What school nurses need to know about vector-borne diseases in Indiana

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Indiana Association of School Nurses
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Noblesville, Indiana

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- I will not discuss unapproved/investigative use of a commercial product/device in my presentation.
- I acknowledge that today's activity may be certified for educational credits and thus cannot be promotional. I will give a balanced presentation using the best available evidence to support my conclusions and recommendations.

Learning objectives:

Upon completion of this session, you should be able to:

1. Recognize the importance of vectorborne pathogens.
2. Have a better understanding of the epidemiology and clinical manifestations of vectorborne infections such as Lyme disease, RMSF, and dengue.
3. Effectively recommend and use proper insect repellents for bite prevention.

The problem we all face

- The vectors are here.
- The pathogens are here.
- We are here along with them.
- It is a global problem.
- The number of infections is increasing in Indiana and worldwide.
- While some infections are no longer seen in Indiana, the vectors [mainly mosquitoes] are still here.
- **Good news**: They are preventable.

Vector-borne infections: A global problem[1]

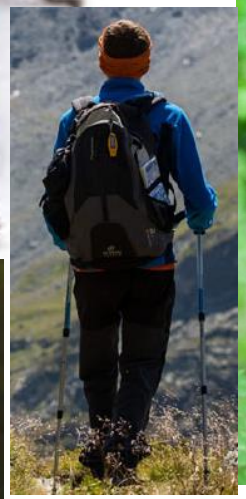
- Vector-borne diseases account for >17% of all infectious diseases, causing >700,000 deaths annually. These are caused by either parasites, bacteria or viruses.
- Malaria is a parasitic infection transmitted by Anopheline mosquitoes. It causes an estimated 219 million cases globally and results in >400,000 deaths every year. Most of the deaths occur in children aged <5 years.

WHO

Vector-borne infections: A global problem$_2$

- Dengue is the most prevalent viral infection transmitted by *Aedes* mosquitoes. More than 3.9 billion people in >129 countries are at risk of contracting dengue, with an estimated 96 million symptomatic cases and an estimated 40,000 deaths every year.
- Other viral diseases include chikungunya fever, Zika, yellow fever, West Nile fever, Japanese encephalitis and tick-borne encephalitis.
- Many vector-borne diseases are preventable, through protective measures, and community mobilization.





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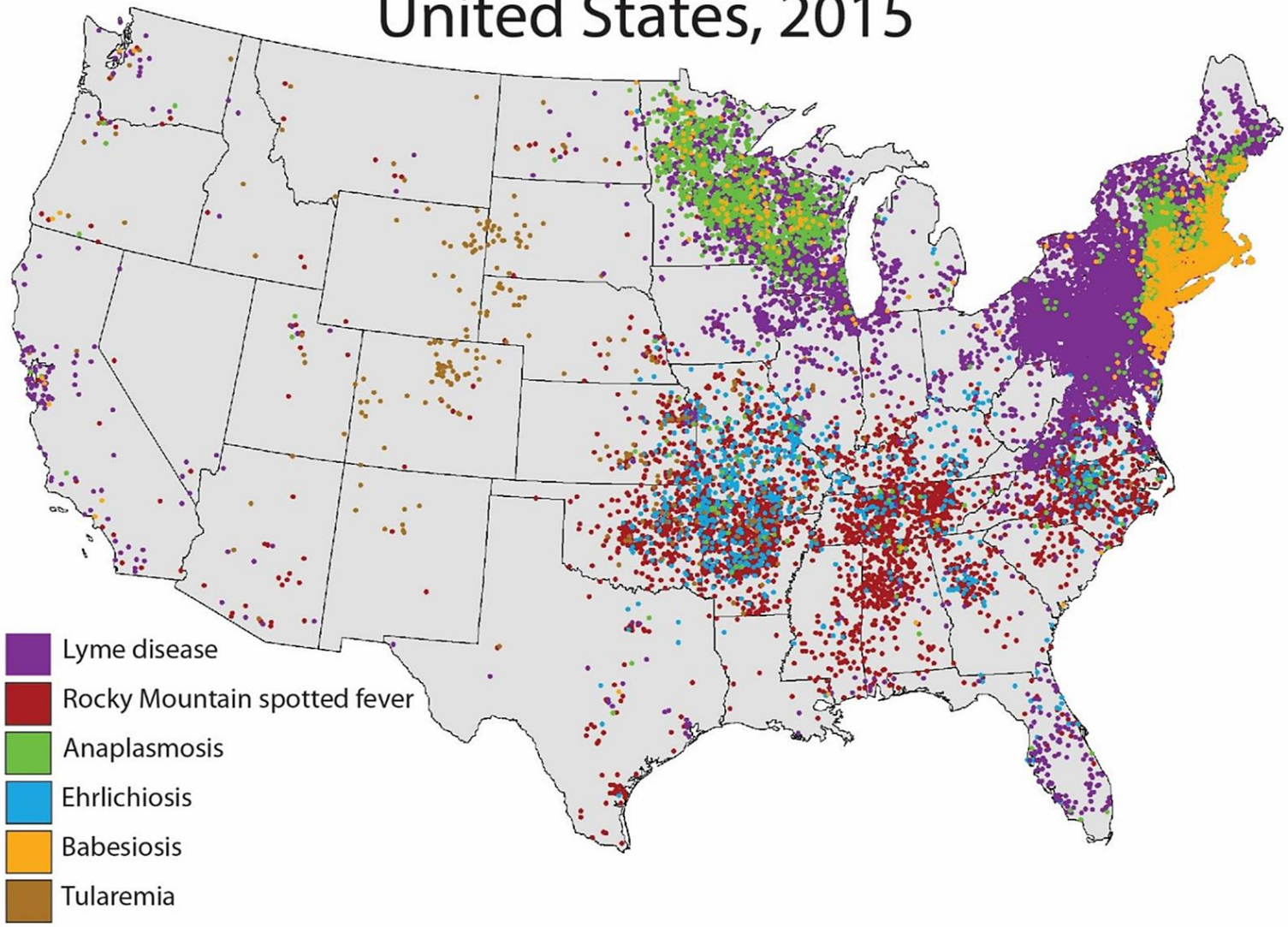
Public enemies: Transmitters of disease

- *Ctenocephalides felis* [Cat & oppossum flea]
- *Xenopsylla cheopis* [Rat flea]
- *Dermacentor andersoni* [Rocky Mountain wood tick]
- *Dermacentor variabilis* [Dog tick]
- *Rhipicephalus sanguineus* [Brown dog tick in SW US, Mexico]
- *Pediculus humanus humanus* [*Human* louse]
- *Ixodes scapularis, Ixodes pacificus*

Zoonosis

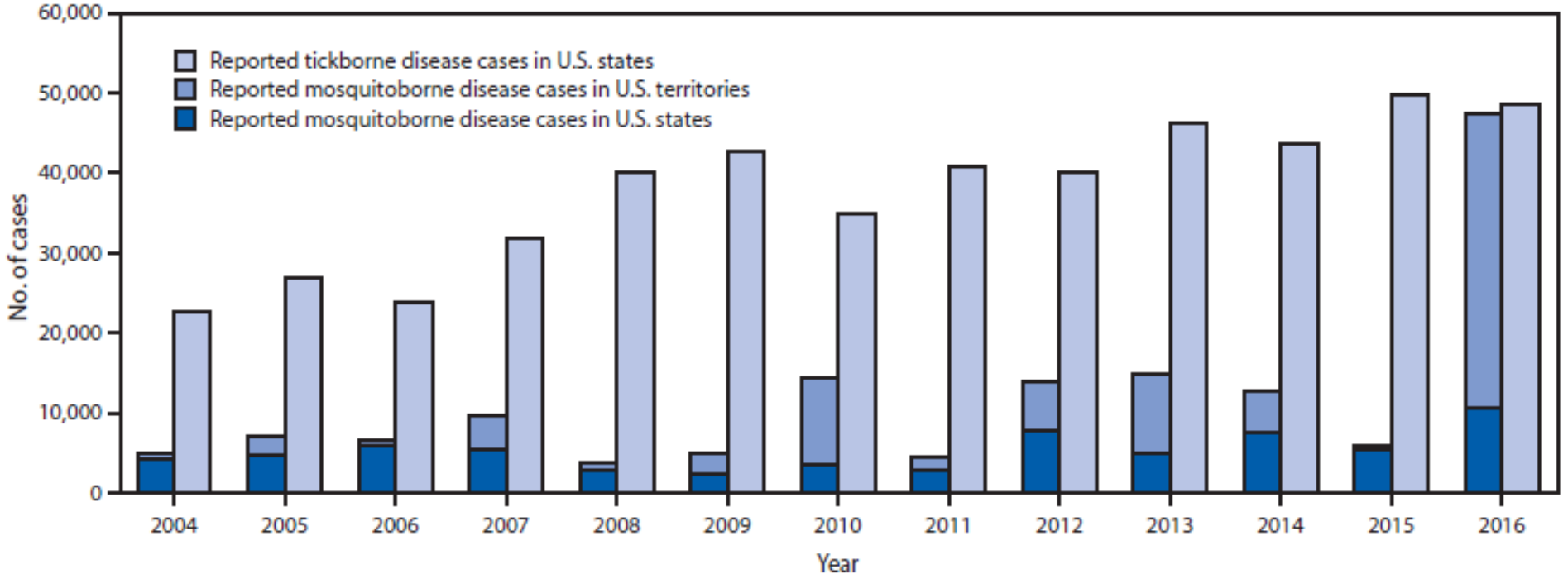
Vector-Borne

Distribution of Key Tickborne Diseases, United States, 2015



CDC

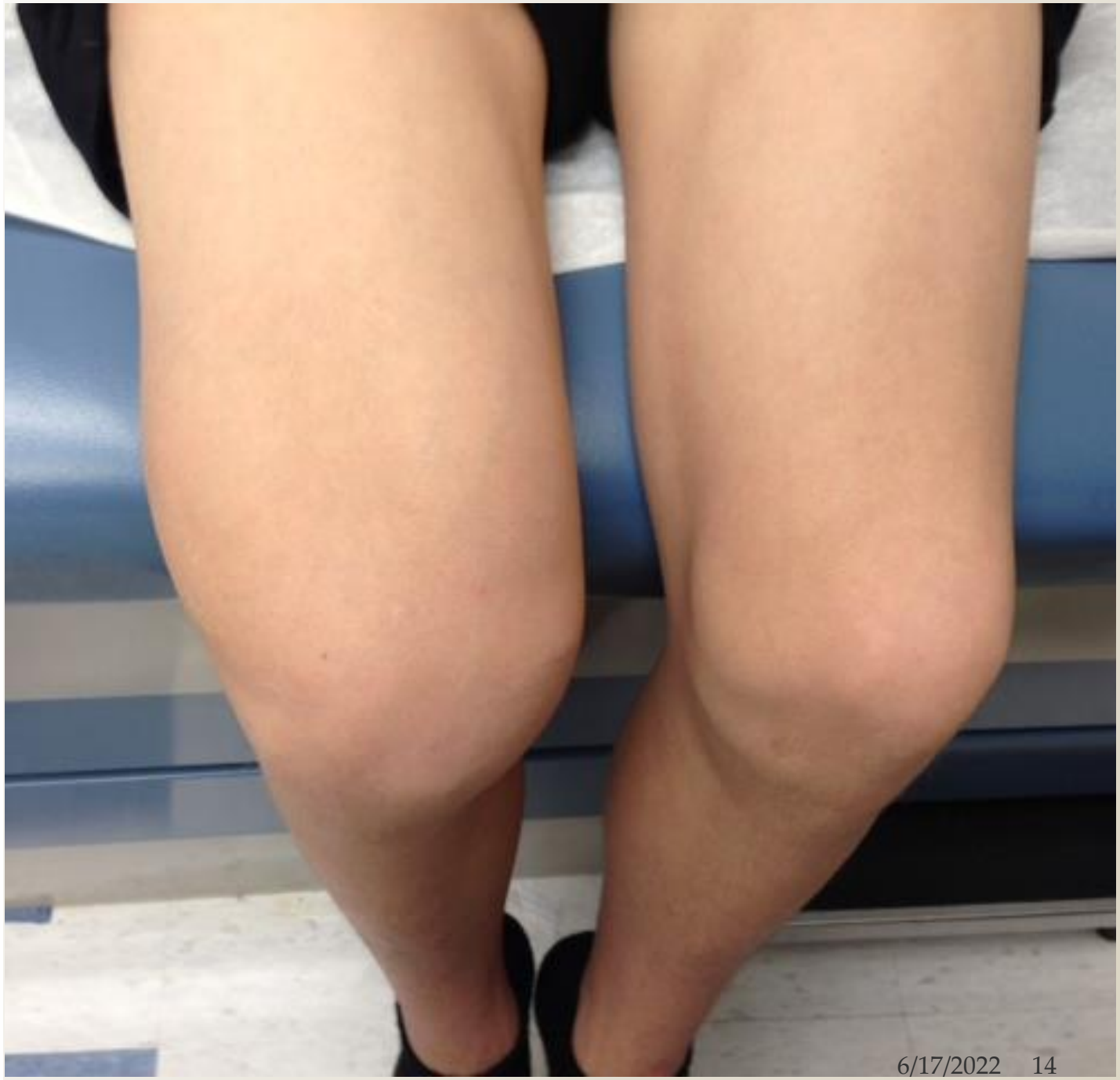
FIGURE 3. Reported nationally notifiable mosquitoborne,* tickborne, and fleaborne† disease cases — U.S. states and territories, 2004–2016



* Mosquitoborne case counts include both locally transmitted and travel-associated cases. Only 305 arbovirus cases were reported from the territories in 2015.
† A total of 89 fleaborne disease cases (plague) were reported during 2004–2018, ranging from two cases in 2010 to 16 cases in 2015. The cases are not depicted on the figure.

National Notifiable Diseases Surveillance System: 16 notifiable vector-borne diseases, 2004-2016.
642,602 cases reported. Cases doubled 2004 to 2016: >22,000 to >48,000.
~82% of all tick-borne diseases in US: Lyme disease
Mosquito-borne epidemics: Dengue, chikungunya, and Zika. PR, AS, and USVI.
West Nile virus is endemic.

Rosenberg R et al. MMWR 2018;67:496-501. [Public Domain]



Patient:
Baseball player with swollen right knee for ~1 year. Parent thought swollen knee was related to sports injury.
Afebrile.
Aspirated by Orthopedic surgeon.
WBC ~57,000. Cultures negative.

