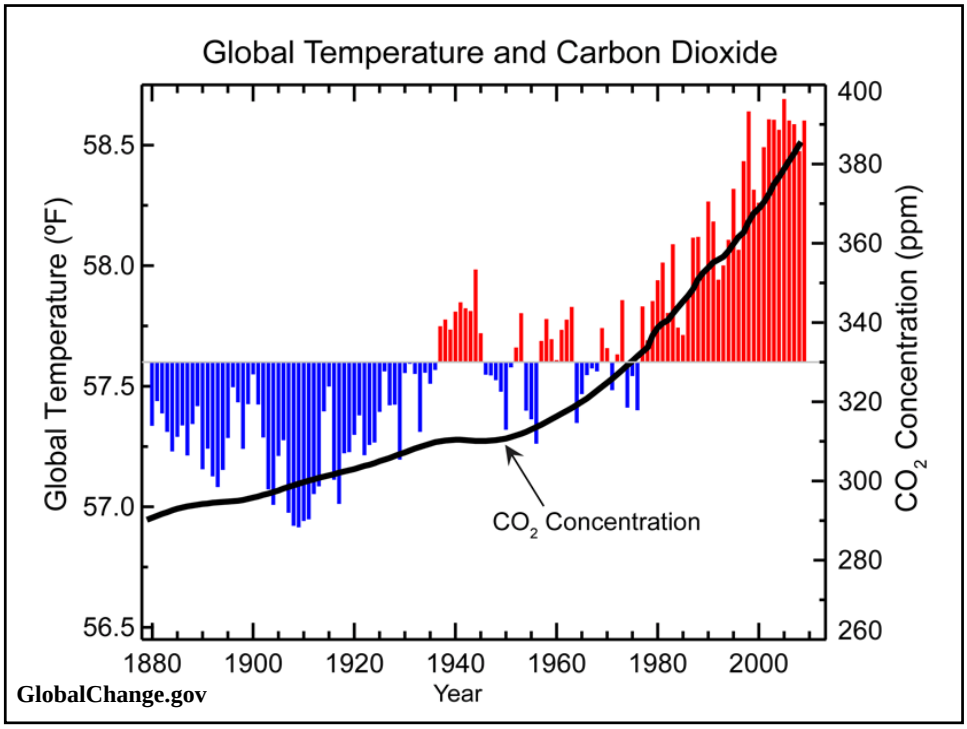




Areas with Yellow Fever

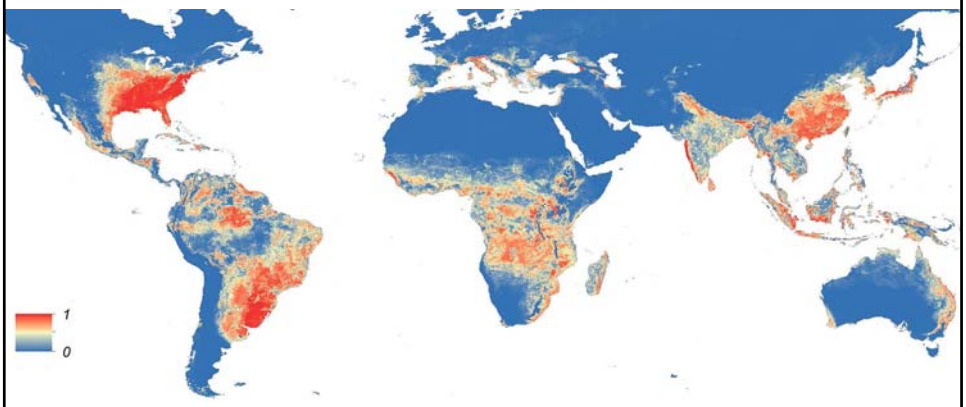

CHIKUNGUNYA
World Health Organization
Country Office for India


Current or previous local transmission of chikungunya virus
CDC

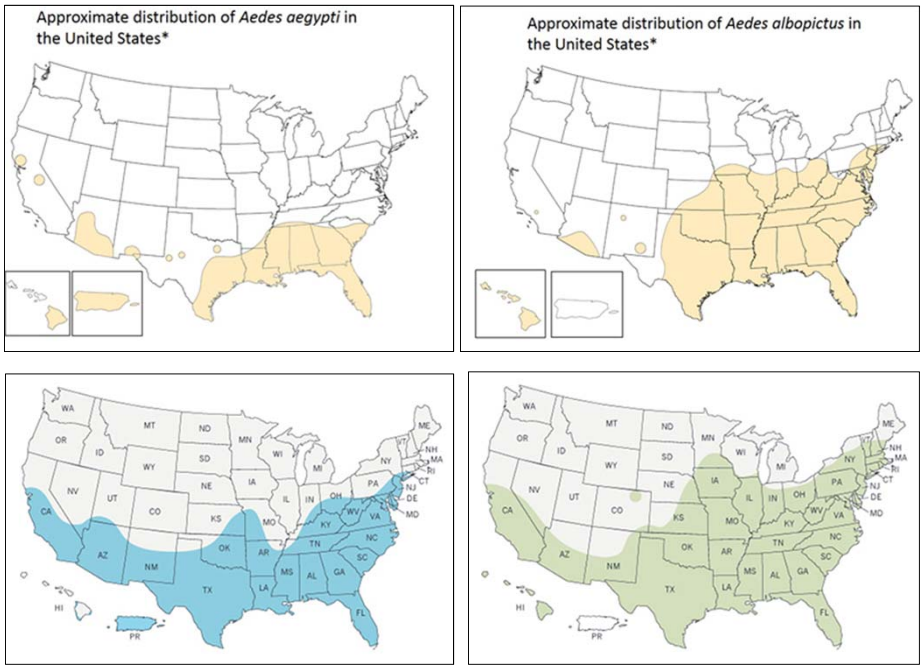

