Vector-borne infections in children: Preventing tiny bites that may kill

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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.

Vector-borne infections: A global problem[1]

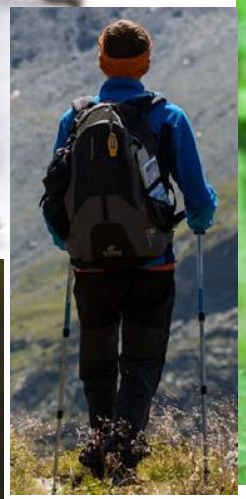
- Vector-borne diseases account for >17% of all infectious diseases, causing >700,000 deaths annually. These are caused by either parasites, bacteria or viruses.
- Malaria is a parasitic infection transmitted by Anopheline mosquitoes. It causes an estimated 219 million cases globally and results in >400,000 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 wook tick]
- *Dermacentor variabilis* [Dog tick]
- *Rhipicephalus sanguineus* [Brown dog tick in SW US, Mexico]
- *Pediculus humanus humanus* [*Human* louse]
- *Ixodes scapularis, Ixodes pacificus*

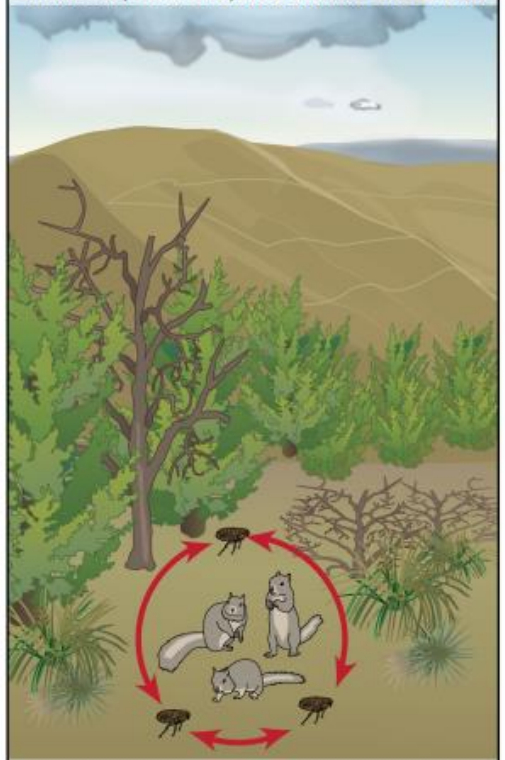
Zoonosis

Vector-Borne

Plague Ecology in the United States

Plague in Nature

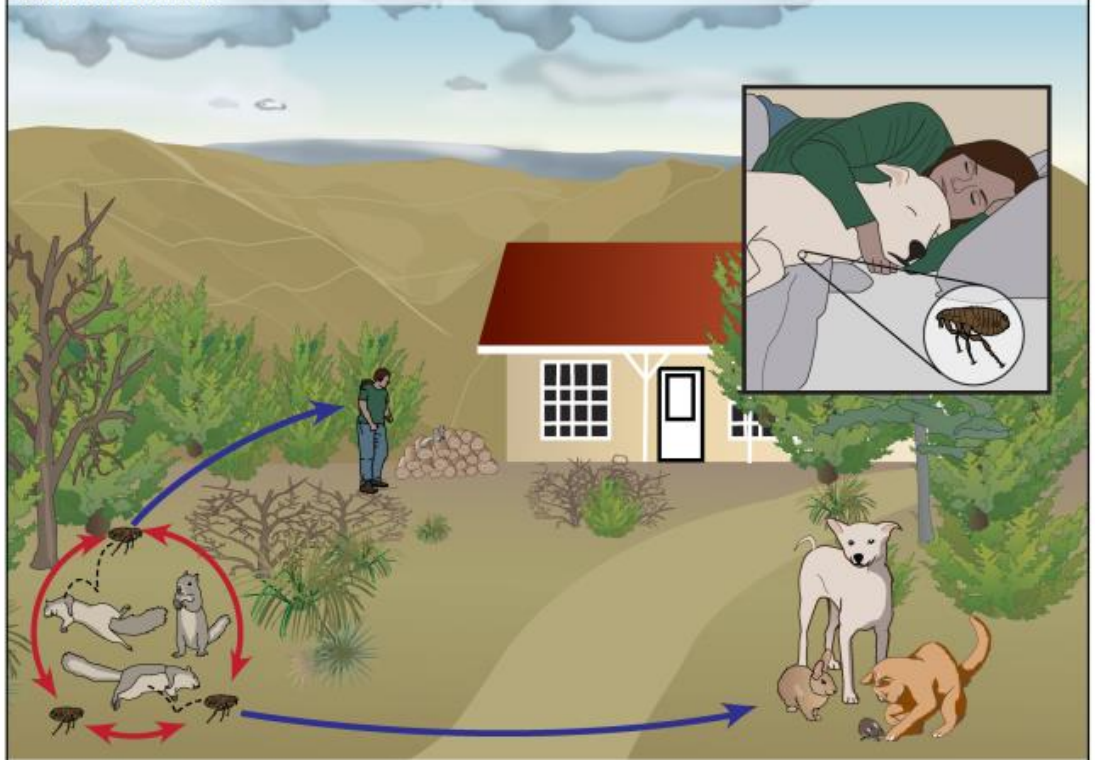
Plague occurs naturally in the western U.S., especially in the semi-arid grasslands and scrub woodlands of the southwestern states of Arizona, Colorado, New Mexico and Utah.



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.