Ixodes scapularis
CDC Public Library

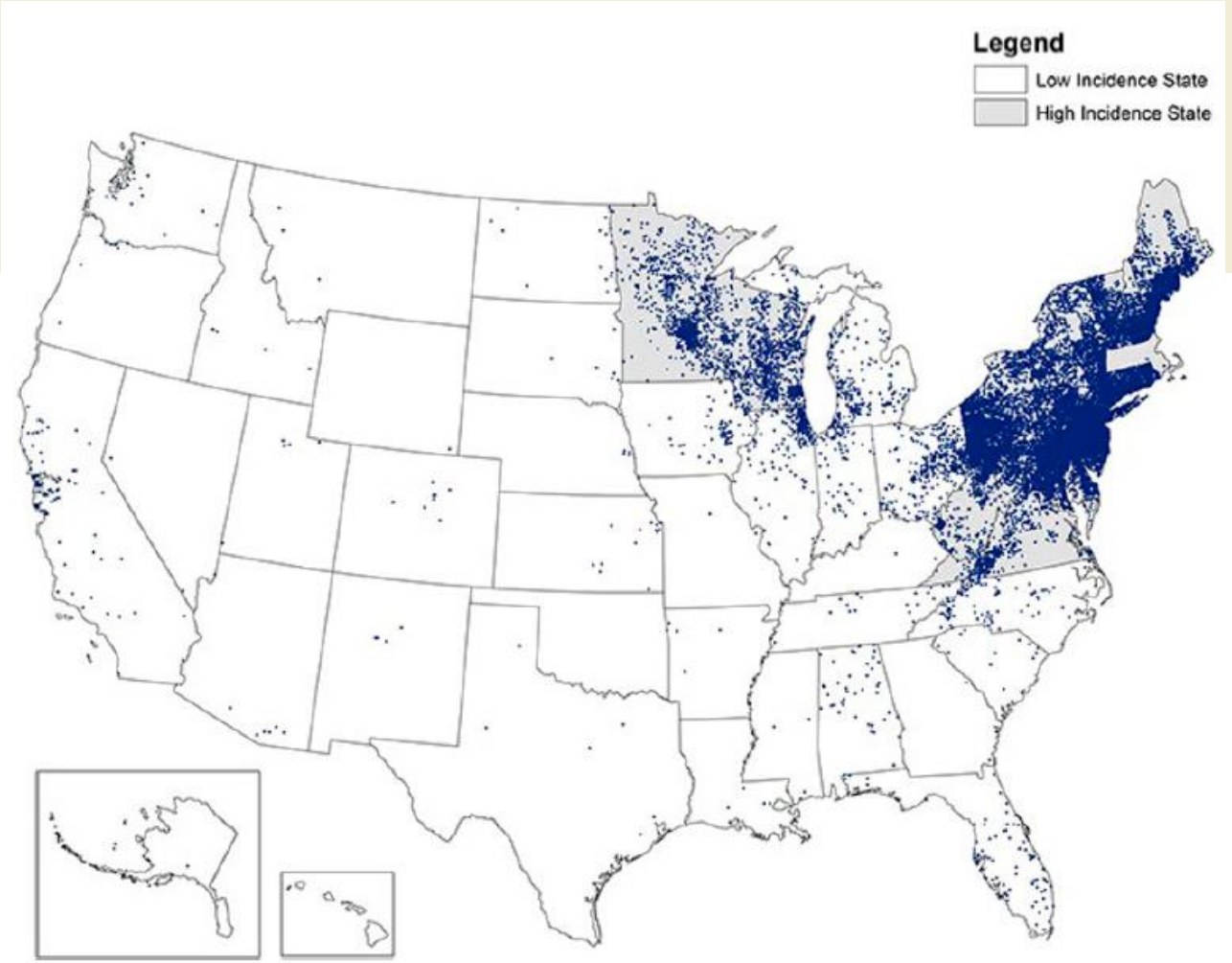


FIGURE 1

Reported cases of Lyme disease: United States, 2019. Each dot represents 1 case of Lyme disease and is placed randomly in the patient's county of residence. The presence of a dot in a state does not necessarily mean that Lyme disease was acquired in that state. (Reprinted from Centers of Disease Control and Prevention. Reported Cases of Lyme Disease—United States, 2019. Available at: https://www.cdc.gov/lyme/datasurveillance/maps-recent.html. Accessed November 22, 2021.)

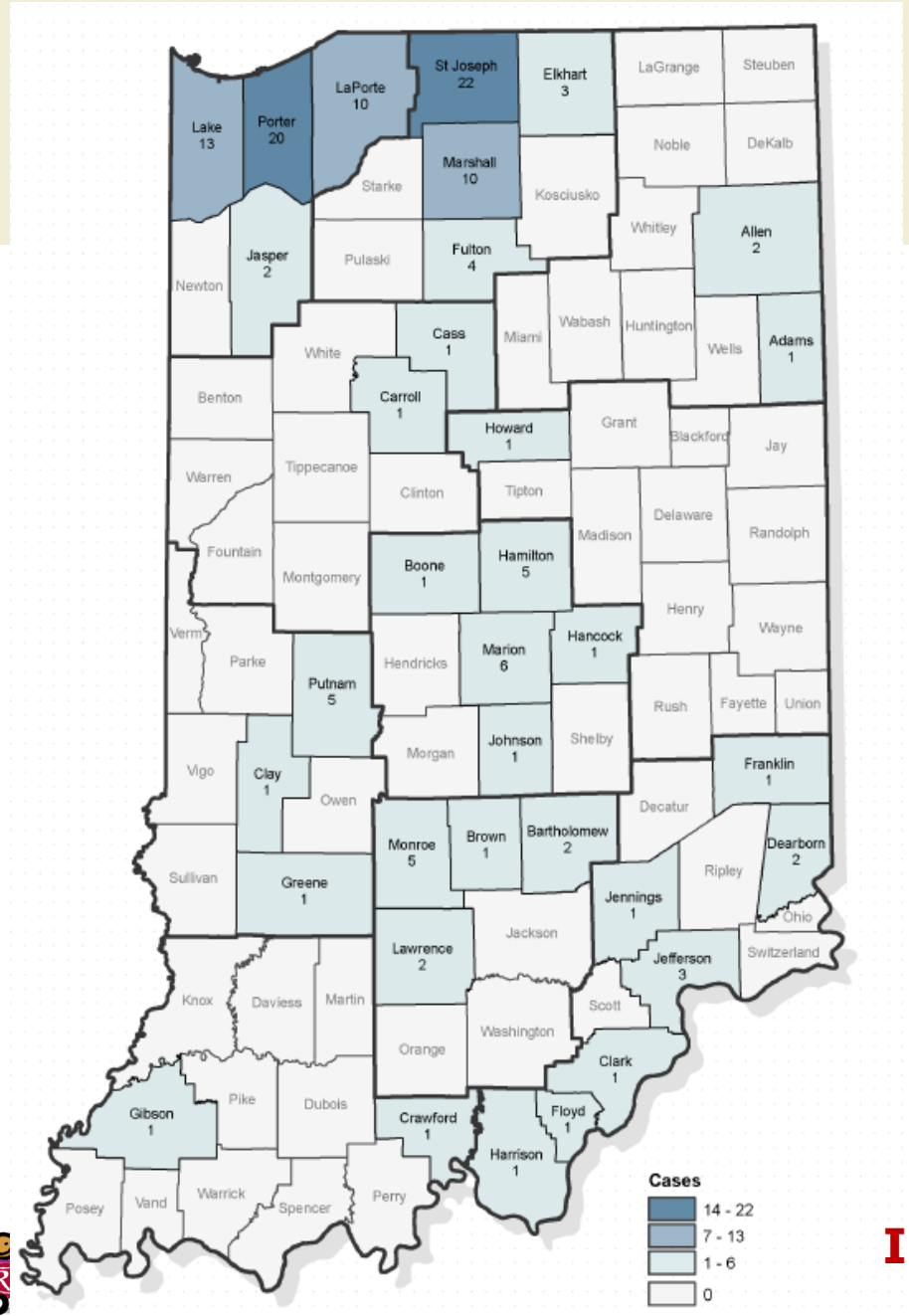


Figure 1. Lyme Disease Cases by Year — Indiana, 2014–2018

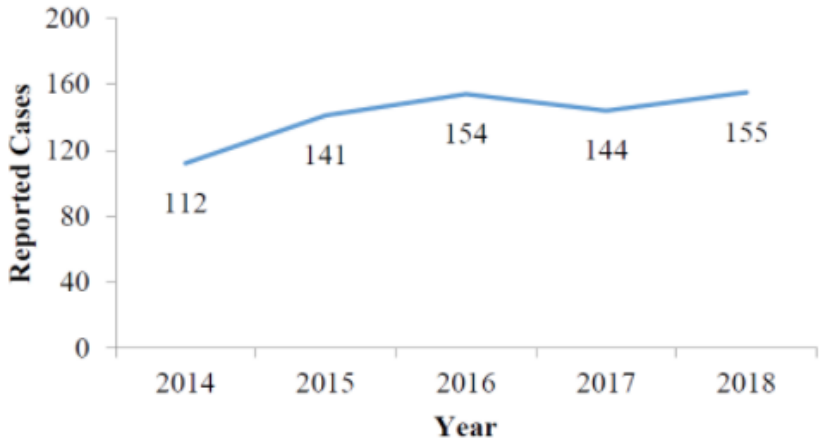
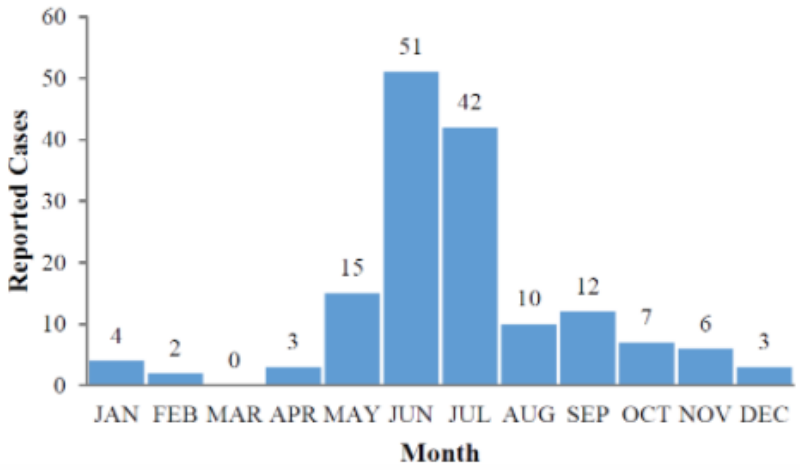


Figure 2. Lyme Disease Cases by Month of Illness Onset – Indiana, 2018



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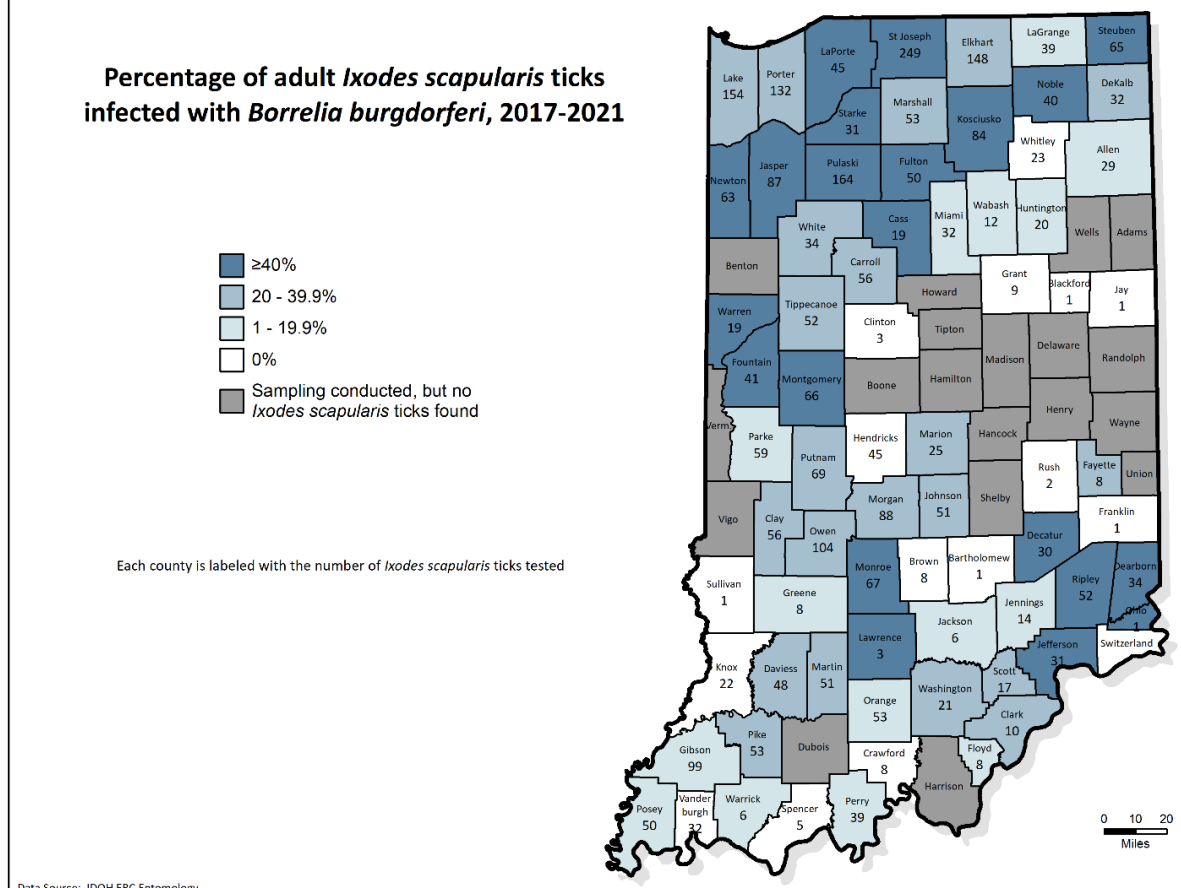
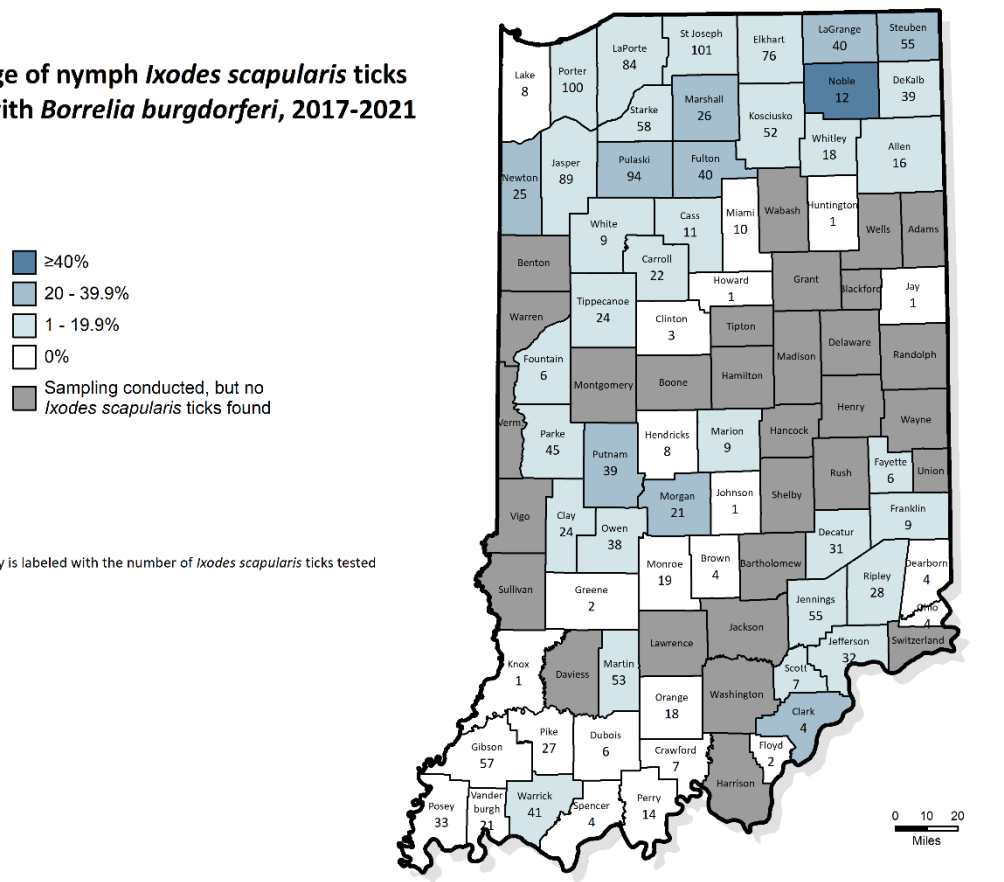
Percentage of adult *Ixodes scapularis* ticks infected with *Borrelia burgdorferi*, 2017-2021



Each county is labeled with the number of *Ixodes scapularis* ticks tested

Data Source: IDOH ERC Entomology
Map Author: IDOH ERC ODA, 12/10/2021

Percentage of nymph *Ixodes scapularis* ticks infected with *Borrelia burgdorferi*, 2017-2021



Each county is labeled with the number of *Ixodes scapularis* ticks tested

Data Source: IDOH ERC Entomology
Map Author: IDOH ERC ODA, 12/10/2021

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Clinical manifestations of Lyme disease

Erythema migrans:

- ~80 percent of patients. Lesions appear 7-14 days after bite [3-30 days], at ≥5 cm.
- No serologic confirmation needed. **Treat.**

CNS [days or weeks later]:

- Facial nerve palsy common. Meningitis

Cardiac [within weeks]: AV block

Arthritis [months after onset of illness]

Wormser GP et al. Clin Infect Dis 2006;43:1089-1134

Treatment of Lyme disease

Manifestation	Agent	Duration [Days]
Erythema migrans	Doxycycline	10
	Amoxicillin or cefuroxime axetil	14
	Azithromycin	7 [range, 5-10]
Meningitis or radiculopathy	Doxycycline [oral]	14-21
	Ceftriaxone	14-21

