A Primer on Vector-Borne Disease

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UNMC Ag Med Course
7/19/2023

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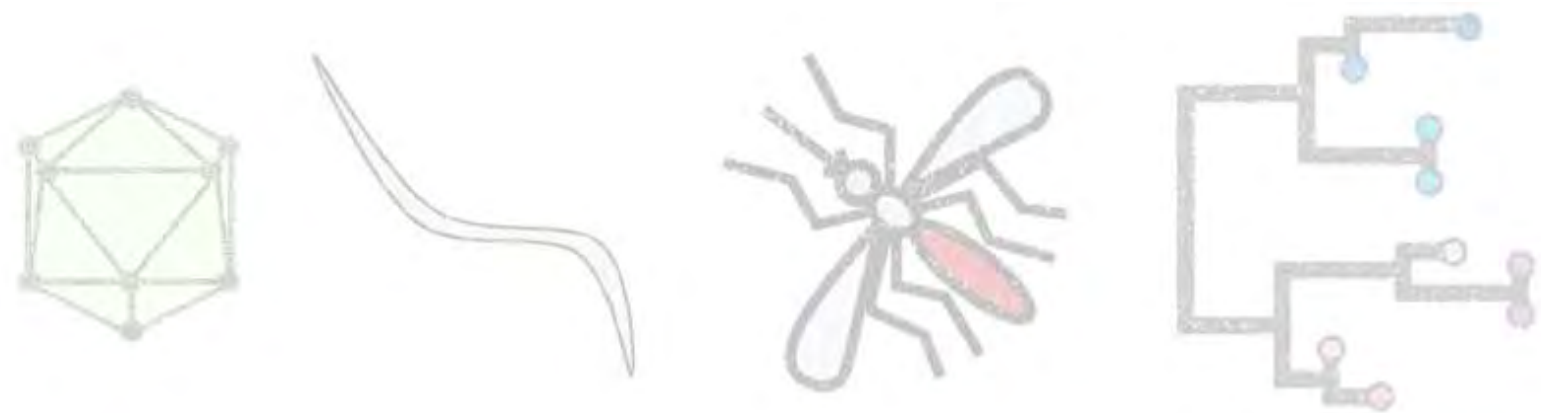
Outline

- 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



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People, Places, and Parasites

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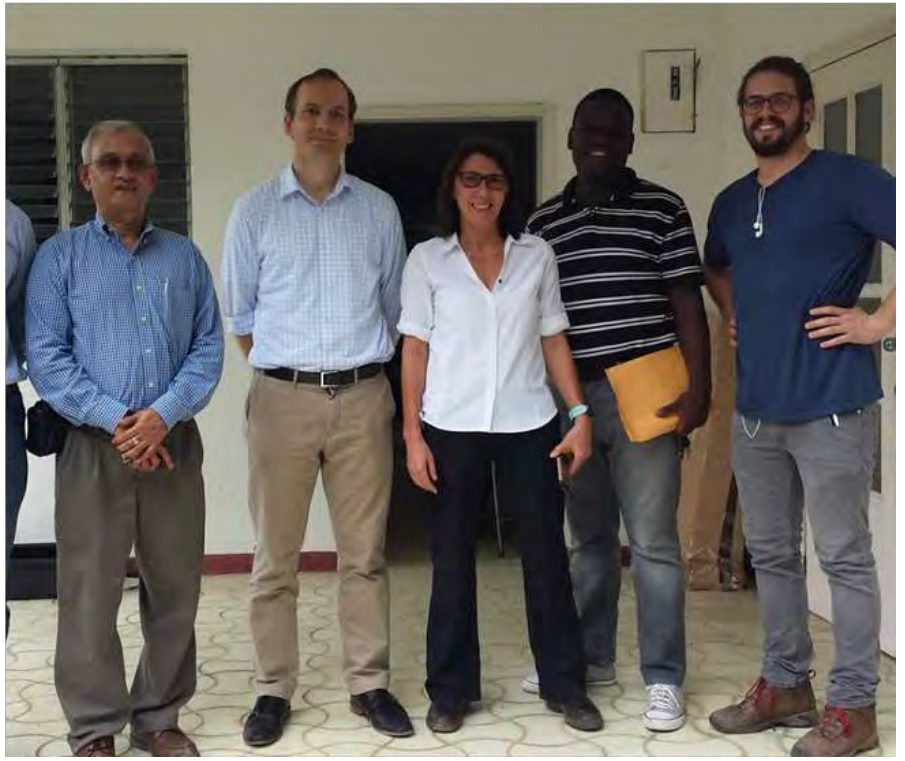

What are Vector-Borne Diseases?

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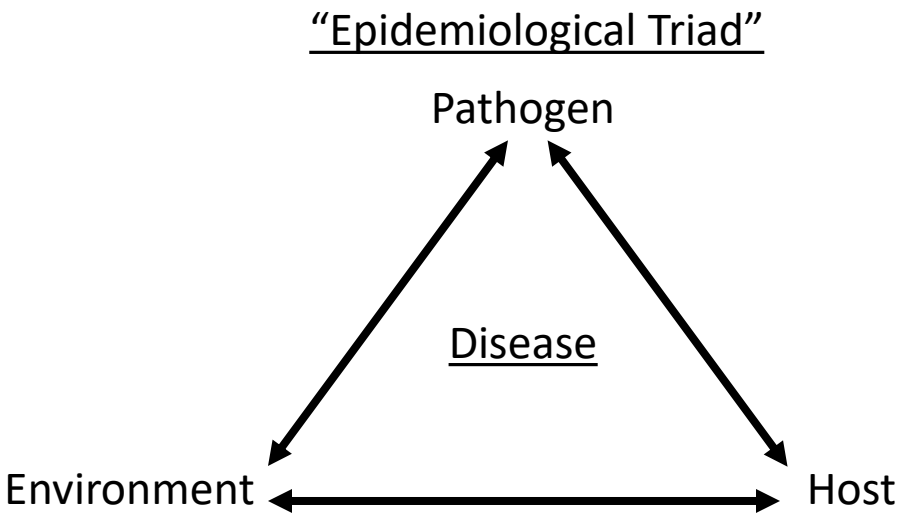
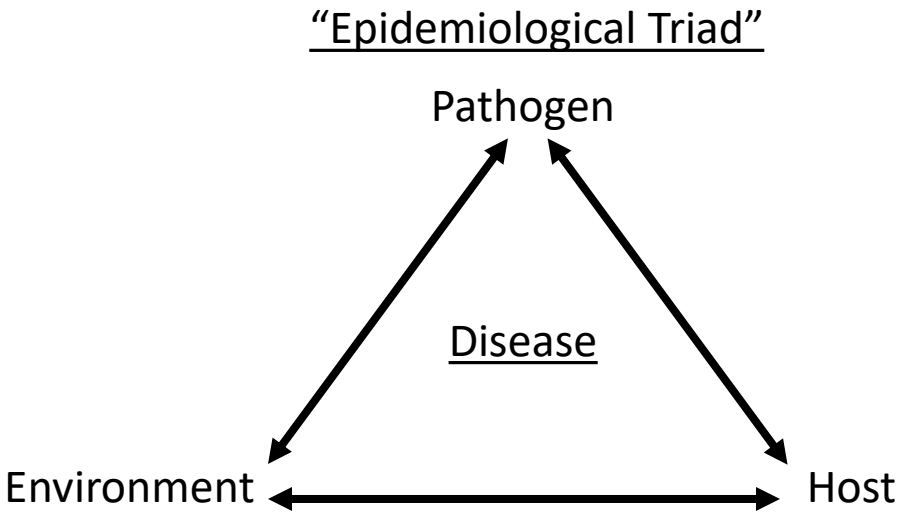
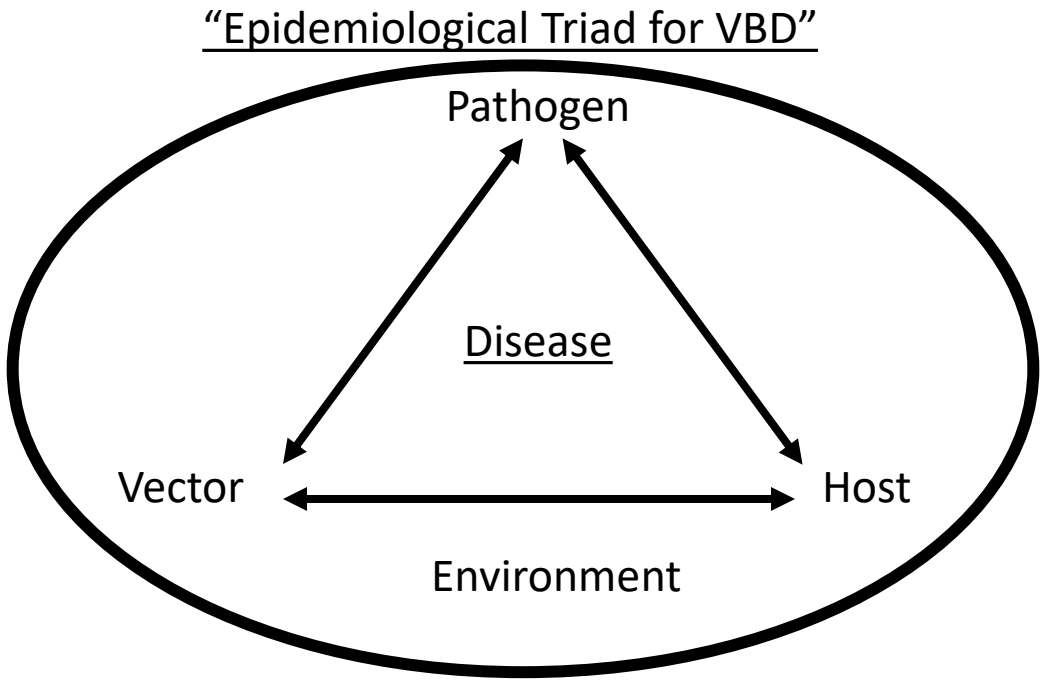


What are Vector-Borne Diseases?