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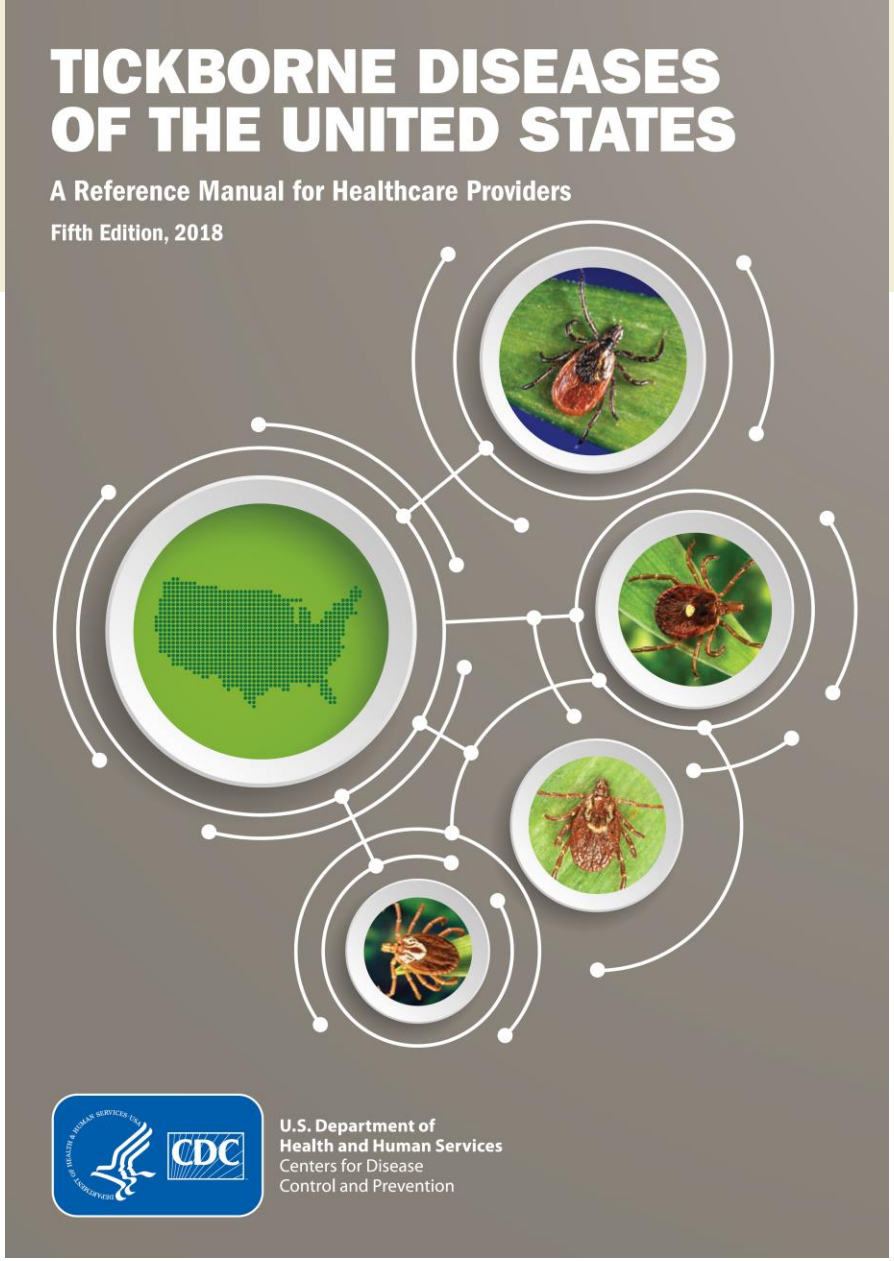
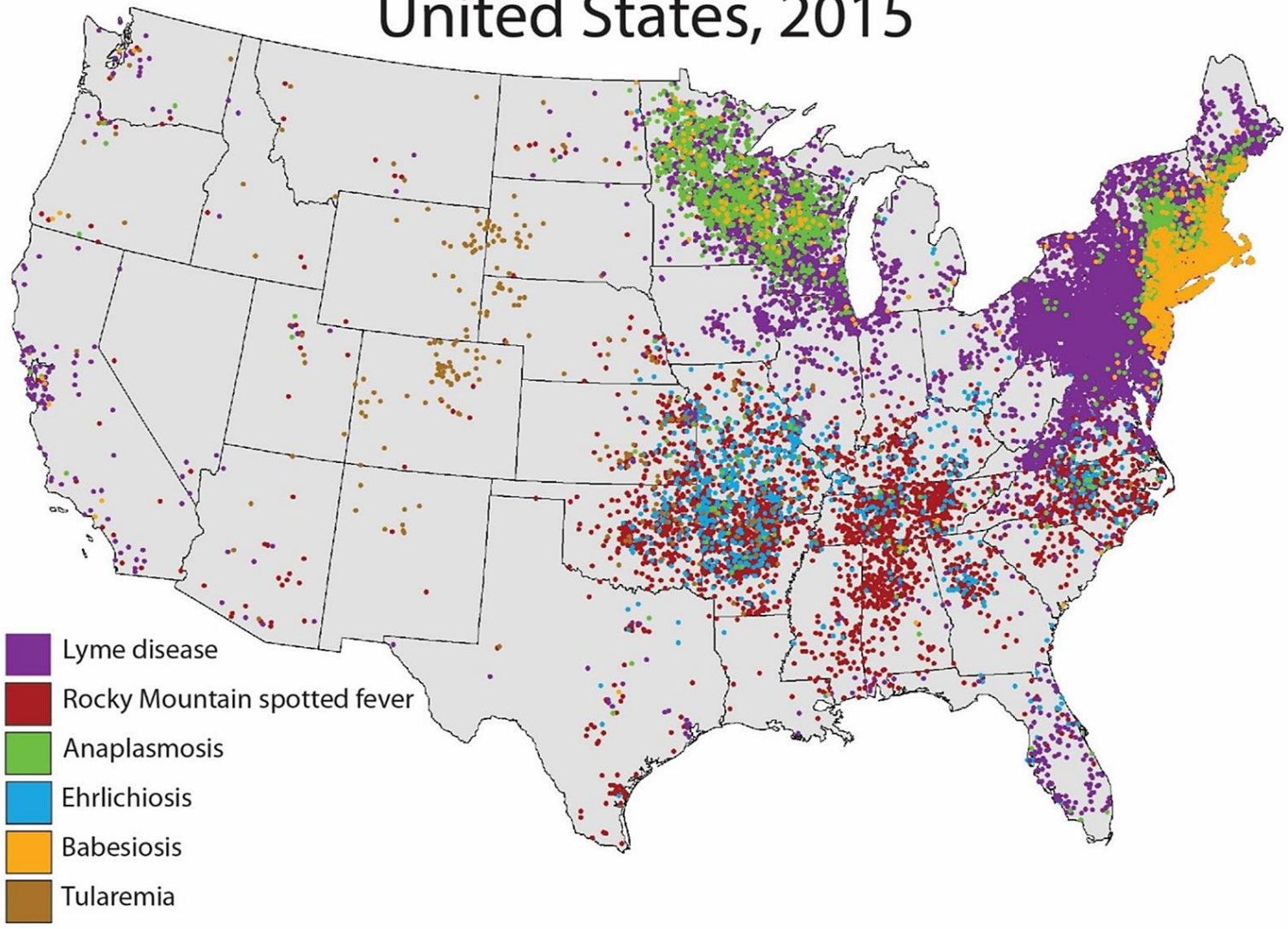

TICKBORNE DISEASES
OF THE UNITED STATES
A Reference Manual for Healthcare Providers
Fifth Edition, 2018
CDC
U.S. Department of
Health and Human Services
Centers for Disease
Control and Prevention