Lantos PM et al. Clin Infect Dis 2020;online December 2020

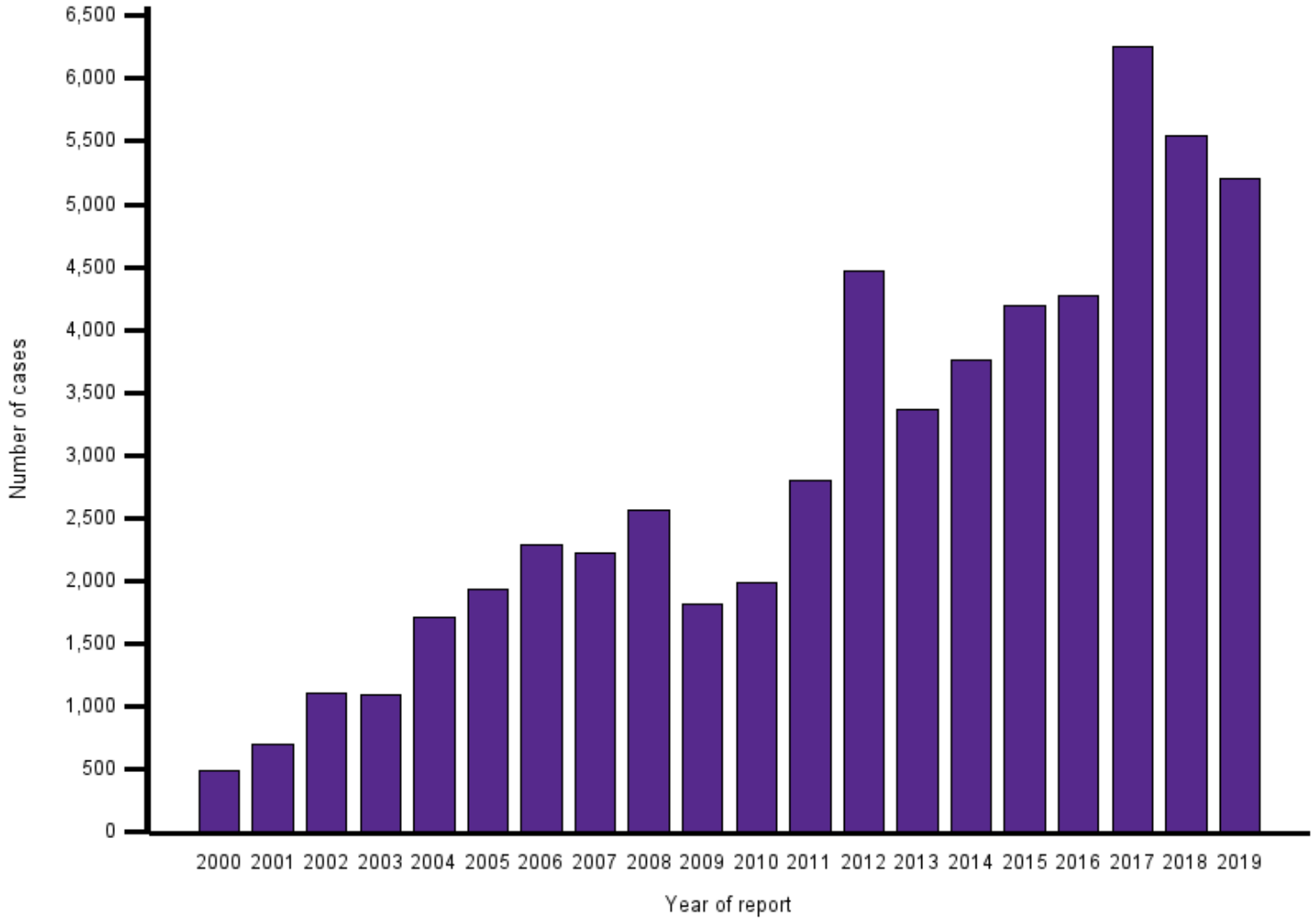
Treatment of Lyme disease

Manifestation	Agent	Duration [Days]
Cranial nerve palsy	Doxycycline [oral]	14-21
Arthritis	Doxycycline, amoxicillin or cefuroxime axetil	28
Arthritis, recurrent or refractory	Doxycycline, amoxicillin or cefuroxime axetil	28
	Ceftriaxone	14

Lantos PM et al. Clin Infect Dis 2020;online December 2020

17 years-old adolescent male who lives in Franklin, IN. Likes the outdoors. Wooded area in his backyard. Has been exposed to ticks in the past.
He presents with fevers, fatigue, headaches, bodyaches. Mother bring him to clinic because he developed a rash. It is July. He is sexually-active.

Figure 1–Number of reported cases of spotted fever rickettsiosis –United States, 2000–2019



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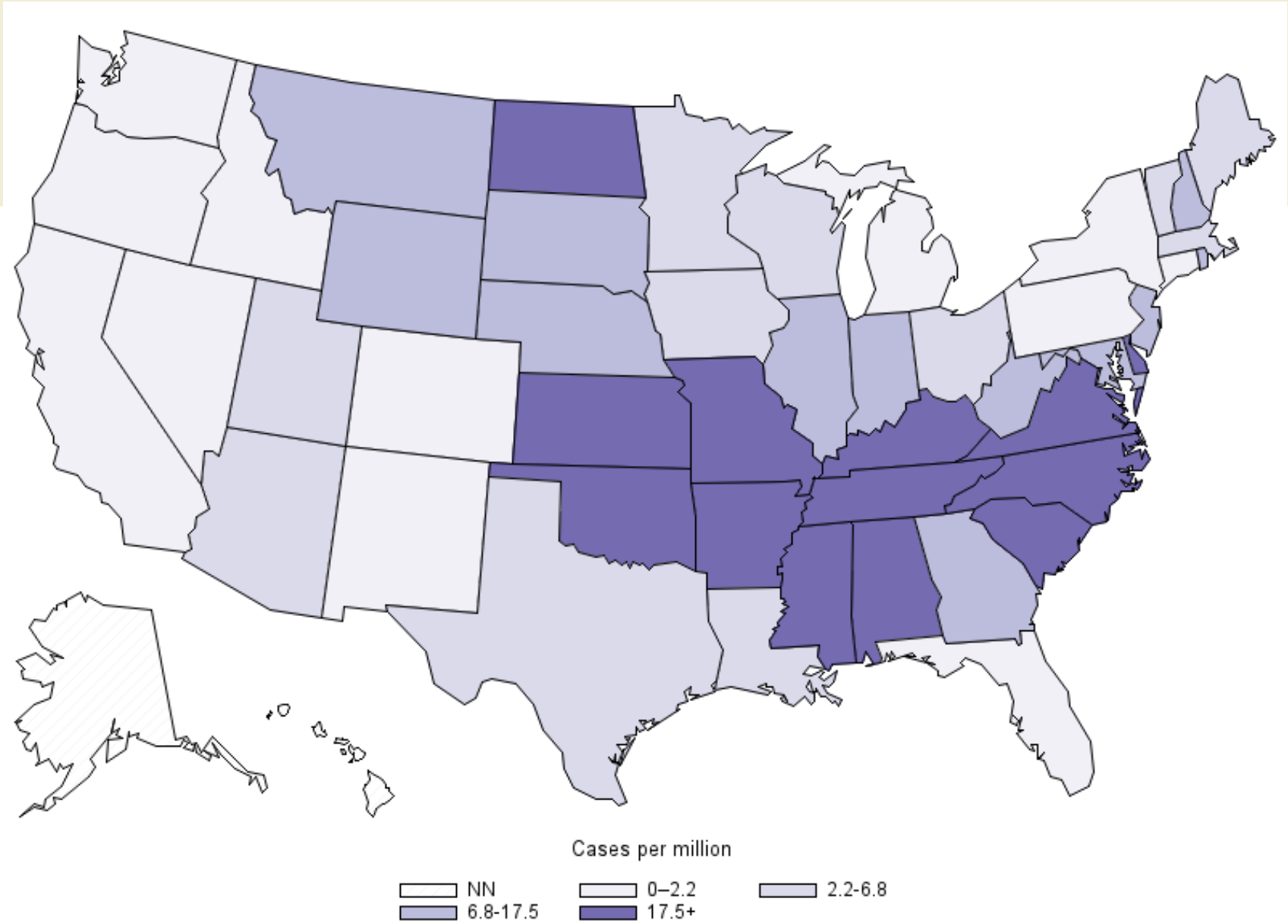


RMSF 2017, **CDC**

Figure 1. Rocky Mountain Spotted Fever Cases by Year — Indiana, 2014–2018

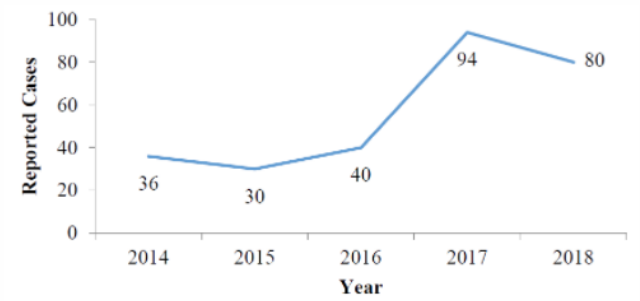
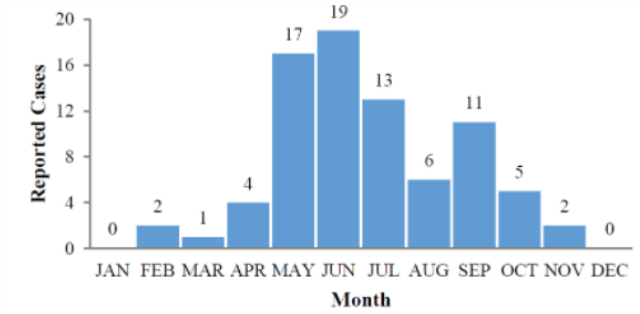
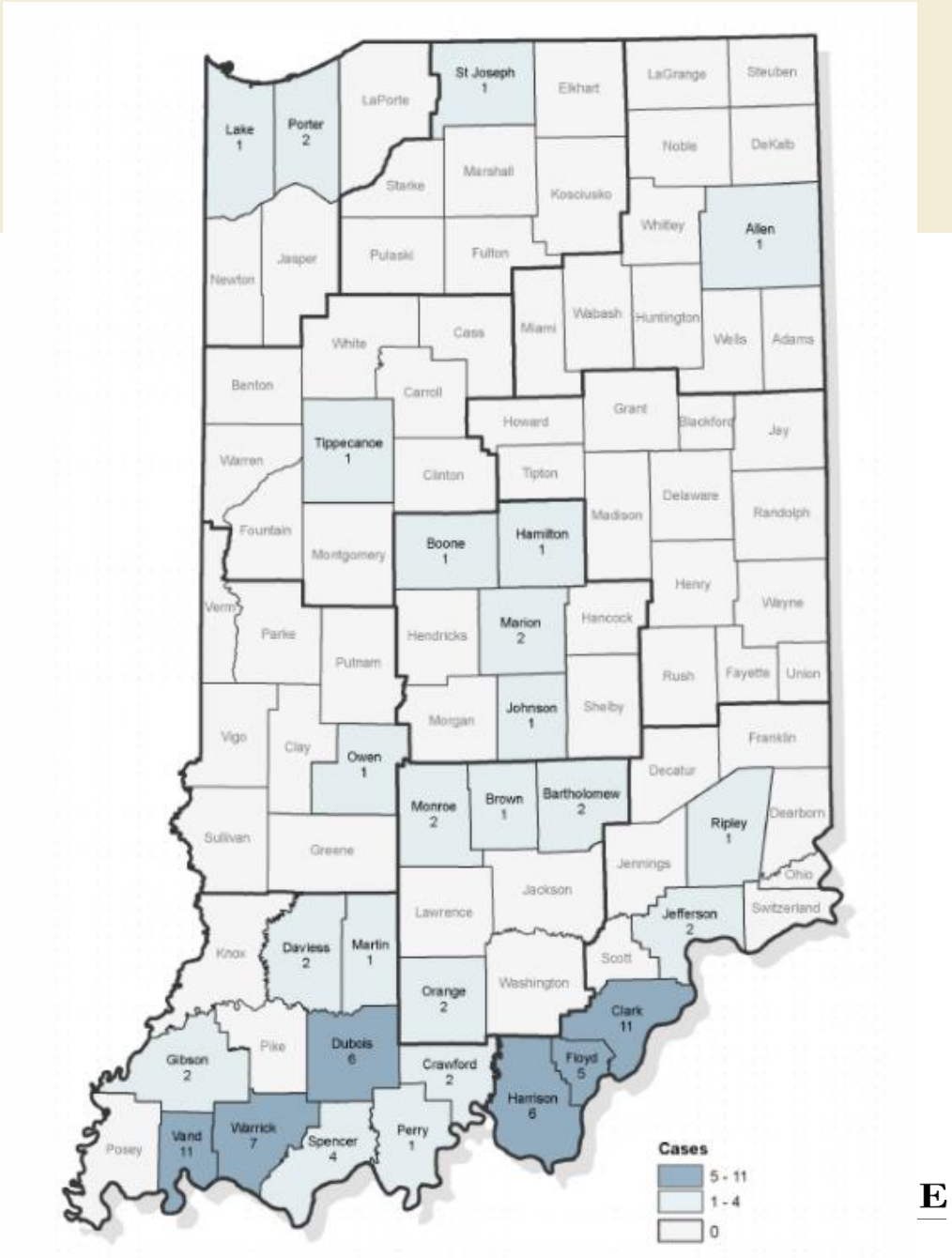


Figure 2. Rocky Mountain Spotted Fever Cases by Month of Illness Onset – Indiana, 2018





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Dermacentor andersoni

CDC Public Library

Rocky Mountain Spotted Fever: *Rickettsia rickettsii*

- Vectors: *Dermacentor variabilis* [American dog tick]; Eastern US.
- *D. andersoni* [Rocky Mountain wood tick]; Western US.
- *Rhipicephalus sanguineus*: Mexico; Arizona
- *Amblyomma cajennense*: Central, South America; Texas
- *Amblyomma americanum*: Lone Star tick
- Most cases [56%] in: NC, SC, TN, OK, AR

Rickettsia parkeri eschars

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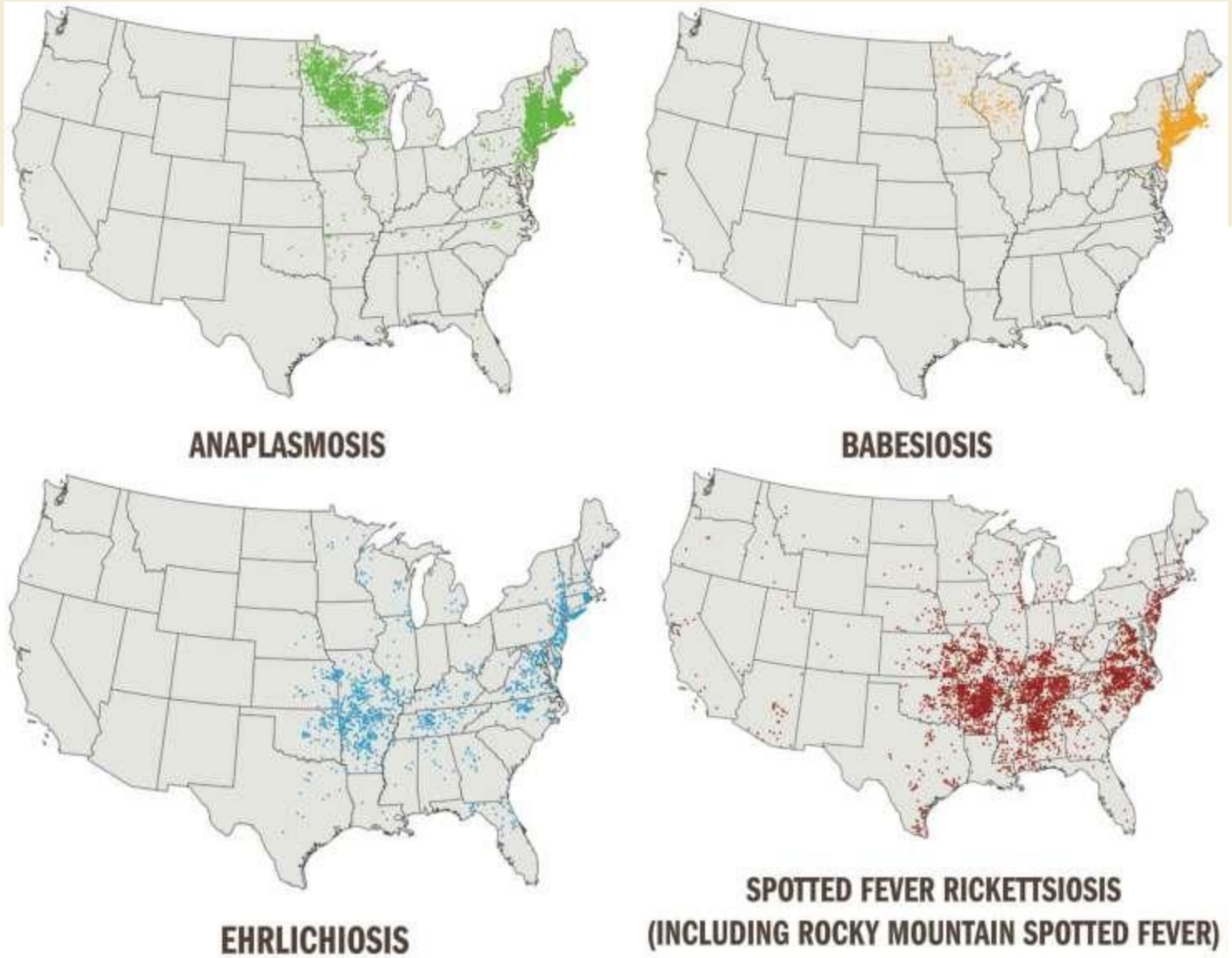