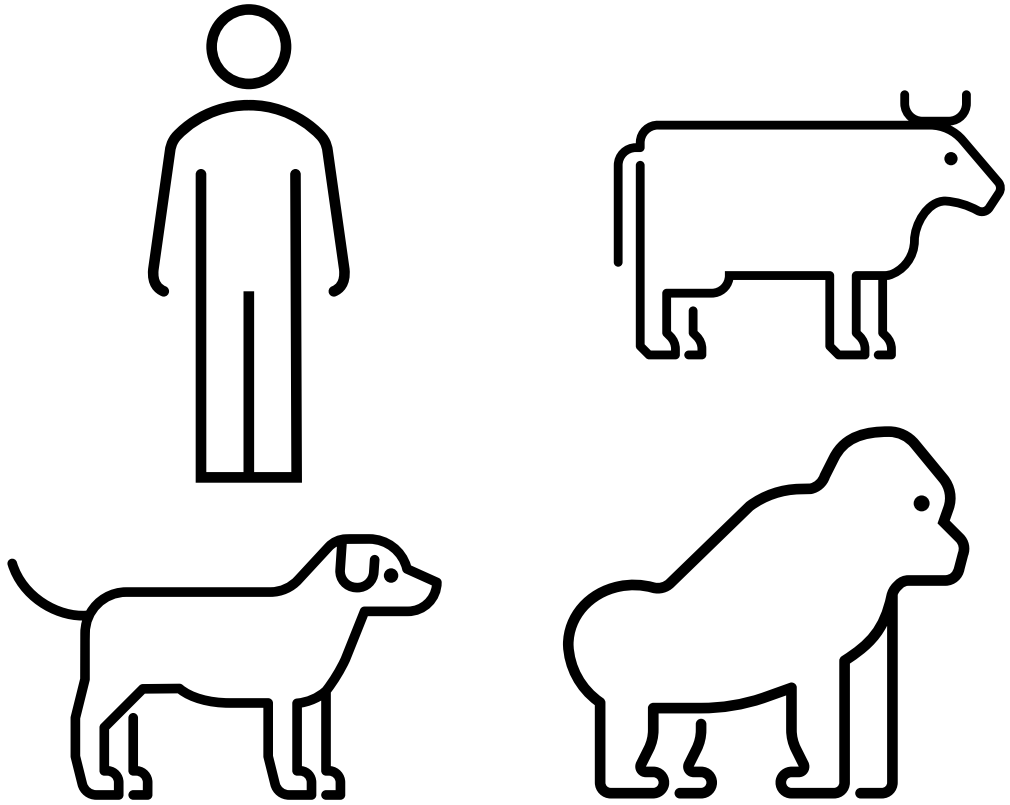
- Vector-borne diseases are human, animal, or plant illnesses caused by parasites, viruses and bacteria (pathogens) that are transmitted by vectors.





What hosts are we concerned about?

- Humans!
- Companion Animals
- Livestock
- Wildlife



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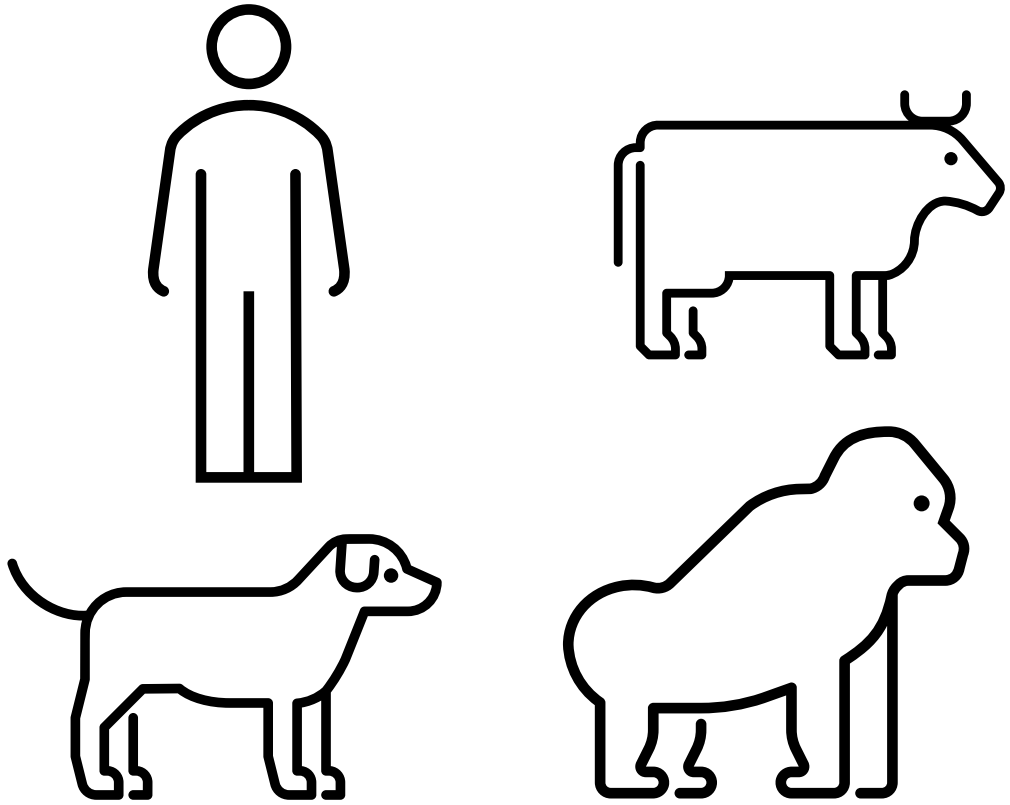

- We are healthcare workers, why should we care about wildlife diseases?

What is a vector?

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








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What pathogens are transmitted by vectors?