Global Temperature and Carbon Dioxide
Global Temperature (ºF)
58.5
58.0
57.5
57.0
56.5
400
380
360
340
320
300
280
260
CO2 Concentration (ppm)
CO2 Concentration
1880
1900
1920
1940
1960
1980
2000
Year
GlobalChange.gov


CDC

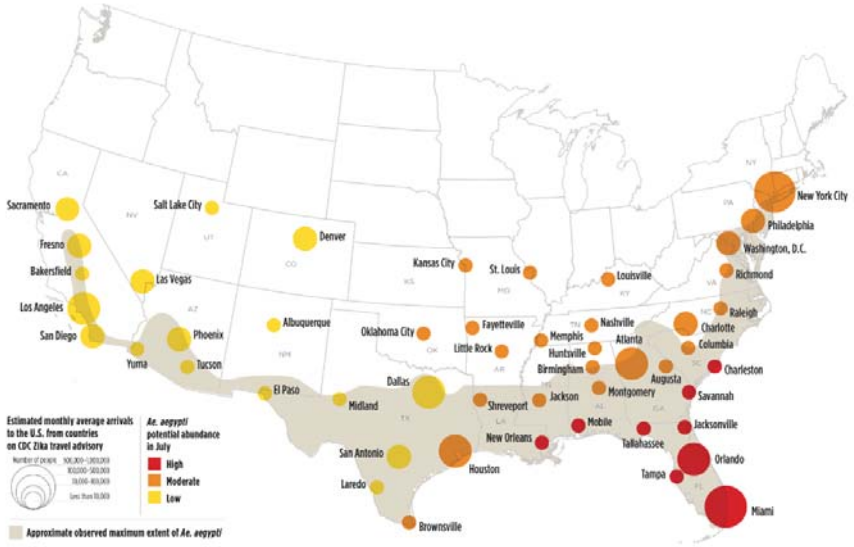
Global Distribution of *Aedes albopictus*