Source: Tickborne Diseases of the United States: Reference Manual, Centers for Disease Control, 5th Edition 2018 (link below)

Human monocytic **ehrlichiosis**

Ehrlichia chaffeensis

Ehrlichia muris-like

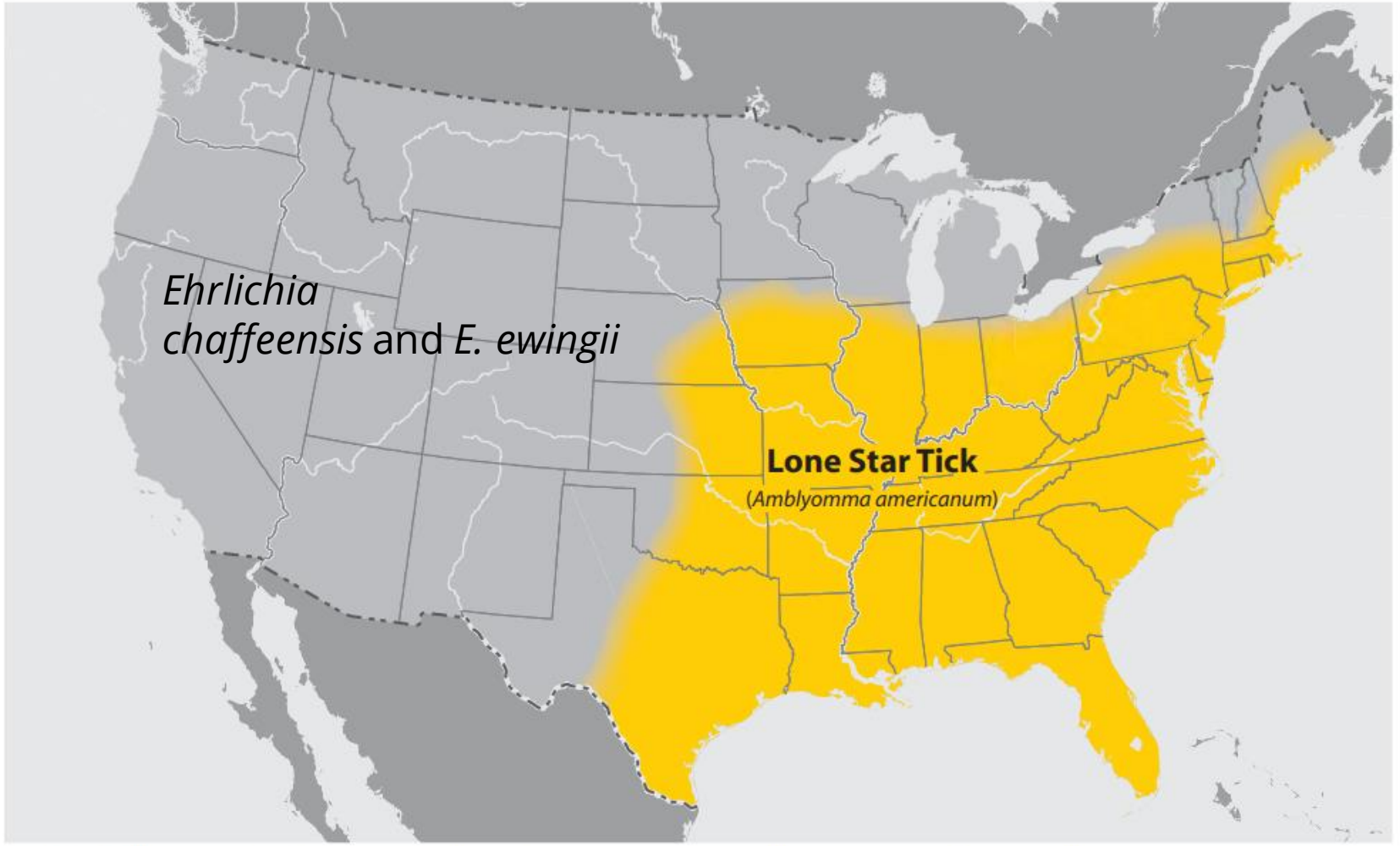
Ehrlichia canis

Human granulocytic **anaplasmosis**

Anaplasma phagocytophilum

Ehrlichia ewingii

Amblyomma americanum
CDC Public Library



ABOUT THIS MAP: This map shows the extent of established *Amblyomma americanum* tick populations, commonly known as lone star ticks. However, tick abundance within this area varies locally. The map does not represent the risk of contracting any specific tickborne illness. Please consult your local health department or USDA Cooperative Extension office to learn about the risks of tickborne disease in your local area. Rev. 07/2011.

National Center for Emerging and Zoonotic Infectious Diseases
Division of Vector-Borne Diseases

ABOUT THIS MAP: This map shows the estimated distribution of *Ixodes scapularis* tick populations, commonly known as blacklegged or deer ticks. However, tick abundance within this area varies locally. The map does not represent the risk of contracting any specific tickborne illness. Please consult your local health department or Cooperative Extension office to learn about the risks of tickborne disease in your local area. 08/2018

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Figure 3 – Annual incidence (per million population) of reported *Ehrlichia chaffeensis* ehrlichiosis–United States, 2019. (NN= Not notifiable)

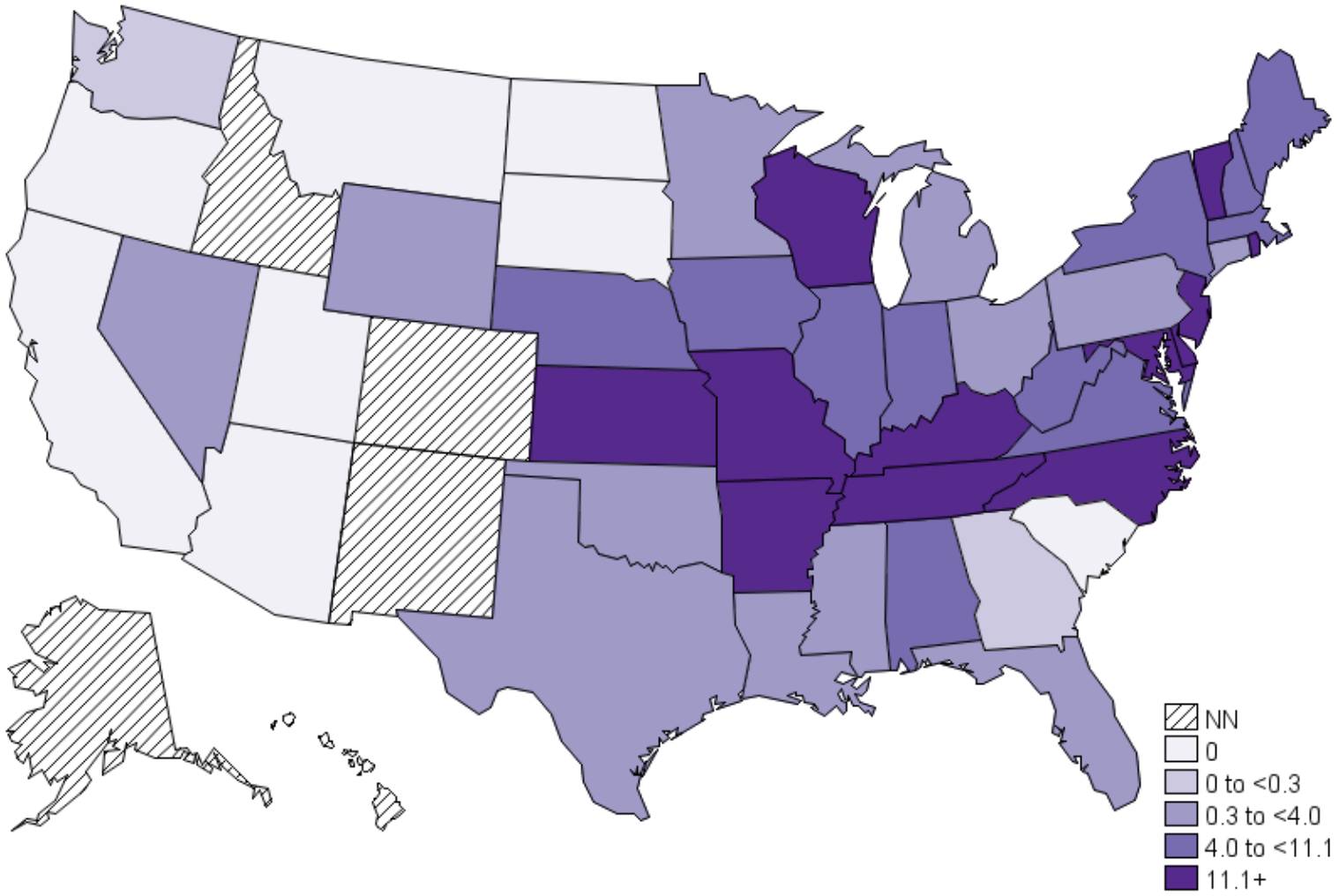

Figure 1 – Number of reported cases of *Ehrlichia chaffeensis* ehrlichiosis –United States, 2000–2019

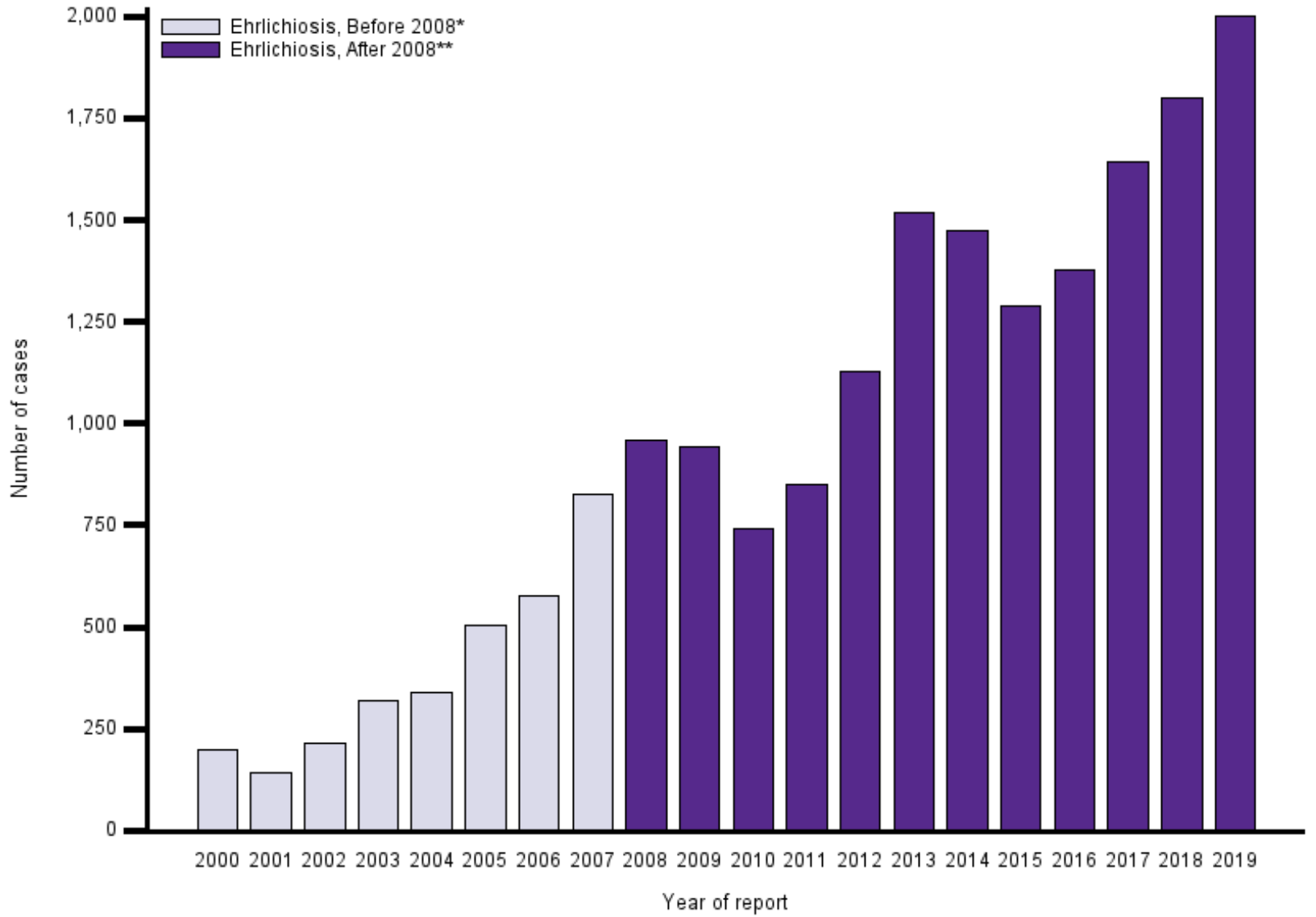

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Figure 1. Ehrlichiosis and Anaplasmosis Cases by Year — Indiana, 2014–2018

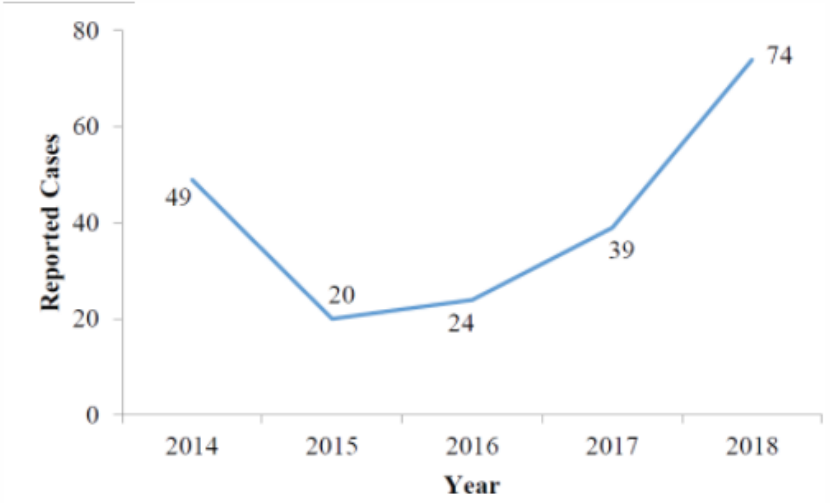
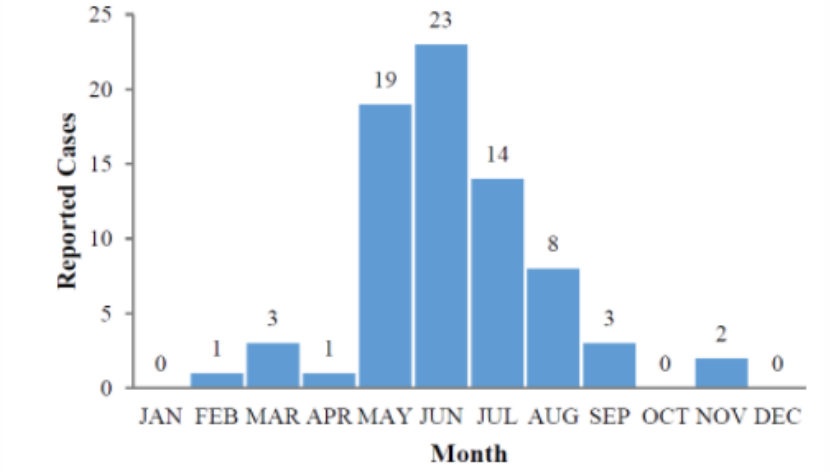