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

Wucheria bancrofti

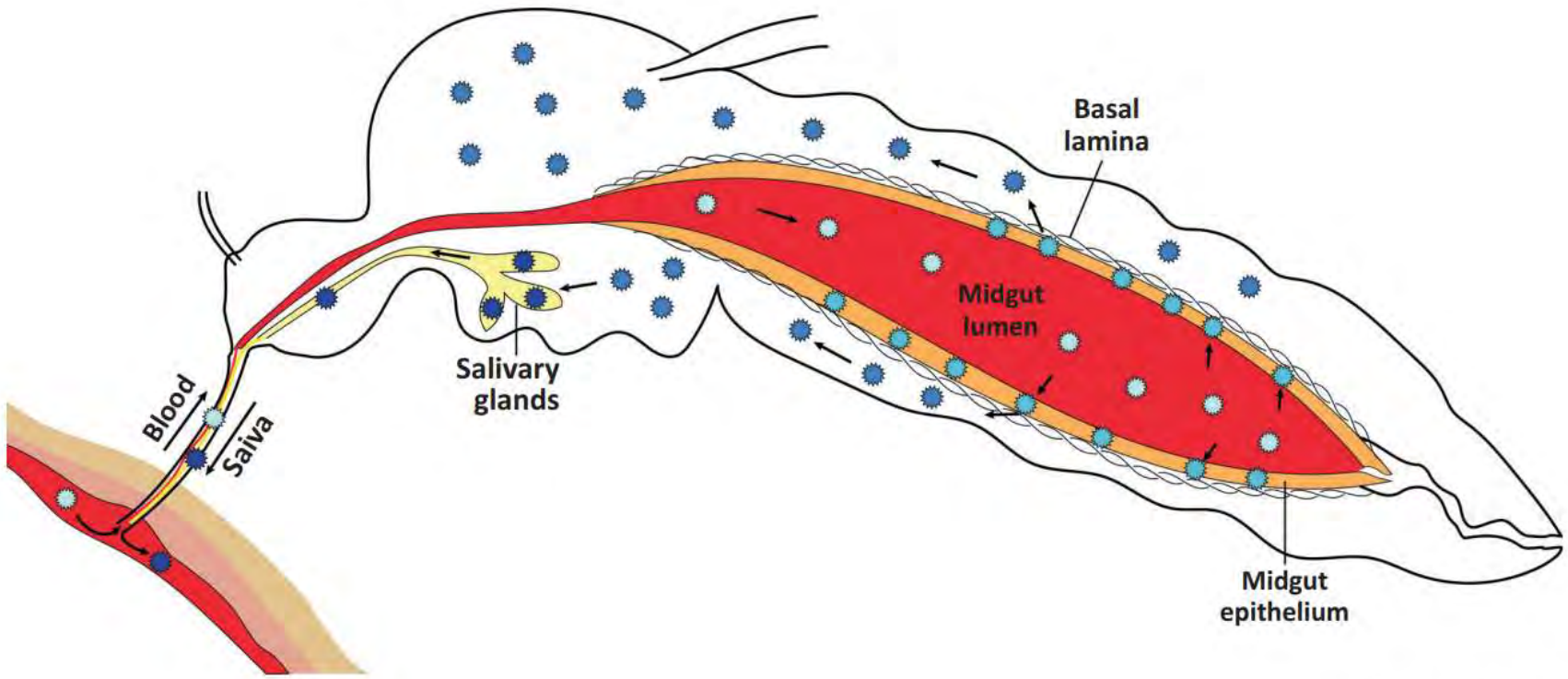
Borrelia burgdorferi

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

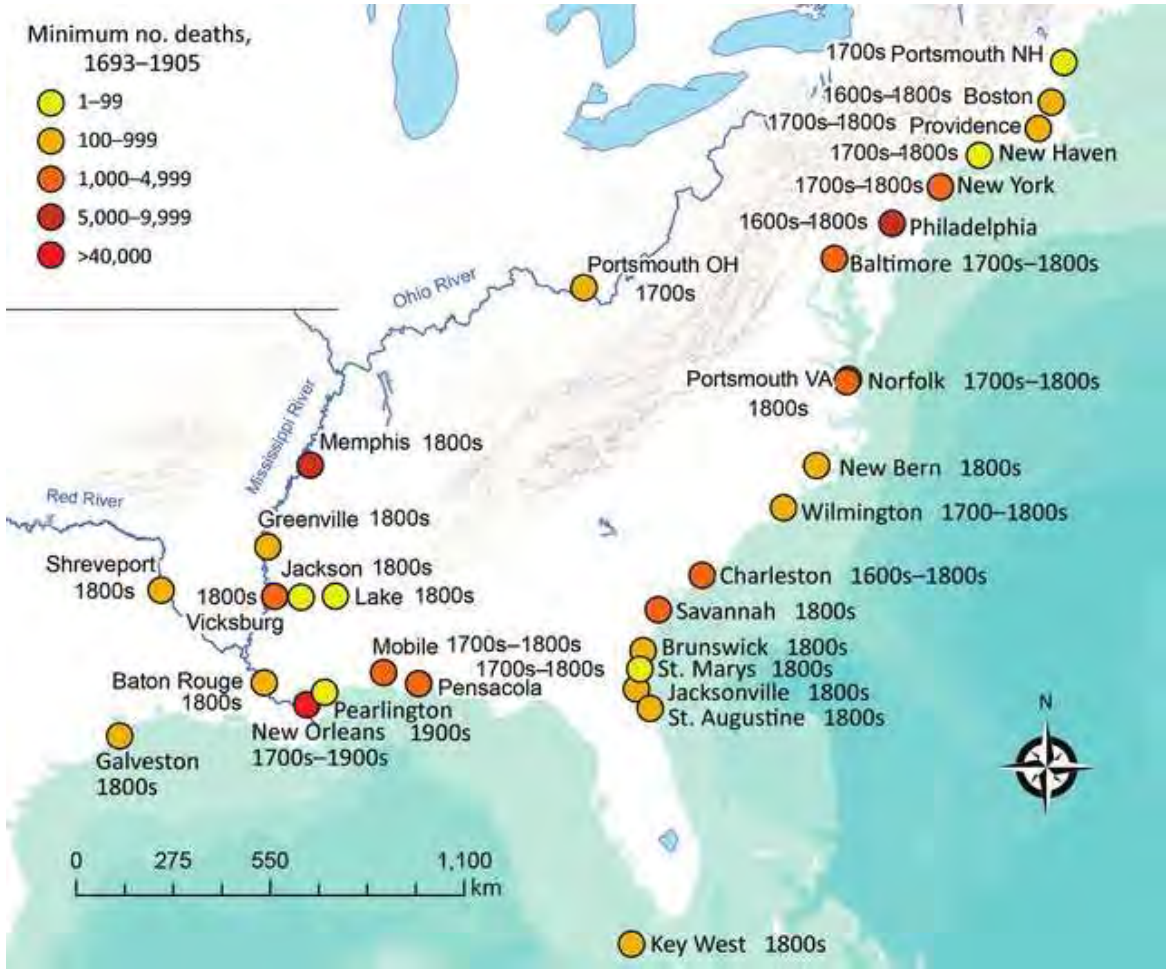
Tick Hypostome

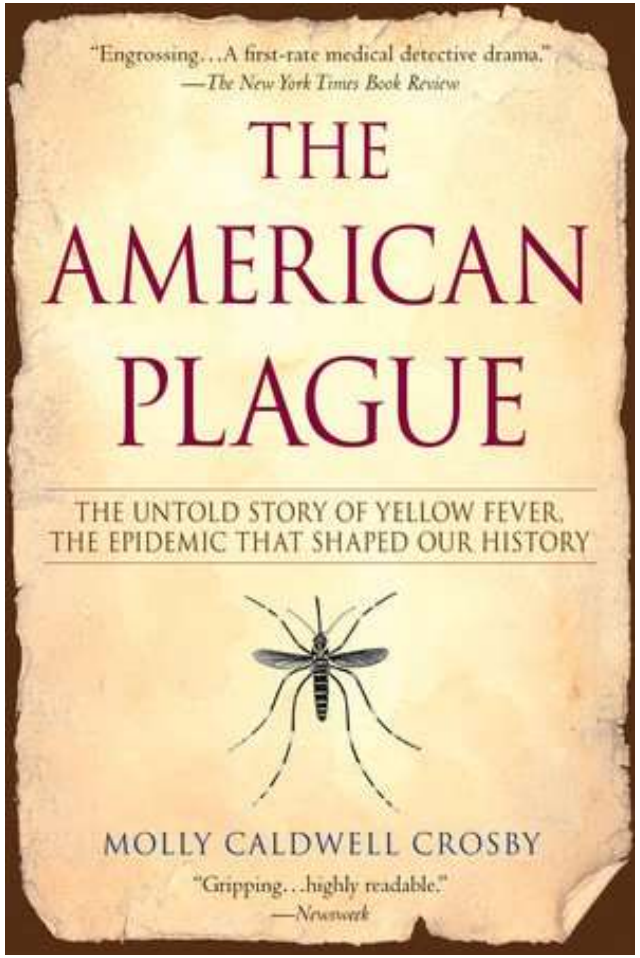
History of Vector-Borne Diseases

- 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





Moreno-Madrinan, Turell, EID 2018

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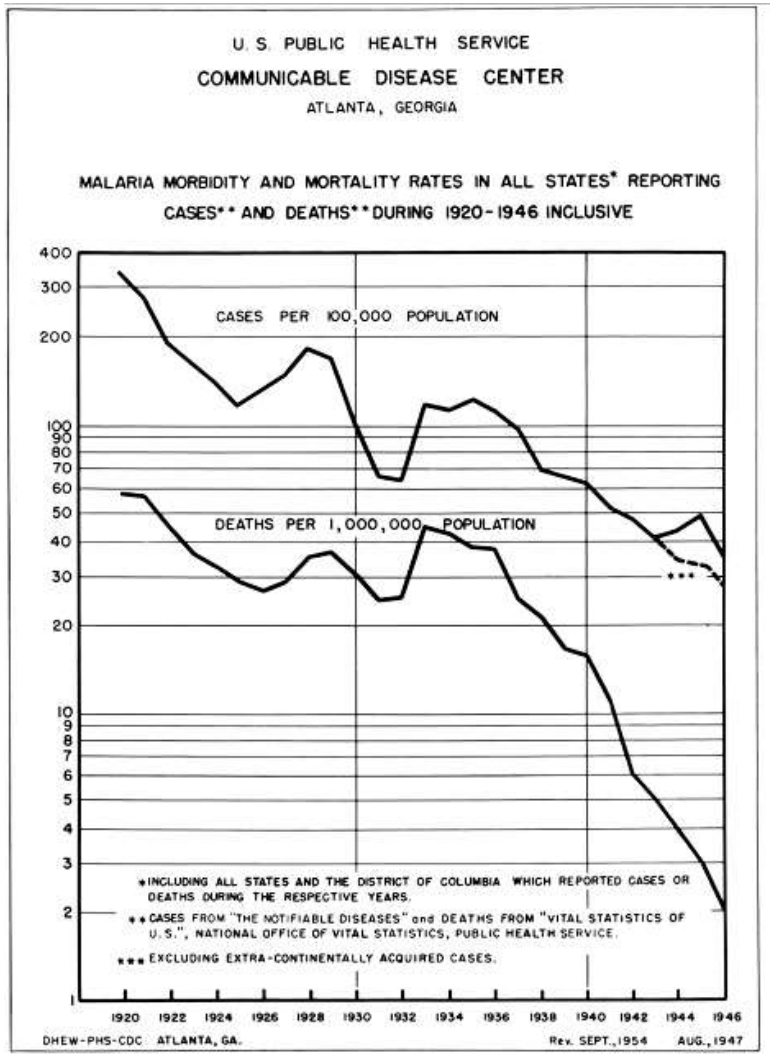

