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# A Primer on Vector-Borne Disease

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UNMC COPH DEPARTMENT OF EPIDEMIOLOGY  
UNMC Ag Med Course  
7/19/2023



# Outline

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- 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



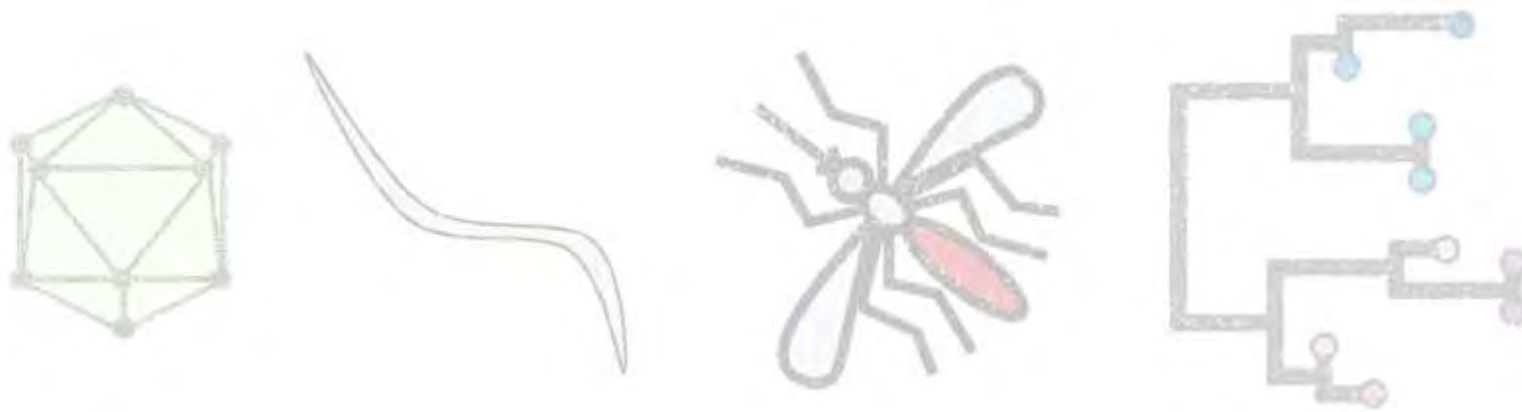
# Pathogens, genomics, and global health

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## The Fauver Lab

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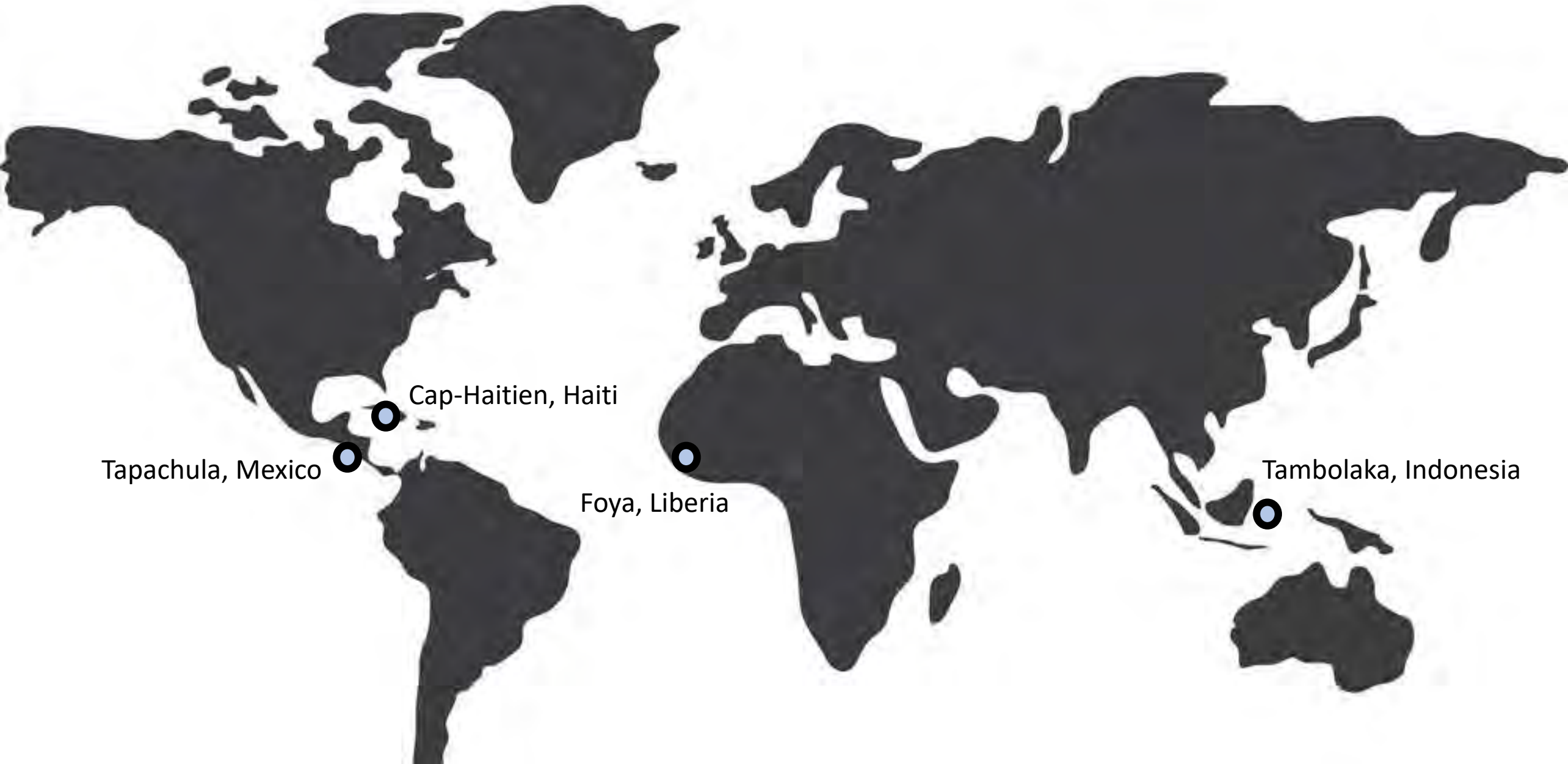
### UNMC College of Public Health



[thefauverlab.com](http://thefauverlab.com)

# People, Places, and Parasites

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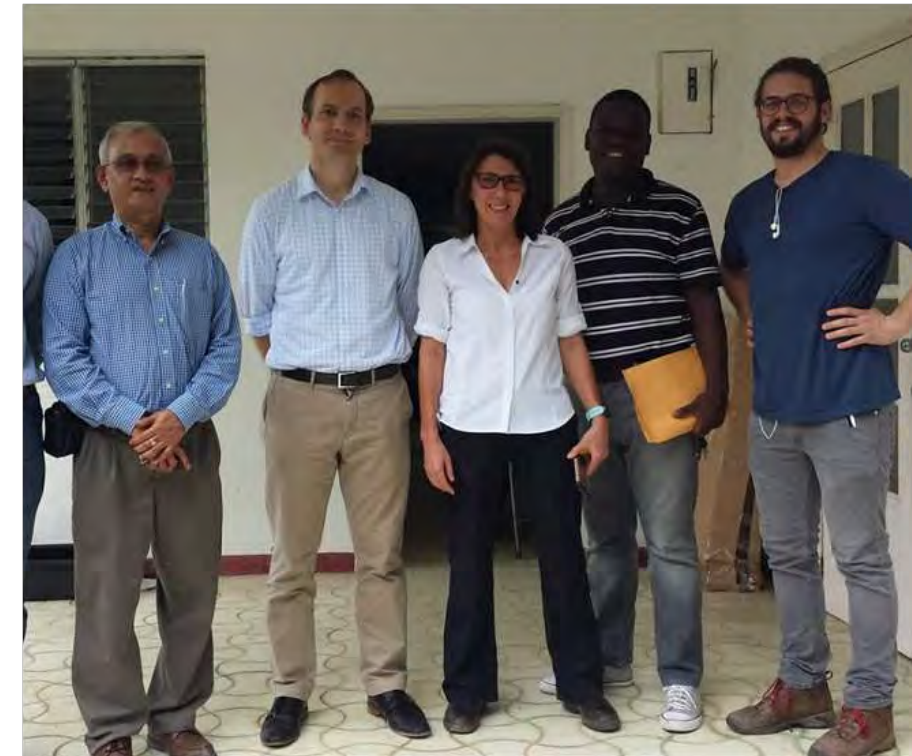
Tapachula, Mexico

Cap-Haitien, Haiti

Foya, Liberia

Tambolaka, Indonesia

# People, Places, and Parasites



# What are Vector-Borne Diseases?

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

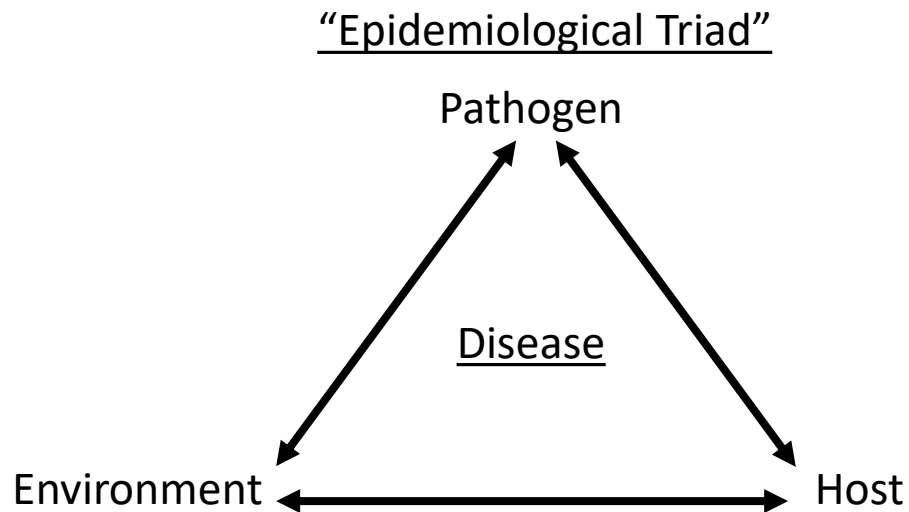
# What are Vector-Borne Diseases?