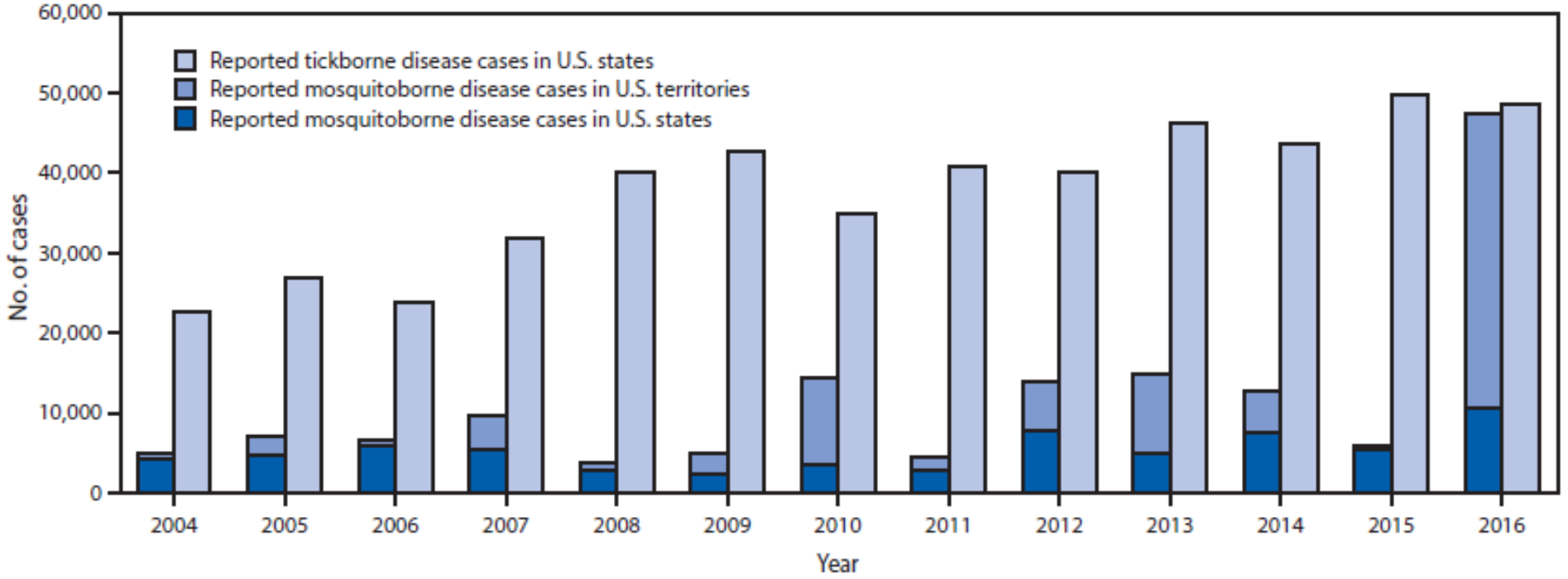
CDC, 2018

Distribution of Key Tickborne Diseases, United States, 2015



CDC

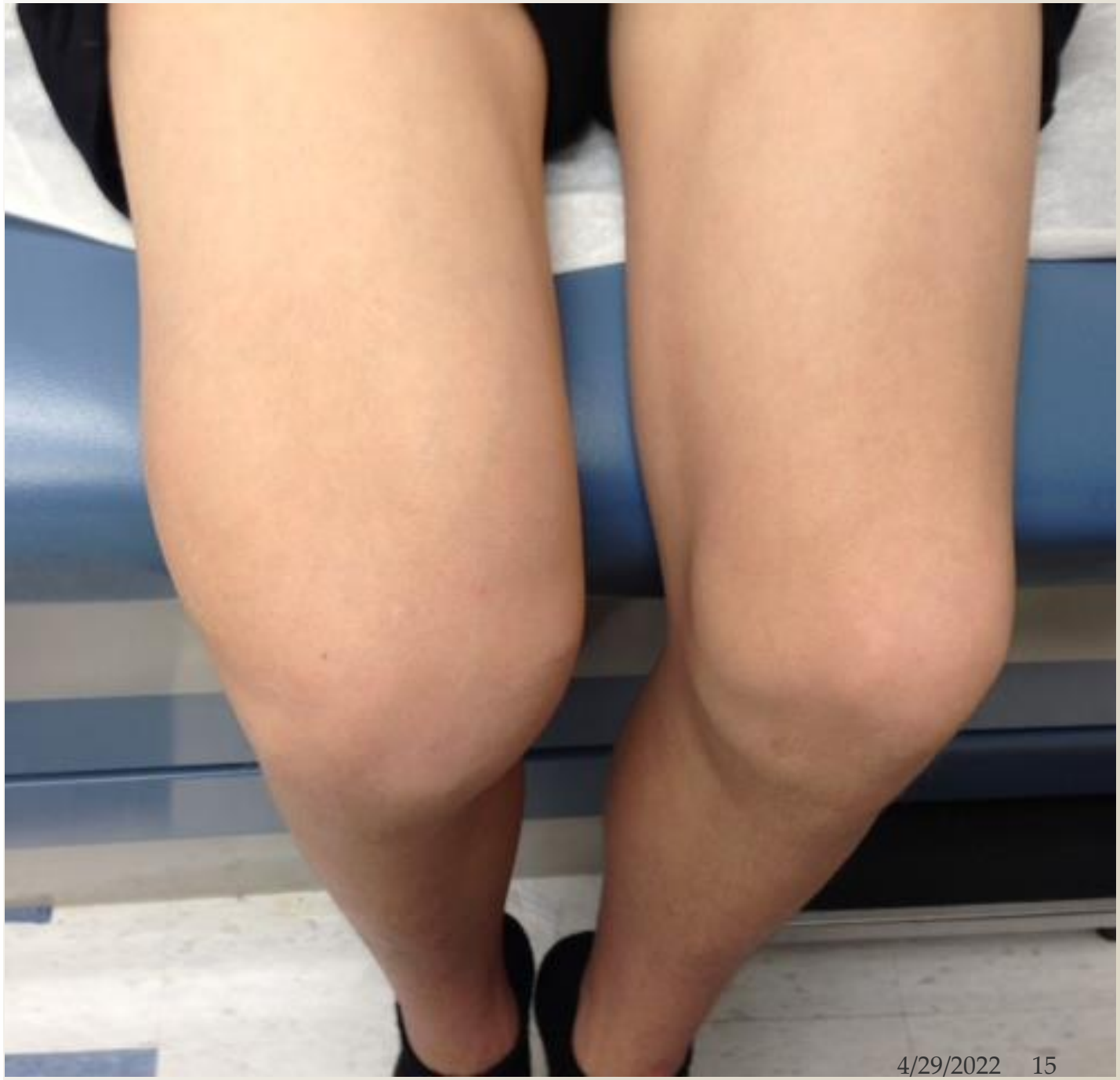
FIGURE 3. Reported nationally notifiable mosquitoborne,* tickborne, and fleaborne† disease cases — U.S. states and territories, 2004–2016



* 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 tickborne diseases in US: Lyme disease
Mosquitoborne 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.