Kraemer et al. eLife 2015;4:e08347. DOI: 10.7554/eLife.08347

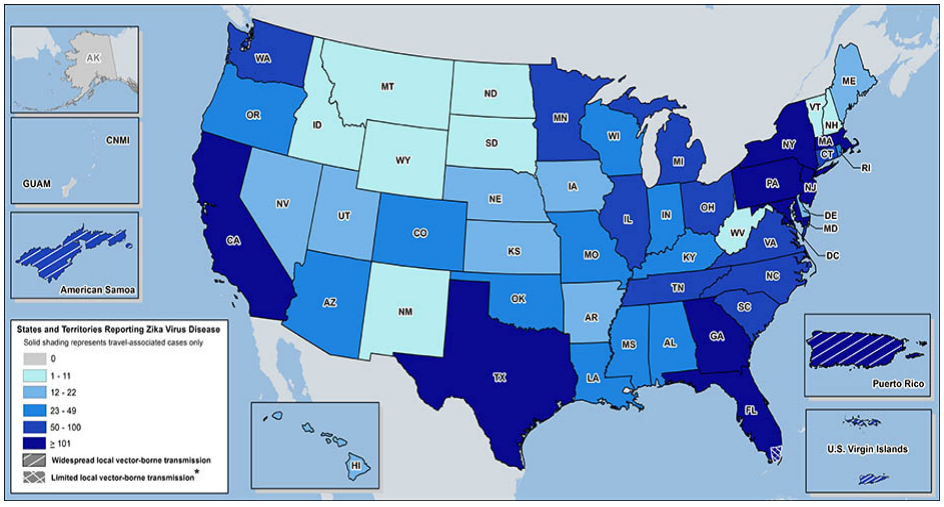


NASA Risk-Assessment Map Shows *Aedes aegypti* Potential Abundance for July and the Monthly Average Number Arrivals to the U.S. by Air and Land from Countries on the Center for Disease Control Zika Travel Advisory



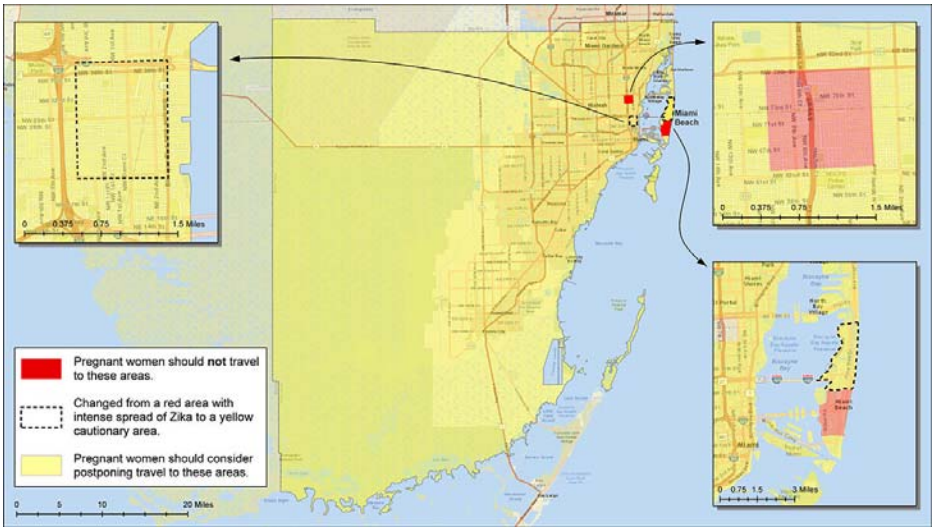
http://www.nasa.gov/topics/earth/index.html