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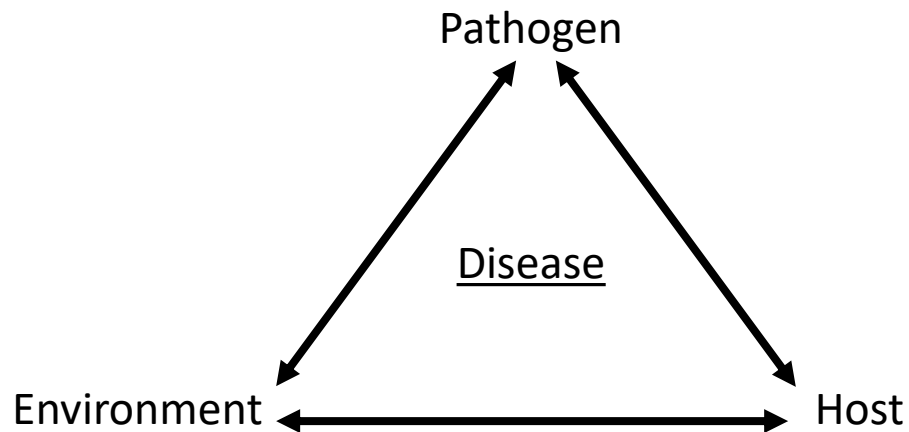




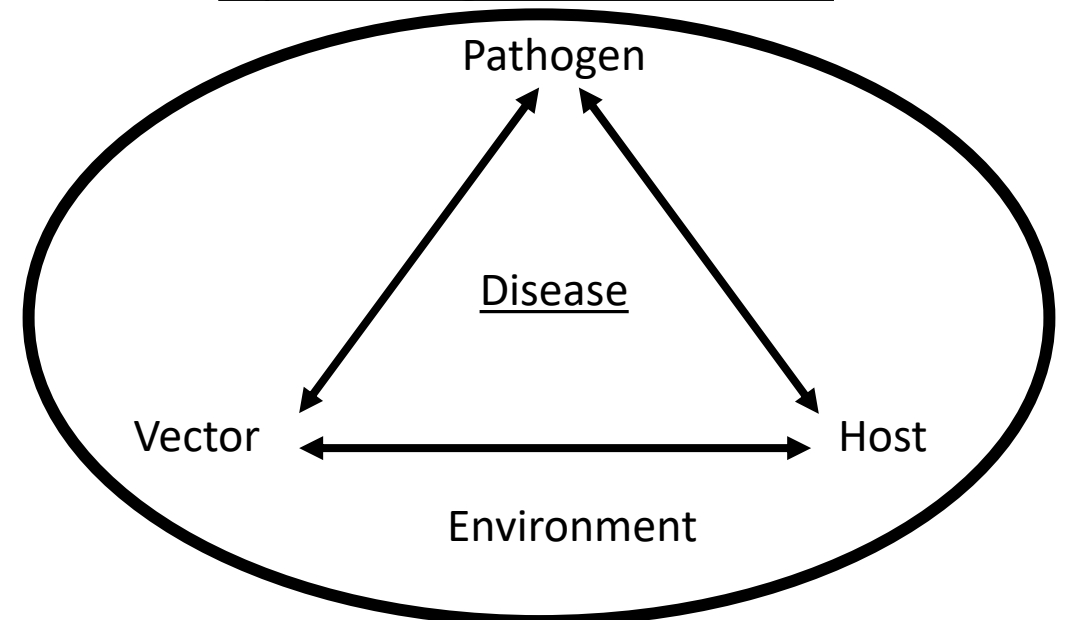
# What are Vector-Borne Diseases?

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

“Epidemiological Triad”



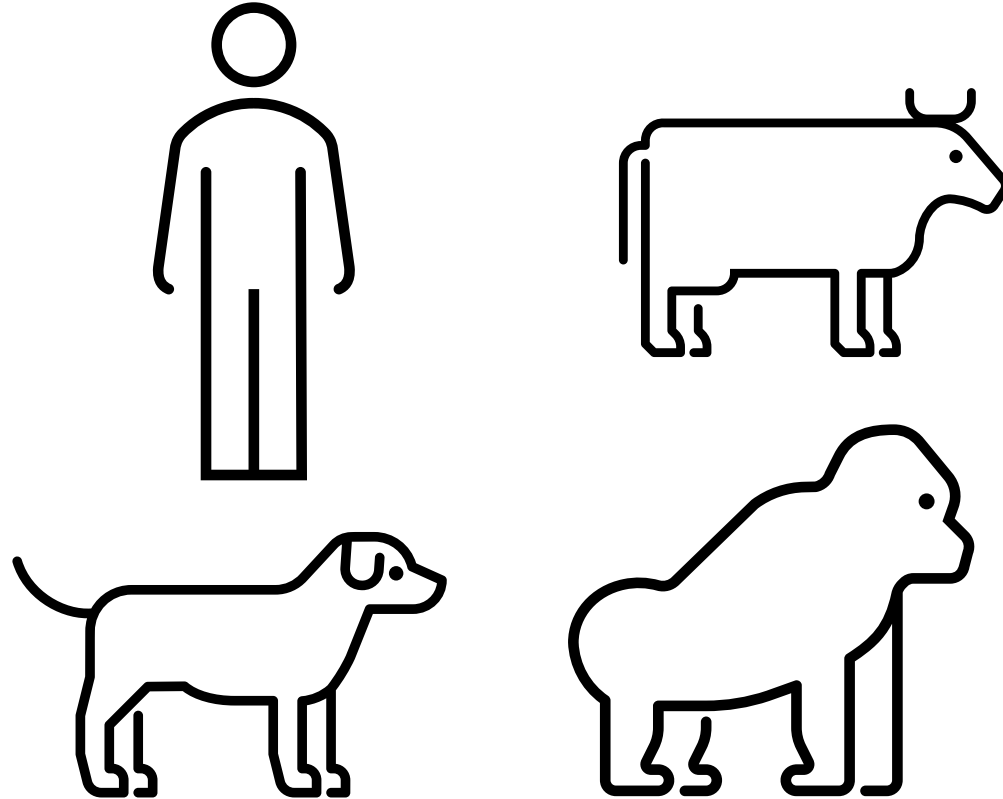
“Epidemiological Triad for VBD”



# What hosts are we concerned about?

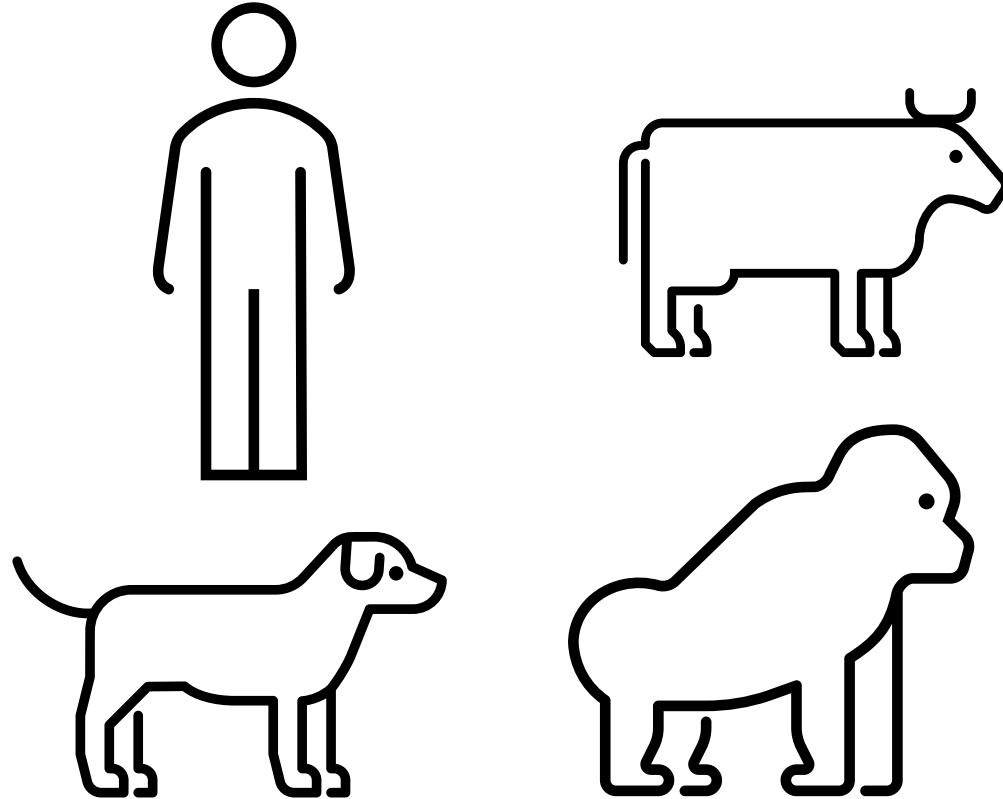
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- Humans!
- Companion Animals
- Livestock
- Wildlife