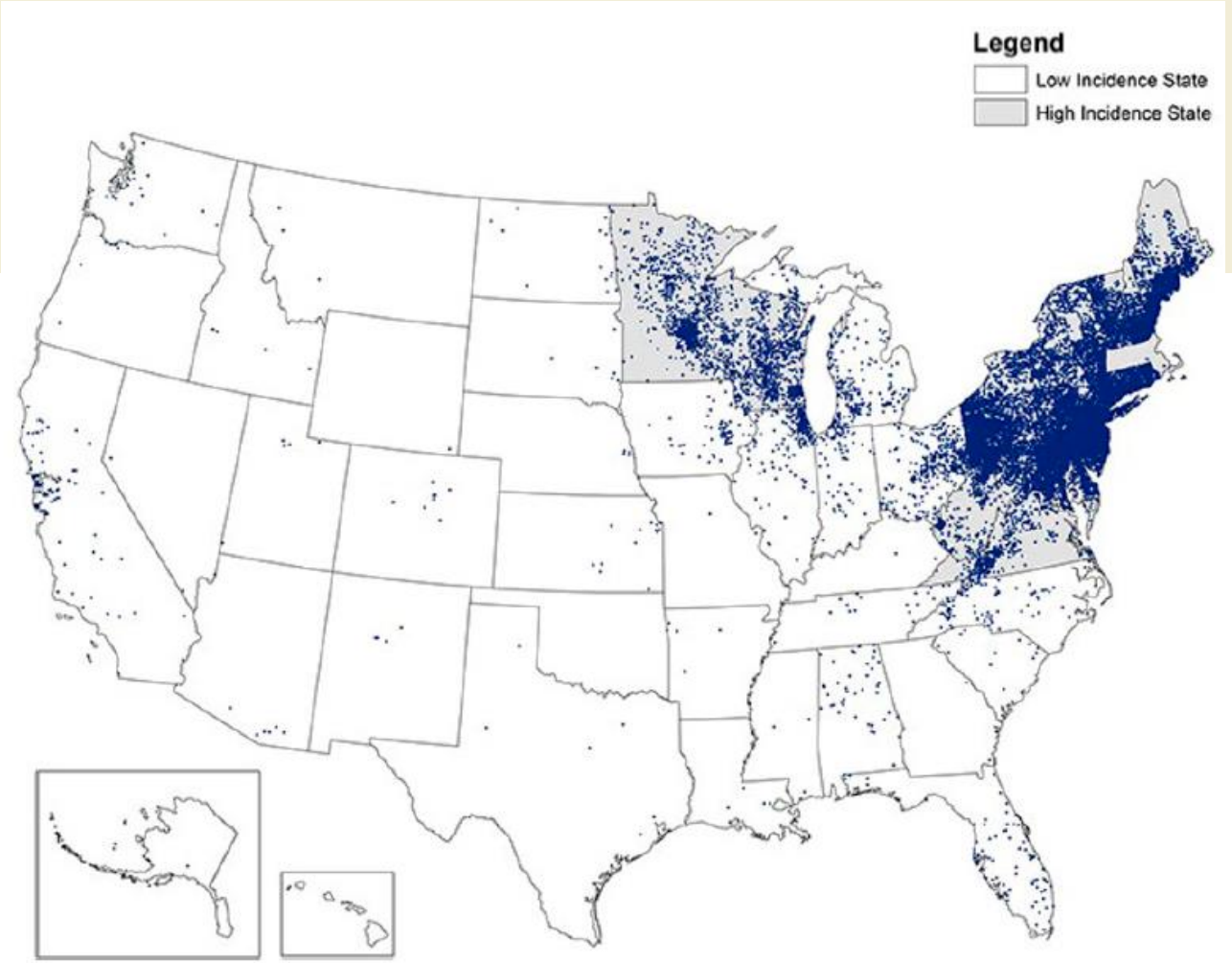


FIGURE 1

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.)

Ixodes scapularis
CDC Public Library

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

Treatment of Lyme disease

Manifestation	Agent	Duration [Days]
Carditis	Doxycycline [oral], amoxicillin or cefuroxime axetil	14-21
	Ceftriaxone	14-21

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

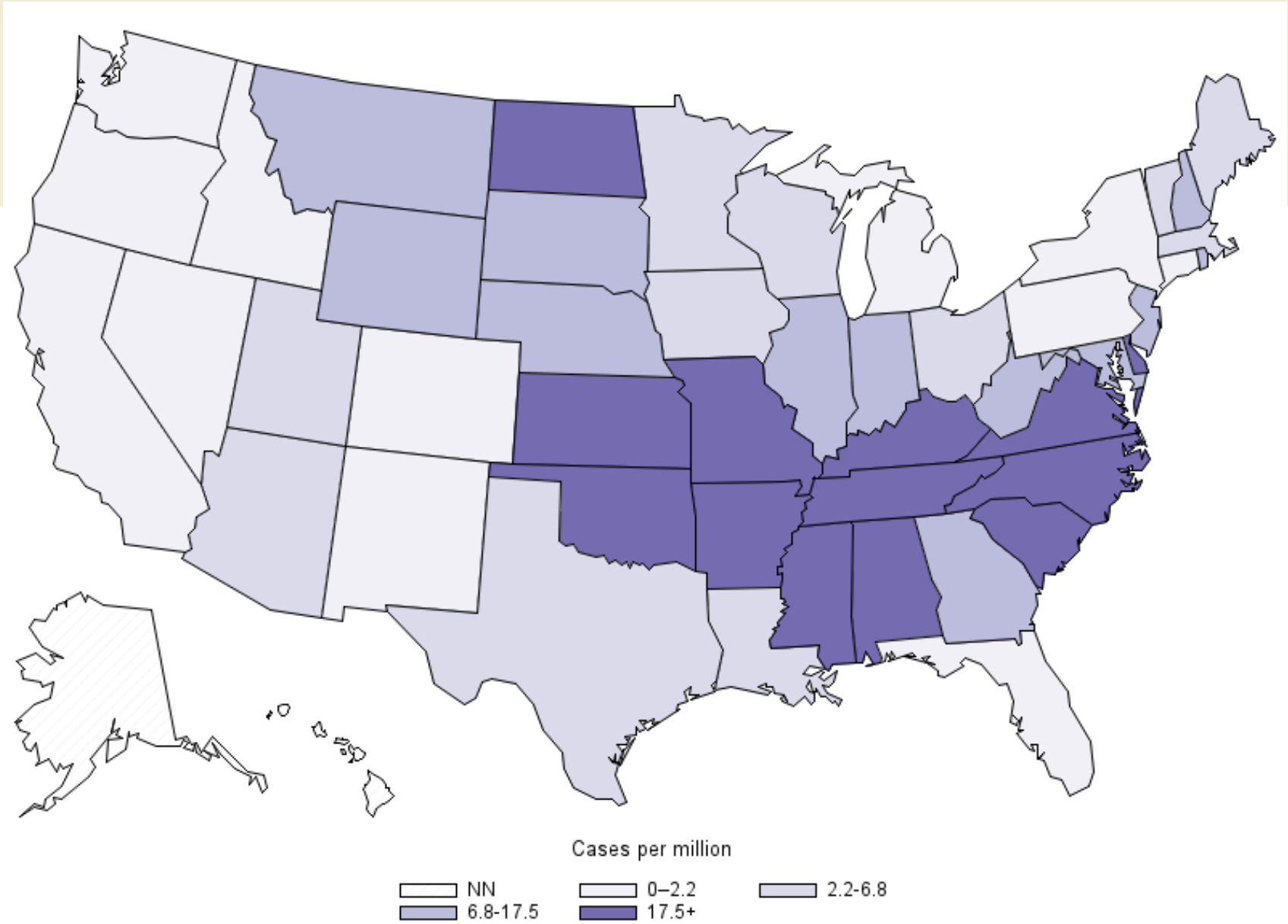
"I found a tick, is prophylactic antibiotic needed?"