Zika Cases Reported in the United States



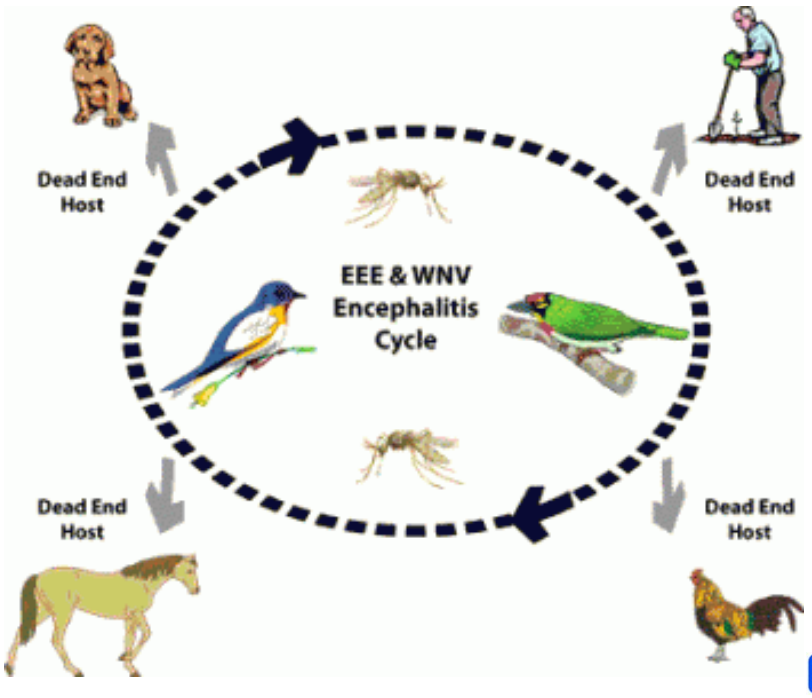
(as of November 23, 2016)

Active Zika Virus Transmission in Florida



Factors Related to Arbovirus Transmission

- **Reservoir host present**
- **Vector(s) present**
  - **Favorable climate**
  - **Habitat and food sources present**
- **Vectorial competence**
  - **Abundance**
  - **Bites reservoir host**
  - **Sustains virus replication**
  - **Virus incubation period consistent with life cycle and biting behavior**
  - **Pathogen reaches saliva**
- **Vectorial capacity**
  - **Physiology**
  - **Host preference**
  - **Biting behavior**
  - **Contact probability**



Transmission of Eastern Equine Encephalitis (EEE) Virus, West Nile Virus (WNV) and Zika Virus – Vectors and Vector Characteristics			
	EEE	**WNV**	**Zika**
Virus host reservoir	**Birds**	**Birds**	**Humans**
Amplifying vector(s)			
Primary species	***Culiseta melanura***	***Culex* species**	1. ***Aedes aegypti*** 2. ***A. albopictus***
Breeding habitat	**White cedar/red maple swamp**	**Puddles and containers, dirty water**	**Containers**
Transmitting vector(s)			
Primary species	***Coquillettidia perturbans, Aedes vexans*, other bridge mosquitoes**	***Culex* species**	1. ***Aedes aegypti*** 2. ***A. albopictus***
Primary host	**Mammals and birds**	**Birds**	1. **Humans** 2. **Mammals**
Breeding habitat	**Cattail swamps, flood plain**	**Puddles and containers, dirty water**	**Containers**
Habitat of adults	**Rural**	**Tree canopy, ubiquitous**	**Peridomestic**
Biting habits	**Dawn/dusk, outdoors; one host meal**	**Dawn/dusk, outdoors; one host meal**	**All day, indoor/outdoor; multiple host meal**


CDC

Prevention

- **Reduce mosquito exposure**
  - **Window and door screens**
  - **Mosquito netting**
  - **Staying indoors at peak mosquito times**
- **Reduce mosquito bites**
  - **Clothing**
  - **Repellents – use according to product label**
- **Reduce mosquitoes**
  - **Reduce standing water**
  - **Mosquito control**
    - **Reduce breeding environment**
    - **Larvicide**
    - **Adulticide**