# 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*

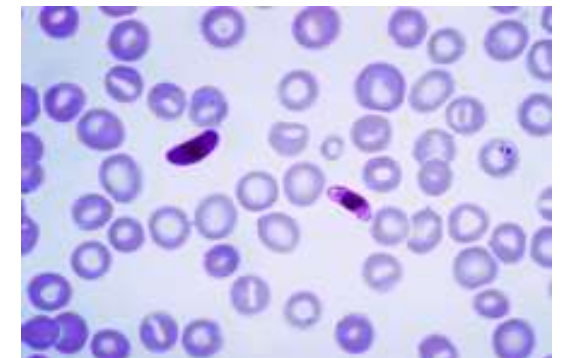


*Borrelia burgdorferi*

Vector	Disease caused	Type of pathogen	
Mosquito	<i>Aedes</i>	Chikungunya	Virus
		Dengue	Virus
		Lymphatic filariasis	Parasite
		Rift Valley fever	Virus
		Yellow Fever	Virus
	Zika	Virus	
	<i>Anopheles</i>	Lymphatic filariasis	Parasite
		Malaria	Parasite
	<i>Culex</i>	Japanese encephalitis	Virus
		Lymphatic filariasis	Parasite
West Nile fever		Virus	
<del>Aquatic snails</del>	<del>Schistosomiasis (bilharziasis)</del>	<del>Parasite</del>	
Blackflies	Onchocerciasis (river blindness)	Parasite	
Fleas	Plague (transmitted from rats to humans)	Bacteria	
	<del>Tungiasis</del>	<del>Ectoparasite</del>	
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	

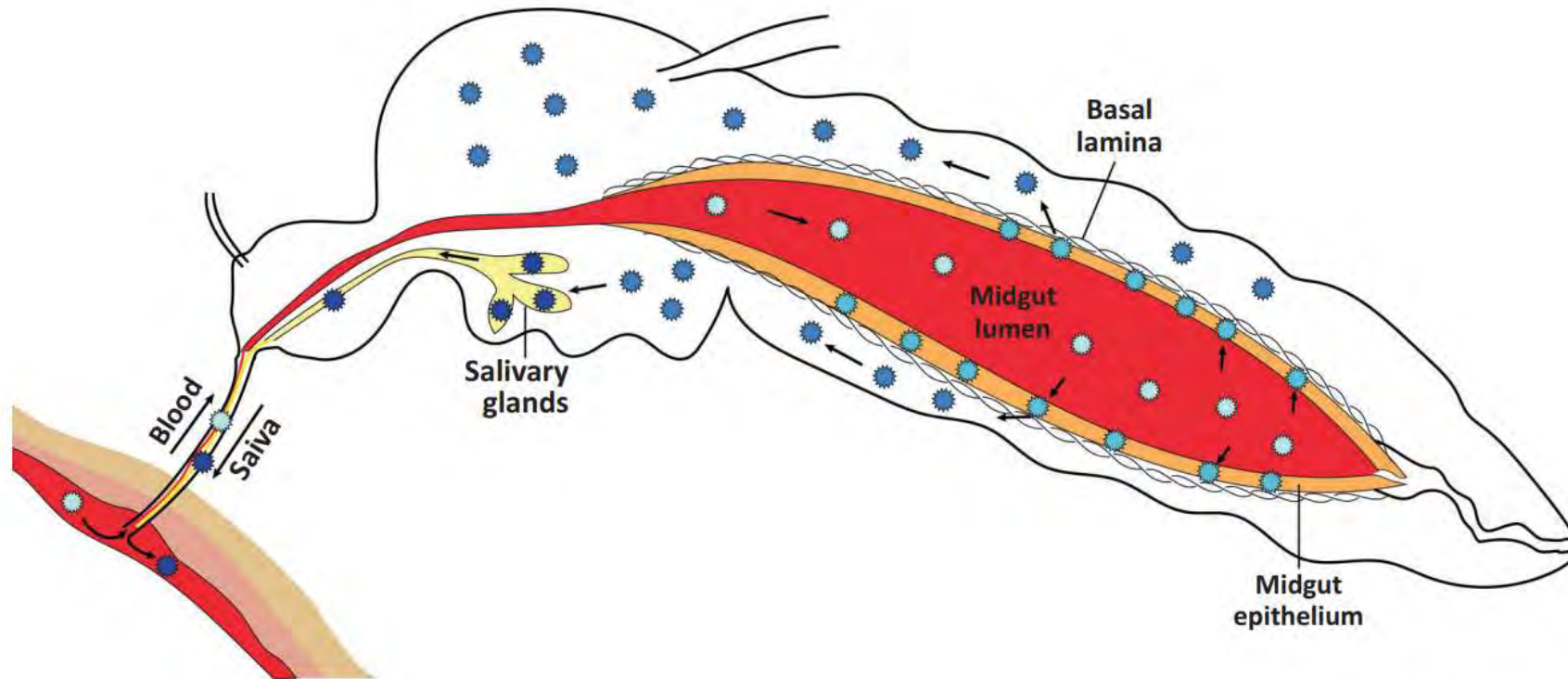


West Nile virus



*Plasmodium falciparum*

# How does it work?



Trends in Parasitology



# How does it work?



Mosquito Proboscis



Tick Hypostome

# History of Vector-Borne Diseases

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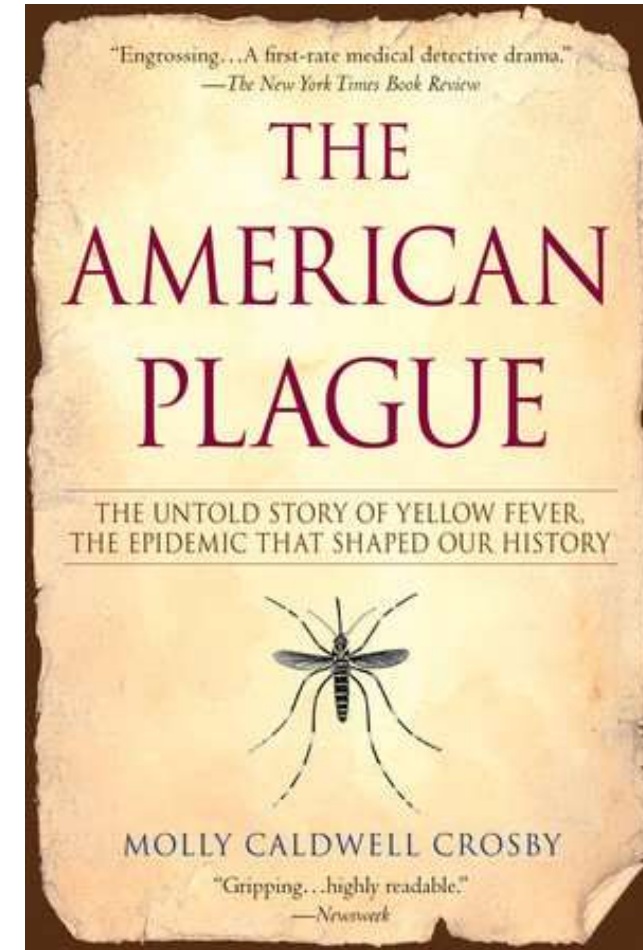
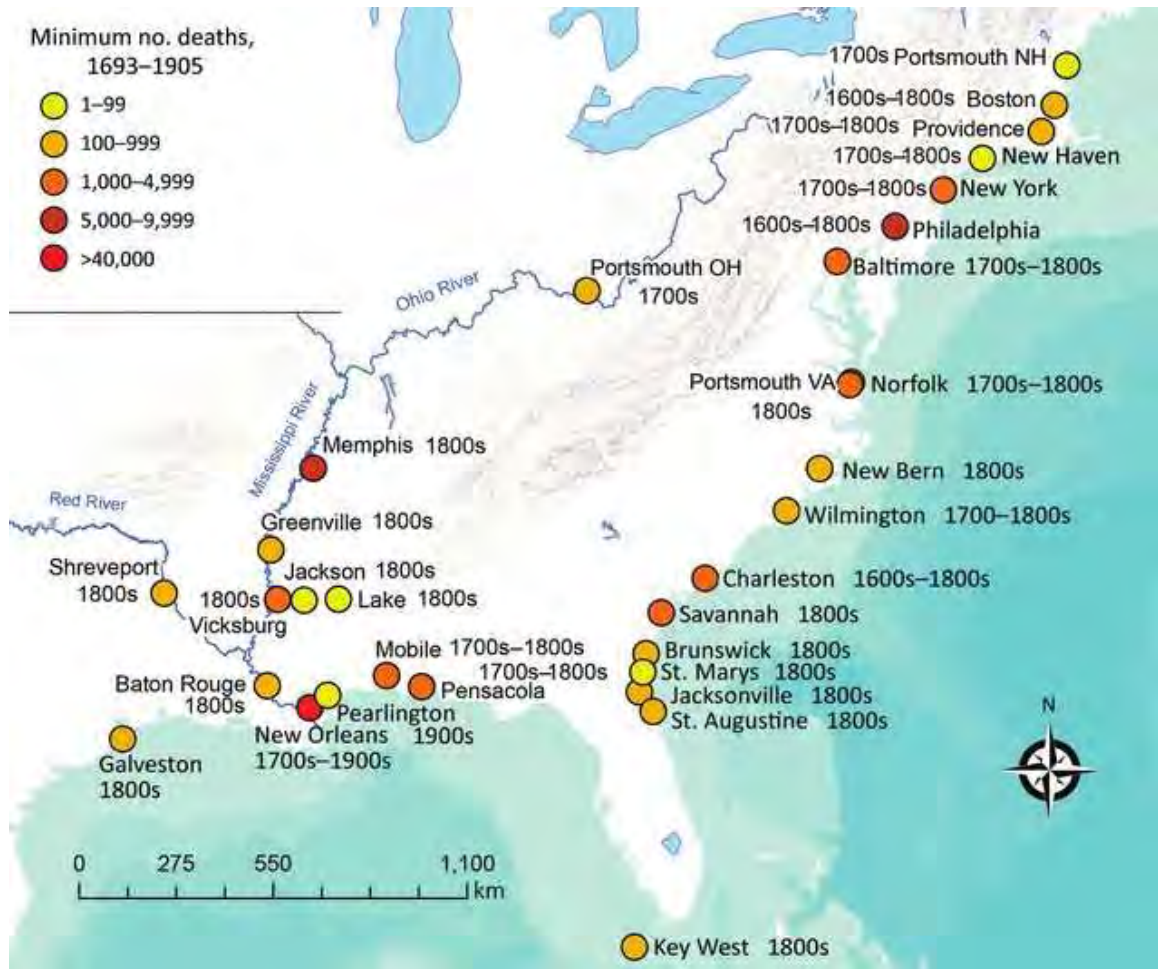
- Lymphatic filariasis was the first “identified” vector-borne disease by Patrick Manson in 1870s
- Malaria soon followed suit, with a number of folks involved, but most credit goes to Ronald Ross in 1897
- Yellow fever was the first virus to be discovered as transmitted by mosquitoes in the early 1900s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