1. Prophylactic antibiotic therapy could be given [and only] to adults and children within 72 hours of removal of an identified high-risk tick bite.

2. A tick bite is considered to be **high-risk only** if it meets the following 3 criteria: Tick bite was from (a) An identified *Ixodes* spp. vector species, (b) It occurred in a highly endemic area, and (c) Tick was attached for ≥36 hours.

3. Administration of a **single dose** of oral **doxycycline** within 72 hours of tick removal over observation. Comment: Doxycycline is given as a single oral dose, 200 mg for adults and 4.4 mg/kg [up to a maximum dose of 200 mg] for children.

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



RMSF 2017, **CDC**

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.

Dermacentor andersoni

CDC Public Library

Rocky Mountain Spotted Fever: *Rickettsia rickettsii*

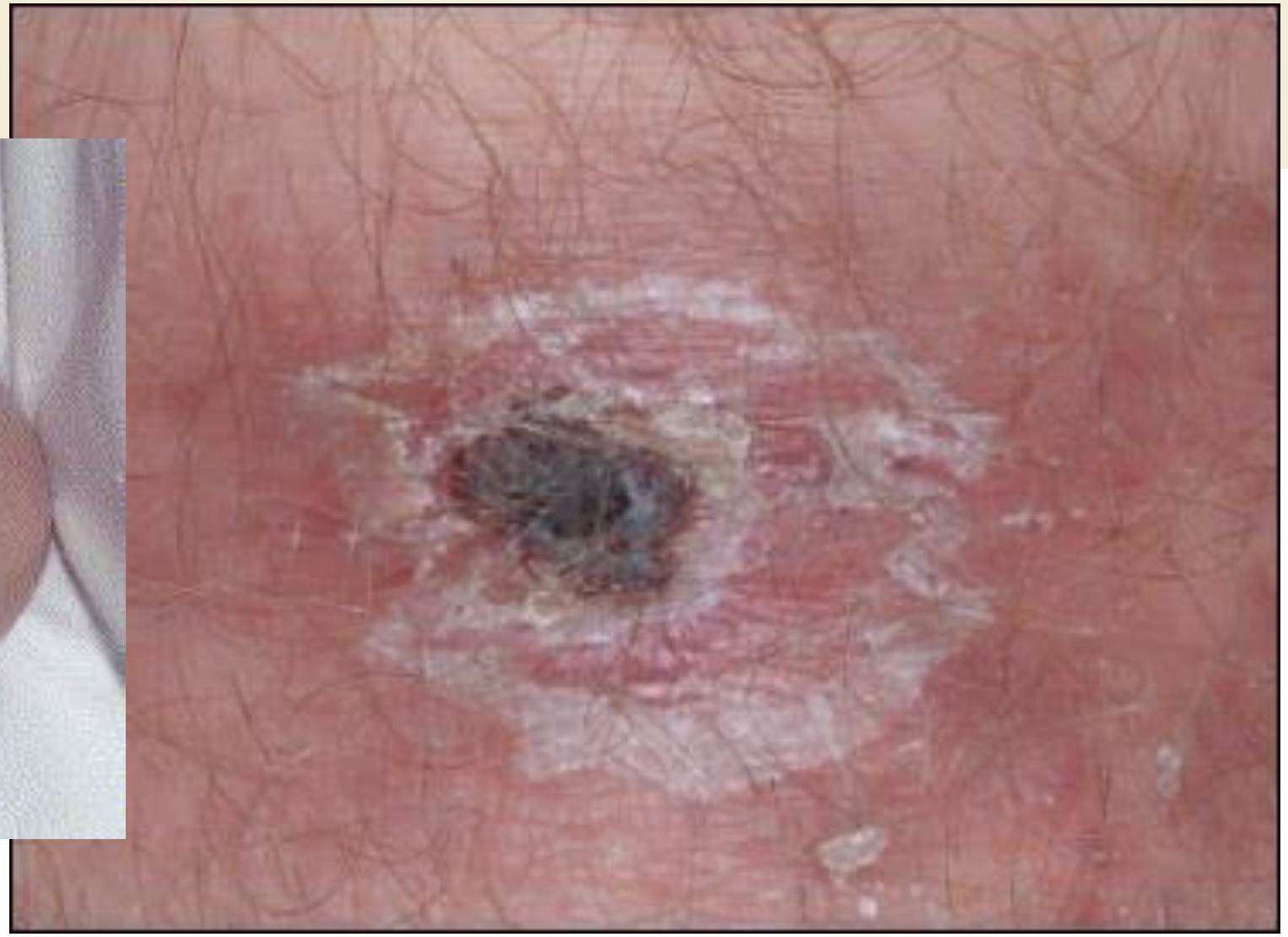
- Vectors: *Dermacentor variabilis* [American dog tick]; Eastern US.
- *D. andersoni* [Rocky Mountain wood tick]; Western US.
- *Rhipicephalus sanguineus*: Mexico; Arizona
- *Amblyomma cajennense*: Central, South America; Texas
- *Amblyomma americanum*: Lone Star tick
- Most cases [56%] in: NC, SC, TN,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

- *Rickettsia akari*: Rickettsialpox; mite-borne
- *Rickettsia felis*: Cat-flea
- *Rickettsia parkeri*: Eschar-associated illness

  Amblyomma maculatum, Gulf Coast tick: FL, GA, KY, MS, OK, SC

Paddock CD et al. Clin Infect Dis 2004;38:805-811

Sumner JW et al. Emerg Infect Dis 2007;13:751-753



Rickettsia parkeri eschars

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Southern States rickettsiosis: *Rickettsia parkeri*

- Gulf Coast tick, *Amblyomma maculatum*
- Patients ill late July-early September.
- Known tick bite in ~50% of patients
- Eschar at bite sites. Crusted, nonpruritic, mildly tender.
- Incubation period: 2-10 days [median, 5 days].
- Sore or pimple at bite site. Fever, fatigue, myalgia, headache, generalized exanthem. RMSF-like.

Paddock CD et al. Clin Infect Dis 2008;47:1188-1196.

Southern tick-associated rash illness [STARI]

- Vector: *Amblyomma americanum*
- Organism: *Borrelia lonestari*
- Erythema migrans-like rash: SE, SC US.