Mosquito Repellents

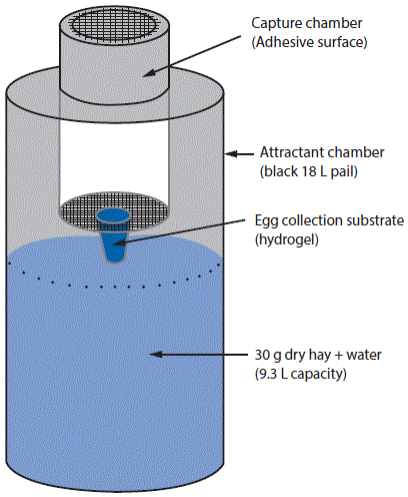
- **DEET (N-N-diethyl-meta-toluamide)**
  - **Should not be used on infants under two months of age and should be used in concentrations of 30% or less on older children**
- **Picaridin (KBR 3023)**
- **IR3535 (3-[N-butyl-N-acetyl]-aminopropionic acid)**
- **Oil of lemon eucalyptus [p-menthane 3, 8-diol (PMD)]**
  - **Should not be used on children under three years of age**
- **Permethrin**
  - **Intended for use on items such as clothing, shoes, bed nets and camping gear and should not be applied to skin**

Mosquito Control Methods Under Development

- **Pathogenic fungal larvicides**
- **Release of insects with dominant lethality**
  - **Female-specific late-acting flightless phenotype**
- **Toxic sugar baits**
- **Symbionts that block transmission**
  - ***Wolbachia* species**
- **Anti-pathogen genes**
- **Indoor residual spraying, curtains**
- **Lethal ovitraps**
- **Auto-dissemination of insecticide**
- **Molecular and other new insecticides**


CENTRAL MASSACHUSETTS
MOSQUITO CONTROL PROJECT
MOSQUITO
OVITRAP
Figure 1

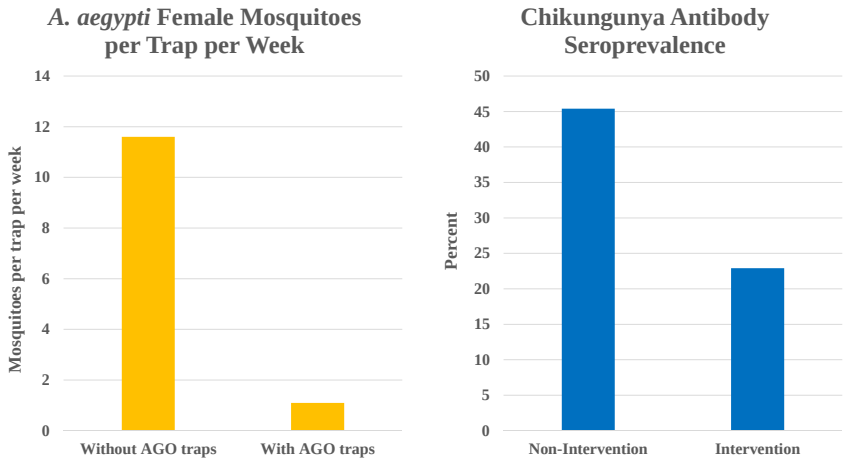
Diagram of an Autocidal Gravid Ovitrap used to attract and capture female *Aedes aegypti* mosquitoes



Mackay AJ, Amador M, Barrera R. An improved autocidal gravid ovitrap for the control and surveillance of Aedes aegypti. Parasit Vectors 2013;6:225.

Reduced Incidence of Chikungunya Virus Infection in Communities with Ongoing *Aedes Aegypti* Mosquito Trap Intervention Studies - Salinas and Guayama, Puerto Rico, November 2015 - February 2016

MMWR, May 13, 2016 / 65(18)