Figure 2. Ehrlichiosis and Anaplasmosis Cases by Month of Illness Onset – Indiana, 2018



Distribution of *Ehrlichia chafeensis* in *Amblyomma americanum* ticks in Indiana and Ohio, 1998

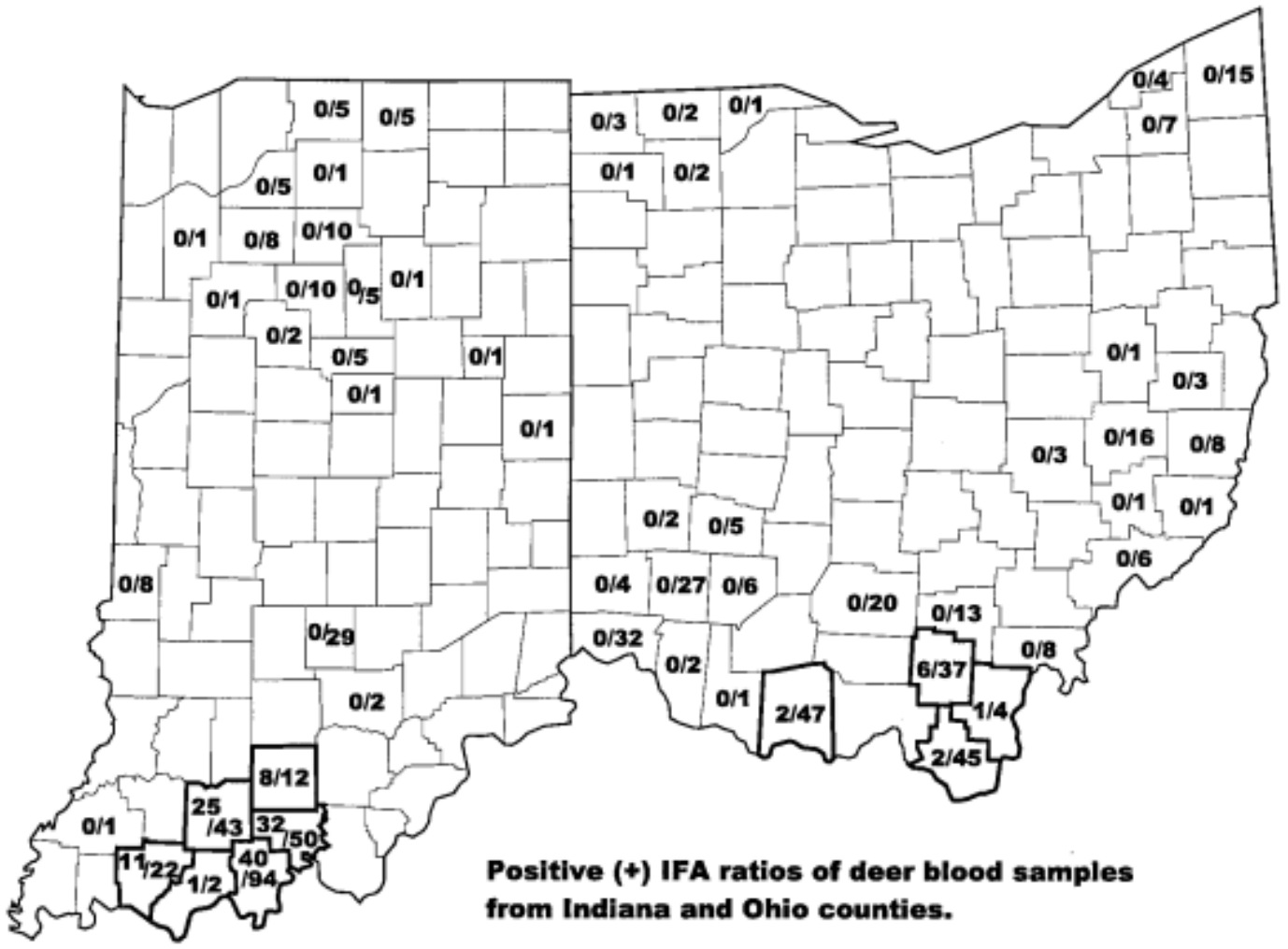


Fig. 2. Positive (+) IFA ratios of deer blood samples from Indiana and Ohio counties.

Irving RP et al. J Med Entomol 2000;37:595-600

Human monocytic ehrlichiosis: Clinical features

Fever	100*	Tick attachment	82
Rash	66	Headache	63
Myalgia	63	Anorexia/nausea	57
HSM	41	Heart murmur	33
High AST,ALT	89	Decreased platelets	82
Lymphopenia	80	Leukopenia	69
Anemia	38	* percent	

Others: conjunctival hemorrhage, arthralgias, edema, DIC, seizures, coma, renal failure

Jacobs RF, Schutze GE. J Pediatr 1997;131:184-192

Anaplasma phagocytophilum [human granulocytotropic anaplasmosis]

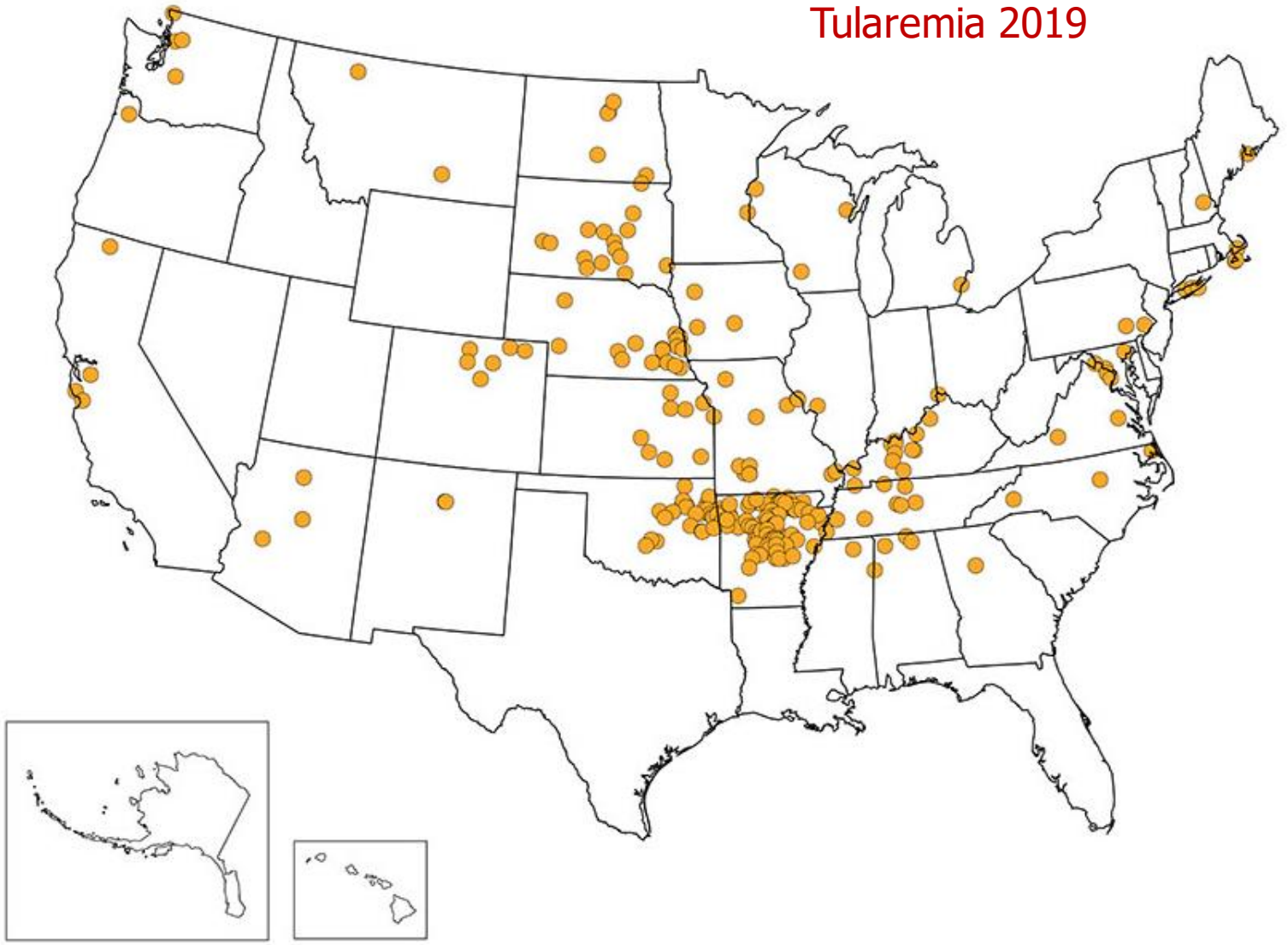
- *Ixodes scapularis* and *I. pacificus*: vectors of Lyme borreliosis and babesiosis.
- New England, North Central and Pacific states [Rhode Island > MN > **NY** > MD]
- Incubation period: 5-21 days
- Symptoms: Fever, headache, malaise, myalgia and vomiting. Rash: Rare.
- Leukopenia, thrombocytopenia, elevated LFTs
- Fatality: <1%

MMWR 2006;55[RR-4]:1-27

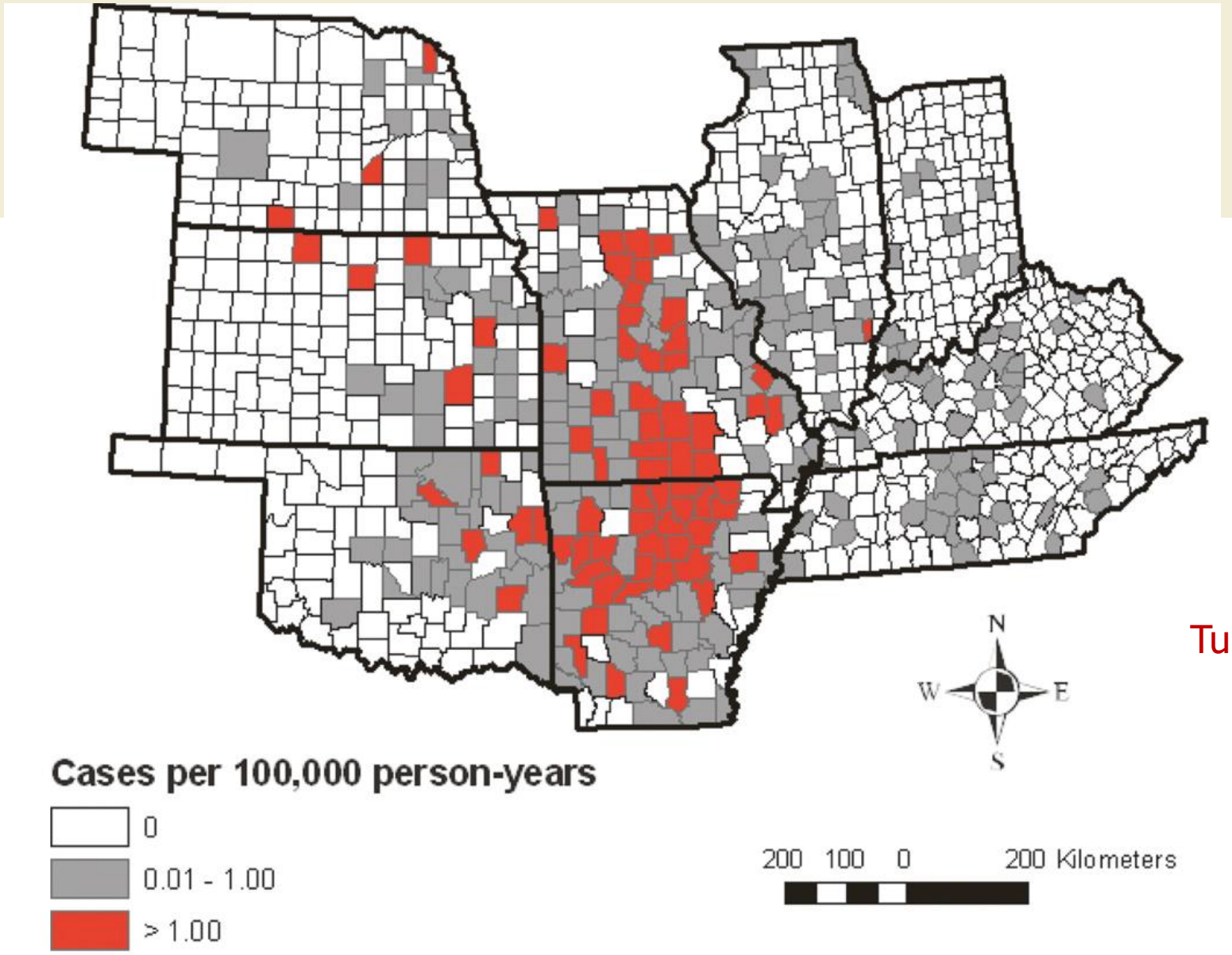
Tularemia: Distinct clinical syndromes

- Ulceroglandular: **Tick** or **deer fly** bite
- Glandular: Lymphadenopathy
- Oropharyngeal: Consumption of undercooked meats
- Typhoidal: Generalized systemic illness
- Pneumonic: Pneumonia. Inhalation
- Oculoglandular: Splash to eyes of contaminated secretions or blood.

Tularemia 2019



1 dot placed randomly within county of residence for each reported case



Tularemia cases

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Eisen RJ et al. Am J Trop Med Hyg 2008;78:586-594.

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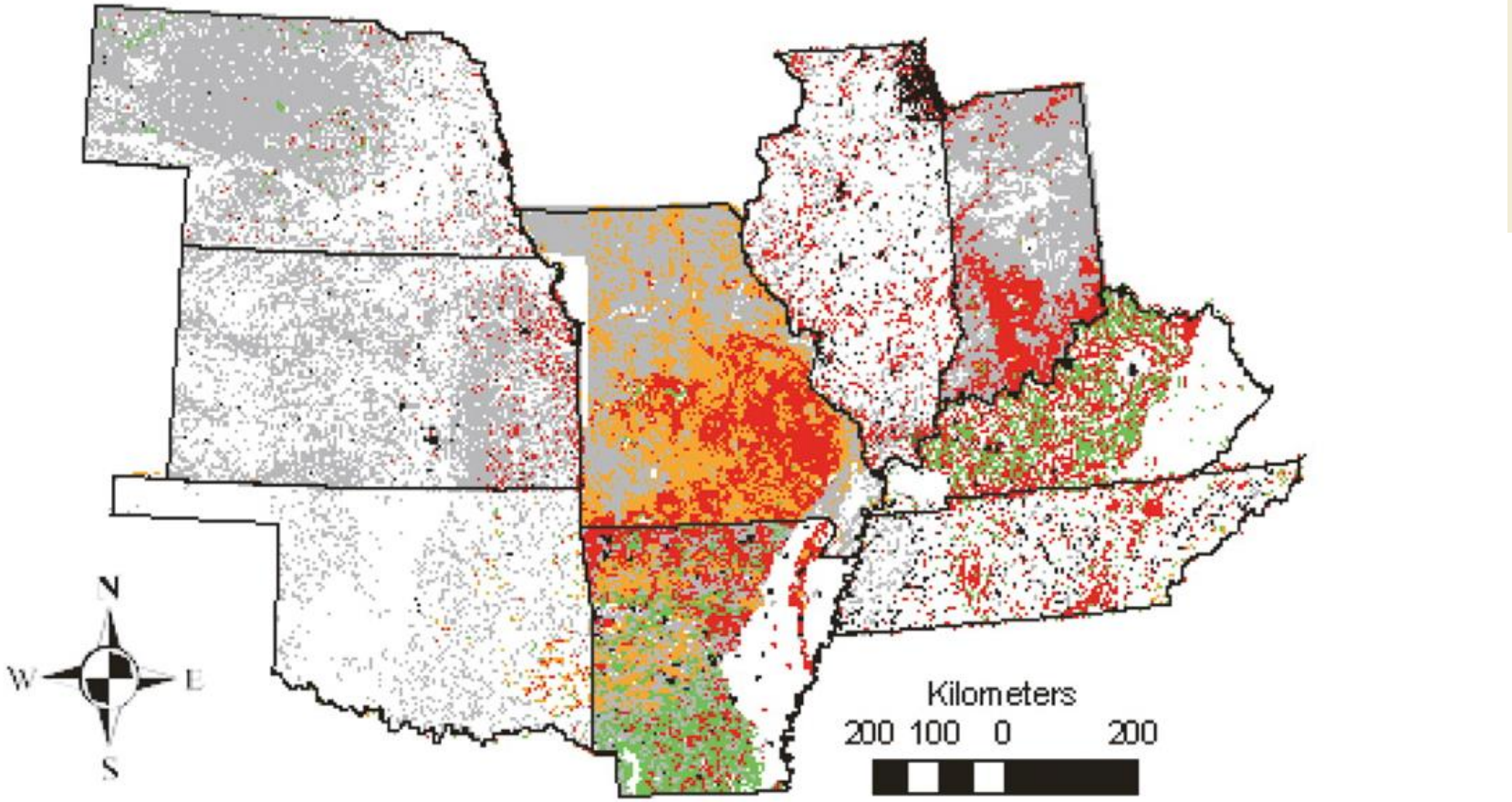

UNSUITABLE HABITAT FOR TICKS

- Other habitat

PARTIALLY SUITABLE HABITAT FOR TICKS

- Grass/Shrub
- Urban

SUITABLE HABITAT FOR

- Dry deciduous forest
- Dry coniferous forest
- Dry mixed forest

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Eisen RJ et al. Am J Trop Med Hyg 2008;78:586-594.

