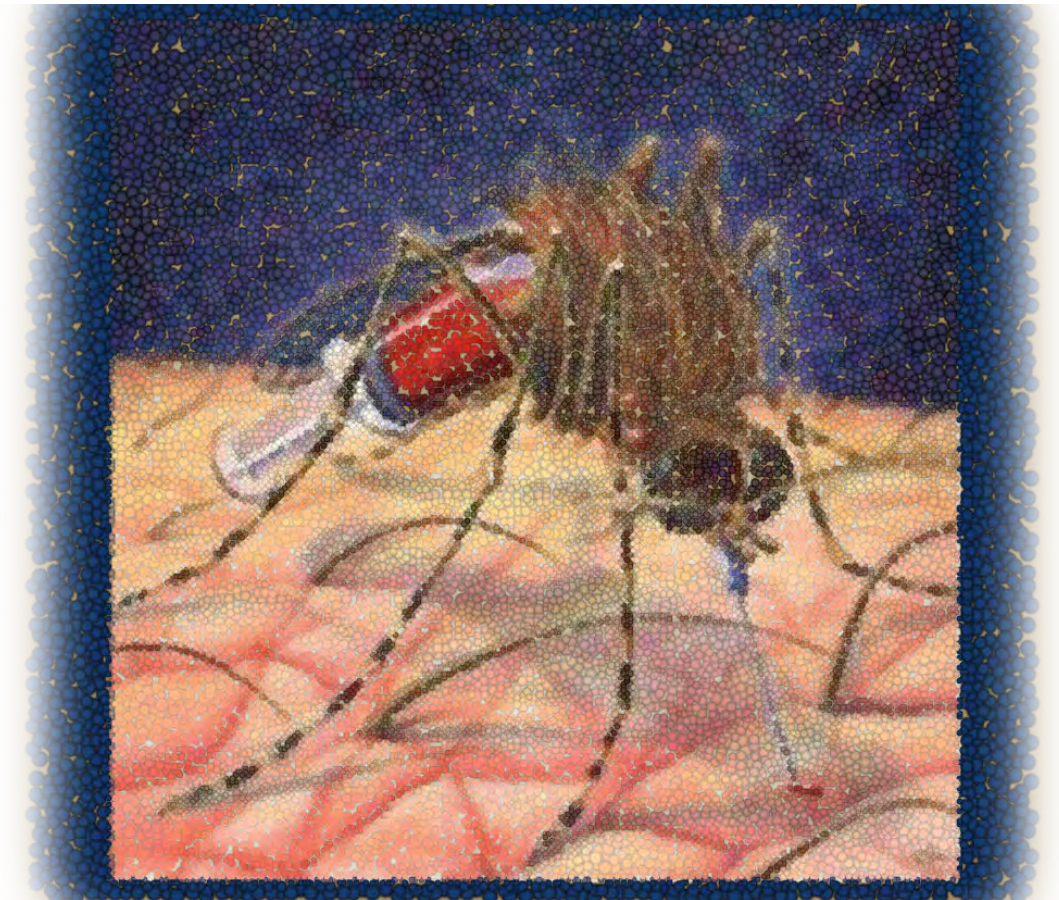

A Primer on Vector-Borne Disease

JOSEPH FAUVER, PH.D.
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UNMC COPH DEPARTMENT OF EPIDEMIOLOGY
UNMC Ag Med Course
7/19/2023



Outline

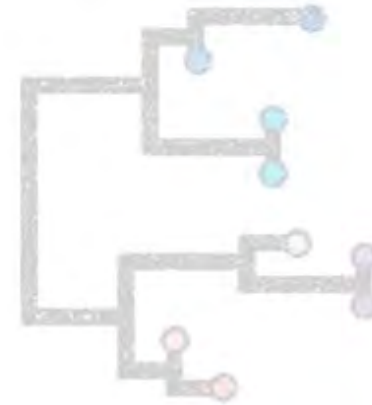
- Introduction
- What are Vector-Borne Diseases (VBD)?
- History of VBDs and VBDs in the US
- Current Statistics and Risk Estimates
- VBD Control and Prevention
- Questions



Pathogens, genomics, and global health

The Fauver Lab

UNMC College of Public Health



thefauverlab.com



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People, Places, and Parasites



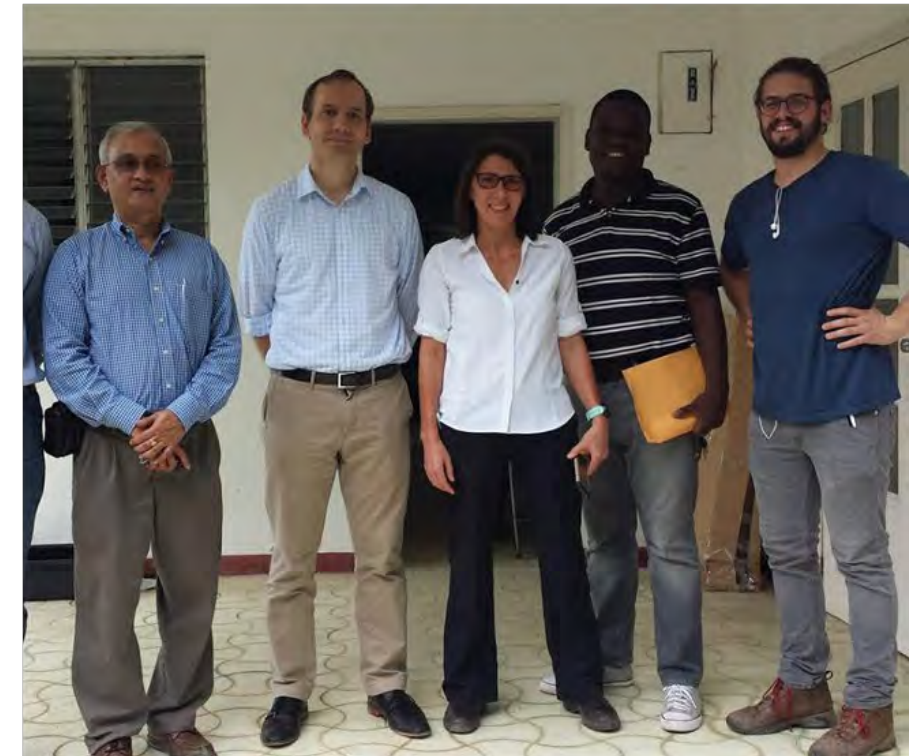
Tapachula, Mexico

Cap-Haitien, Haiti

Foya, Liberia

Tambolaka, Indonesia

People, Places, and Parasites



What are Vector-Borne Diseases?

- Vector-borne diseases are human, animal, or plant illnesses caused by parasites, viruses and bacteria that are transmitted by vectors.

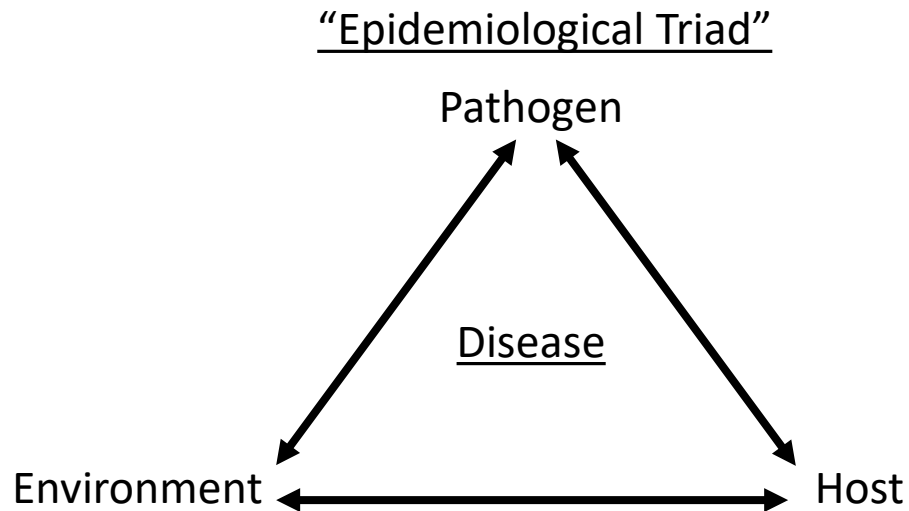
What are Vector-Borne Diseases?

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What are Vector-Borne Diseases?

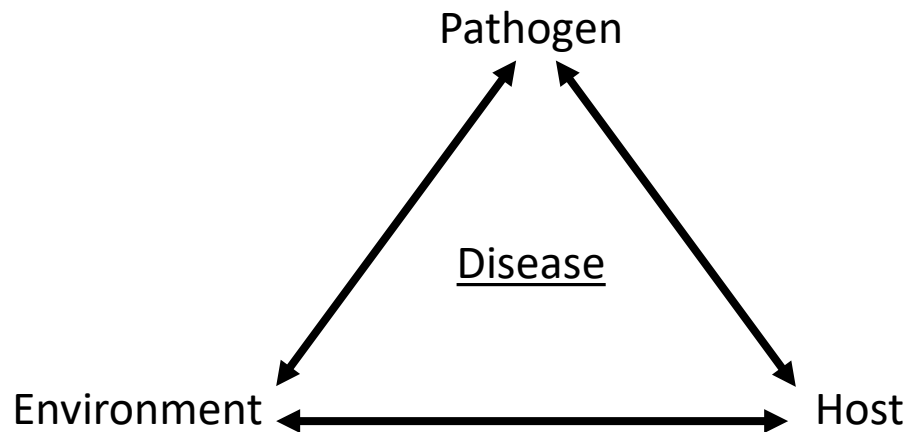
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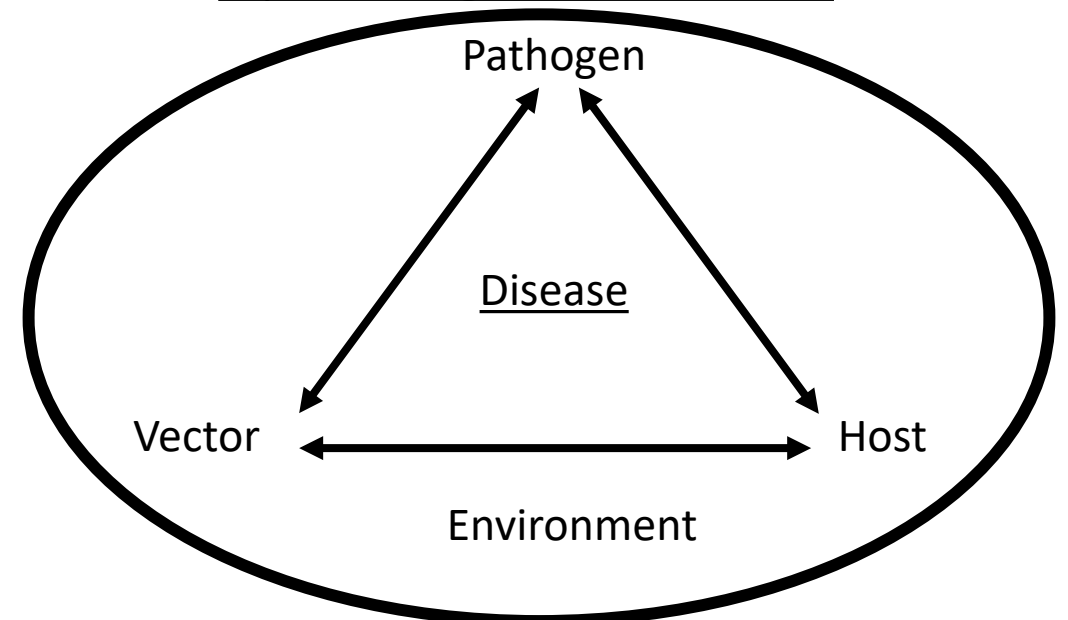
What are Vector-Borne Diseases?