Dr. Carlos Finlay

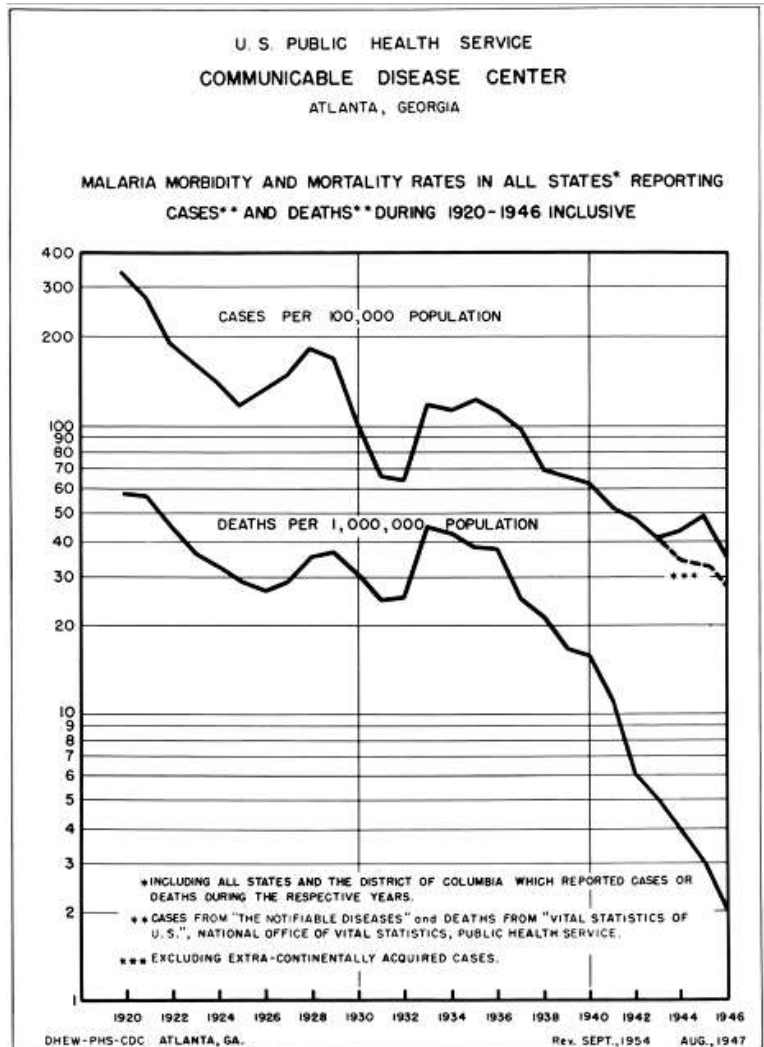




# VBDs have played an outsized roll in shaping US



# VBDs have played an outsized roll in shaping US



MALARIOUS AREA OF THE UNITED STATES  
1862



MALARIOUS AREA OF THE UNITED STATES  
1932



MALARIOUS AREA OF THE UNITED STATES  
1942



MALARIOUS AREA OF THE UNITED STATES  
1944-5

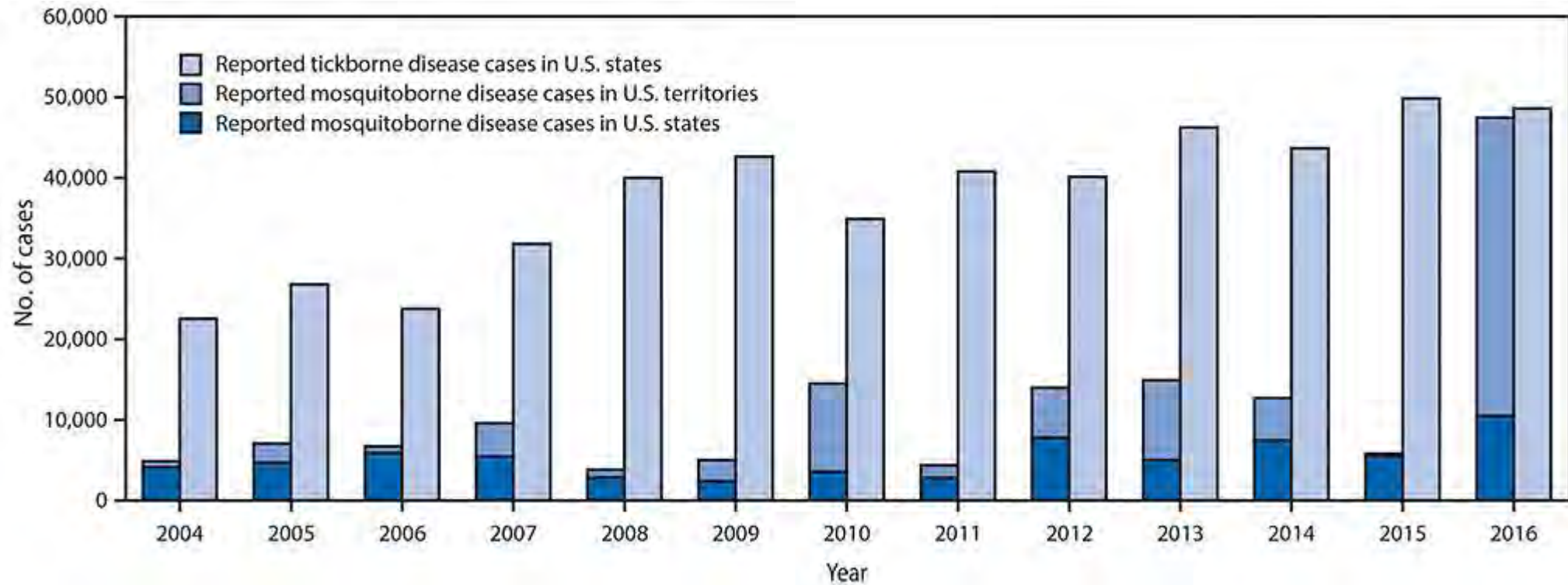


# What's old is new again..

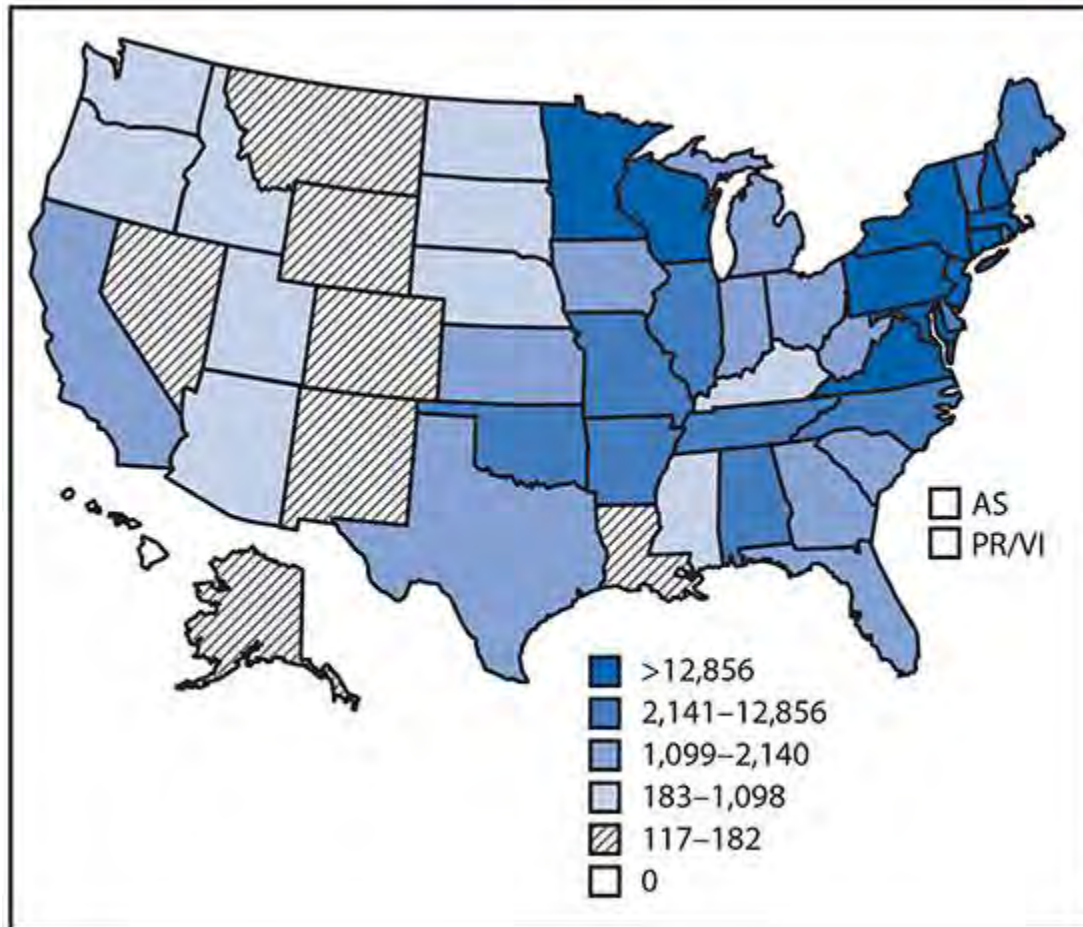
The screenshot shows the CDC Health Alert Network (HAN) interface. At the top left is the CDC logo with the text "Centers for Disease Control and Prevention" and "CDC 24/7: Saving Lives, Protecting People™". A search bar is located at the top right. Below the header is a blue navigation bar with the text "Emergency Preparedness and Response". Underneath, there is a breadcrumb trail: "Resources for Emergency Health Professionals > Health Alert Network (HAN) > HAN Archive > 2023".