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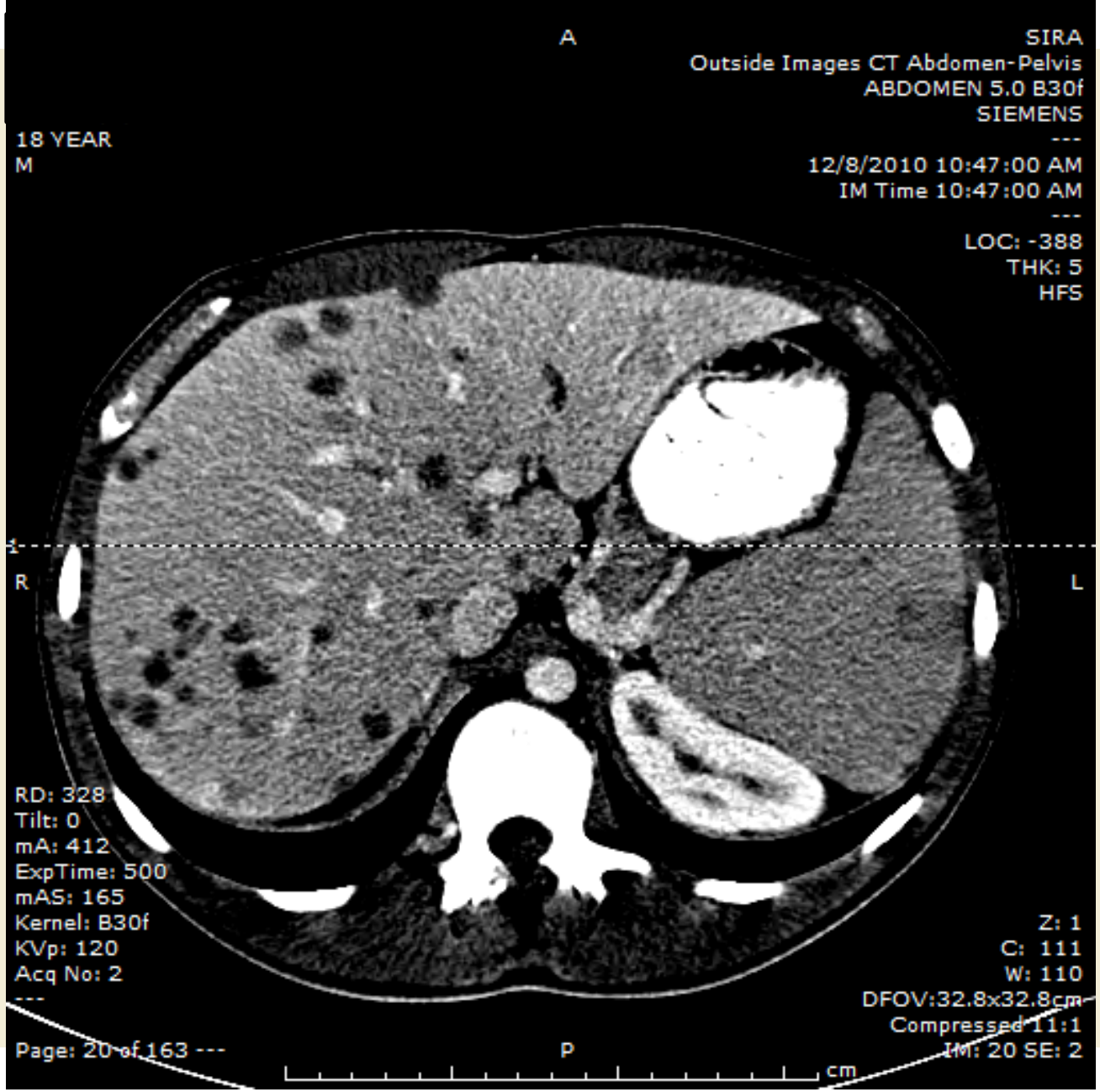
TABLE 1. FREQUENCY OF SELECTED RISK FACTORS FOR PRIMARY PNEUMONIC TULAREMIA.

RISK FACTOR*	PERIOD ANALYZED†	PATIENTS (N=10)	CONTROLS (N=99)	ODDS RATIO (95% CI)‡
		no. (%)		
Male sex		10 (100)	41 (41)	— (2.9 to ∞)
Worked as landscaper		5 (50)	3 (3)	32.0 (4.6 to 257)
Used lawn mower or brush cutter	2 Wk before illness or control period	8 (80)	30 (30)	9.2 (1.6 to 68.0)
Used lawn mower or brush cutter	Summer	10 (100)	48 (48)	— (1.8 to ∞)
Cut brush or mowed over rabbit	2 Wk before illness or control period	1 (10)	0	— (0.3 to ∞)
Worked with bark chips	2 Wk before illness or control period	3 (30)	5 (5)	8.1 (1.2 to 53.7)
Worked with weed whacker	Summer	7 (70)	27 (27)	6.2 (1.3 to 33.6)
Worked with lumber	Summer	7 (70)	29 (29)	5.6 (1.2 to 30.3)
Owned a dog on Martha's Vineyard		8 (80)	44 (44)	5.0 (0.9 to 36.6)
Smoked	2 Wk before illness or control period	5 (50)	18 (18)	4.5 (1.0 to 20.9)
Saw dead rabbit on property	2 Wk before illness or control period	2 (20)	11 (11)	2.3 (0.3 to 14.9)
Found ticks crawling on person	Summer	8 (80)	55 (56)	3.2 (0.6 to 23.4)

*All other risk factors (not shown) were not significantly associated with primary pneumonic tularemia.

†Summer was defined as the period from May 15 to the time of interview. The control period refers to the two weeks before controls were interviewed.

‡The dashes indicate that the odds ratio was undefined. CI denotes confidence interval.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Outside Images CT Abdomen-Pelvis
ABDOMEN 5.0 B30f
SIEMENS

12/8/2010 10:47:00 AM
IM Time 10:47:00 AM

LOC: -388
THK: 5
HFS
18 YEAR
M
R
L
RD: 328
Tilt: 0
mA: 412
ExpTime: 500
mAS: 165
Kernel: B30f
KVp: 120
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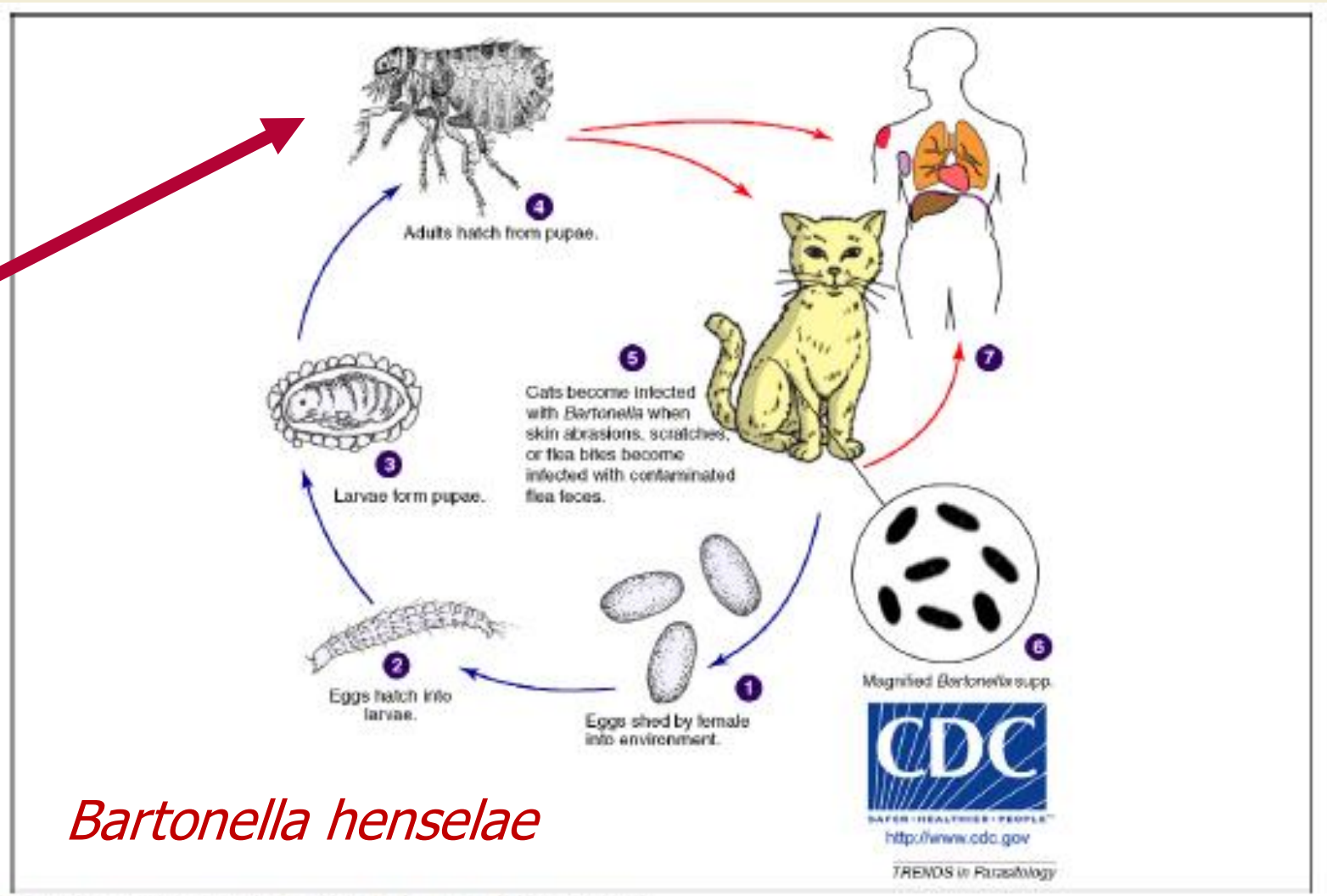
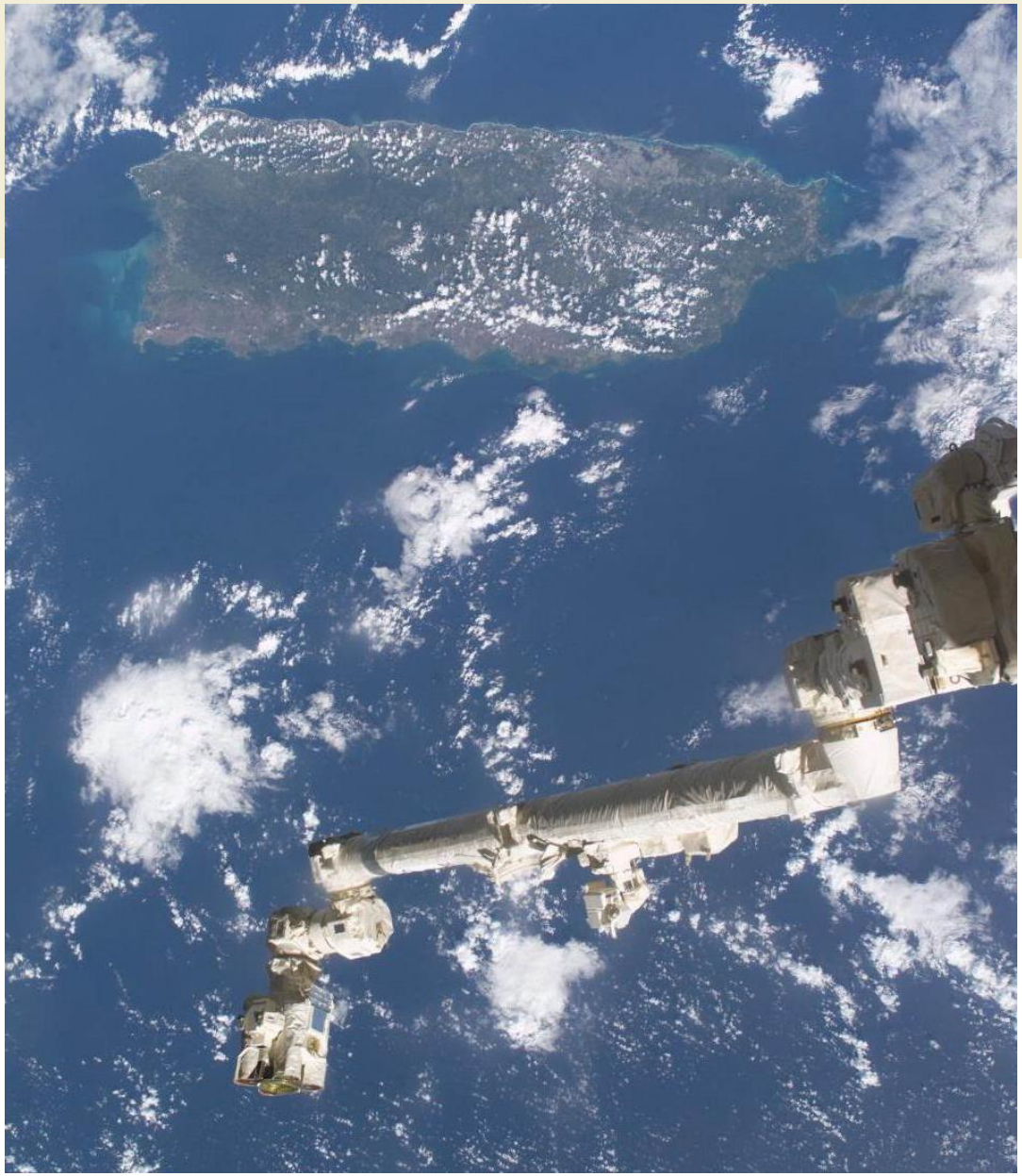


Bartonella henselae

Figure 1. Common transmission cycles of cat-scratch disease: *Bartonella henselae*.
Bartonella henselae is primarily an infection of cats. The most common vector is the cat flea, *Ctenocephalides felis* (although other fleas and ticks have been implicated in the spread of bartonellosis). Adult fleas lay eggs into the environment ❶. Eggs hatch into larvae within two weeks ❷ and feed on organic material in the environment. Larvae form pupae, which takes another 1–2 weeks to mature ❸. Adults emerge from the pupae ❹ and seek out a host for a bloodmeal. Cats become infected when skin abrasions, scratch wounds or flea bite sites are contaminated with feces from *Bartonella henselae*-infected fleas ❺. Fleas become infected through feeding on bacteremic cats. In cats and other mammalian hosts, the bacteria colonize erythrocytes and endothelial cells after infection ❻. Humans may become infected through intradermal inoculation of bacteria in either cat saliva or flea feces lodged in under claws, usually through a bite or scratch ❼.