Varela AS et al. J Clin Microbiol 2004;42:1163-1169

Human monocytic **ehrlichiosis**

Ehrlichia chaffeensis

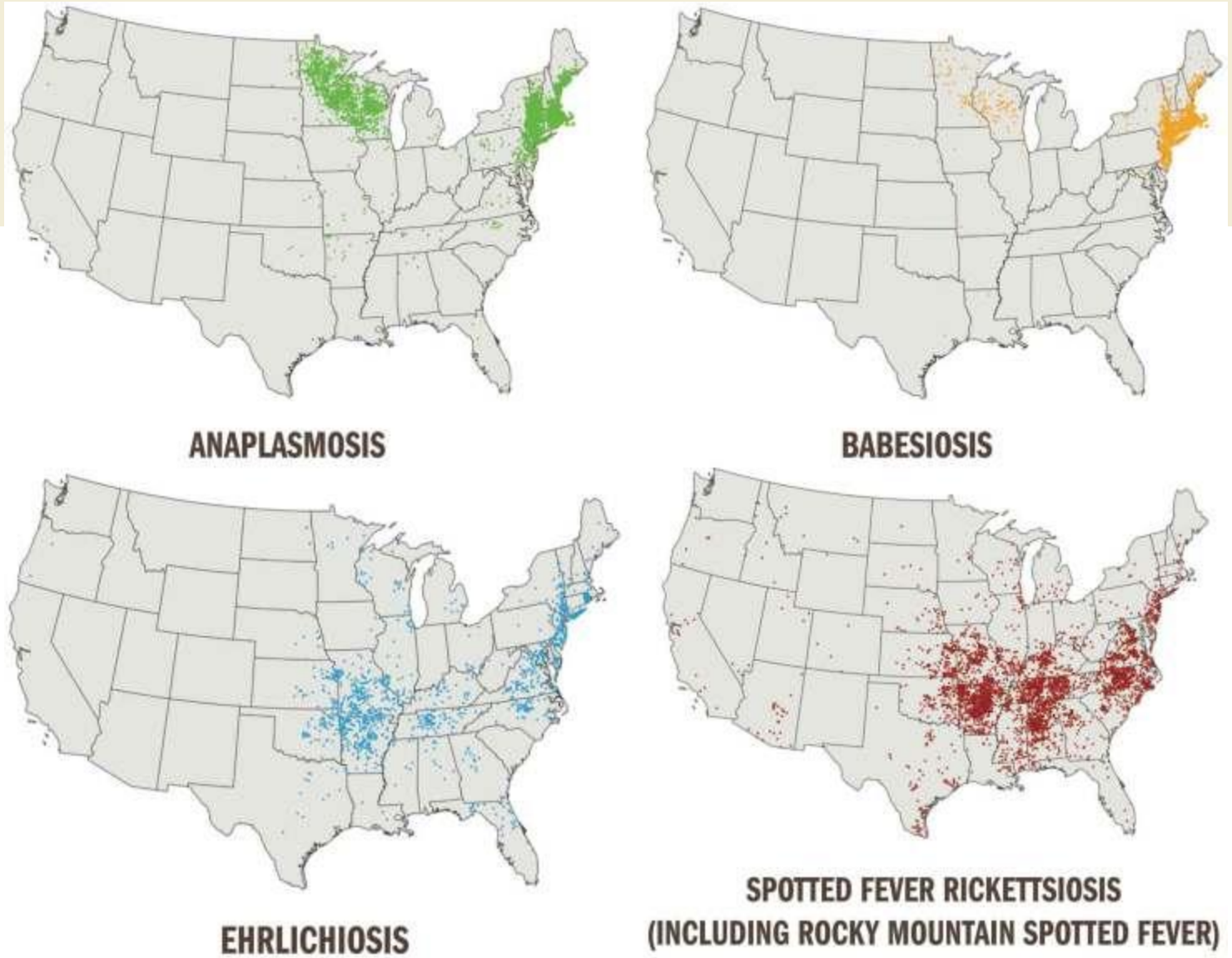
Ehrlichia muris-like

Ehrlichia canis

Human granulocytic **anaplasmosis**

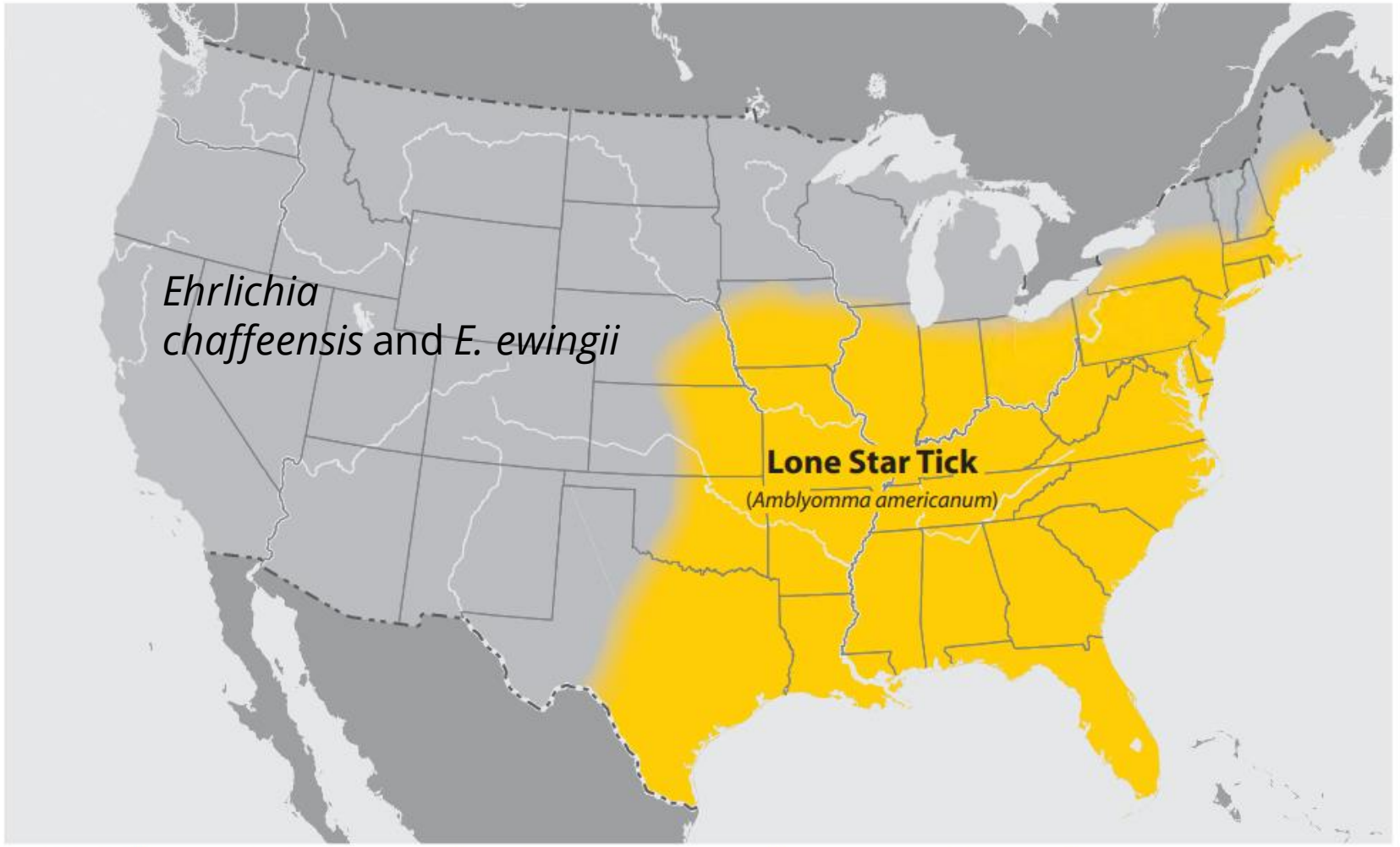
Anaplasma phagocytophilum

Ehrlichia ewingii



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

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

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

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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Babesiosis