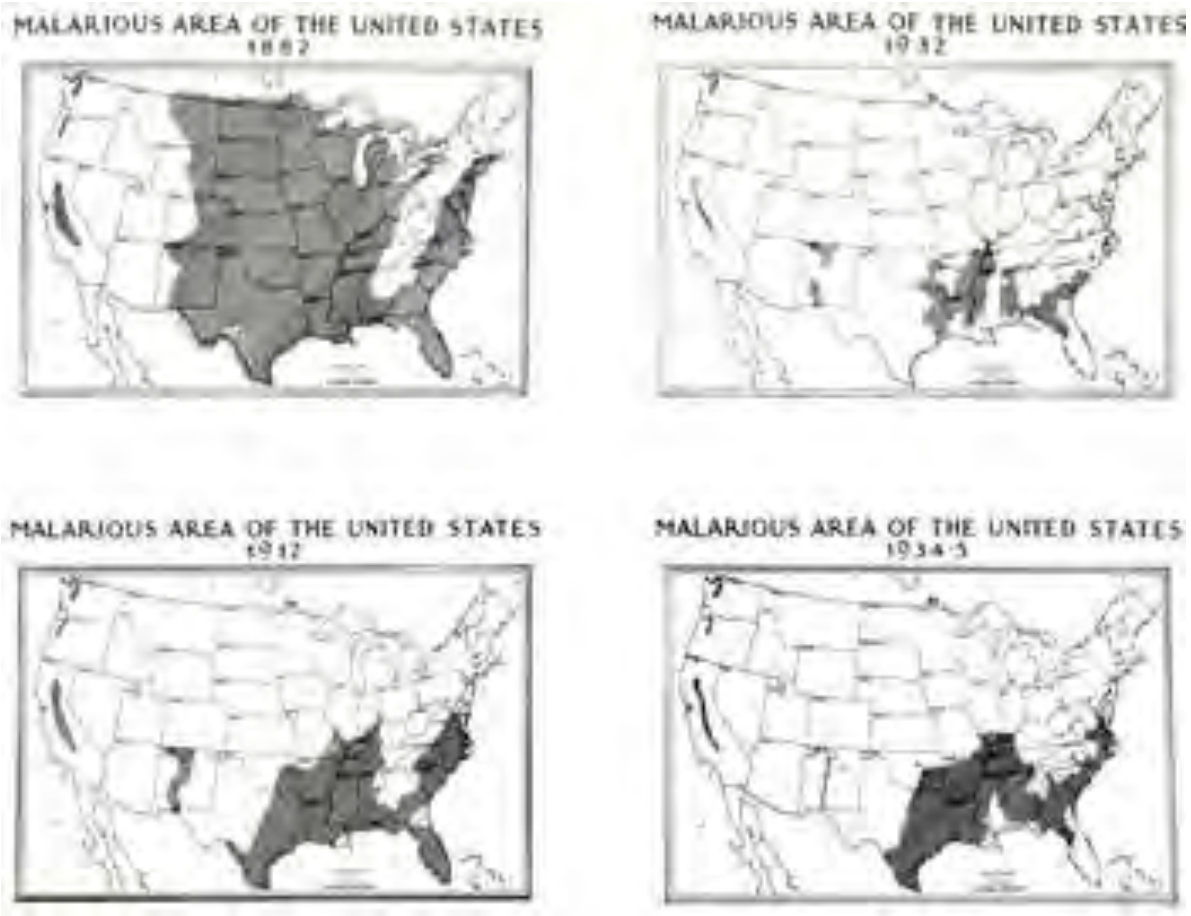

https://www.cdc.gov/malaria/about/history/elimination_us.html

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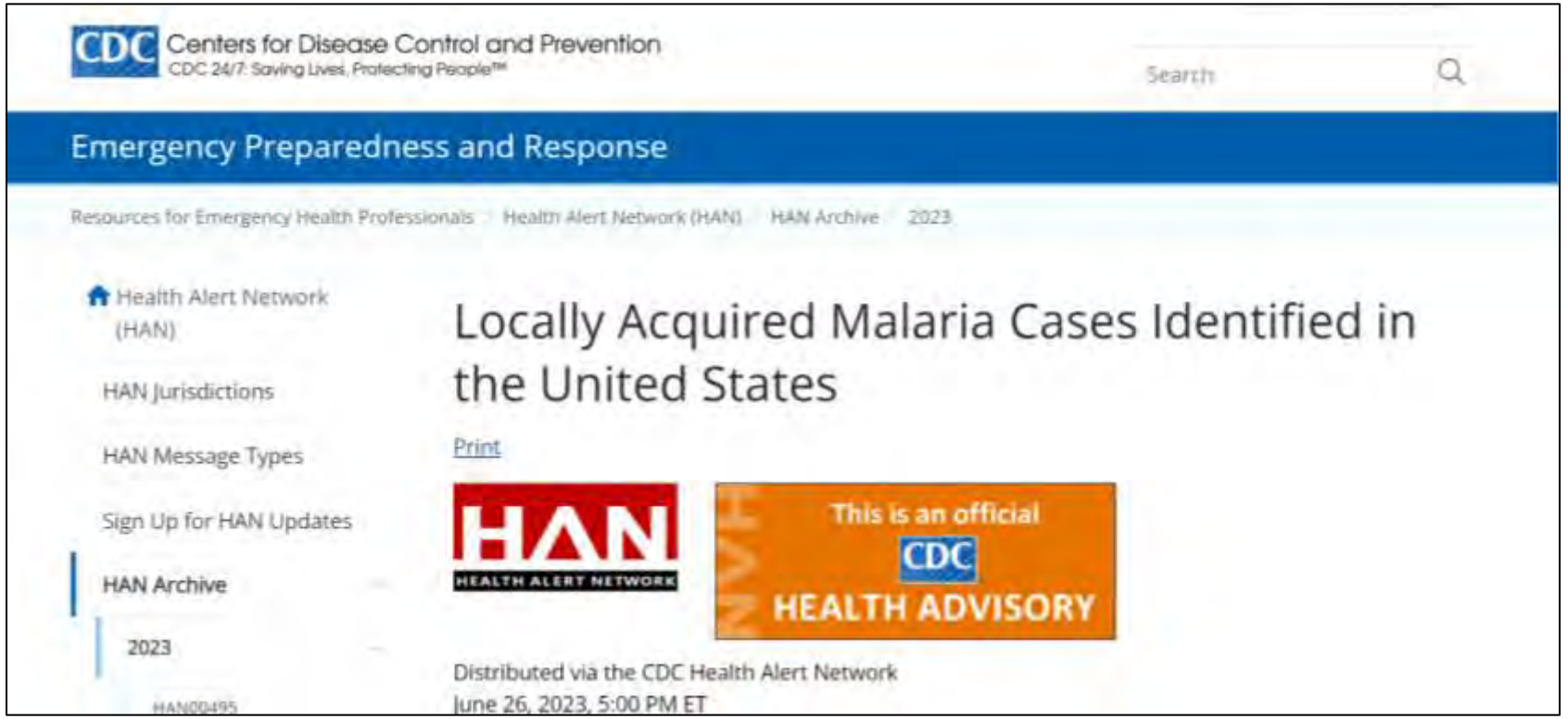
What's old is new again..



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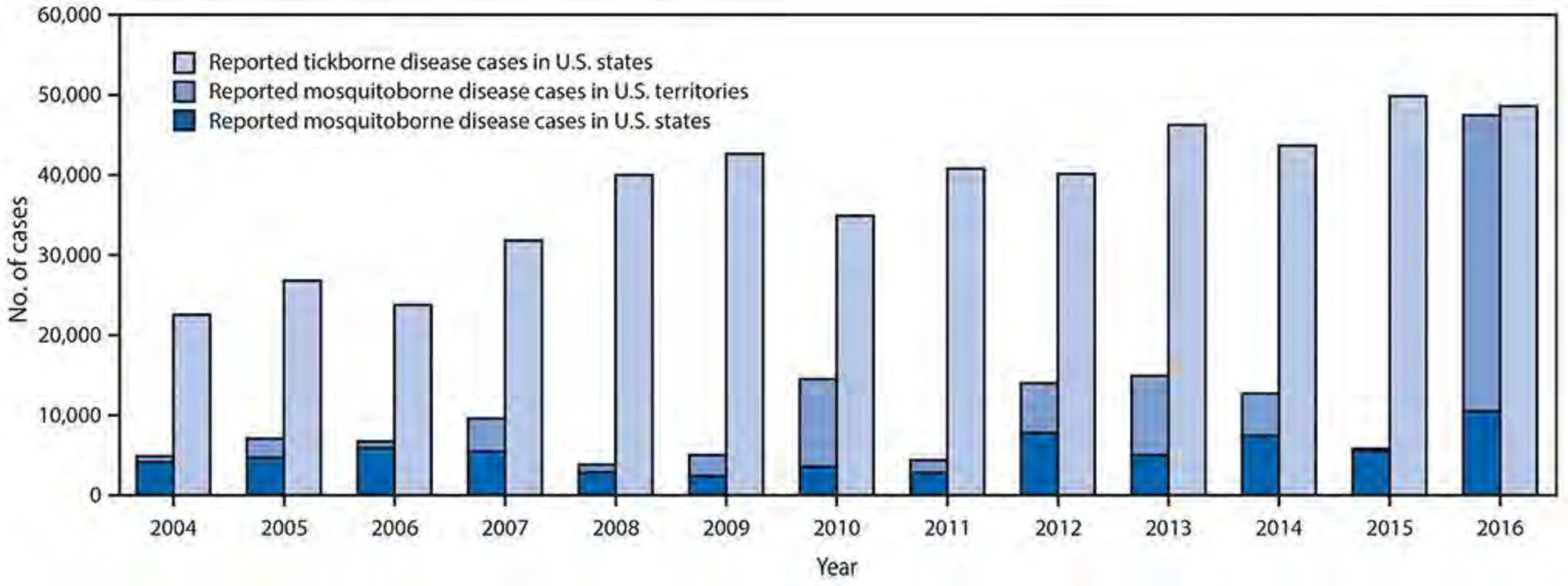
Different pathogens, same problems- VBD in US



Rosenberg et al. MMWR 2018

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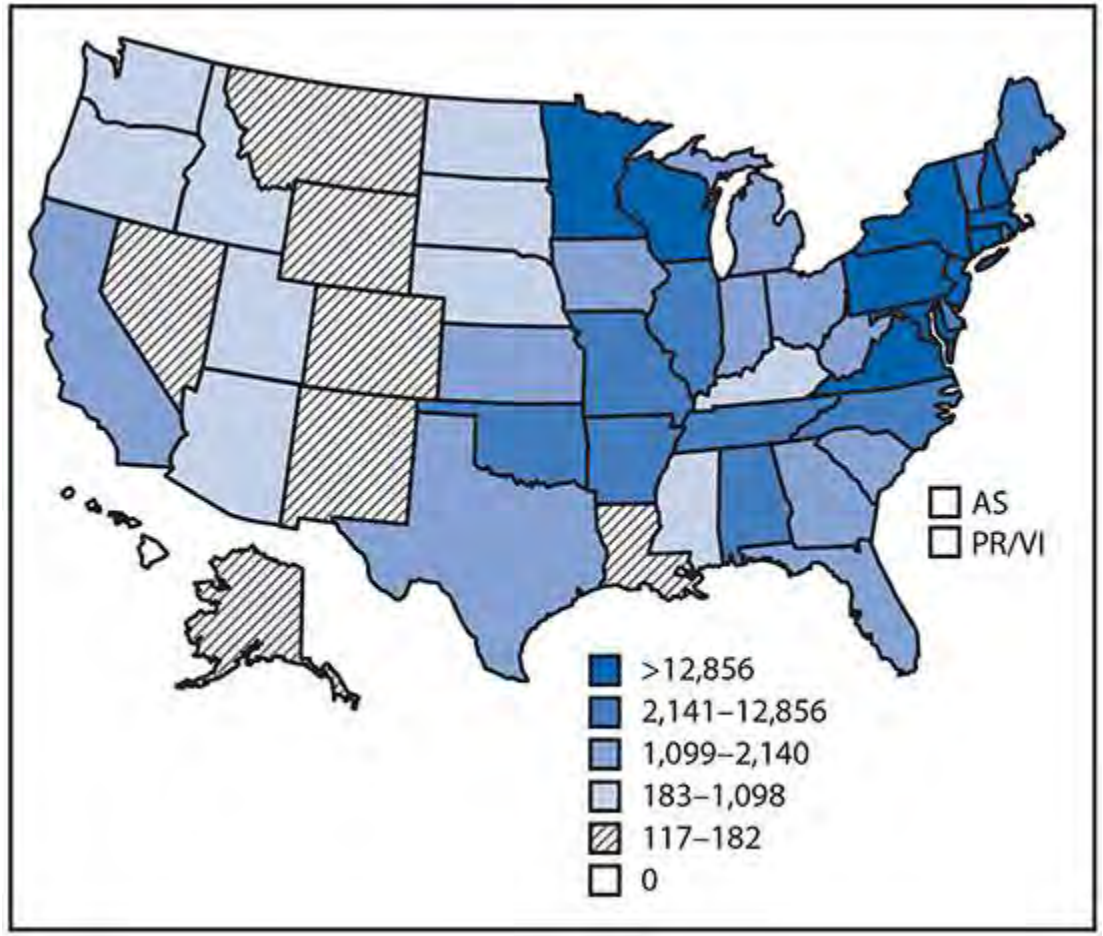