McElroy KM et al. Trends Parasitol 2010;26:197-204


MOSQUITO BITES ARE BAD!
U.S. Department of Health and Human Services
Centers for Disease Control and Prevention



Mosquito-borne pathogens

- Dengue: Hemorrhagic complications
- Chikungunya: Severe arthralgias, arthritis
- Zika virus: Fetal brain and neurological abnormalities
- West Nile virus: CNS involvement. Poliomyelitis-like manifestations
- Arboviruses [La Crosse, Eastern equine encephalitis et al]: CNS involvement

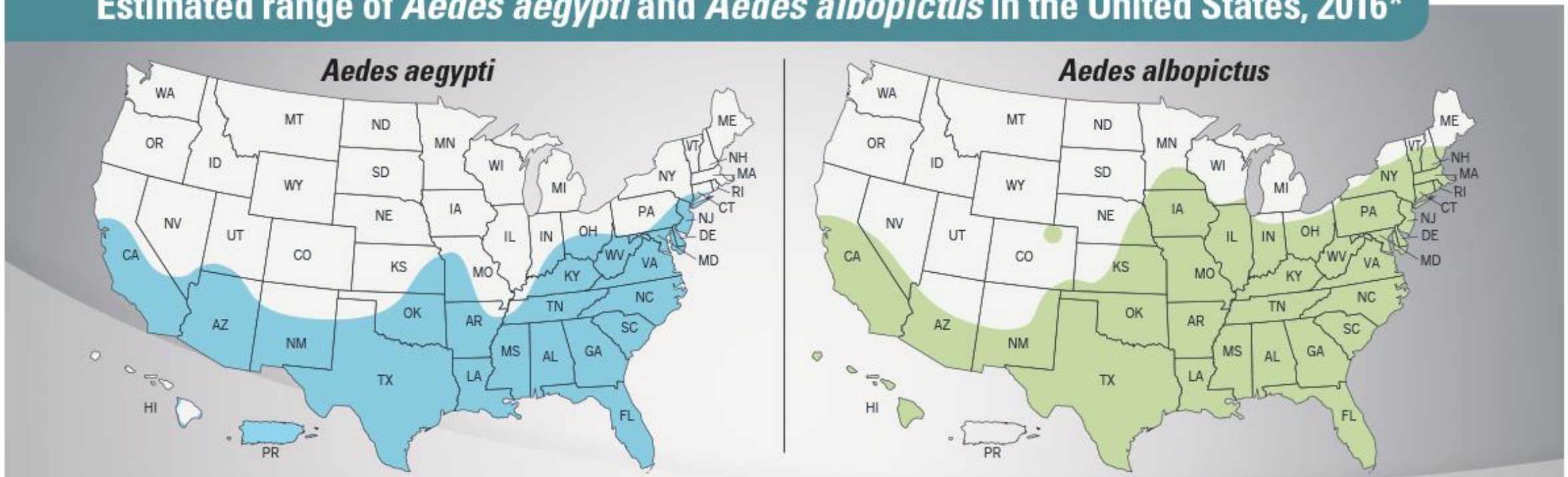
CDC.gov

Aedes aegypti

CDC.gov

Aedes albopictus

Estimated range of *Aedes aegypti* and *Aedes albopictus* in the United States, 2016*



***Aedes aegypti* mosquitoes are more likely to spread viruses like Zika, dengue, chikungunya than other types of mosquitoes such as *Aedes albopictus* mosquitoes.**

- These maps show CDC's best estimate of the potential range of *Aedes aegypti* and *Aedes albopictus* in the United States.
- These maps include areas where mosquitoes are or have been previously found.
- Shaded areas on the maps do not necessarily mean that there are infected mosquitoes in that area.

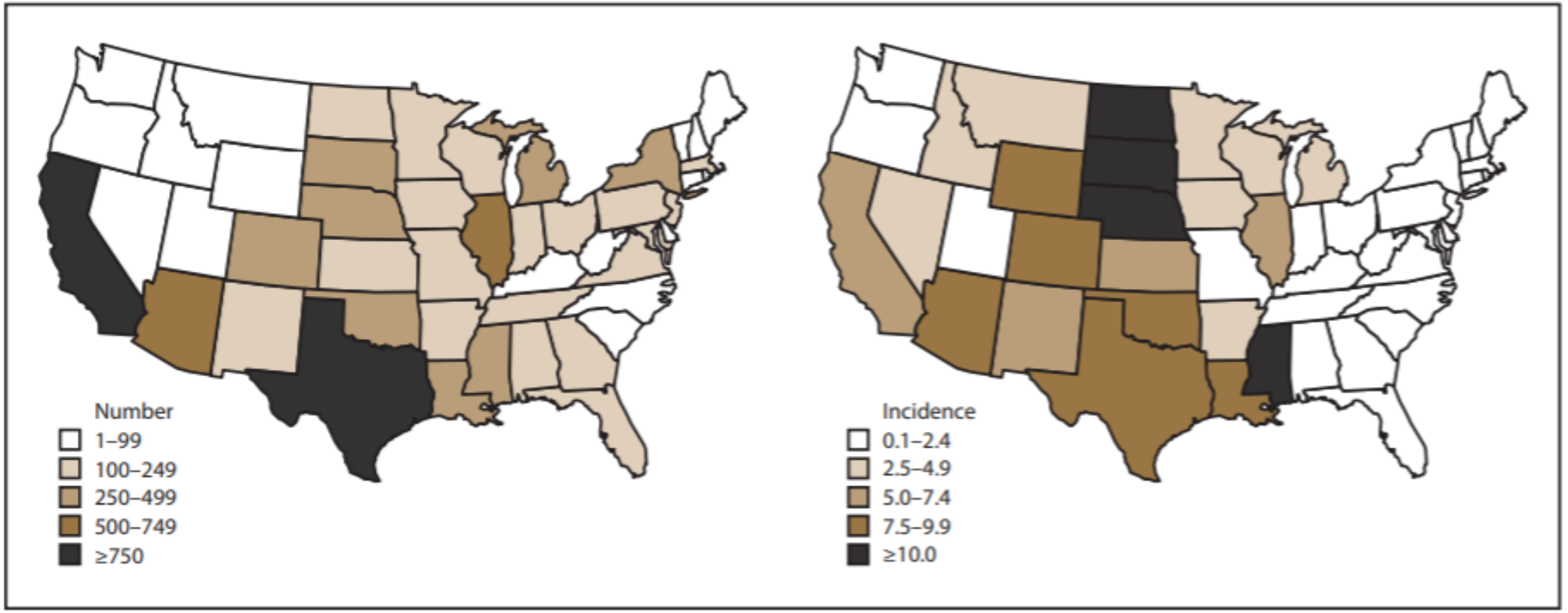
**Maps have been updated from a variety of sources. These maps represent CDC's best estimate of the potential range of Aedes aegypti and Aedes albopictus in the United States. Maps are not meant to represent risk for spread of disease.*

SOURCE: Zika: Vector Surveillance and Control. www.cdc.gov/zika/vector/index.html

CDC.Gov [public domain]

Surveillance for West Nile Virus Disease: United States, 2009–2018

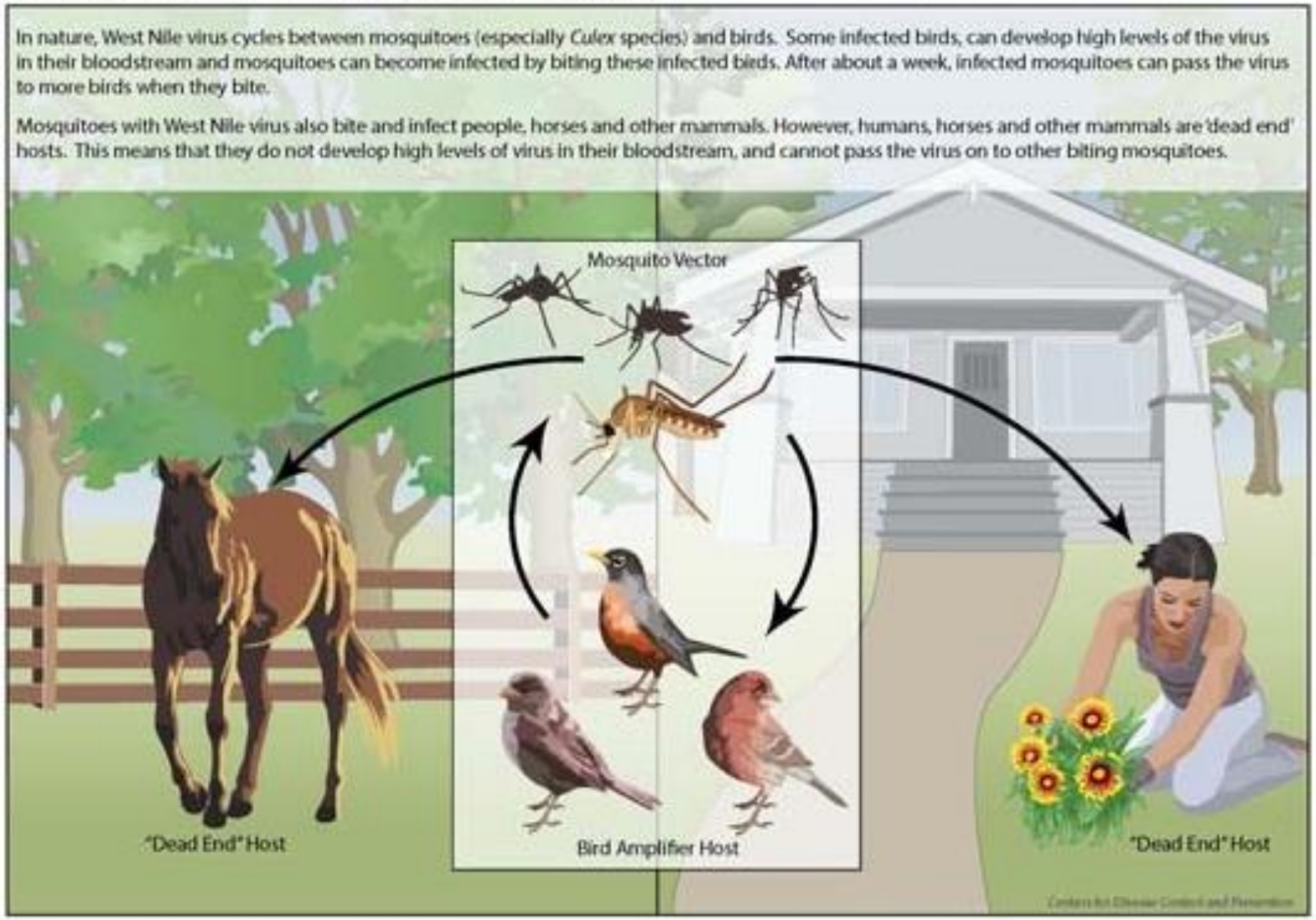
FIGURE 5. Total number and cumulative incidence* of West Nile virus neuroinvasive disease cases, by state of residence — United States, 2009–2018*



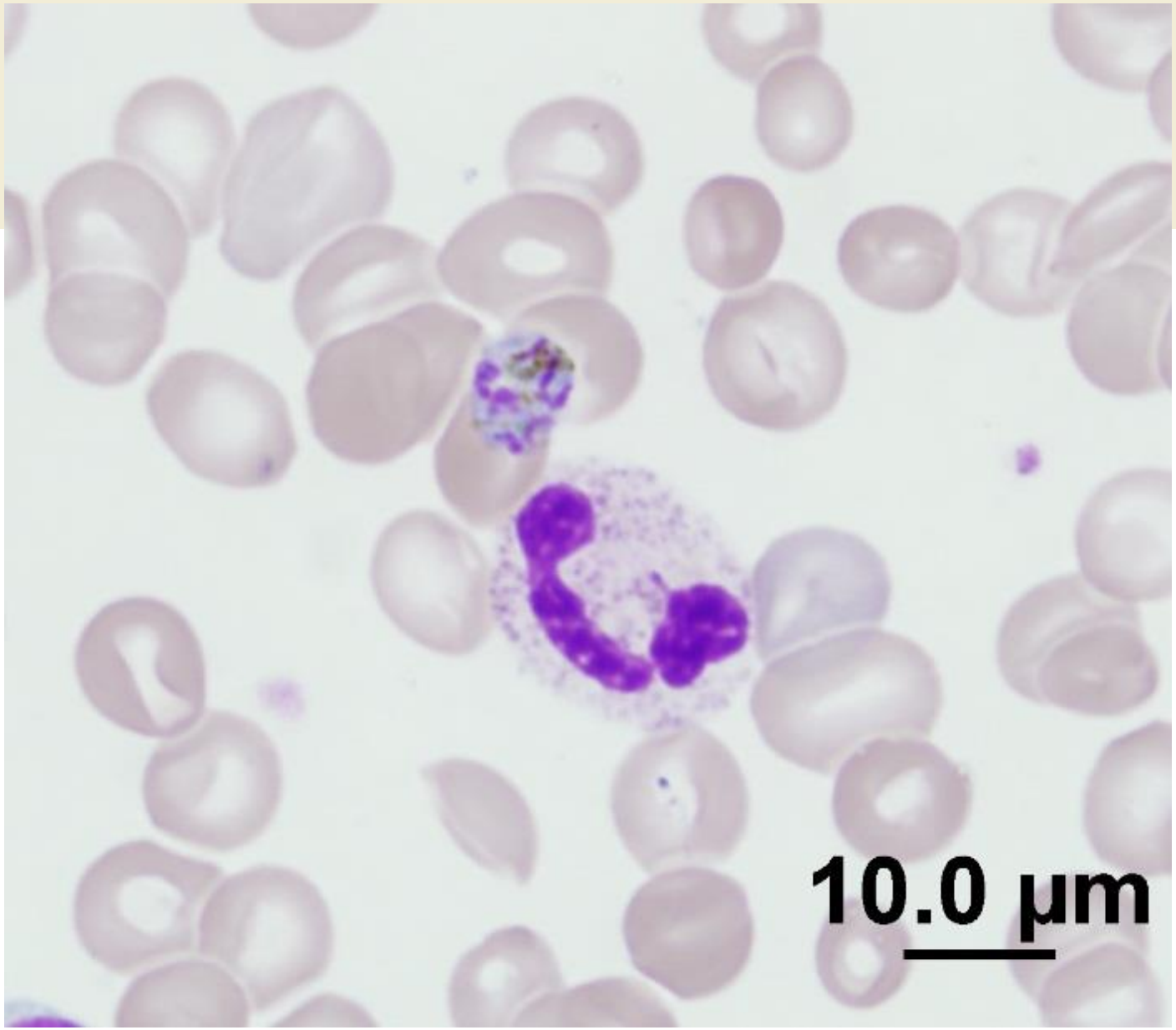
* Per 100,000 population. Incidence calculated using U.S. Census Bureau population estimates for July 1, 2014. Cutpoints determined by Jenks natural breaks classification method, then rounded for ease of display.