- **Malaria-like** tickborne disease
- Symptomatic disease: Asplenics, persons >50 years of age, compromised hosts, congenital and perinatal transmission, transfusions.
- *Babesia microti* in NE, Upper Midwest US. *B. duncani* in western US. *B. divergens* in Europe [more severe]. *Ixodes* ticks are vectors.
- Most pediatric disease is asymptomatic. When symptoms, influenza-like illness. Incubation period: up to 33 days.
- Fever, malaise, and hemolytic anemia. DIC reported. Elevated LFTs.
- Atovaquone and azithromycin: Treatment of choice, 7-10 days.

* N = 2,070; county of residence was known for all but four (<1%) of the 2,074 total patients. Each dot represents one case; dots were placed randomly within the patient's county of residence.
† Year as reported by the health department.

New tick-borne pathogen? Newly recognized in US.

- *Borrelia miyamotoi* disease in the Northeastern US. Newly recognized, 2013.
- High fevers, chills, marked headaches, myalgias or arthralgias.
- Elevated liver enzymes, neutropenia and thrombocytopenia.
- Good response to doxycycline.
- No long-term sequelae.
- Co-infections with Lyme.

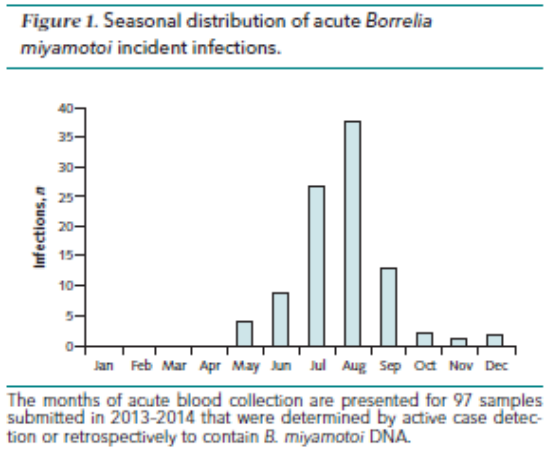

Figure 1. Seasonal distribution of acute *Borrelia miyamotoi* incident infections.

The months of acute blood collection are presented for 97 samples submitted in 2013-2014 that were determined by active case detection or retrospectively to contain *B. miyamotoi* DNA.

Molloy PJ et al. Ann Intern Med 2015;163:91-98.

A new phlebovirus, febrile illness: Heartland virus

- Northwestern Missouri. June 2009. Tick bite on a farm. 57 year-old male.
- Fever, severe fatigue, headache, anorexia, nausea, diarrhea.
- Leukopenia, thrombocytopenia, low sodium, ALT 57 [rising to 315], AST 44 [up to 431].
- Treated empirically with doxycycline.
- Second case: 20 tick bites daily.

McMullan LK et al. N Engl J Med 2012;367:834-841.

Haemaphysalis longicornis: Longhorned tick
CDC Public Image Library [public domain]

Powassan encephalitis virus: Tick-borne disease

- Rare, emerging infection, upper Midwest
- Flaviridae, tick-borne. Only severe cases reported?
- Seroprevalence: Canada [5.8%], NY [0.7%]
- *Ixodes* and *Dermacentor* ticks are vectors.
- 1958-2000: <40 cases
- 2001-2010: 33 cases in MN, WI; 12 in NY

  2011: 14 cases in MN, WI
- Incubation period: 1-4 weeks. Fever, headache, mental status changes, cerebellar symptoms, hemiplegia.

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Birge & Sonnesyn. Emerg Infect Dis October 2012