Tick-borne diseases US 2016

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

Rosenberg et al. MMWR 2018

Risk Depends on the Vector- Tick-Borne Diseases US

Ixodes scapularis (Blacklegged tick, deer tick)

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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)

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Risk Depends on the Vector- Tick-Borne Diseases US

Dermacentor variabilis (American dog tick)

Spotted fever rickettsiosis reported cases

Tularemia reported cases

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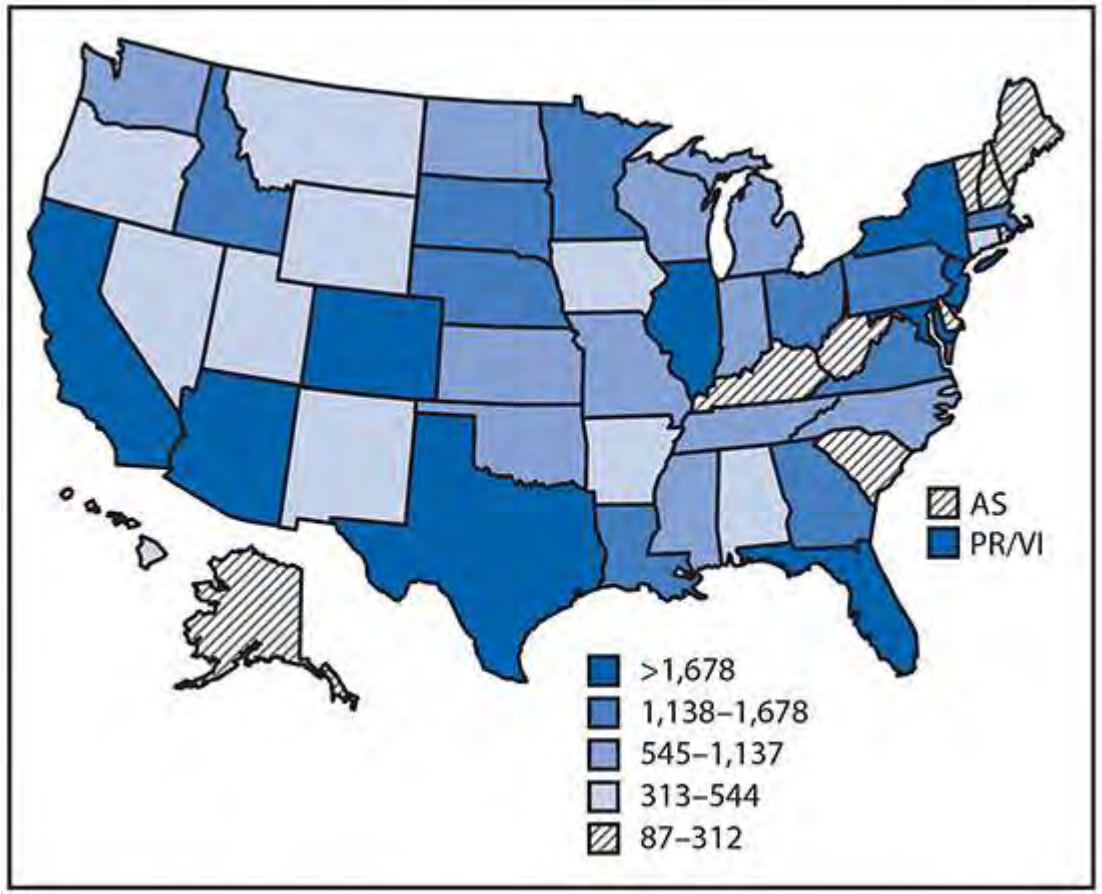
Different pathogens, same problems- VBD in US

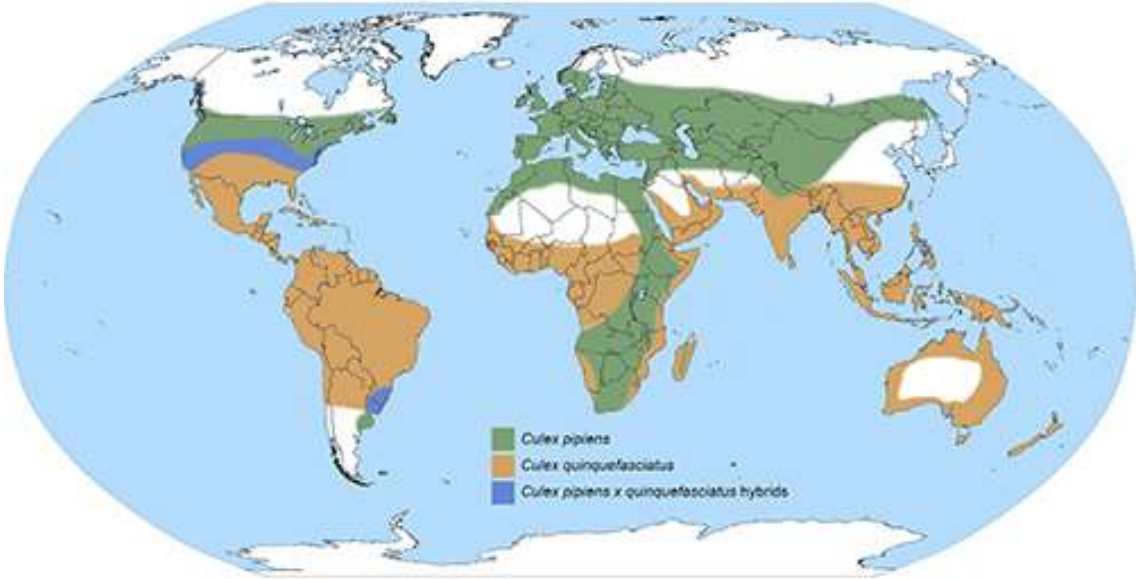


Mosquito-borne diseases US 2021

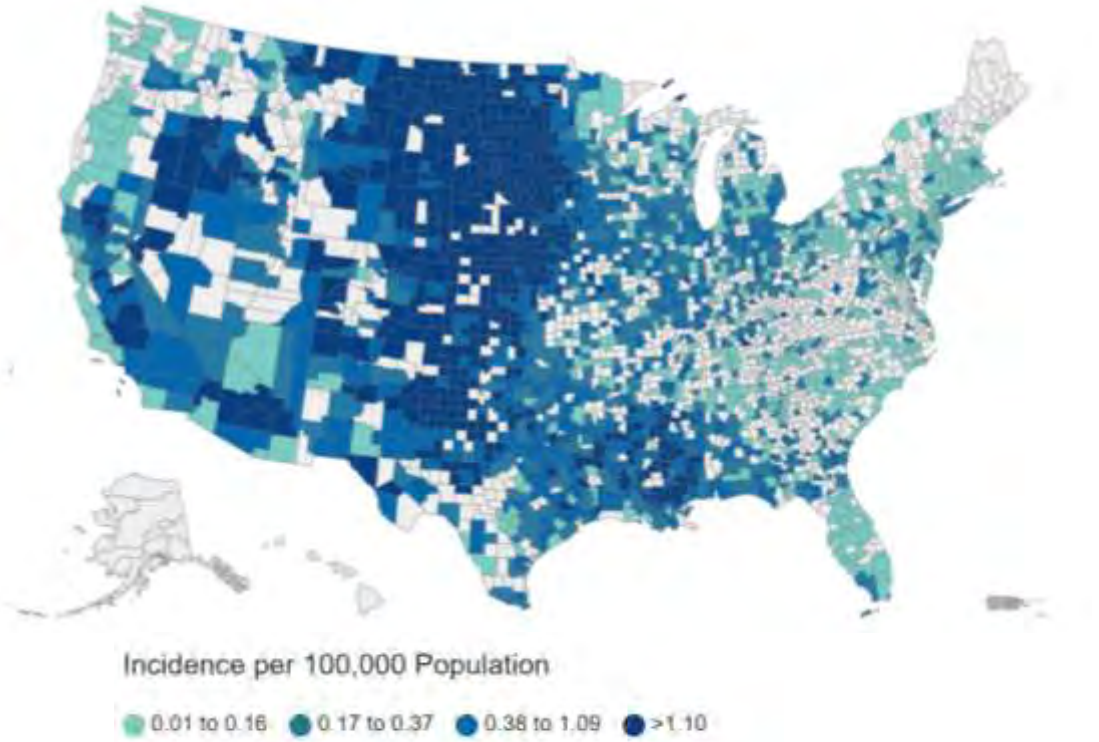
- West Nile virus (2,911)
- St. Louis encephalitis (17)
- Dengue virus (<100 locally acquired)
- Chikungunya virus (<100 locally acquired)
- Eastern equine encephalitis virus (5)