- Vector-borne diseases are human, animal, or plant illnesses caused by parasites, viruses and bacteria (pathogens) that are transmitted by vectors.

“Epidemiological Triad”

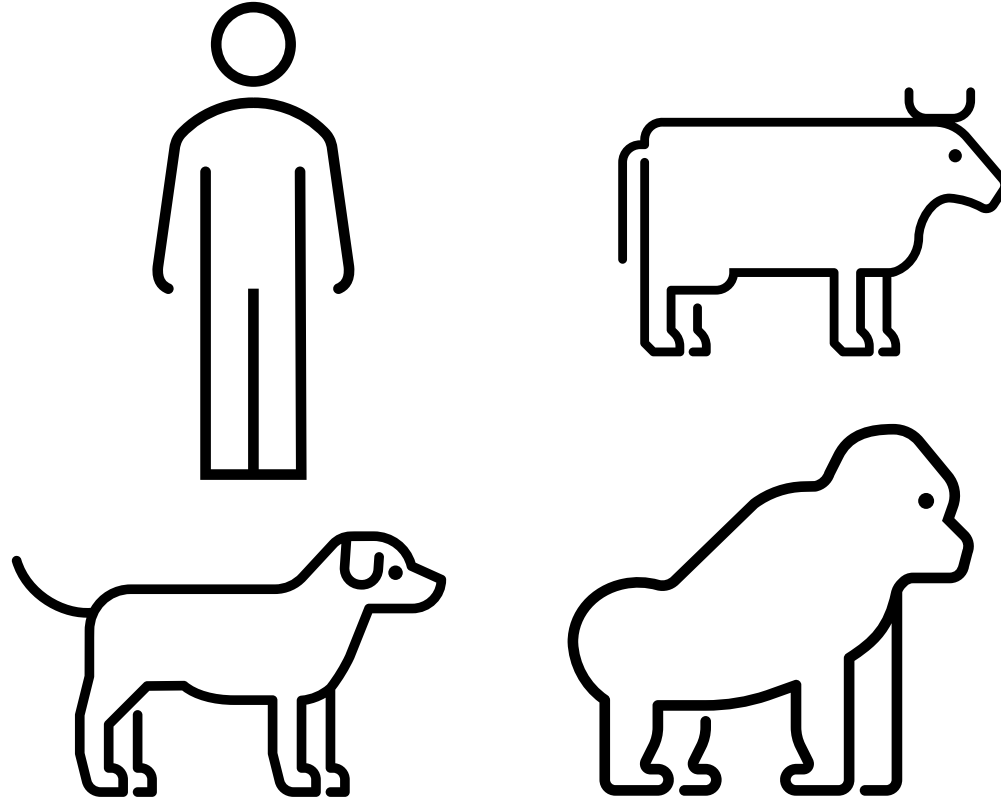


“Epidemiological Triad for VBD”



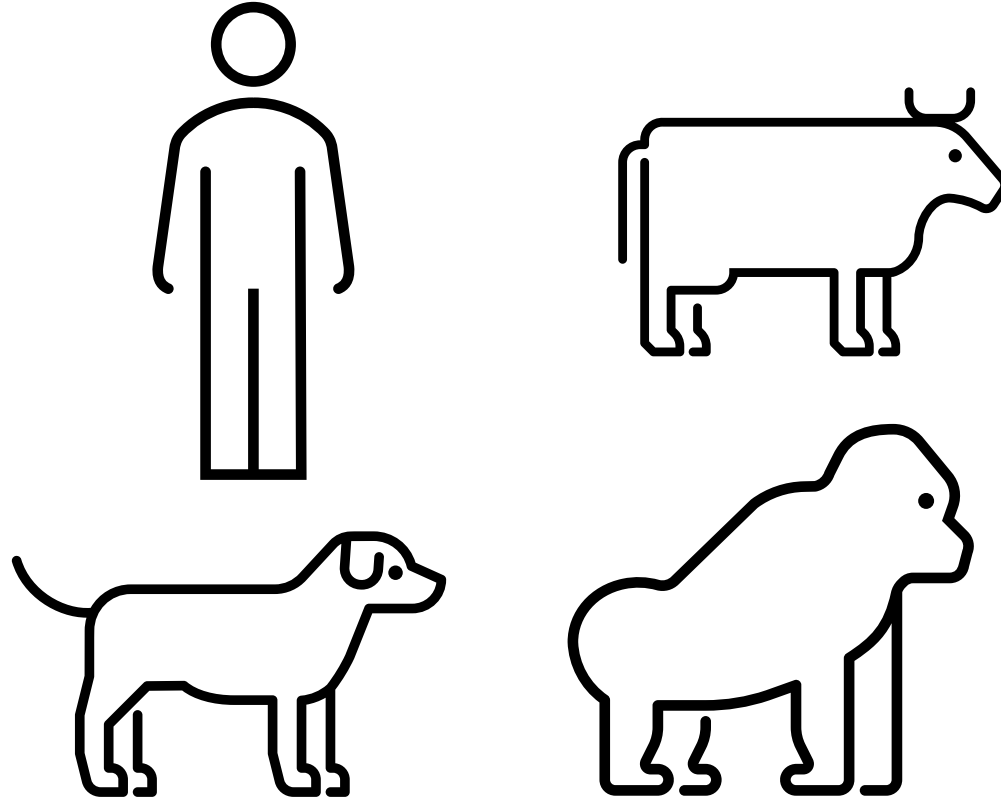
What hosts are we concerned about?

- Humans!
- Companion Animals
- Livestock
- Wildlife



What hosts are we concerned about?

- Humans!
 - Companion Animals
 - Livestock
 - Wildlife
-
- We are healthcare workers, why should we care about wildlife diseases?



What is a vector?

- Vectors are hematophagous arthropods capable of transmitting infectious agents (pathogens) to hosts



What pathogens are transmitted by vectors?

- Three main categories: viruses (arboviruses), bacteria, and parasites



Wucheria bancrofti

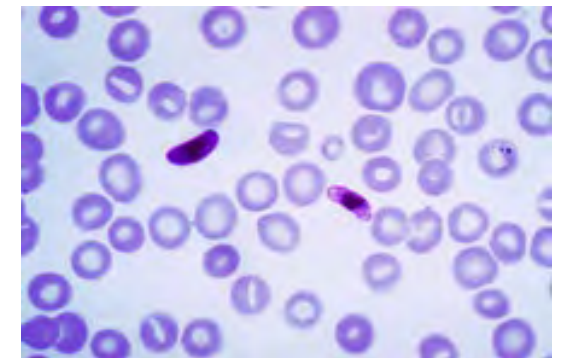


Borrelia burgdorferi

Vector	Disease caused	Type of pathogen	
Mosquito	<i>Aedes</i>	Chikungunya Dengue Lymphatic filariasis Rift Valley fever Yellow Fever Zika	Virus Virus Parasite Virus Virus Virus
	<i>Anopheles</i>	Lymphatic filariasis Malaria	Parasite Parasite
	<i>Culex</i>	Japanese encephalitis Lymphatic filariasis West Nile fever	Virus Parasite Virus
	Aquatic snails	Schistosomiasis (bilharziasis)	Parasite
	Blackflies	Onchocerciasis (river blindness)	Parasite
	Fleas	Plague (transmitted from rats to humans)	Bacteria
		Tungiasis	Cetoparasite
	Lice	Typhus	Bacteria
		Louse-borne relapsing fever	Bacteria
	Sandflies	Leishmaniasis	Parasite
Sandfly fever (phlebotomus fever)		Virus	
Ticks	Crimean-Congo haemorrhagic fever	Virus	
	Lyme disease	Bacteria	
	Relapsing fever (borreliosis)	Bacteria	
	Rickettsial diseases (eg: spotted fever and Q fever)	Bacteria	
	Tick-borne encephalitis	Virus	
	Tularaemia	Bacteria	
Triatome bugs	Chagas disease (American trypanosomiasis)	Parasite	
Tsetse flies	Sleeping sickness (African trypanosomiasis)	Parasite	

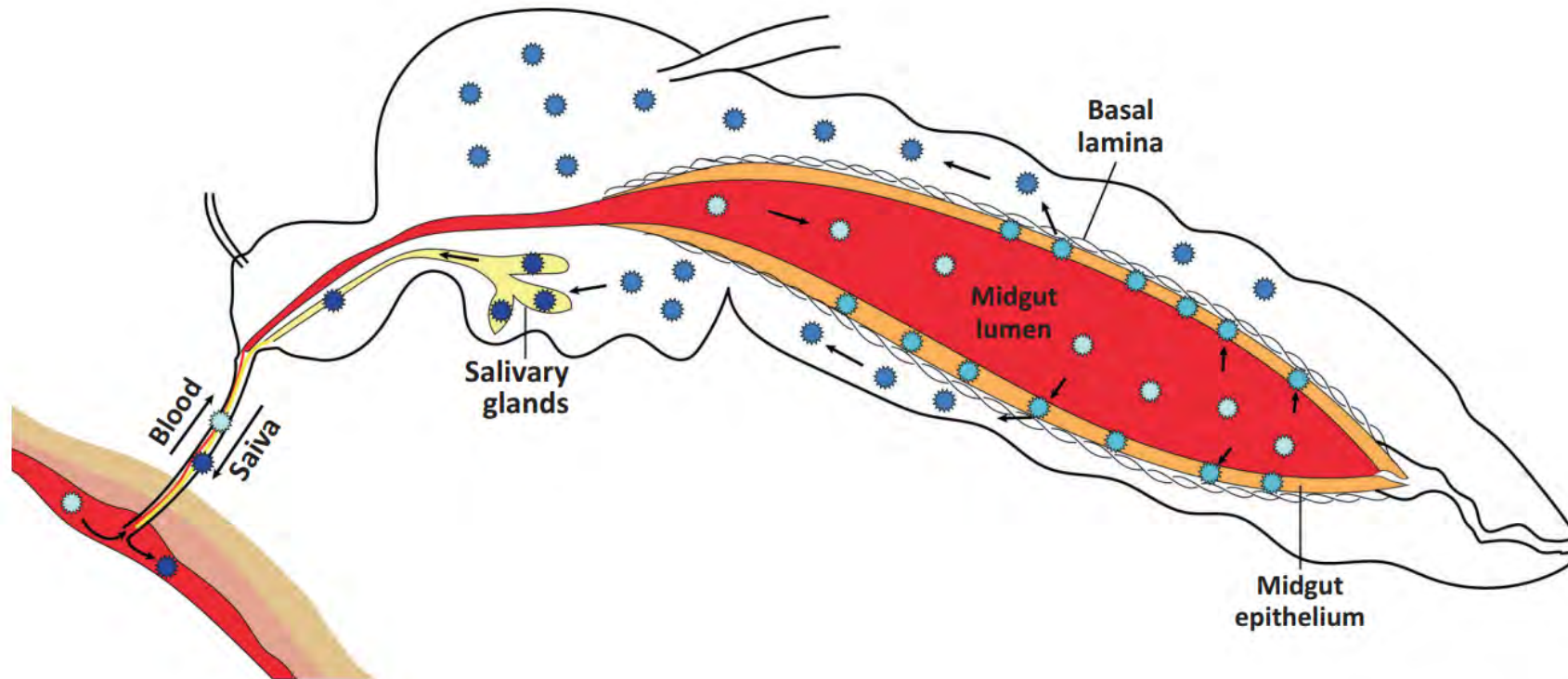


West Nile virus



Plasmodium falciparum

How does it work?