The main content area features a sidebar on the left with the following links: "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 HEALTH ALERT NETWORK" logo and an orange box that says "This is an official CDC HEALTH ADVISORY". At the bottom, it states "Distributed via the CDC Health Alert Network" and "June 26, 2023, 5:00 PM ET".

# 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)

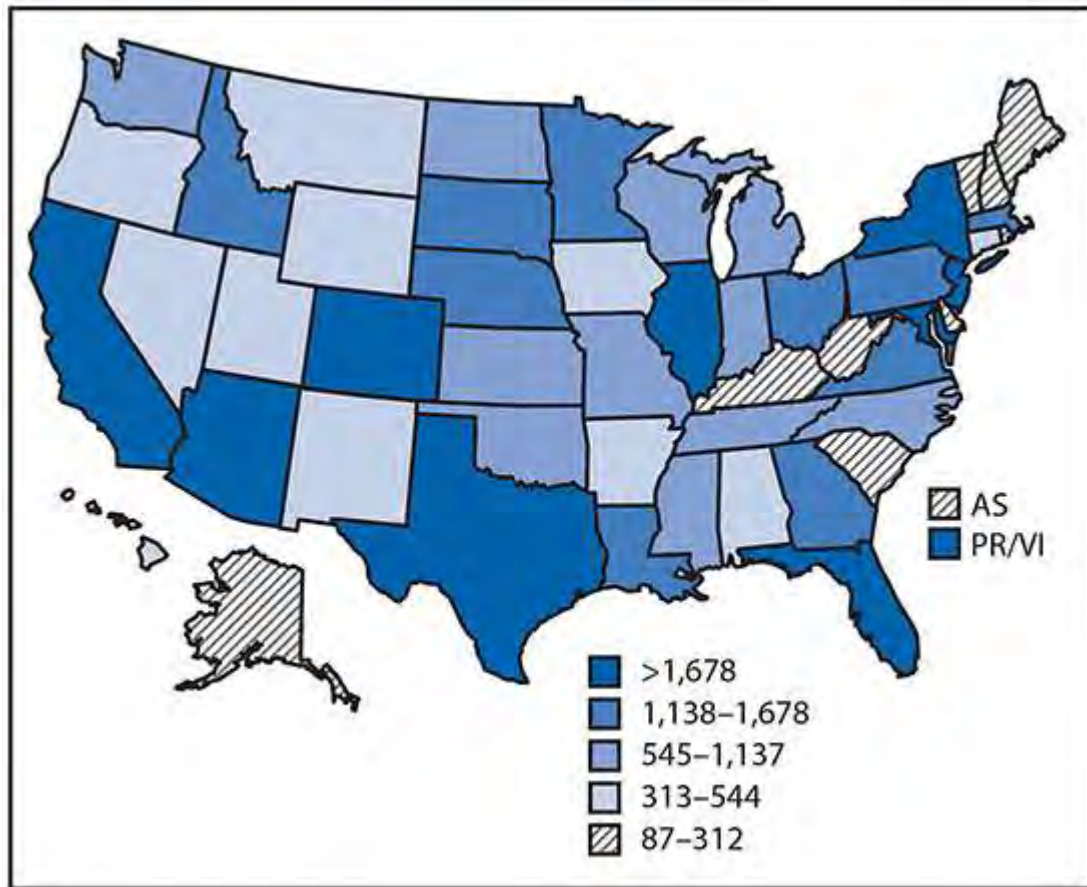


Spotted fever rickettsiosis reported cases



Tularemia reported cases

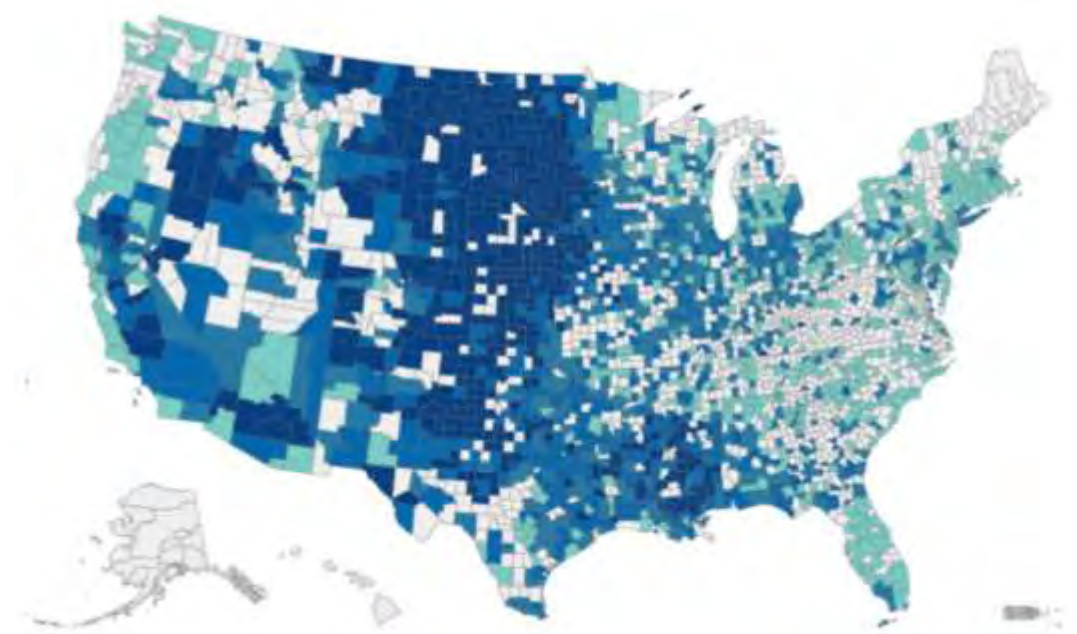
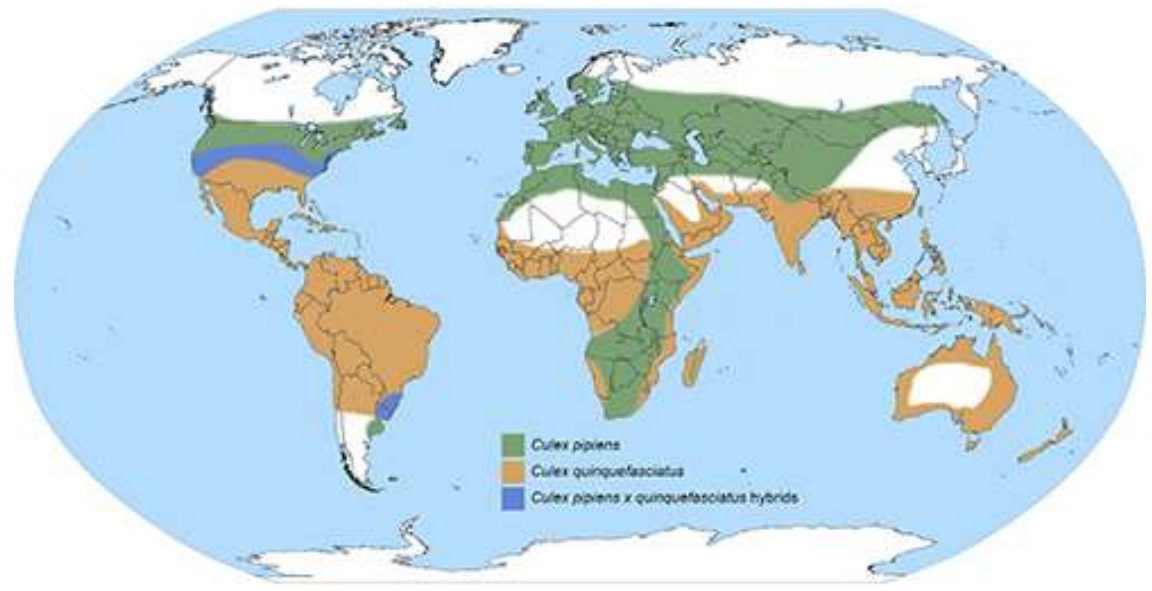
# Different pathogens, same problems- VBD in US



## 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)



# Risk Depends on the Vector- Mosquito -Borne Diseases US

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

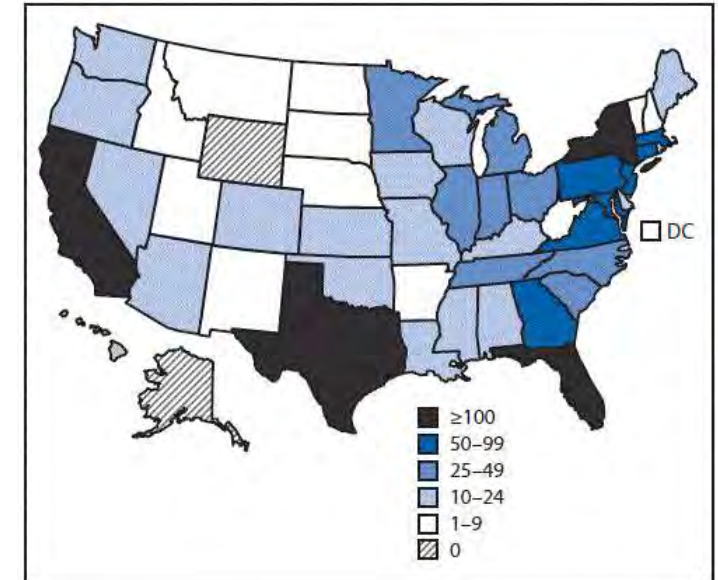


*Aedes aegypti* (Yellow fever mosquito)