Rosenberg et al. MMWR 2018

Risk Depends on the Vector- Mosquito -Borne Diseases US



Culex pipiens (House mosquito)



West Nile virus, 2021

Risk Depends on the Vector- Mosquito -Borne Diseases US

Aedes aegypti (Yellow fever mosquito)

Aedes albopictus (Asian tiger mosquito)

Reported Dengue cases US, 2020*
*Florida reported 71 locally acquired cases

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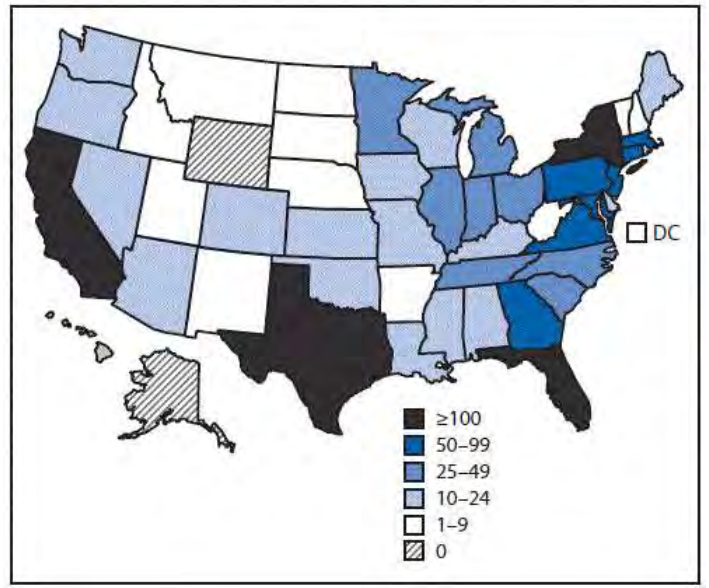
Risk Depends on the Vector- Mosquito -Borne Diseases US

Aedes aegypti (Yellow fever mosquito)

Aedes albopictus (Asian tiger mosquito)



Zika Cases, US 2016-2017

Florida reported >200 locally acquired cases

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Risk Depends on the Vector- Mosquito -Borne Diseases US

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CDC issues travel

CDC issues travel guidance related to Miami neighborhood with active Zika spread

Español (Spanish) | Print

Press Release

For Immediate Release: Monday, August 1, 2016

Contact: Media Relations

(404) 639-3286

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

Aedes aegypti (Yellow fever mosquito)

Aedes albopictus (Asian tiger mosquito)

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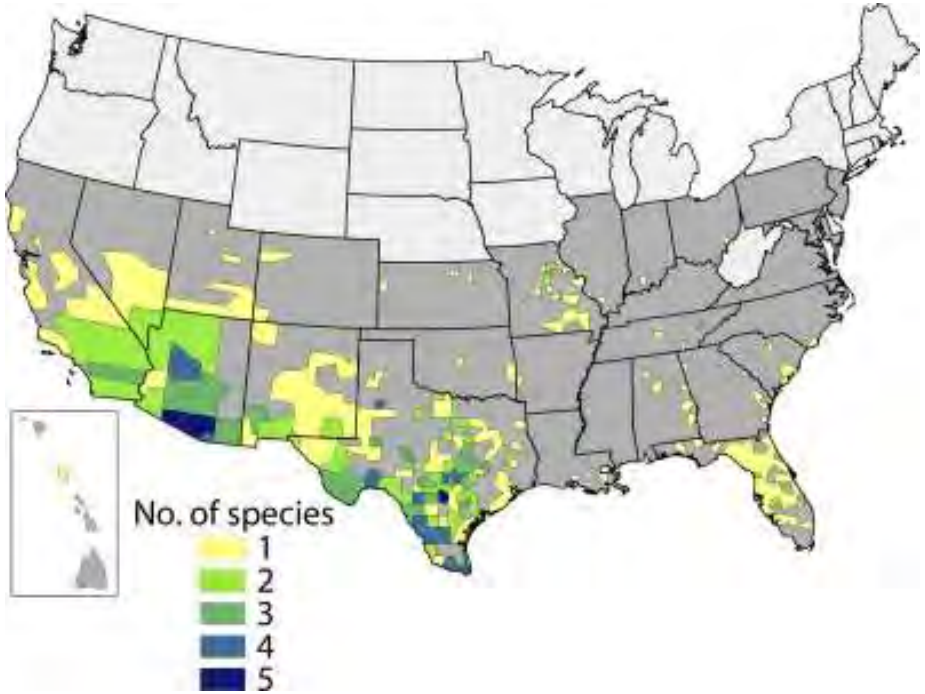
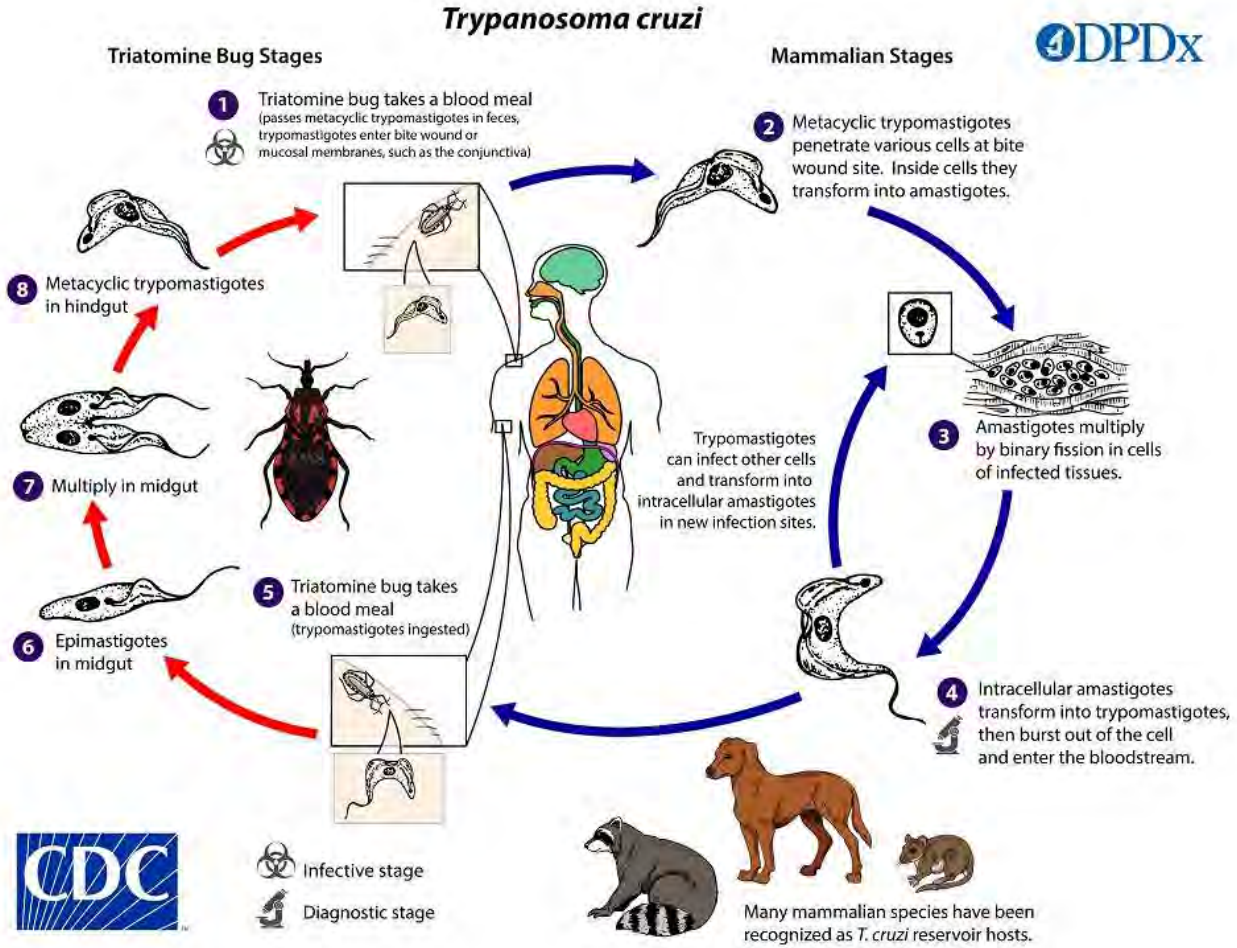
A few other VBDs



Triatominae (Kissing Bug)