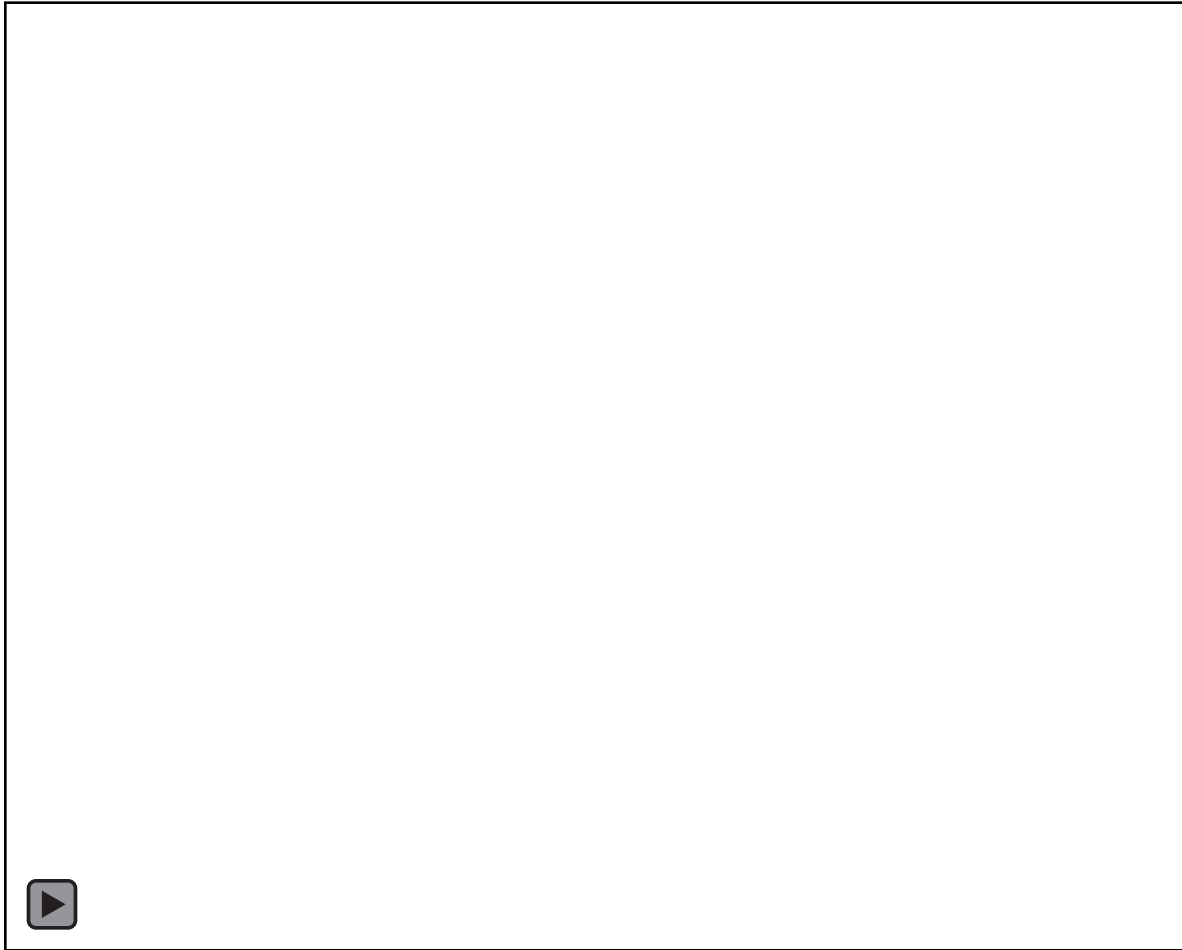
Trends in Parasitology



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How does it work?



Mosquito Proboscis



Tick Hypostome

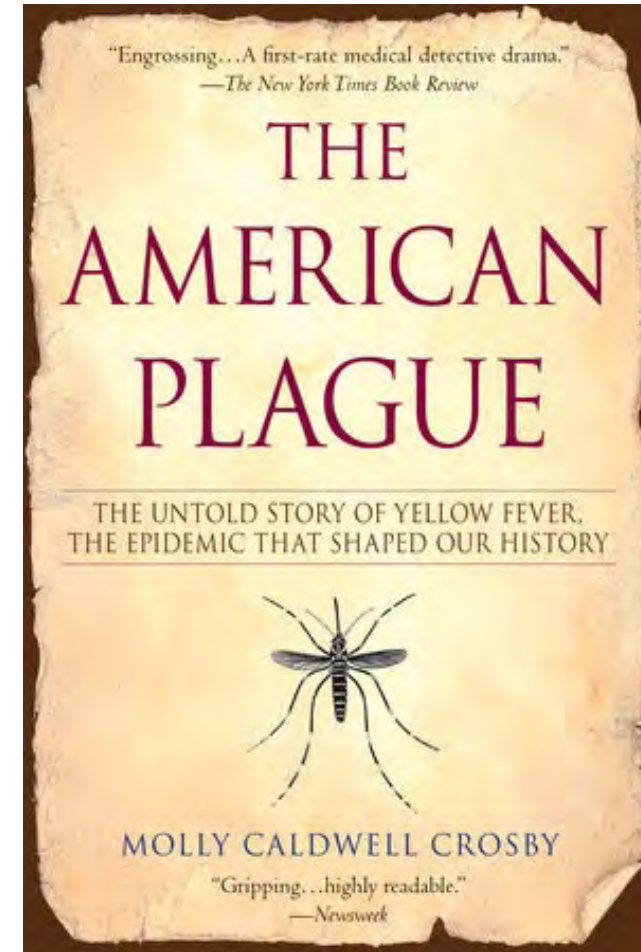
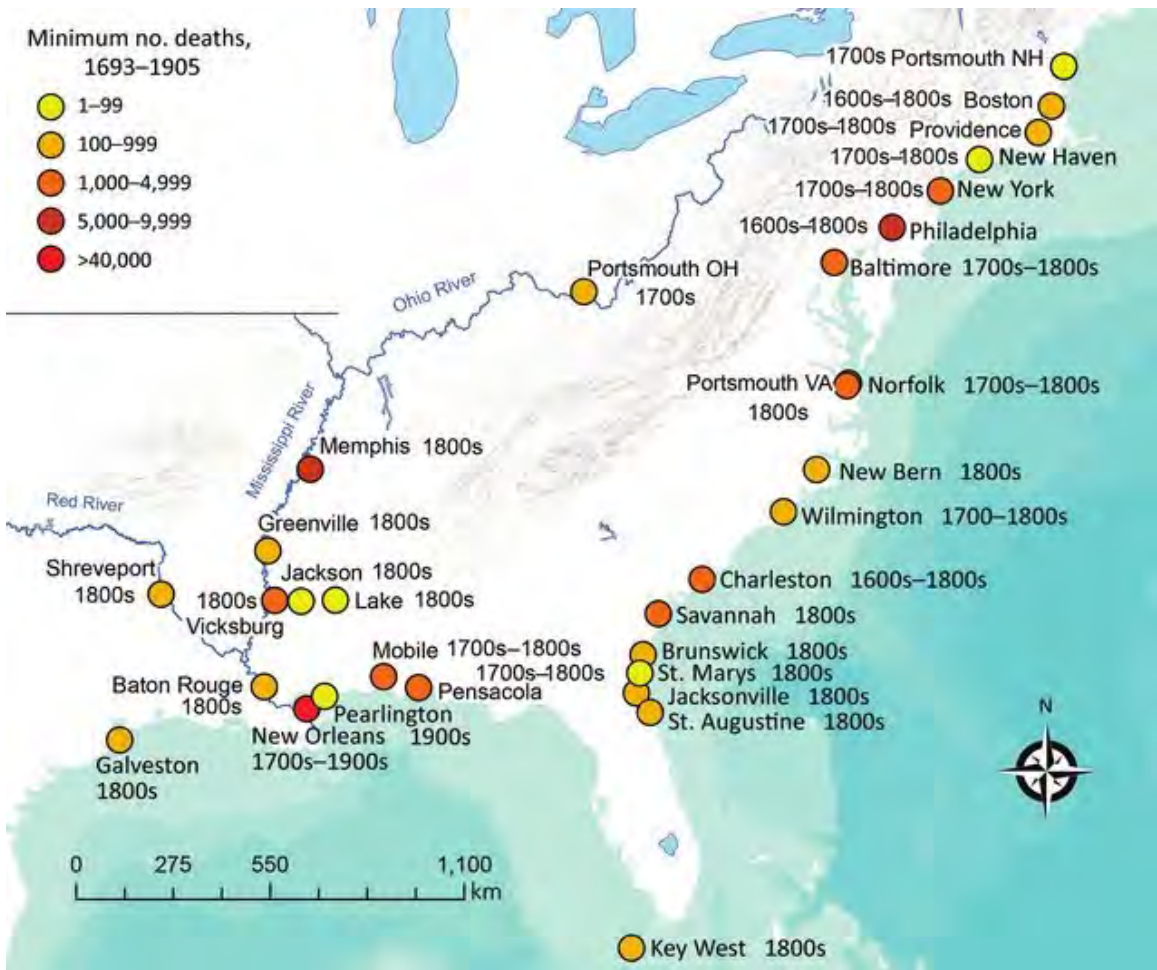
History of Vector-Borne Diseases

- Lymphatic filariasis was the first “identified” vector-borne disease by Patrick Manson in 1870s
- Malaria soon followed suit, with a number of folks involved, but most credit goes to Ronald Ross in 1897
- Yellow fever was the first virus to be discovered as transmitted by mosquitoes in the early 1900s (before viruses were identified!). Most of the credit, correct or not, goes to Walter Reed.

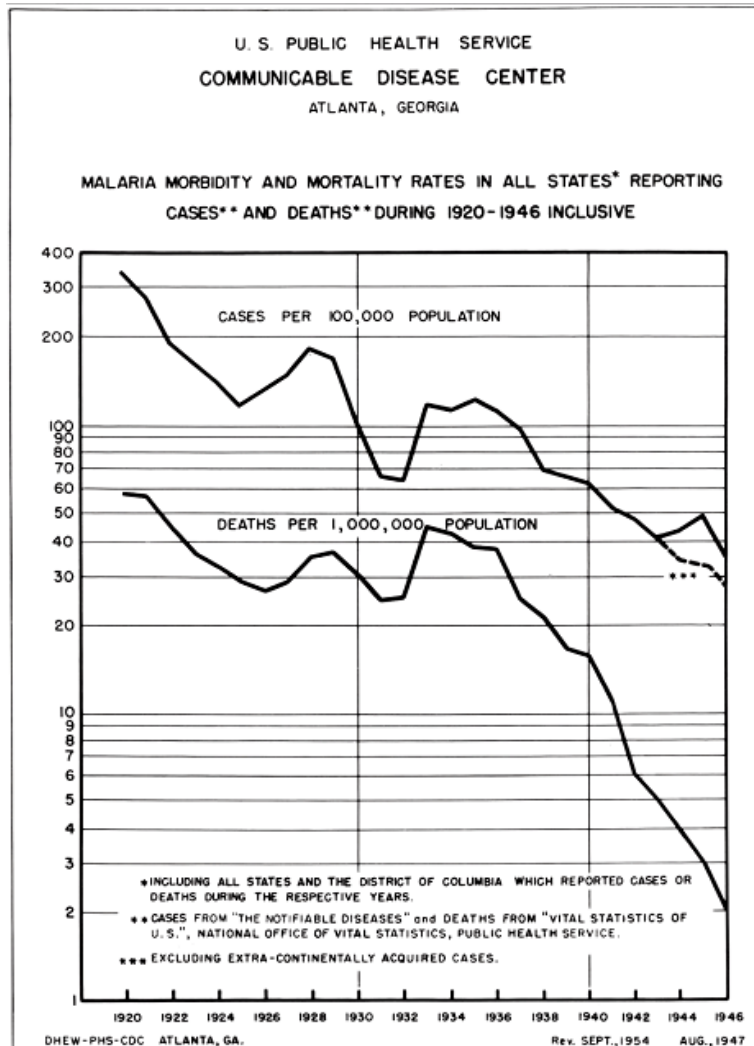
Dr. Carlos Finlay



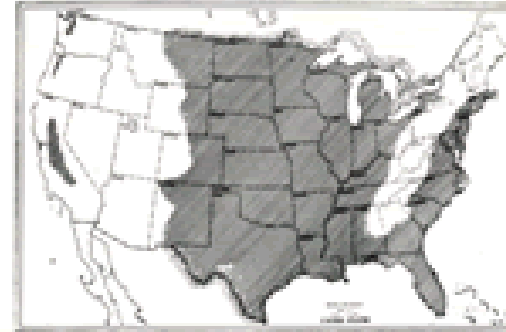
VBDs have played an outsized roll in shaping US