McDonald E et al. MMWR 2021;70[SS No. 1]:5 March 2021

West Nile Virus Transmission Cycle



CDC

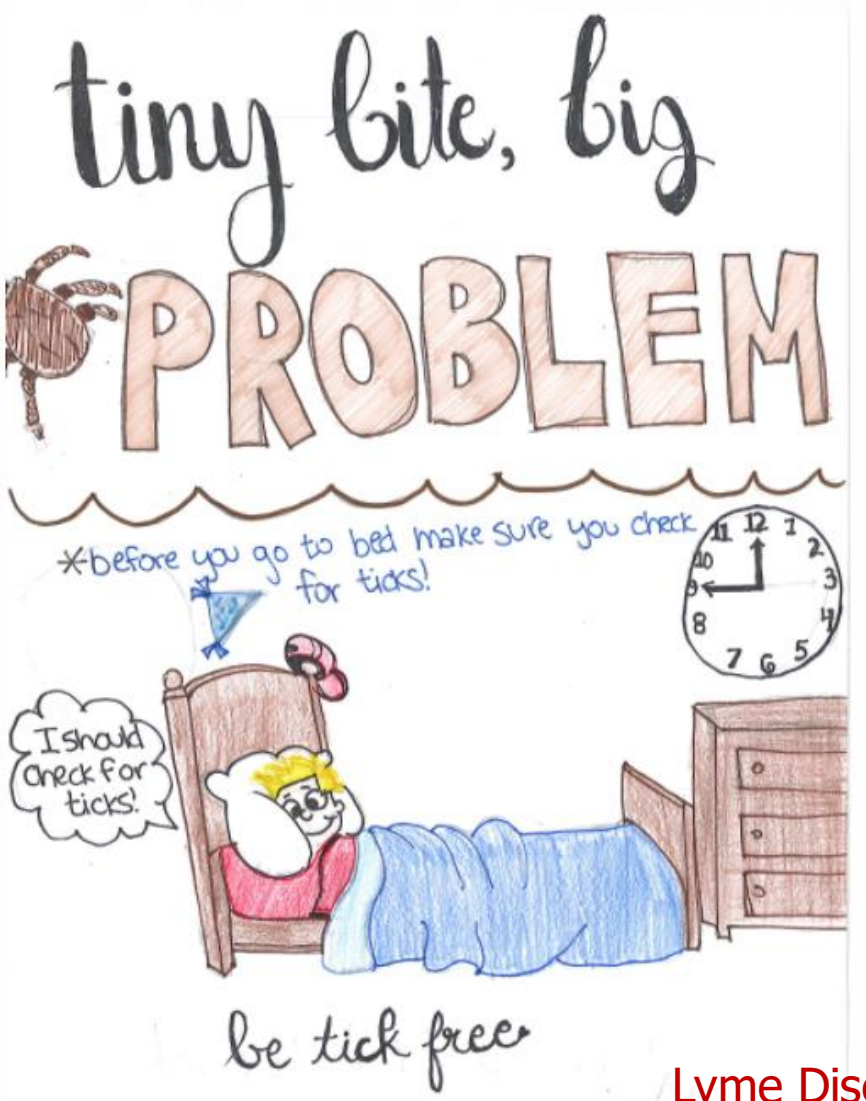

10.0 µm

Fever and a rash: What do I have?

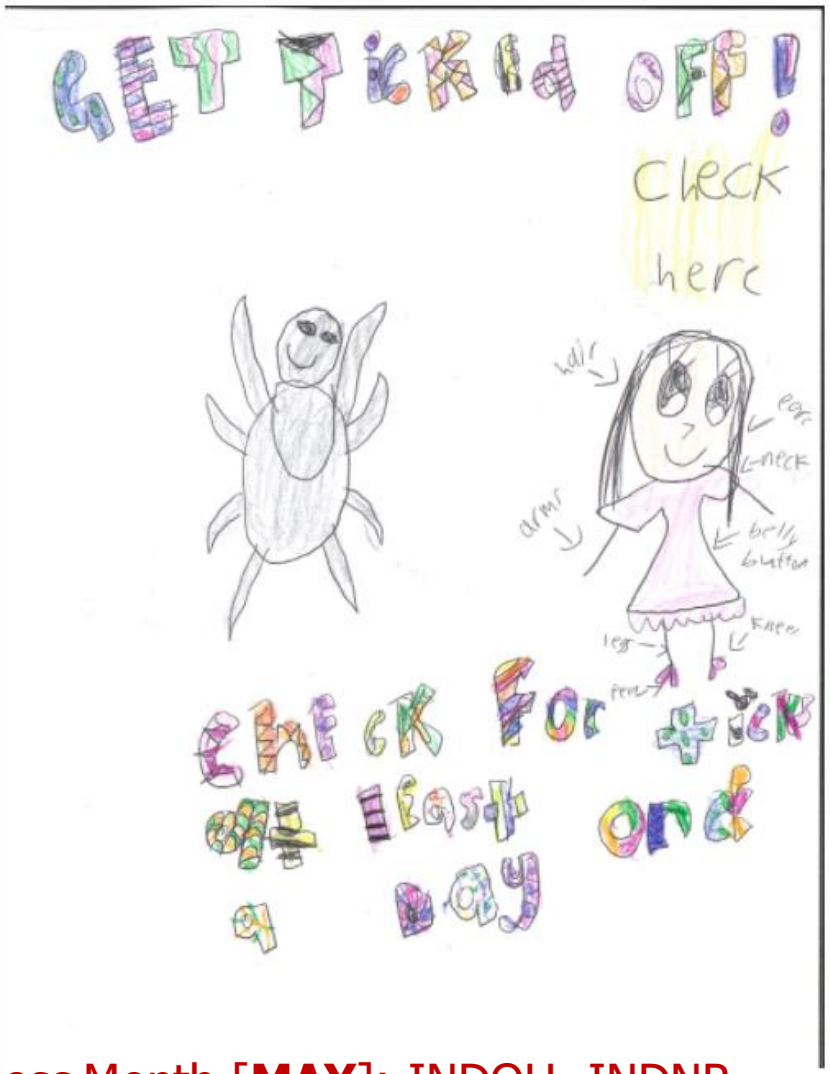
- **17 year-old** male is admitted to Riley Hospital for Children on July 17, 2019 with a 1-week history of fevers, headache, abdominal pain, and night sweats. He is also having some loose stools and shortness of breath. Rash.
- WBC is 3600. Hemoglobin: 15.6. Platelets: 69,000. Neutrophils: 37%, 2% bands. ALT: 532. AST 704. Total bilirubin, 0.6.
- Pertinent history: Spent 1 month in Thailand [June 5-July 5, 2019]. Outside of Bangkok [visiting relatives in a refugee camp]. Parents are Burmese. He was born in Thailand. Been in US ~years. Brother and sister with similar symptoms & labs.

- Studies for hepatitis E, Epstein Barr, malaria, murine typhus, and leptospirosis: Negative
- **Patient 1**: Dengue IgG, 13.51. Dengue IgM, 4.30
- **Patient 2**: Dengue IgM, 10.0. Dengue IgG, negative.

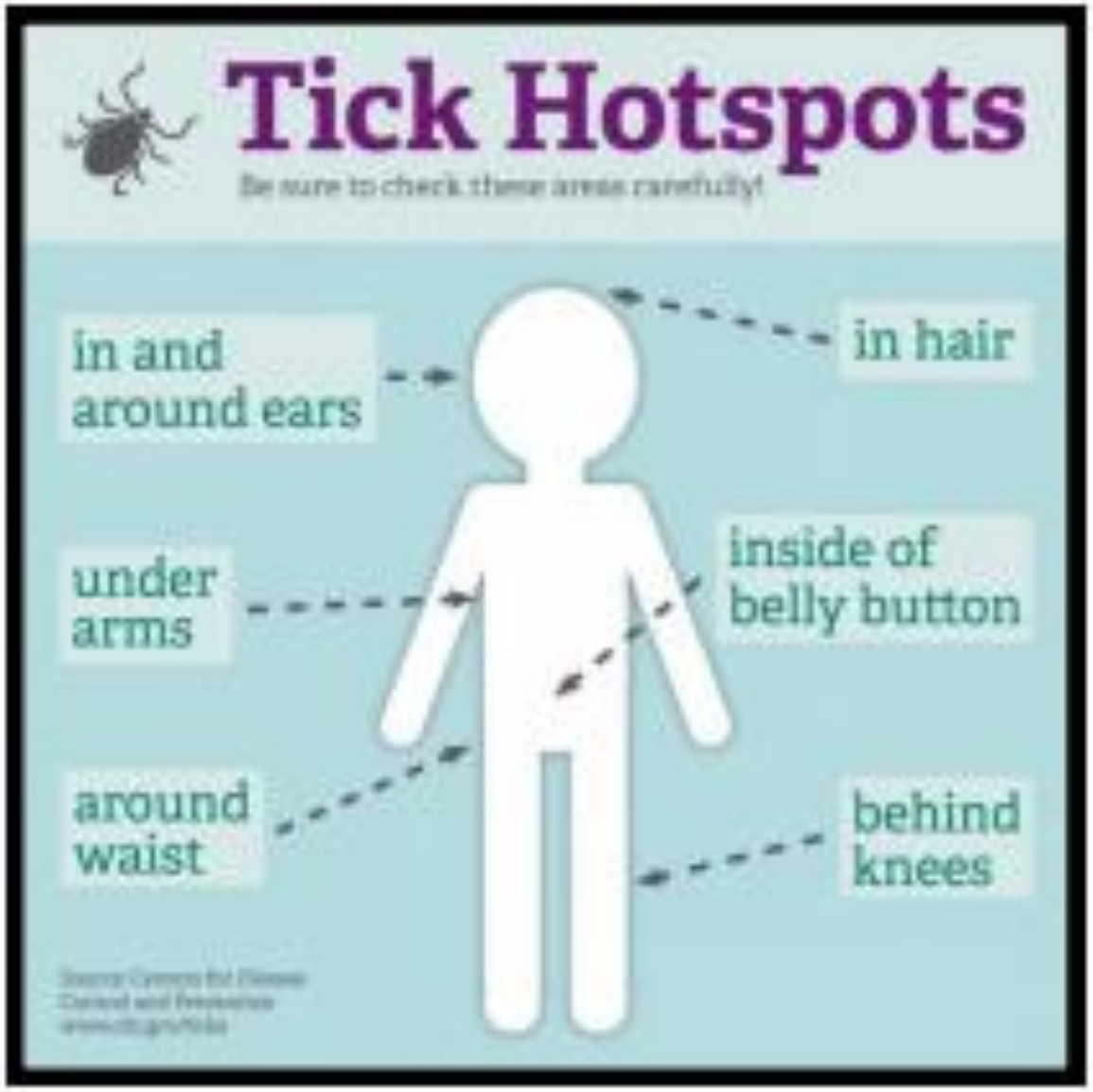
Aviendha C. - Grade 7



Cassandra S. - Grade 2



Lyme Disease Awareness Month [**MAY**]: INDOH, INDNR



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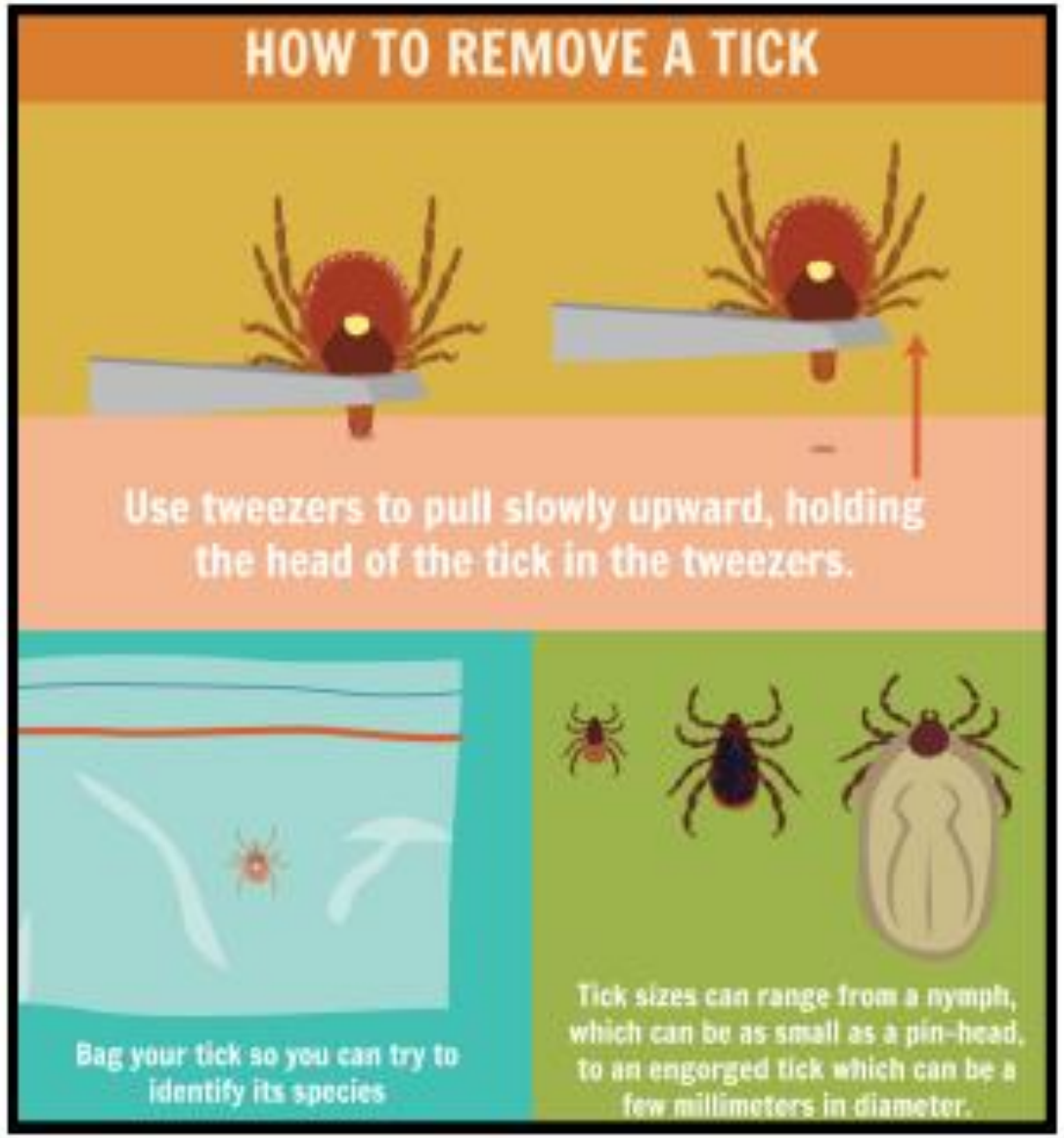
Prevention Tips

1. It is fine to go outside, but protect yourself.
2. The more clothes you use, better the protection against bites.
3. Once returning inside, check for ticks. Minimize duration of tick attachment if you can.



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Selecting and using insect repellents appropriately[1]

- Repellents are safe for children if applied appropriately.
- Permethrin for clothes and garments. DEET and picaridin for exposed skin only [not underneath clothing].
- Avoid pressurized cans [air travelers]. Thin application of lotions.
- Do not apply around eyes, mouths, on children's hands.
- Do not apply direct on children's skin. Use your hands to apply.
- Wash your hands after you apply the repellent.
- Keep repellents away from younger children.

Selecting and using insect repellents appropriately$_2$

- Do not apply repellents to children ≤2 months of age. Use mosquito netting.
- Do not apply repellents on cuts and open wounds.
- Avoid sunscreen-insect repellents combination products.
- Products containing DEET concentrations 20-30% products are effective for travel to tropical countries or other regions endemic with vector-borne diseases.

Insect repellents: Which is best?

- DEET 20-50%: Protection lasting 6-13 hours. Reapply every 6-8 hours for maximal protection. Children >2 months old.
- DEET, extended release, ~33%: Protects against ticks ~12 hours.
- Picaridin [20% = DEET 20%]: Protection ~5 hours. Reapply every 4-6 hours.
- PMD, 30%: Protection for 4-6 hours. Children >3 years old.
- Ethyl butylacetylaminopropionate [IR3535]: not as effective against *Anopheles*.

Alpern JD et al. Med Clin N Am 2016;100:303-316

Natural insect repellents

- Containing citronella, geranium, peppermint and soybean oil.
- Safe, but are they effective?
- "Protection" is of a shorter duration
- Their use may be "reasonable" for use around the house where risk of bite resulting in disease is low.

Quick reference: Insect repellents & duration of protection

- DEET <10%: 1-3 hours
- DEET 10%-30%: 4-6 hours
- DEET 20%-33%, extended duration: 6-12 hours
- Citronella oil 5%-15%: 20-30 minutes
- Lemon eucalyptus oil 10%-30%: 2-5 hours [not proven to be effective against ticks]
- Picaridin 7%: 3-4 hours
- Picaridin 15%: 6-8 hours
- Permethrin 0.5%: Several washings.

Katz TM et al. J Am Acad Dermatol 2008;58:865-871

Insect-borne pathogens, travel: Prevention

- Malaria: Bite-prevention, chemoprophylaxis
- Yellow fever: Vaccine, bite-prevention
- Japanese encephalitis virus: Vaccine, bite-prevention
- Dengue fever: Bite-prevention
- Chikungunya virus: Bite-prevention
- Zika virus: Bite-prevention, travel avoidance
- Rickettsial infections: Bite prevention
- Tick-borne encephalitis virus: Vaccine, bite-prevention
- Chaga's disease: Bite-prevention
- African trypanosomiasis: Bite-prevention