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



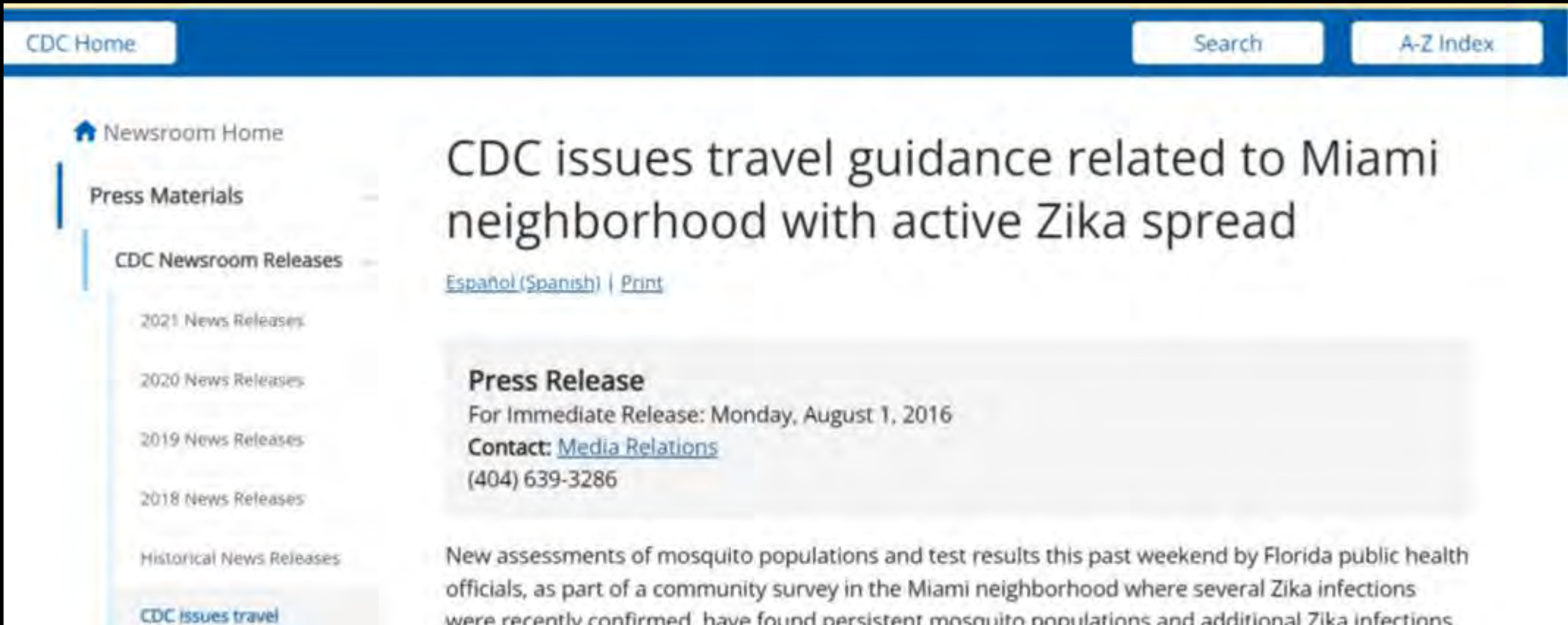
*Aedes albopictus* (Asian tiger mosquito)



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's newsroom page. The main headline is "CDC issues travel guidance related to Miami neighborhood with active Zika spread". Below the headline, it says "Press Release" and "For Immediate Release: Monday, August 1, 2016". The contact information is "Media Relations" at "(404) 639-3286". The text of the release begins with "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".

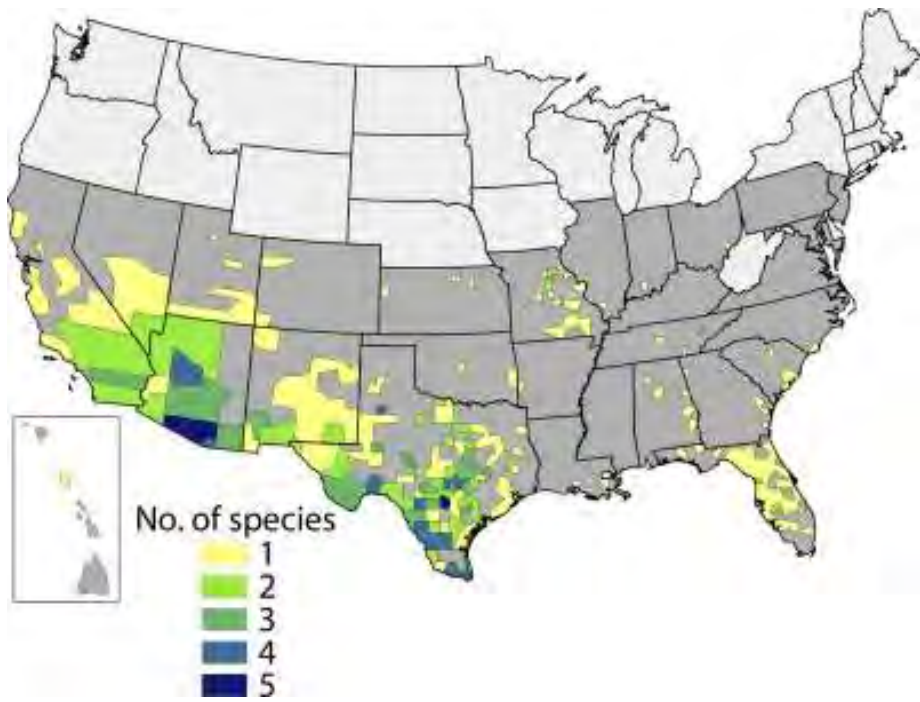
On the left side of the screenshot, there is a sidebar with a legend titled "Mosquito live and r" and a list of "CDC Newsroom Releases" for the years 2021, 2020, 2019, and 2018, along with "Historical News Releases" and "CDC issues travel".

On the right side of the screenshot, there is a map of the United States with a red dot indicating the location of Miami, Florida.

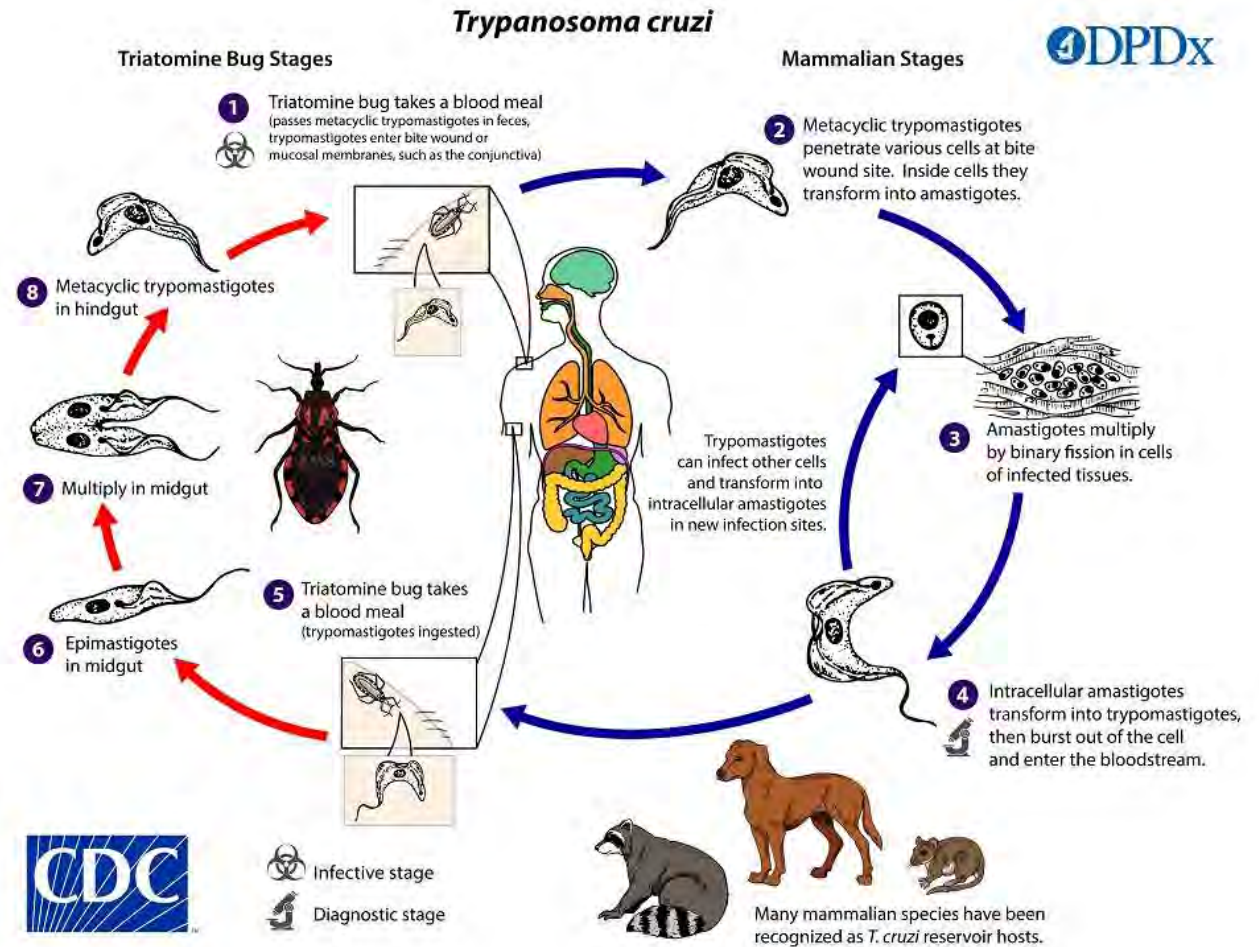
*Aedes aegypti* (Yellow fever mosquito)