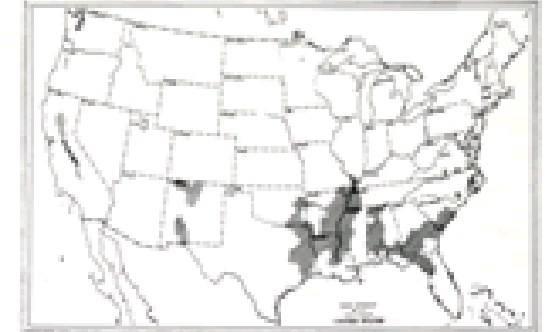
VBDs have played an outsized roll in shaping US



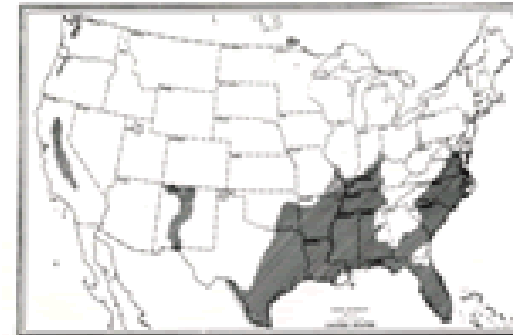
MALARIOUS AREA OF THE UNITED STATES
1882



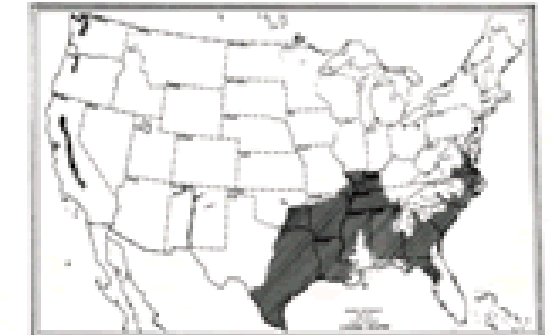
MALARIOUS AREA OF THE UNITED STATES
1932



MALARIOUS AREA OF THE UNITED STATES
1912



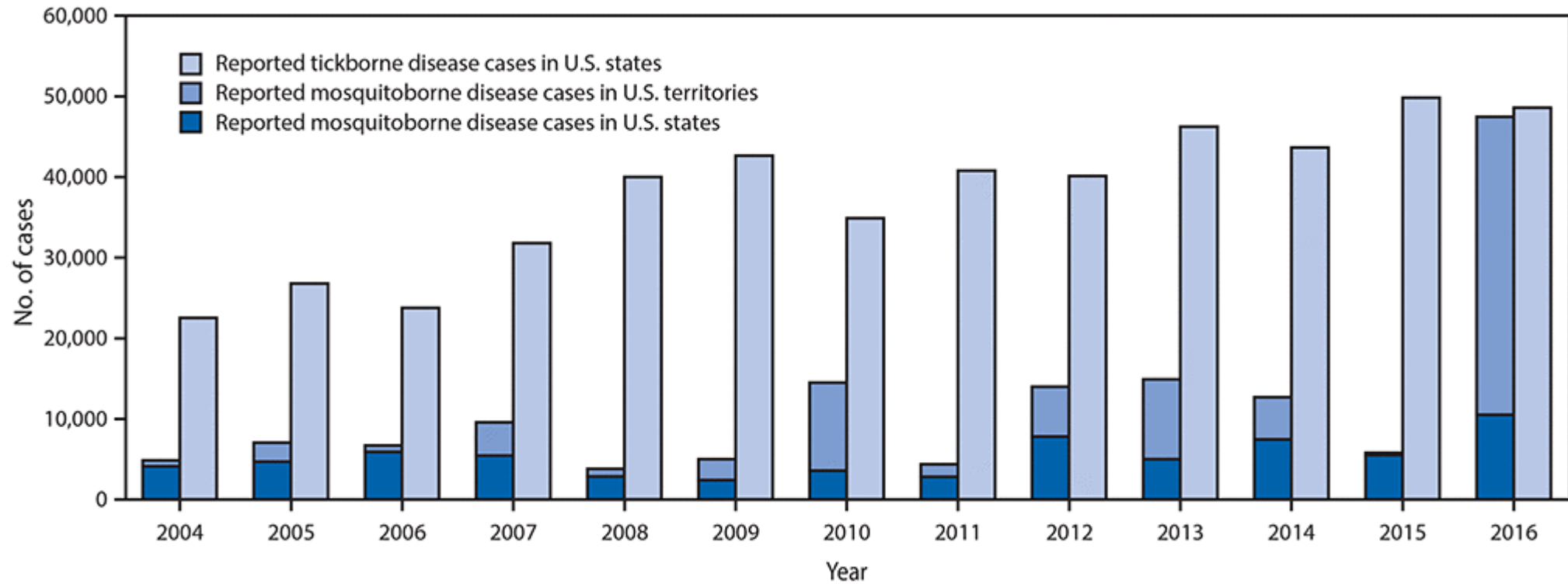
MALARIOUS AREA OF THE UNITED STATES
1934-5



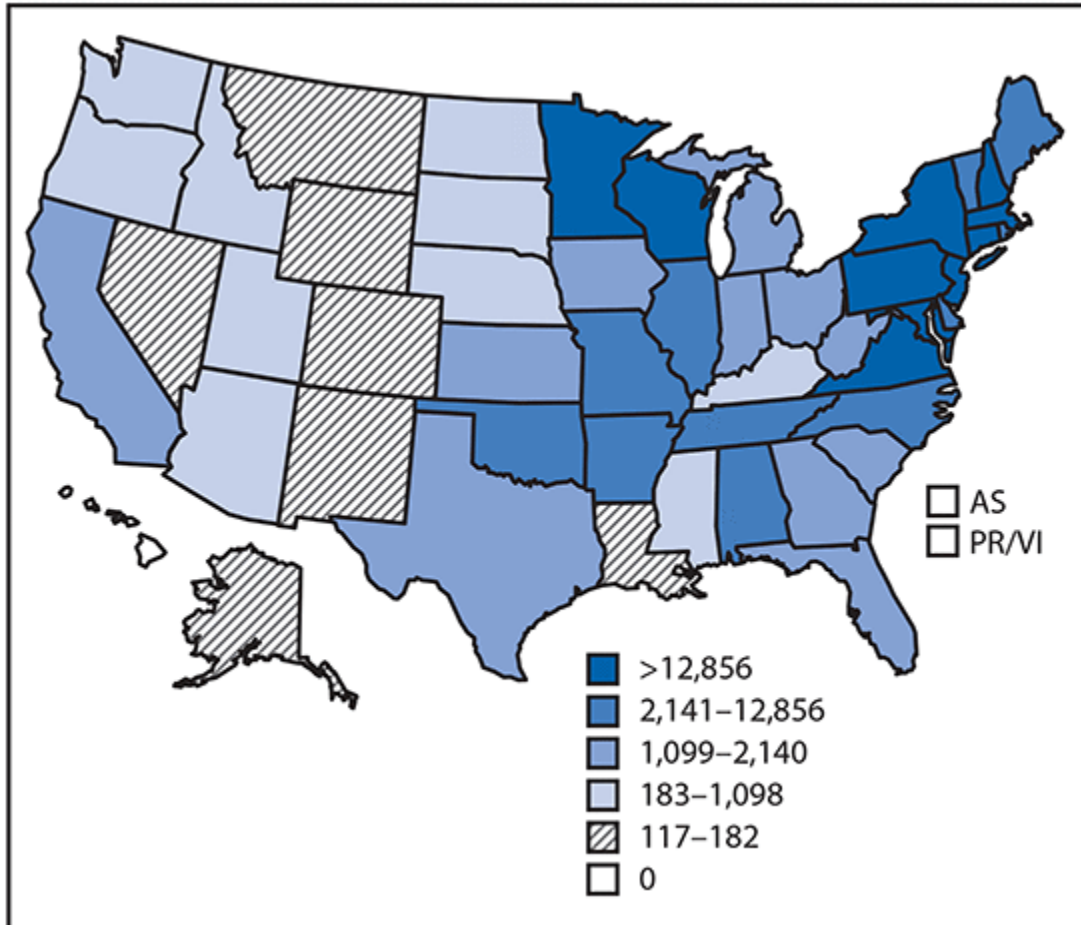
What's old is new again..

The screenshot shows the CDC Health Alert Network (HAN) interface. At the top left is the CDC logo with the text 'Centers for Disease Control and Prevention' and 'CDC 24/7: Saving Lives, Protecting People™'. A search bar is located at the top right. Below the header is a blue navigation bar with the text 'Emergency Preparedness and Response'. The main content area has a breadcrumb trail: 'Resources for Emergency Health Professionals > Health Alert Network (HAN) > HAN Archive > 2023'. On the left side, there is a sidebar menu with options: 'Health Alert Network (HAN)', 'HAN Jurisdictions', 'HAN Message Types', 'Sign Up for HAN Updates', 'HAN Archive', and '2023'. The main title of the alert is 'Locally Acquired Malaria Cases Identified in the United States'. Below the title is a 'Print' link. There are two logos: the HAN logo (Health Alert Network) and an orange box with the text 'This is an official CDC HEALTH ADVISORY'. At the bottom, it says 'Distributed via the CDC Health Alert Network' and 'June 26, 2023, 5:00 PM ET'. The ID 'HAN00495' is visible at the bottom left of the page.