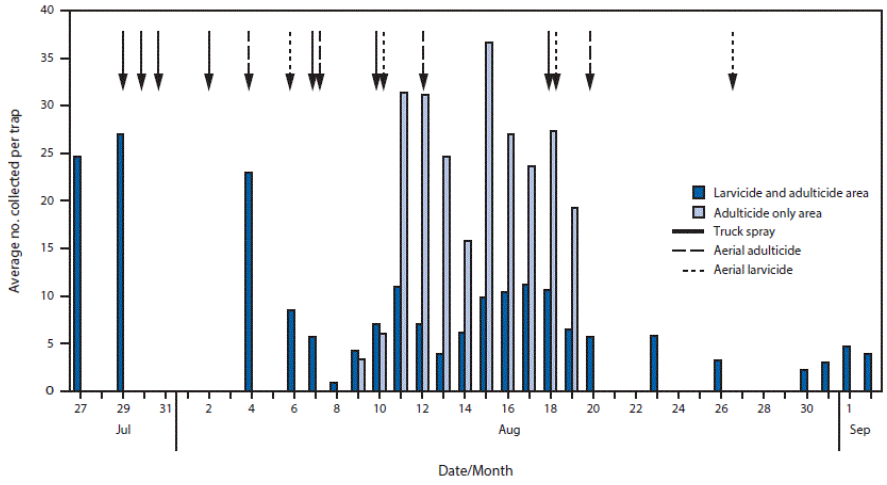


CDC: Photo courtesy of Ed Freytag, City of New Orleans Mosquito & Termite Control Board

CDC: Photo courtesy of Ed Freytag, City of New Orleans Mosquito & Termite Control Board

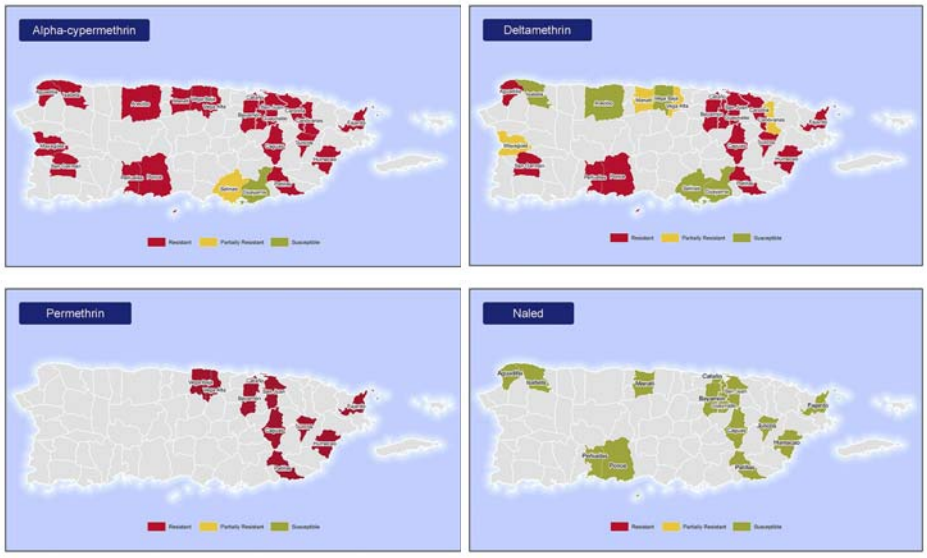
Average number of adult female Aedes aegypti mosquitoes collected per trap, by date

Miami-Dade County, Florida, July–August 2016



MMWR Morb Mortal Wkly Rep 2016;65:1032-1038.

Insecticide Resistance Testing in Puerto Rico (CDC)



What's Next in Mosquitoes?

Togaviruses

- Eastern equine
- Western equine
- Venezuelan
- Chikungunya
- Mayaro
- Sindbis
- Ross River

Bunyaviruses

- California group
  (LaCrosse, Jamestown Canyon, etc.)
- Cache Valley
- Tensaw
- Rift Valley

Flaviviruses

- West Nile
- St. Louis
- Dengue
- Yellow fever
- Zika
- Spondweni
- Usutu
- Japanese
- Murray Valley

Here before 1999
Here since 1999
Could come
Unlikely?

Number of People Killed by Animals Per Year (gatesnotes.com)