*Aedes albopictus* (Asian tiger mosquito)

# A few other VBDs



*Triatominae* (Kissing Bug)



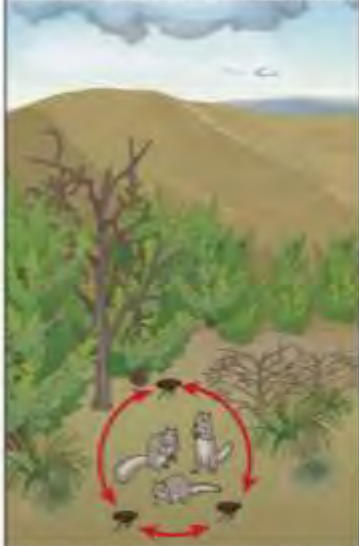
# A few other VBDs

## Plague Ecology in the United States



### Plague in Nature

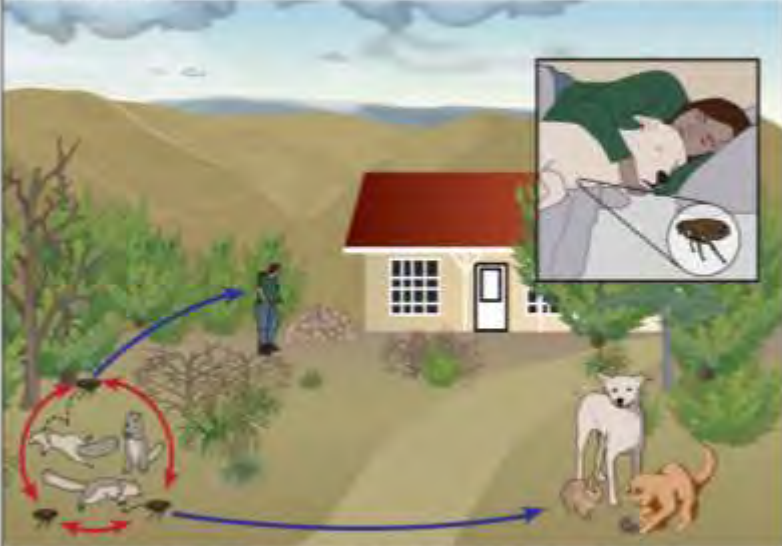
Plague occurs naturally in the western U.S., especially in the semi-arid grasslands and scrub woodlands of the southwestern states of Arizona, Colorado, New Mexico and Utah.



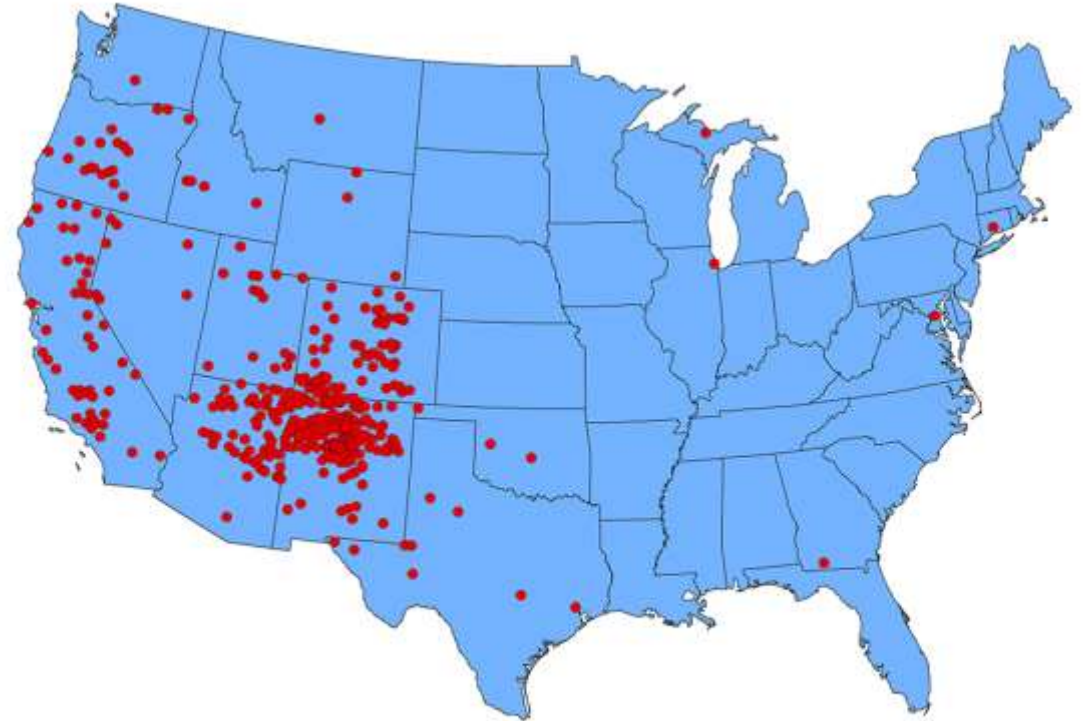
The plague bacterium (*Yersinia pestis*) is transmitted by fleas and cycles naturally among wild rodents, including rock squirrels, ground squirrels, prairie dogs and wood rats.

### 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.



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



*Triatominae* (Kissing Bug)