Different pathogens, same problems- VBD in US



Different pathogens, same problems- VBD in US



Tick-borne diseases US 2016

- Lyme disease (34,945)
- Anaplasmosis (5,655)
- Rickettsiosis (5,207)
- Babesiosis (2,420)
- Ehrlichiosis (2,093)

Risk Depends on the Vector- Tick-Borne Diseases US



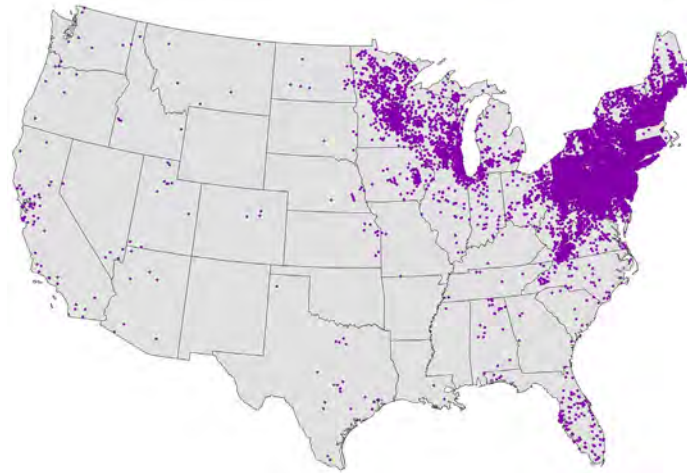
Ixodes scapularis (Blacklegged tick, deer tick)



Risk Depends on the Vector- Tick-Borne Diseases US



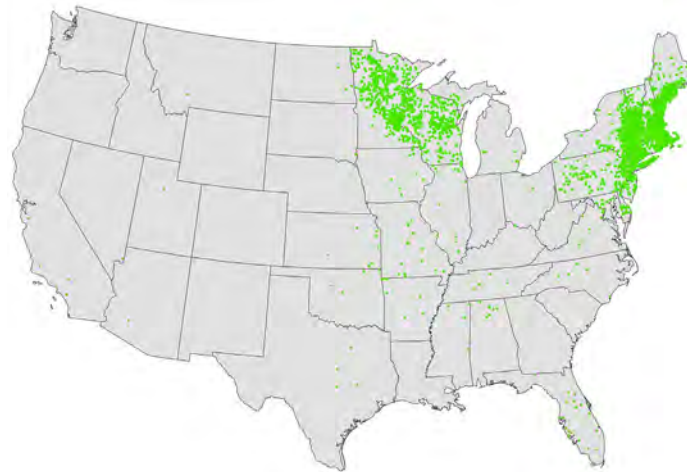
Ixodes scapularis (Blacklegged tick, deer tick)



Lyme disease reported cases



Ehrlichiosis reported cases



Anaplasmosis reported cases



Babesiosis reported cases

Risk Depends on the Vector- Tick-Borne Diseases US



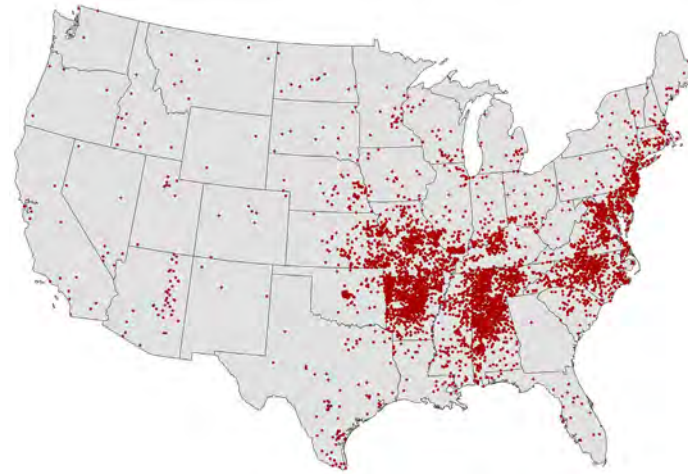
Dermacentor variabilis (American dog tick)



Risk Depends on the Vector- Tick-Borne Diseases US



Dermacentor variabilis (American dog tick)



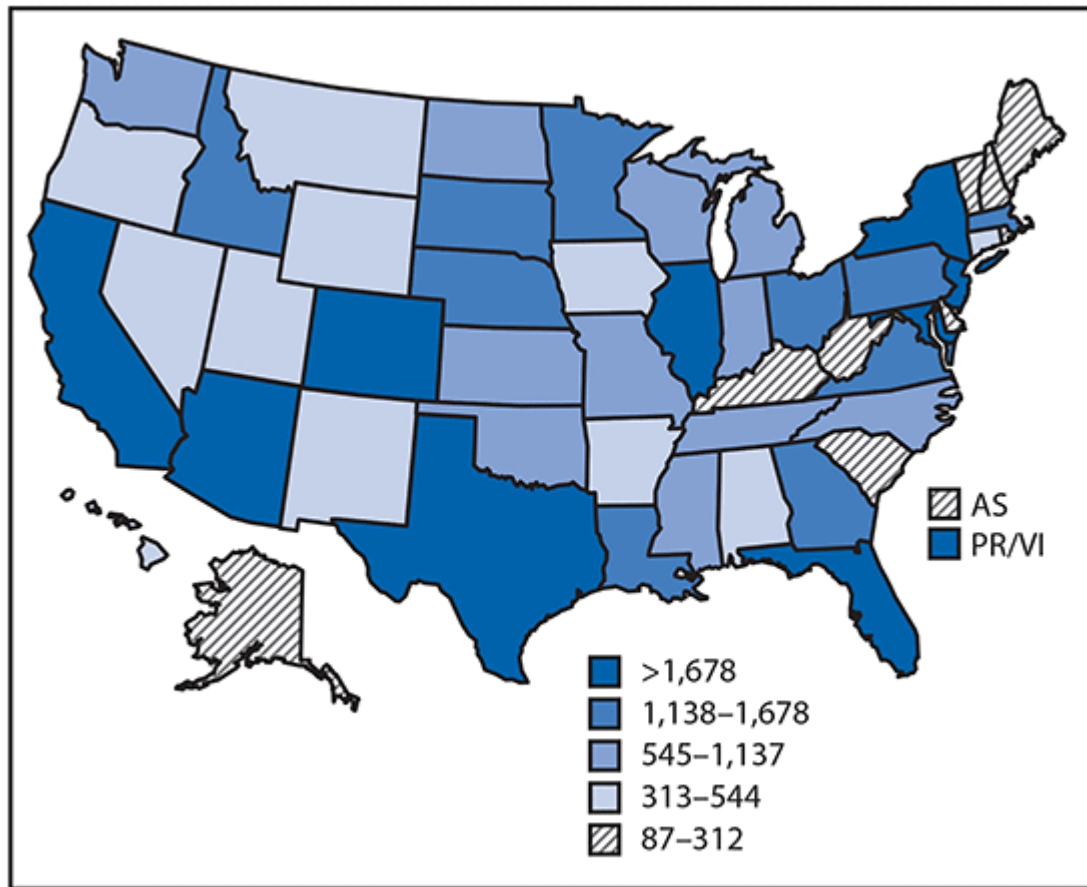
Spotted fever rickettsiosis reported cases



Tularemia reported cases



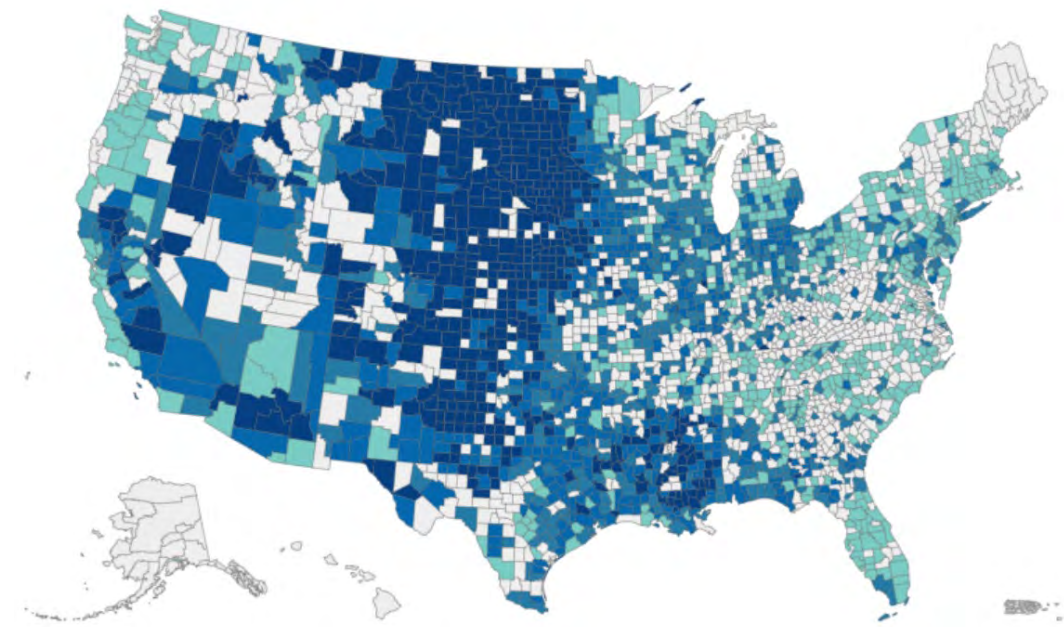
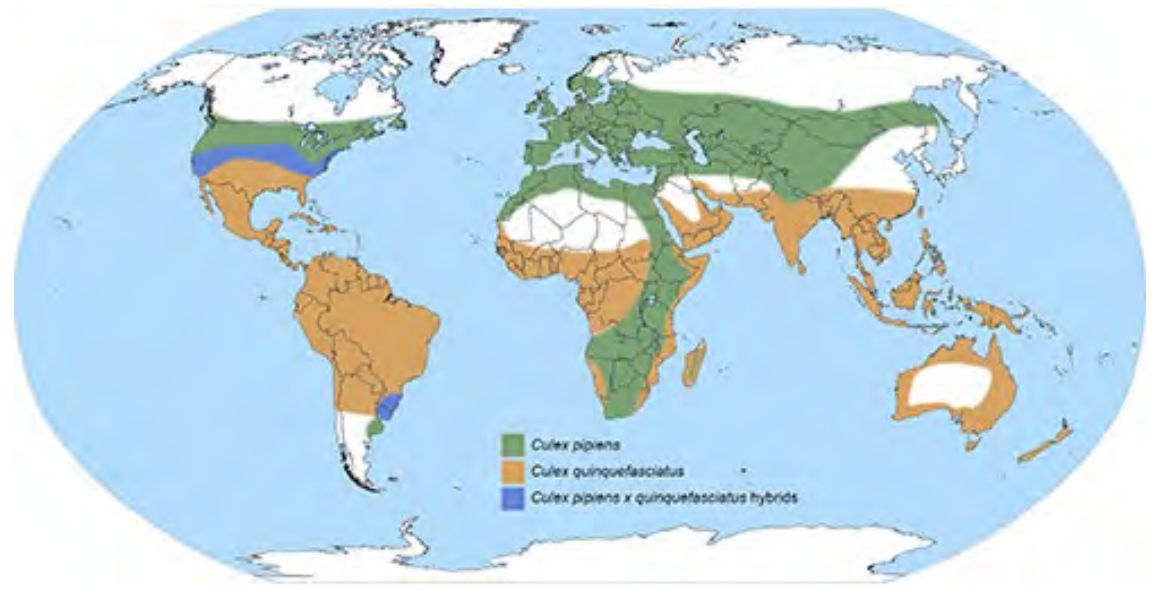
Different pathogens, same problems- VBD in US



Mosquito-borne diseases US 2021

- West Nile virus (2,911)
- St. Louis encephalitis (17)
- Dengue virus (<100 locally acquired)
- Chikungunya virus (<100 locally acquired)
- Eastern equine encephalitis virus (5)

Risk Depends on the Vector- Mosquito -Borne Diseases US



Incidence per 100,000 Population
● 0.01 to 0.16 ● 0.17 to 0.37 ● 0.38 to 1.09 ● >1.10

West Nile virus, 2021



Culex pipiens (House mosquito)