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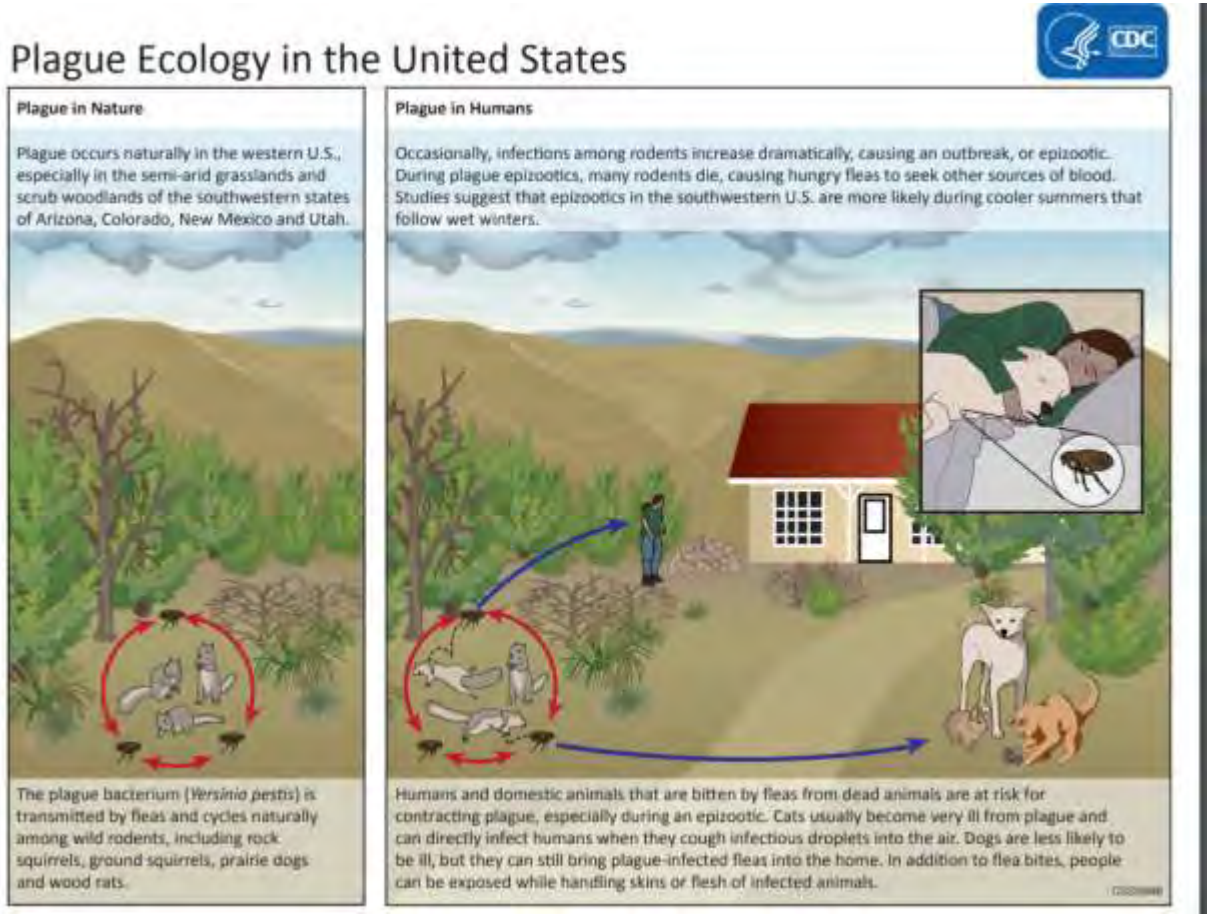

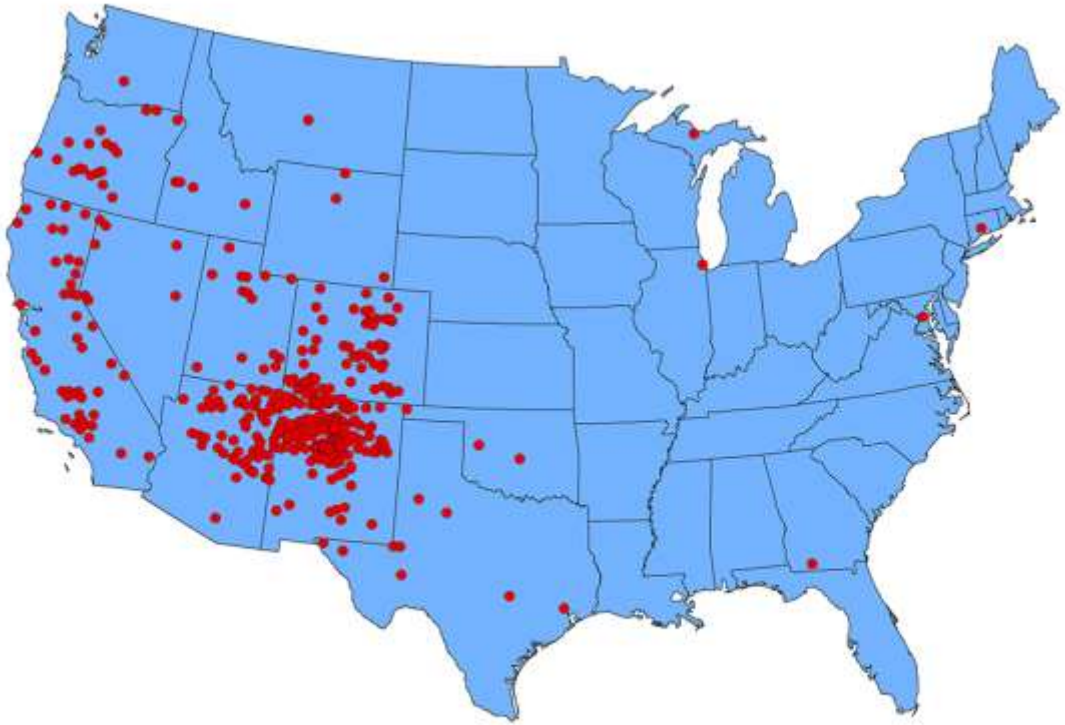

1 dot placed in state of residence for each reported plague case

Triatominae (Kissing Bug)

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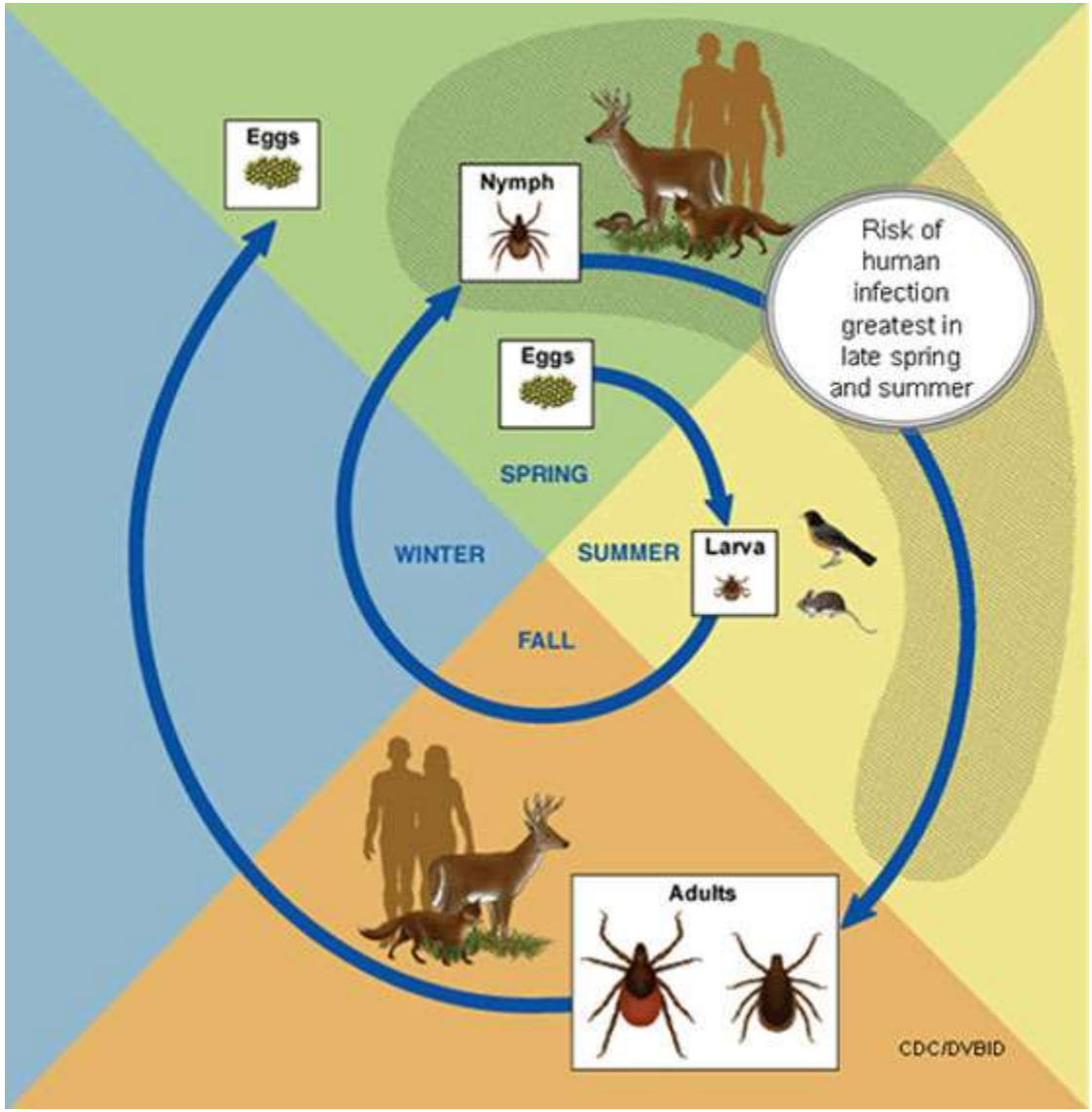
Understanding Lyme Disease Risk