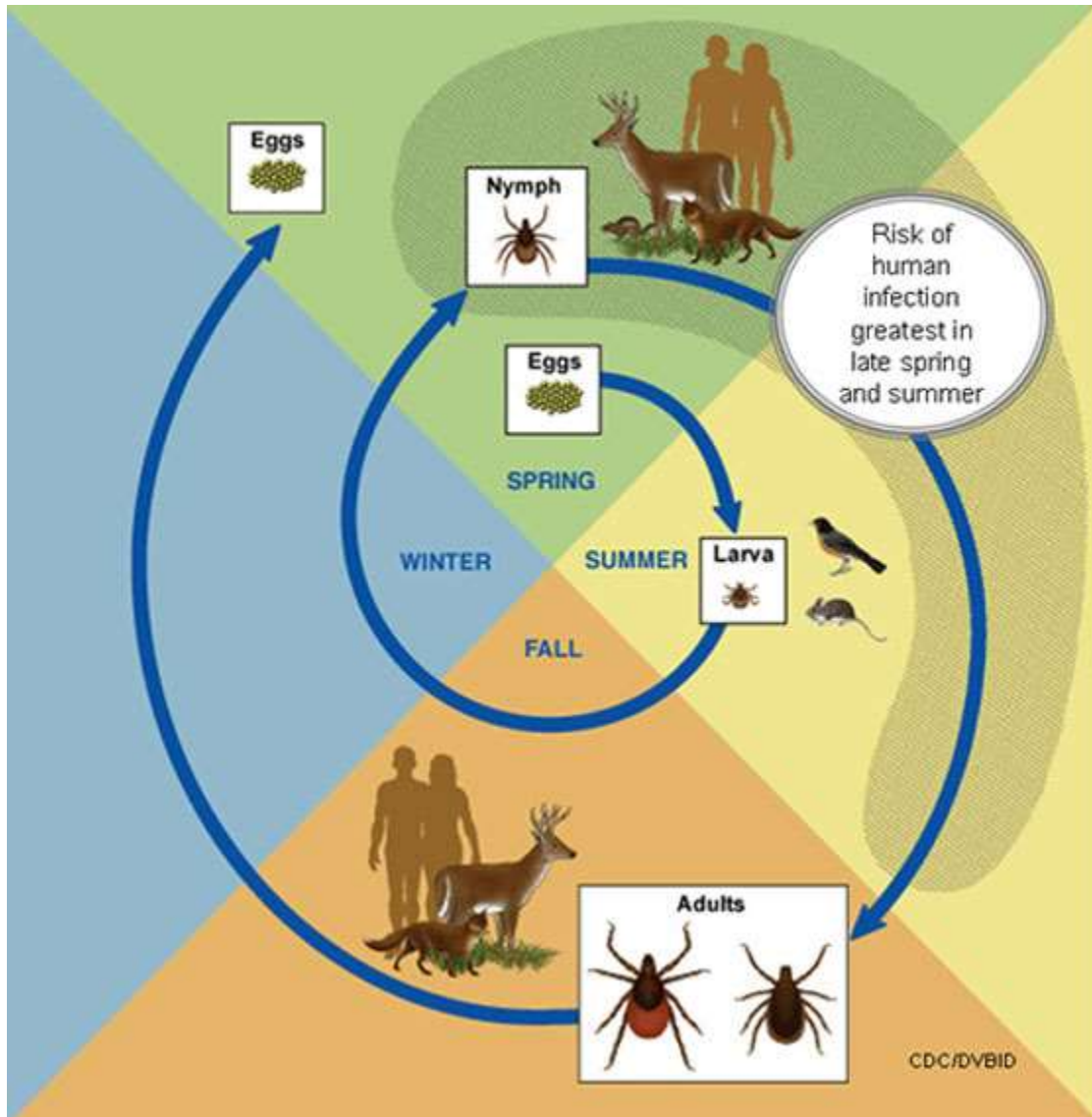
UNIVERSITY OF NEBRASKA MEDICAL CENTER™  
COLLEGE OF PUBLIC HEALTH



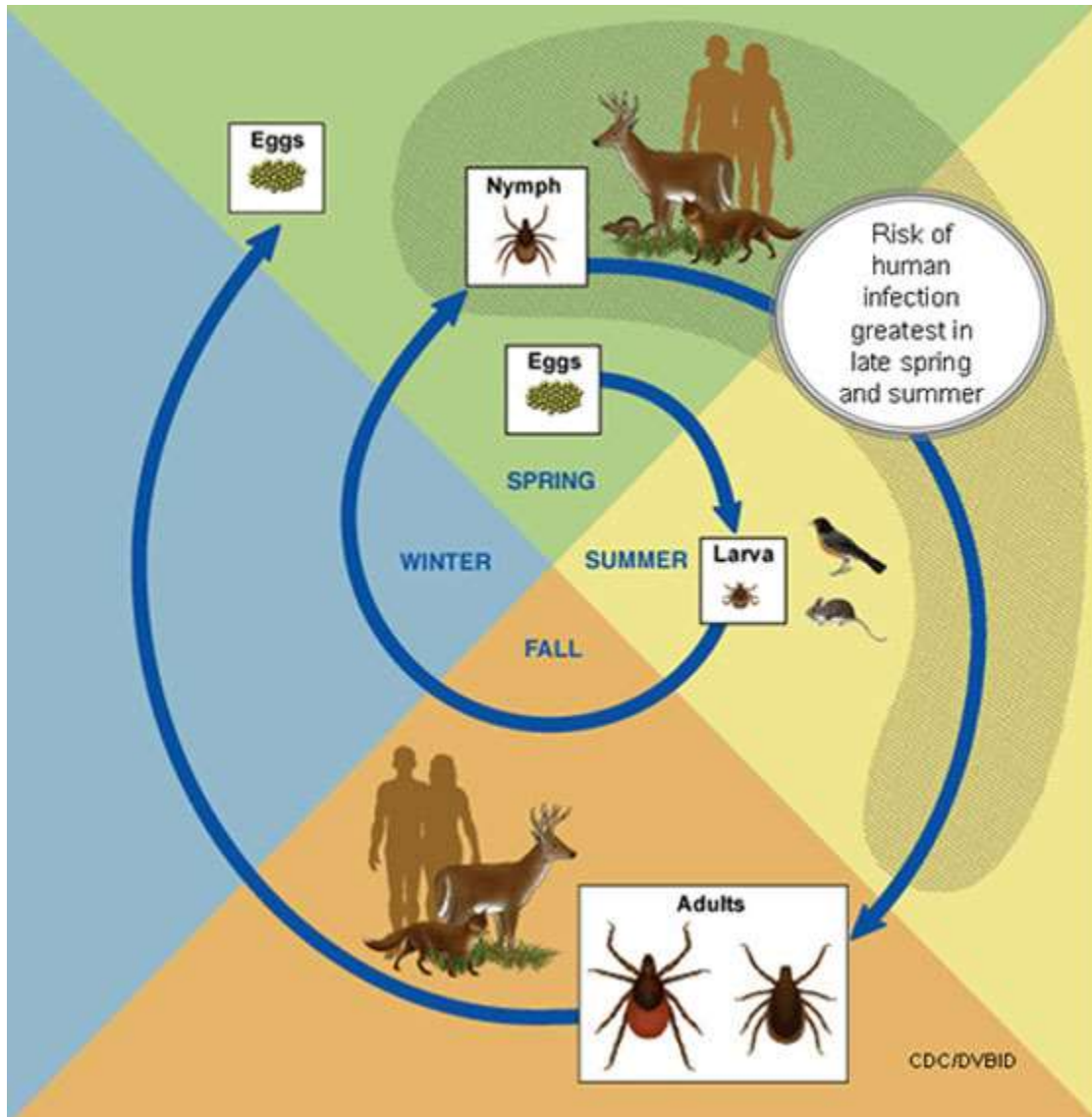
# Understanding Lyme Disease Risk

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# Understanding Lyme Disease Risk



# Understanding Lyme Disease Risk



Blacklegged Tick (*Ixodes scapularis*)



CDC @CDCgov

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](https://bit.ly/2rjox6U)



3:30 PM · May 4, 2018

# Tick Bite Prevention

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

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-Long pants with socks tucked in



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- 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 <sup>25</sup>	<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 <sup>35</sup>	<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 <sup>36</sup>	<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

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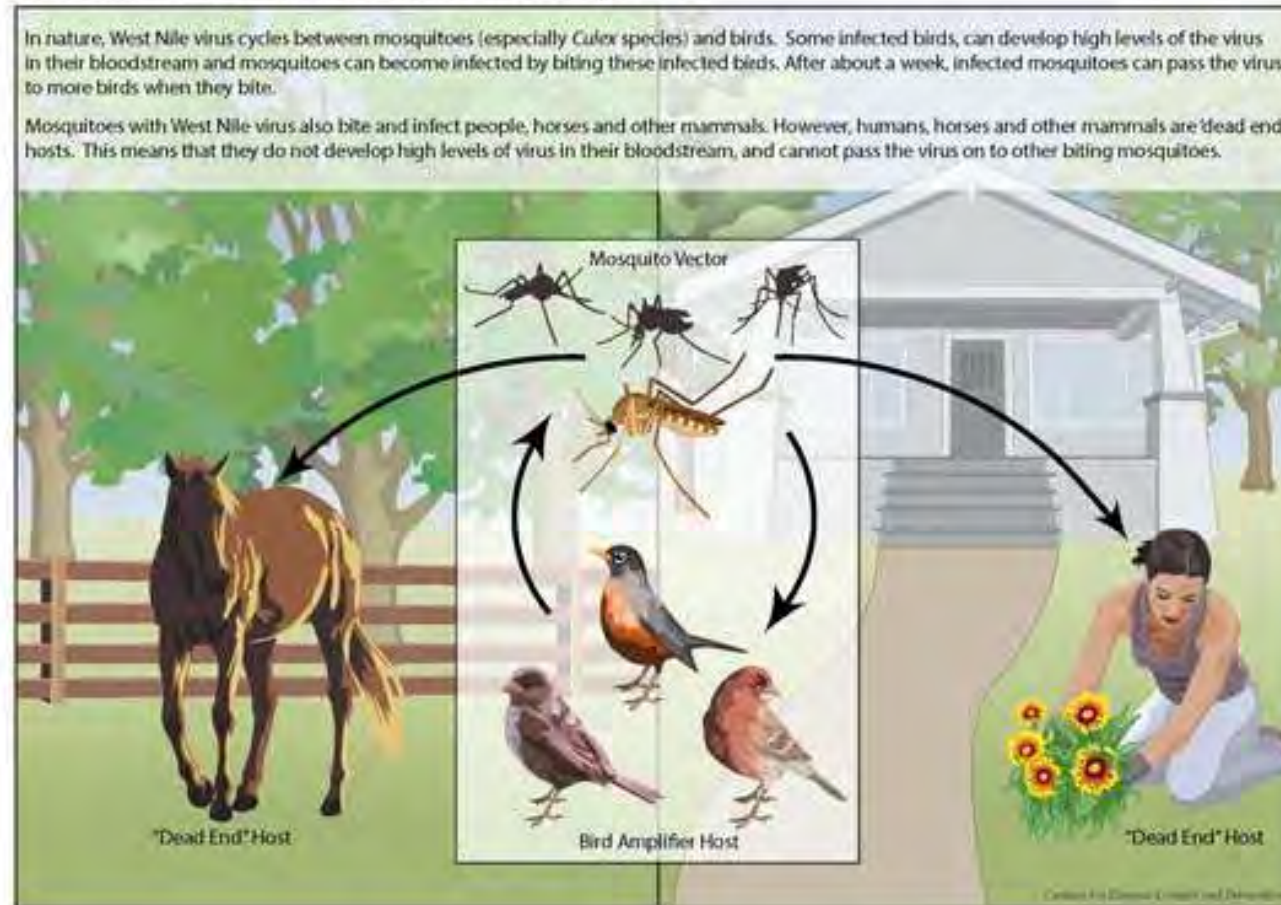
As with all VBDs, prevention of vector bites is the most effective way to prevent transmission.

- 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



# Mosquito Bite Prevention

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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



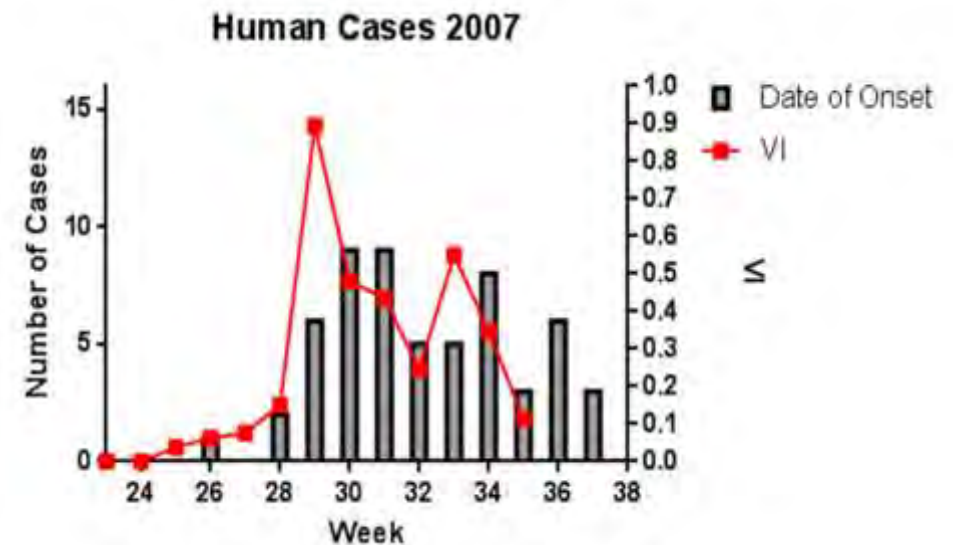
# Mosquito Bite Prevention

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

- Personal protection
- Mosquito abatement



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



# Summary

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- 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](mailto:jfauver@unmc.edu)