Risk Depends on the Vector- Mosquito -Borne Diseases US

Estimated Potential Range of *Aedes aegypti* in the United States, 2017

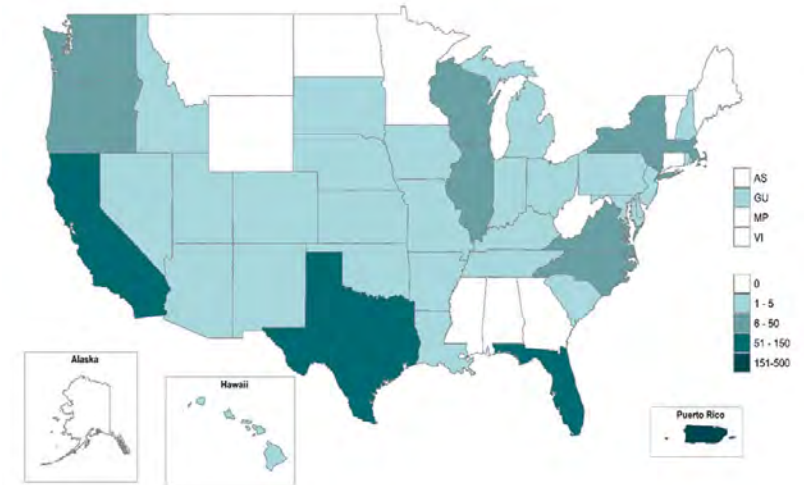


Aedes aegypti (Yellow fever mosquito)

Estimated Potential Range of *Aedes albopictus* in the United States, 2017



Aedes albopictus (Asian tiger mosquito)



Reported Dengue cases US, 2020*

*Florida reported 71 locally acquired cases

Risk Depends on the Vector- Mosquito -Borne Diseases US

Estimated Potential Range of *Aedes aegypti* in the United States, 2017

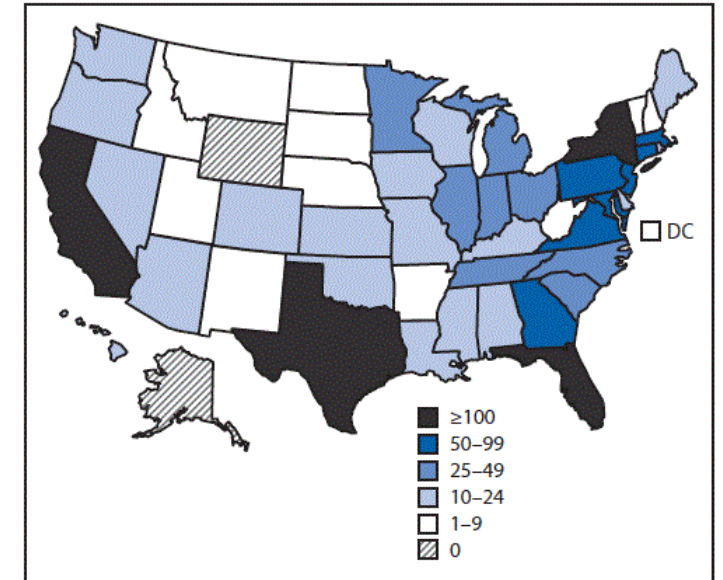


Aedes aegypti (Yellow fever mosquito)

Estimated Potential Range of *Aedes albopictus* in the United States, 2017



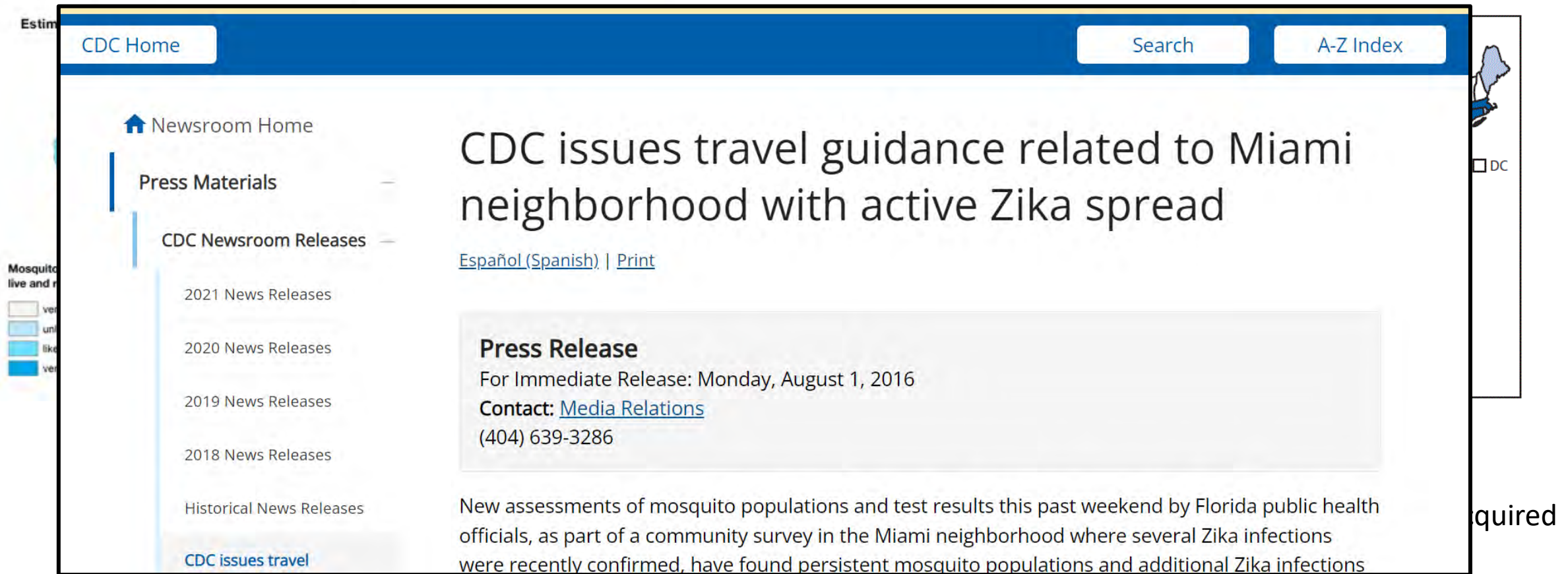
Aedes albopictus (Asian tiger mosquito)



Zika Cases, US 2016-2017

Florida reported >200 locally acquired cases

Risk Depends on the Vector- Mosquito -Borne Diseases US

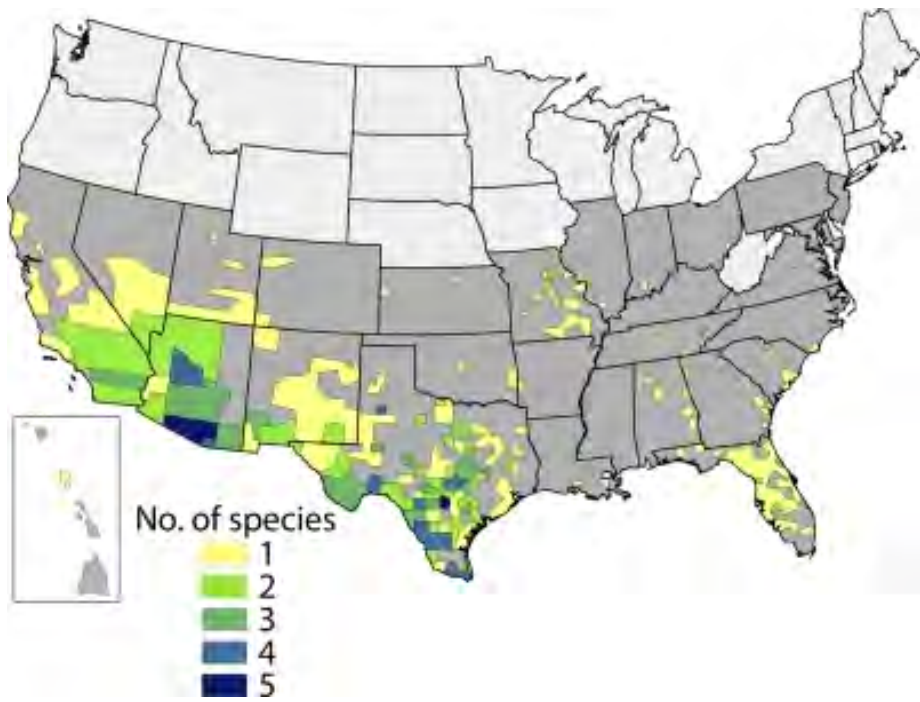


The screenshot shows the CDC website interface. At the top, there is a blue navigation bar with "CDC Home" on the left, a "Search" box, and an "A-Z Index" button. Below the navigation bar, the main content area features a large headline: "CDC issues travel guidance related to Miami neighborhood with active Zika spread". To the left of the headline is a sidebar menu with "Newsroom Home" at the top, followed by "Press Materials" and "CDC Newsroom Releases". Under "CDC Newsroom Releases", there are links for "2021 News Releases", "2020 News Releases", "2019 News Releases", "2018 News Releases", and "Historical News Releases". Below these links is a link that says "CDC issues travel". To the right of the headline, there are links for "Español (Spanish)" and "Print". Below the headline is a "Press Release" box containing the text: "For Immediate Release: Monday, August 1, 2016" and "Contact: [Media Relations](#) (404) 639-3286". Below the "Press Release" box is a paragraph of text: "New assessments of mosquito populations and test results this past weekend by Florida public health officials, as part of a community survey in the Miami neighborhood where several Zika infections were recently confirmed, have found persistent mosquito populations and additional Zika infections". On the far right, there is a small map of the United States with a red dot indicating the location of Miami, Florida.

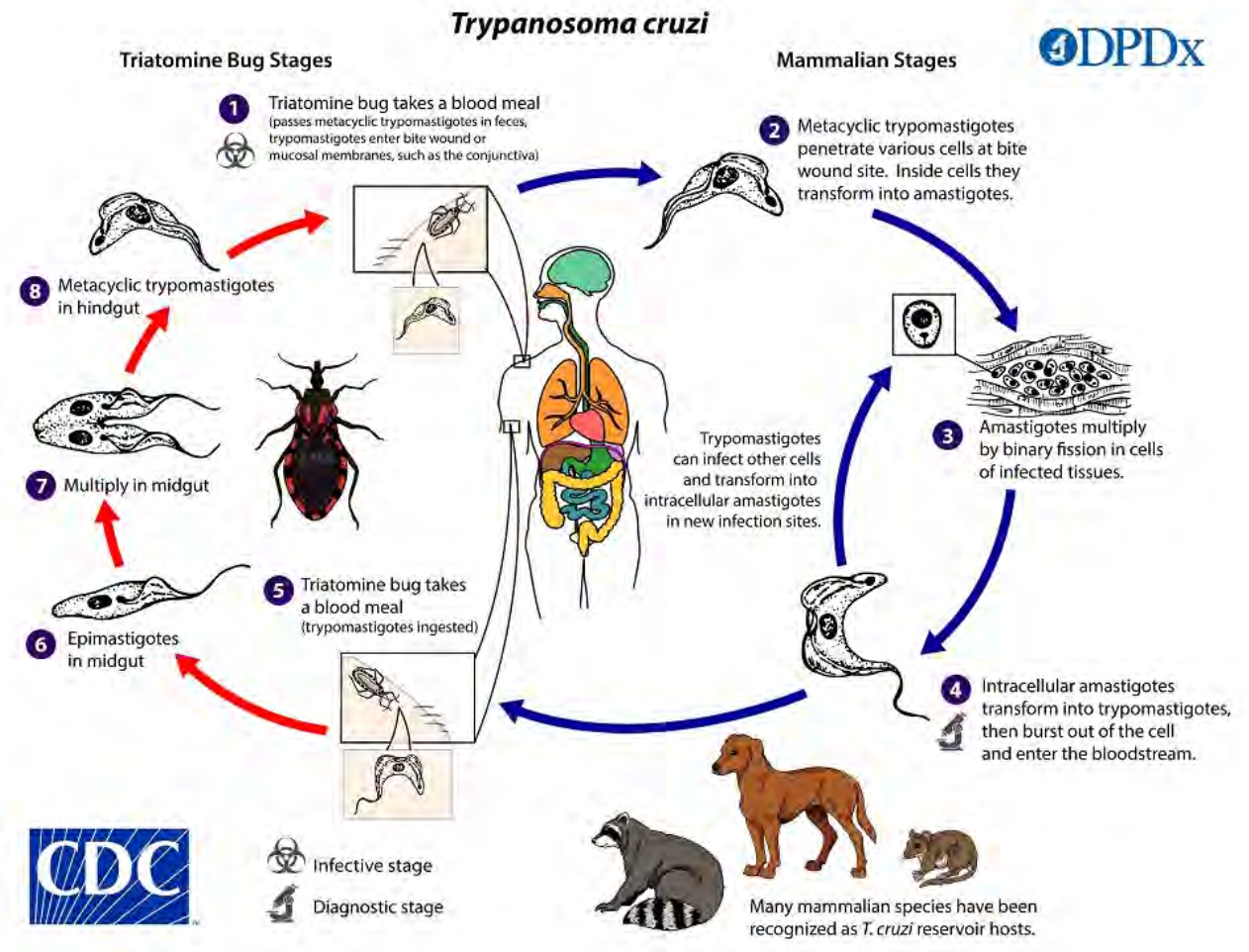
Aedes aegypti (Yellow fever mosquito)