Understanding Lyme Disease Risk



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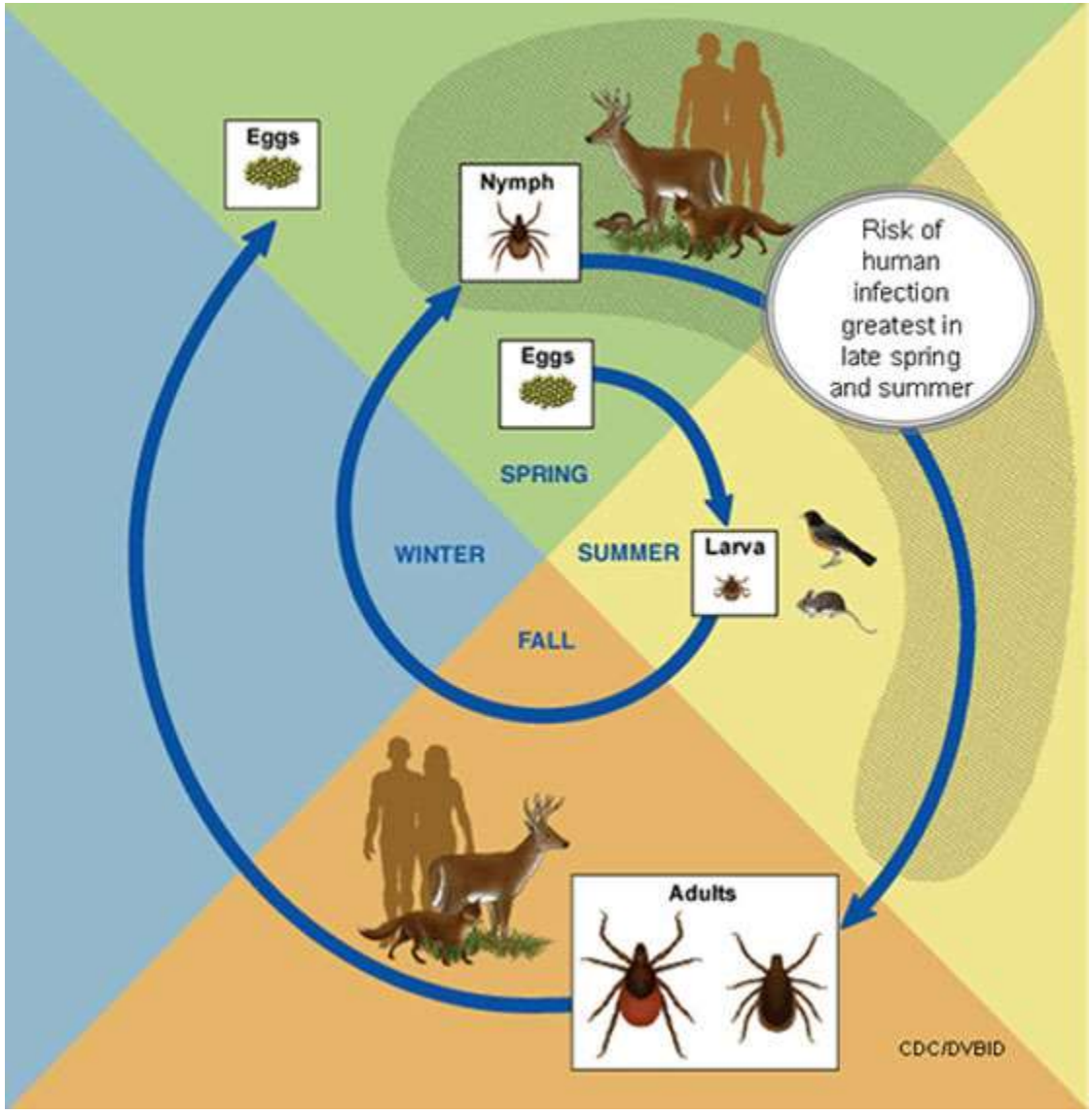
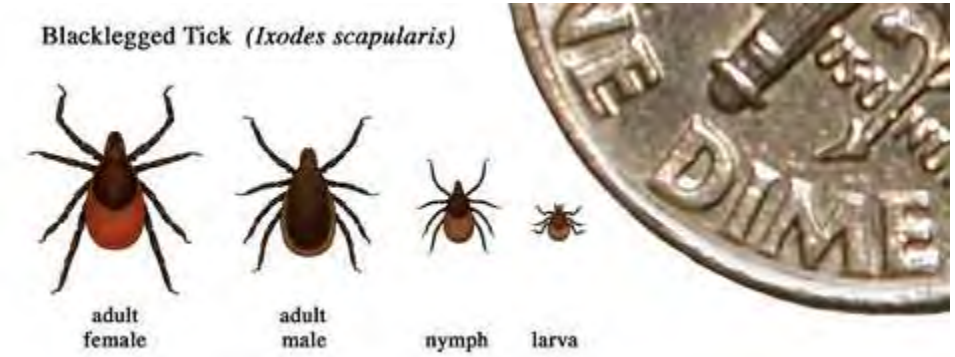
Understanding Lyme Disease Risk





Tick Bite Prevention

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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-Avoid “ticky” habitats

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

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 repellant
-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. dammini* (now *I. scapularis*)	Golden Syrian hamsters, white footed mice	Bb JDI		1/14(7%)			5/14(33%)	13/14(93%)	
Piesman[35]	*I. dammini* (now *I. scapularis*)	Male ICR outbred mice	Bb JDI			1/14(7%)	3/12(25%)	6/8 (75%)		
Shih and Spielman [36]	*I. dammini* (now *I. scapularis*)	CDI mice	Bb JDI	0/8 (0%)	0/9 (0%)	1/7 (14%)		10/10 (100%)		

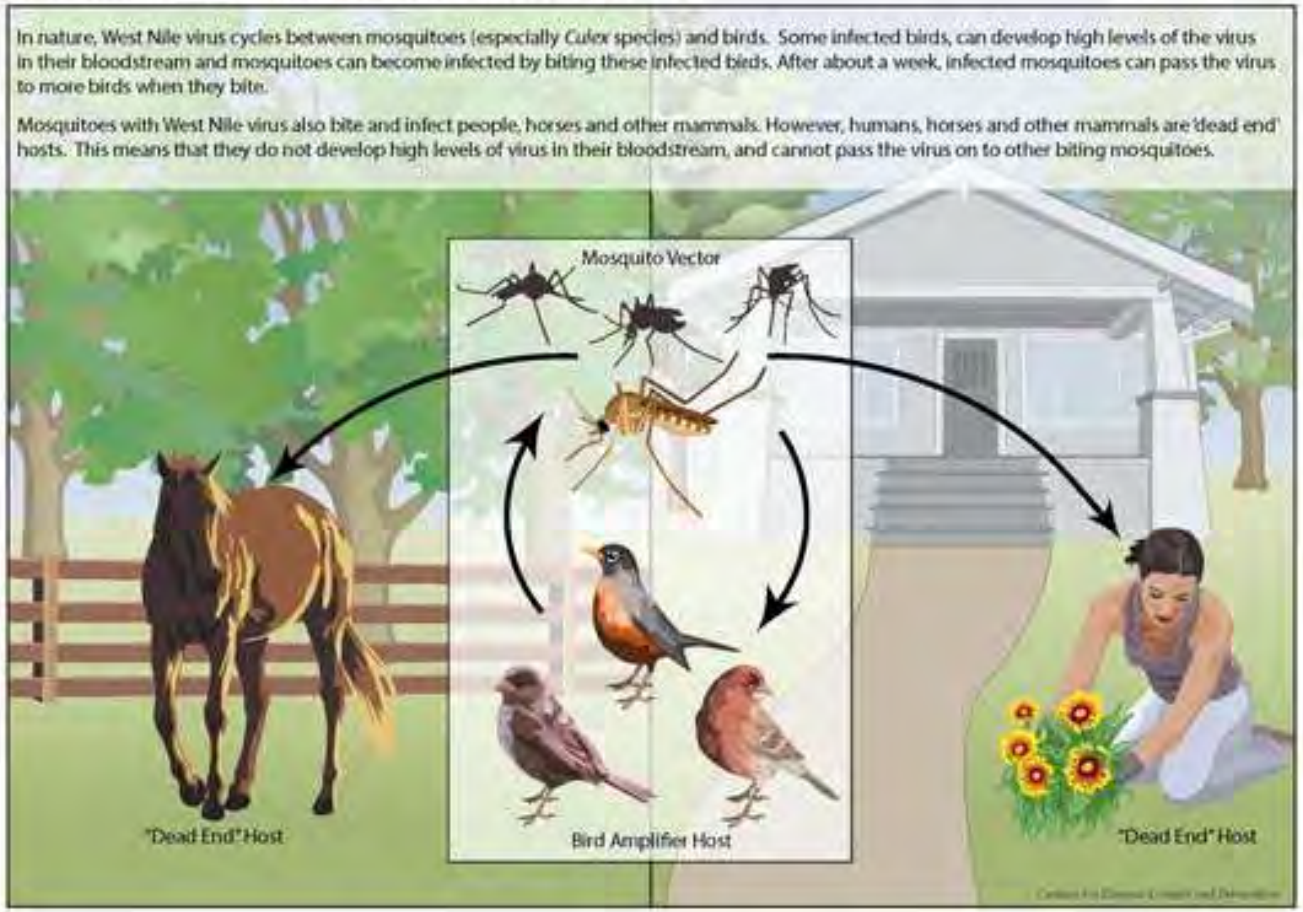
Cook et al. 2022

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 repellant
-Conduct tick checks
-Communicate to the public the risk of tick-borne diseases!

Understanding West Nile Virus Risk



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Mosquito Bite Prevention

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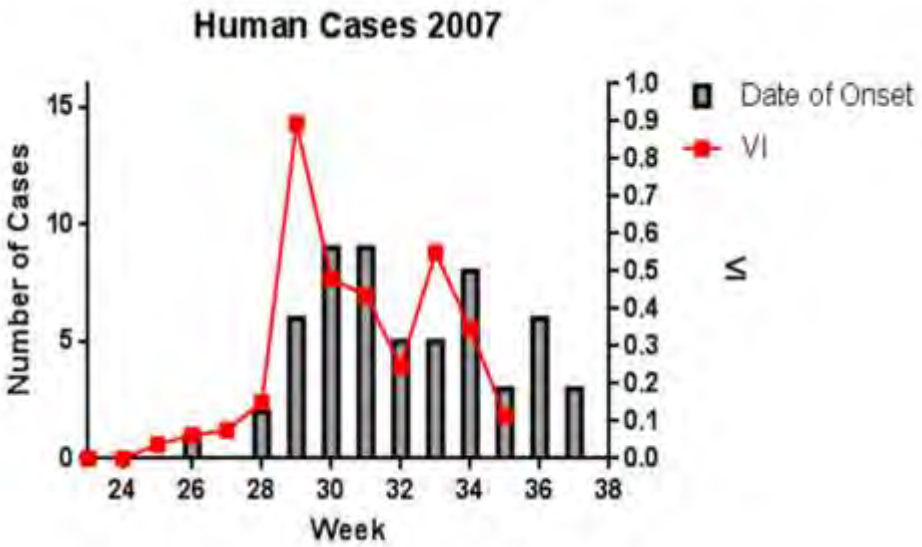
-Personal protection

Mosquito Bite Prevention

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

-Personal protection
-Mosquito abatement

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



Fauver et al. *Med Ent* 2015

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

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