Aedes albopictus (Asian tiger mosquito)

A few other VBDs



Triatominae (Kissing Bug)



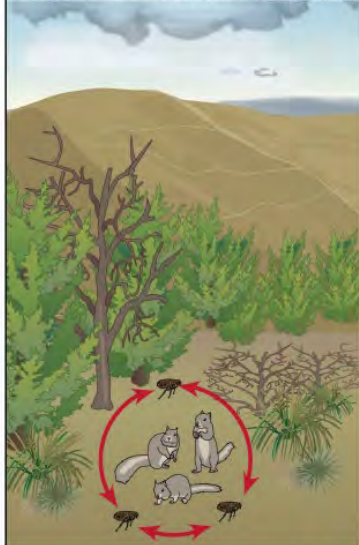
A few other VBDs



Plague Ecology in the United States

Plague in Nature

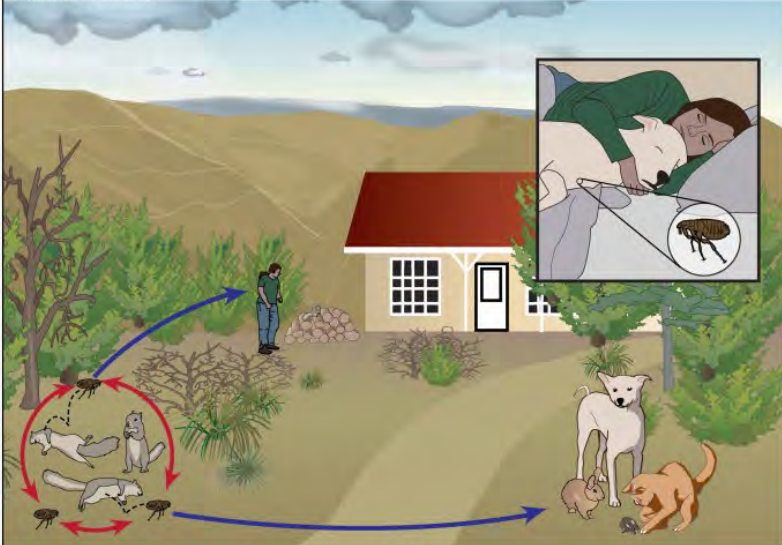
Plague occurs naturally in the western U.S., especially in the semi-arid grasslands and scrub woodlands of the southwestern states of Arizona, Colorado, New Mexico and Utah.



The plague bacterium (*Yersinia pestis*) is transmitted by fleas and cycles naturally among wild rodents, including rock squirrels, ground squirrels, prairie dogs and wood rats.

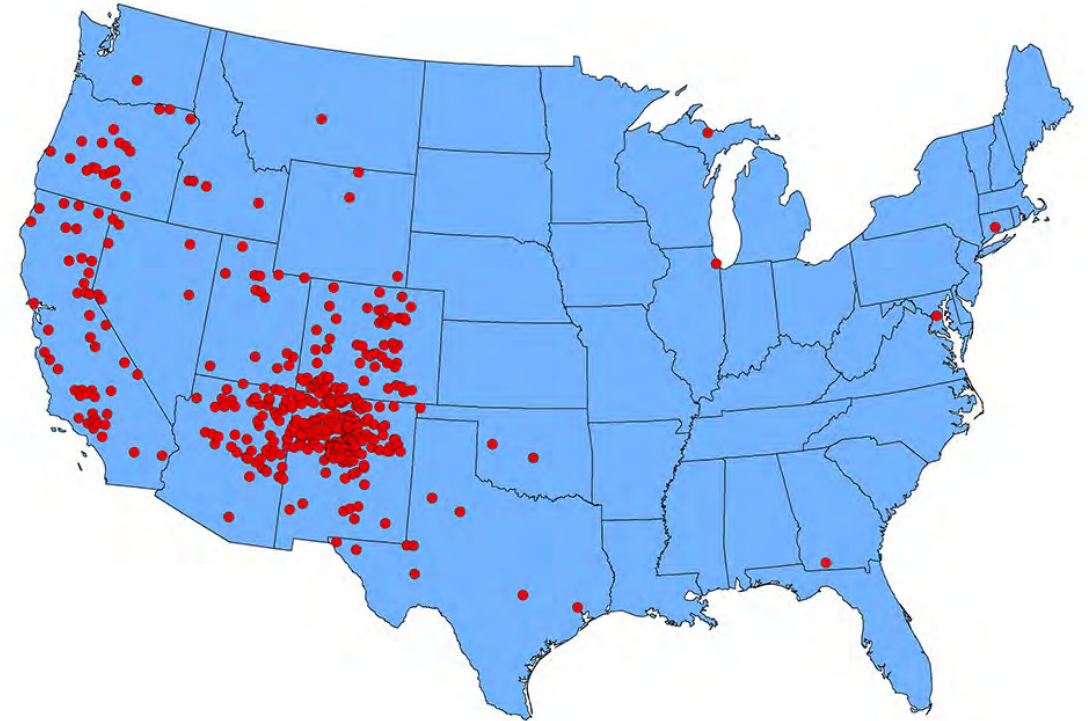
Plague in Humans

Occasionally, infections among rodents increase dramatically, causing an outbreak, or epizootic. During plague epizootics, many rodents die, causing hungry fleas to seek other sources of blood. Studies suggest that epizootics in the southwestern U.S. are more likely during cooler summers that follow wet winters.



Humans and domestic animals that are bitten by fleas from dead animals are at risk for contracting plague, especially during an epizootic. Cats usually become very ill from plague and can directly infect humans when they cough infectious droplets into the air. Dogs are less likely to be ill, but they can still bring plague-infected fleas into the home. In addition to flea bites, people can be exposed while handling skins or flesh of infected animals.

CS225948



1 dot placed in state of residence for each reported plague case



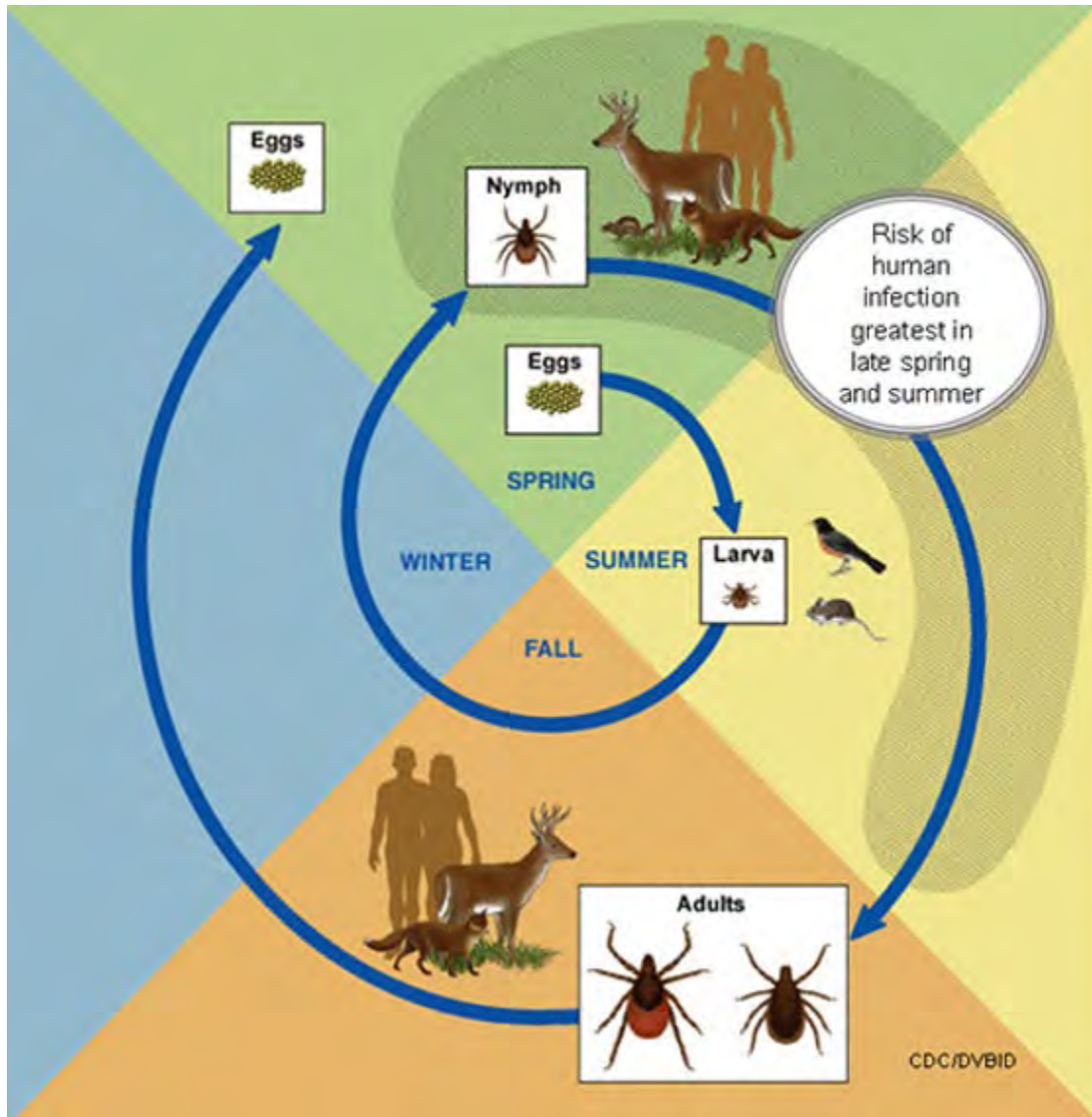
Triatominae (Kissing Bug)



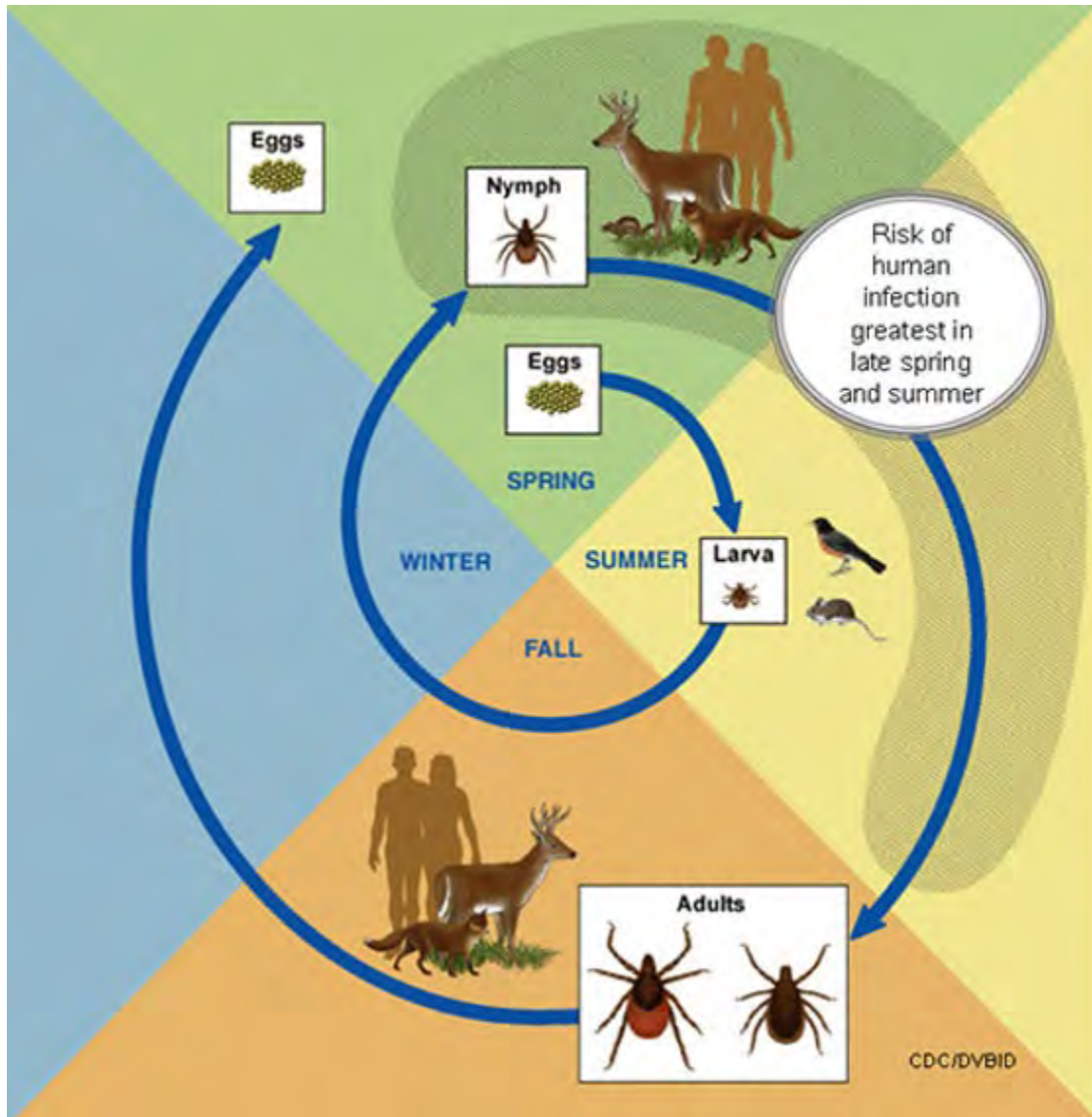
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Understanding Lyme Disease Risk

Understanding Lyme Disease Risk



Understanding Lyme Disease Risk



Blacklegged Tick (*Ixodes scapularis*)



Ticks can be the size of a poppy seed. Can you spot all 5 ticks in this photo? Learn how to prevent tick bites. bit.ly/2rjox6U



3:30 PM · May 4, 2018

Tick Bite Prevention

As with all VBDs, prevention of vector bites is the most effective way to prevent transmission.

Tick Bite Prevention

As with all VBDs, prevention of vector bites is the most effective way to prevent transmission.

-Long pants with socks tucked in



Tick Bite Prevention

As with all VBDs, prevention of vector bites is the most effective way to prevent transmission.

- Long pants with socks tucked in
- Avoid “ticky” habitats



Tick Bite Prevention

As with all VBDs, prevention of vector bites is the most effective transmission.

- Long pants with socks tucked in
- Avoid “ticky habitats”
- Permethrin treated clothing/DEET based repellent

TREAT CLOTHING WITH PERMETHRIN



Tick Bite Prevention

As with all VBDs, prevention of vector bites is the most effective way to prevent transmission.

- Long pants with socks tucked in
- Avoid “ticky habitats”
- Permethrin treated clothing/DEET based repellent
- Conduct tick checks

Host infection rate and tick attachment time				Number of infected animals/total animals (%)						
Study	Tick species	Host	Borrelia species	<16 hrs	<24 hrs	<36 hrs	<42 hrs	<48 hrs	<72 hrs	<96 hrs
Piesman et al ²⁵	<i>I. dammini</i> (now <i>I. scapularis</i>)	Golden Syrian hamsters, white footed mice	Bb JDI		1/14(7%)			5/14(33%)	13/14(93%)	
Piesman ³⁵	<i>I. dammini</i> (now <i>I. scapularis</i>)	Male ICR outbred mice	Bb JDI			1/14(7%)	3/12(25%)	6/8 (75%)		
Shih and Spielman ³⁶	<i>I. dammini</i> (now <i>I. scapularis</i>)	CDI mice	Bb JDI	0/8 (0%)	0/9 (0%)	1/7 (14%)		10/10 (100%)		

Tick Bite Prevention

As with all VBDs, prevention of vector bites is the most effective way to prevent transmission.

- Long pants with socks tucked in
- Avoid “ticky habitats”
- Permethrin treated clothing/DEET based repellent
- Conduct tick checks
- Communicate to the public the risk of tick-borne diseases!

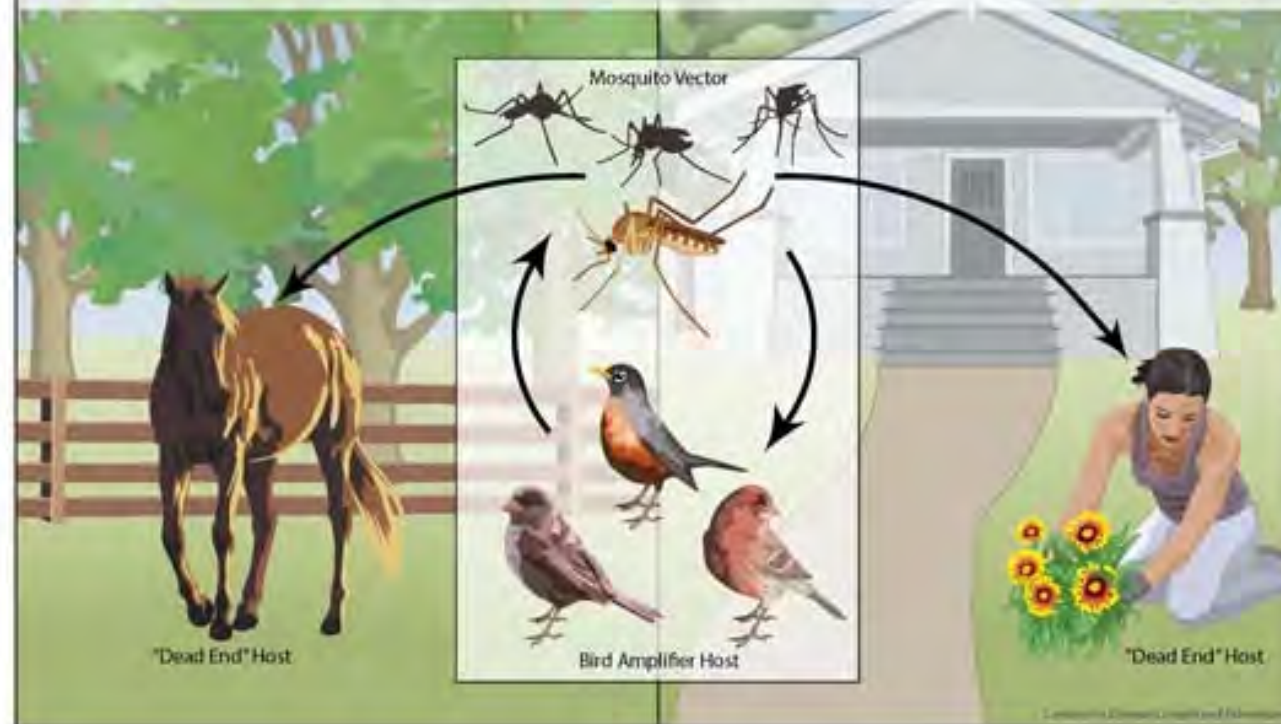


Understanding West Nile Virus Risk

West Nile Virus Transmission Cycle

In nature, West Nile virus cycles between mosquitoes (especially *Culex* species) and birds. Some infected birds, can develop high levels of the virus in their bloodstream and mosquitoes can become infected by biting these infected birds. After about a week, infected mosquitoes can pass the virus to more birds when they bite.

Mosquitoes with West Nile virus also bite and infect people, horses and other mammals. However, humans, horses and other mammals are 'dead end' hosts. This means that they do not develop high levels of virus in their bloodstream, and cannot pass the virus on to other biting mosquitoes.



Mosquito Bite Prevention

As with all VBDs, prevention of vector bites is the most effective way to prevent transmission.

Mosquito Bite Prevention

As with all VBDs, prevention of vector bites is the most effective way to prevent transmission.

-Personal protection



Mosquito Bite Prevention

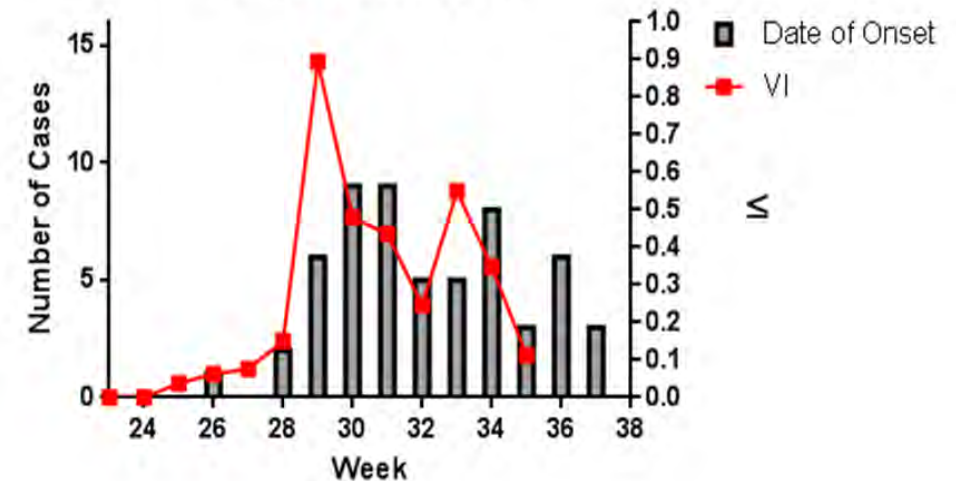
As with all VBDs, prevention of vector bites is the most effective way to prevent transmission.

- Personal protection
- Mosquito abatement



$$VI = \sum \bar{N}_i \hat{P}_i$$

Human Cases 2007



Summary

- Vector-borne diseases are common throughout the world
- Historically, they have been hugely problematic in the US
- The incidence of VBDs is increasing in the US
- Mosquitoes and ticks are the primary vectors of concern in the US
- Preventing vector bites remains the best way to combat VBDs around the world

Questions?

Get in touch: jfauver@unmc.edu