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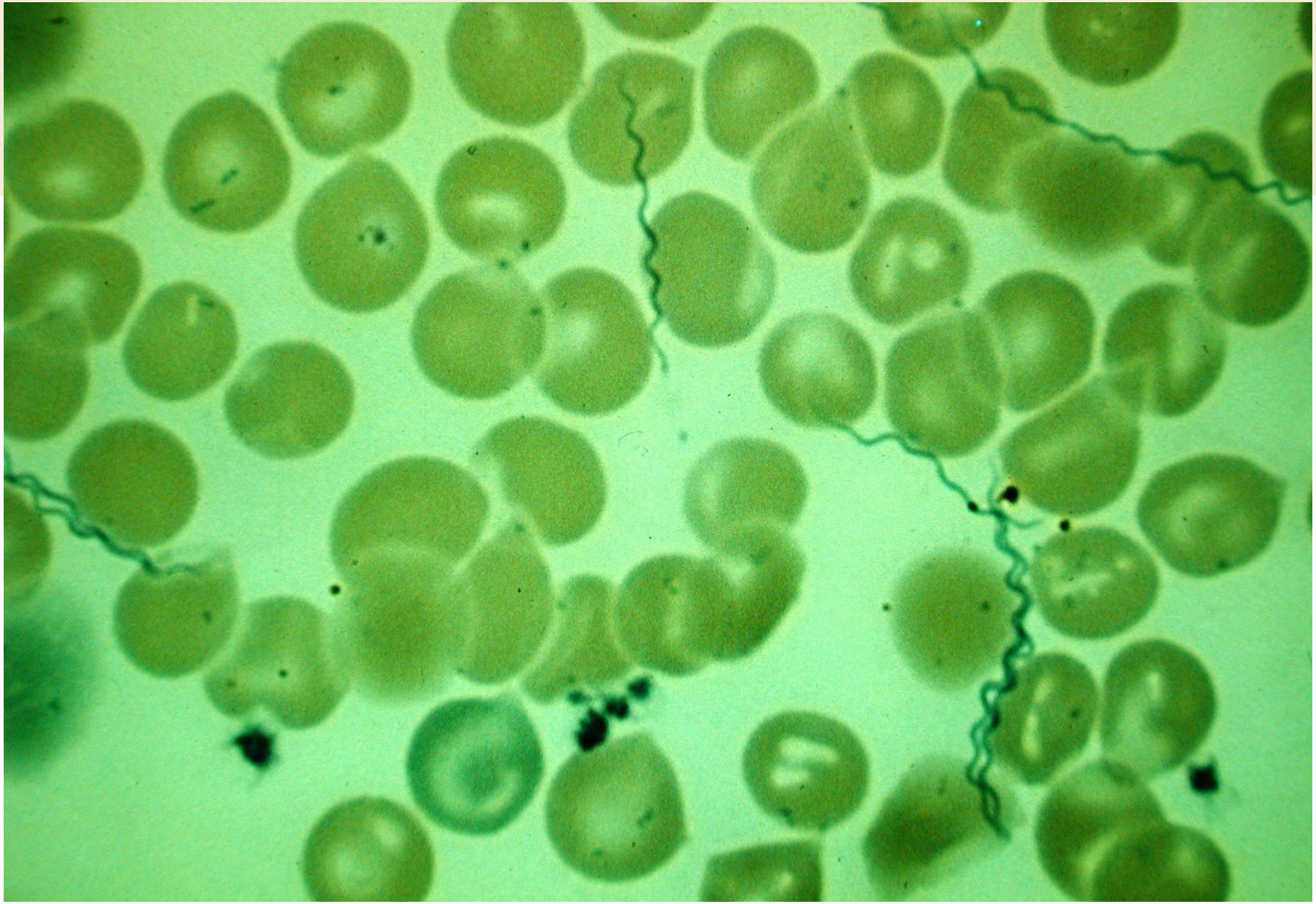
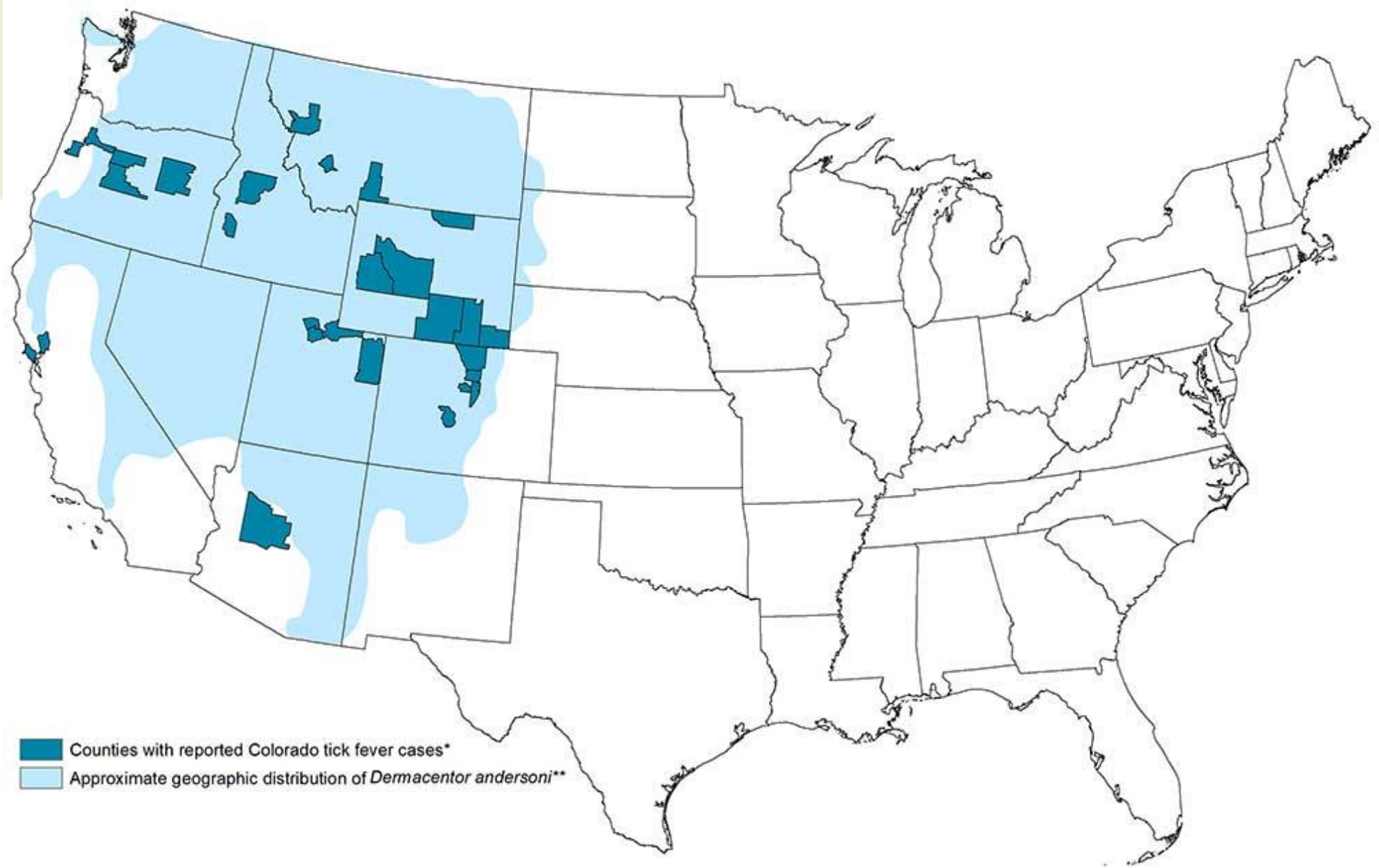
***Ornithodoros* sp.**

CDC Public Library



Dengue fever or Chikungunya in Utah? Leukemia? How about Colorado tick fever?[1]

- **Colorado tick fever virus**, a Coltivirus, infects RBCs. Transmitted by *Dermacenter andersoni*, Rocky Mountain wood tick.
- March-September. Most cases in June.
- Incubation period: ~3-6 days [up to 20 days].
- Most cases in Colorado, Idaho. Rocky Mountain region, 4000-10,000 feet elevation.


Counties with reported Colorado tick fever cases*
Approximate geographic distribution of *Dermacentor andersoni***

Dengue fever or Chikungunya in Utah? Leukemia? How about Colorado tick fever?$_2$

- Two-staged febrile illness: Ill for ~3 days. Well for a few days, ill for another 1-3 days.
- Fever, chills, headaches, retrobulbar pain, photophobia, myalgias, malaise, abdominal pain, hepatosplenomegaly, nausea, vomiting, exanthem.
- Thrombocytopenia, leukopenia, aseptic meningitis, encephalitis, hemorrhagic fever.

Lower extremity weakness: Tick paralysis

- Rare, reversible. Usually: Unnoticed tick in hair [females].
- Most cases described in Australia [*Ixodes holyclus*]. North America: *Dermacenter andersoni, D. variabilis*. Neurotoxin, salivary glands.
- Acute, symmetric, ascending flaccid **paralysis** [hours-to-days].
- Prodrome: Restlessness, irritability, fatigue, myalgias. Fever usually absent.

Chagnon SL et al. Neurology 2014;82:e92-e93.

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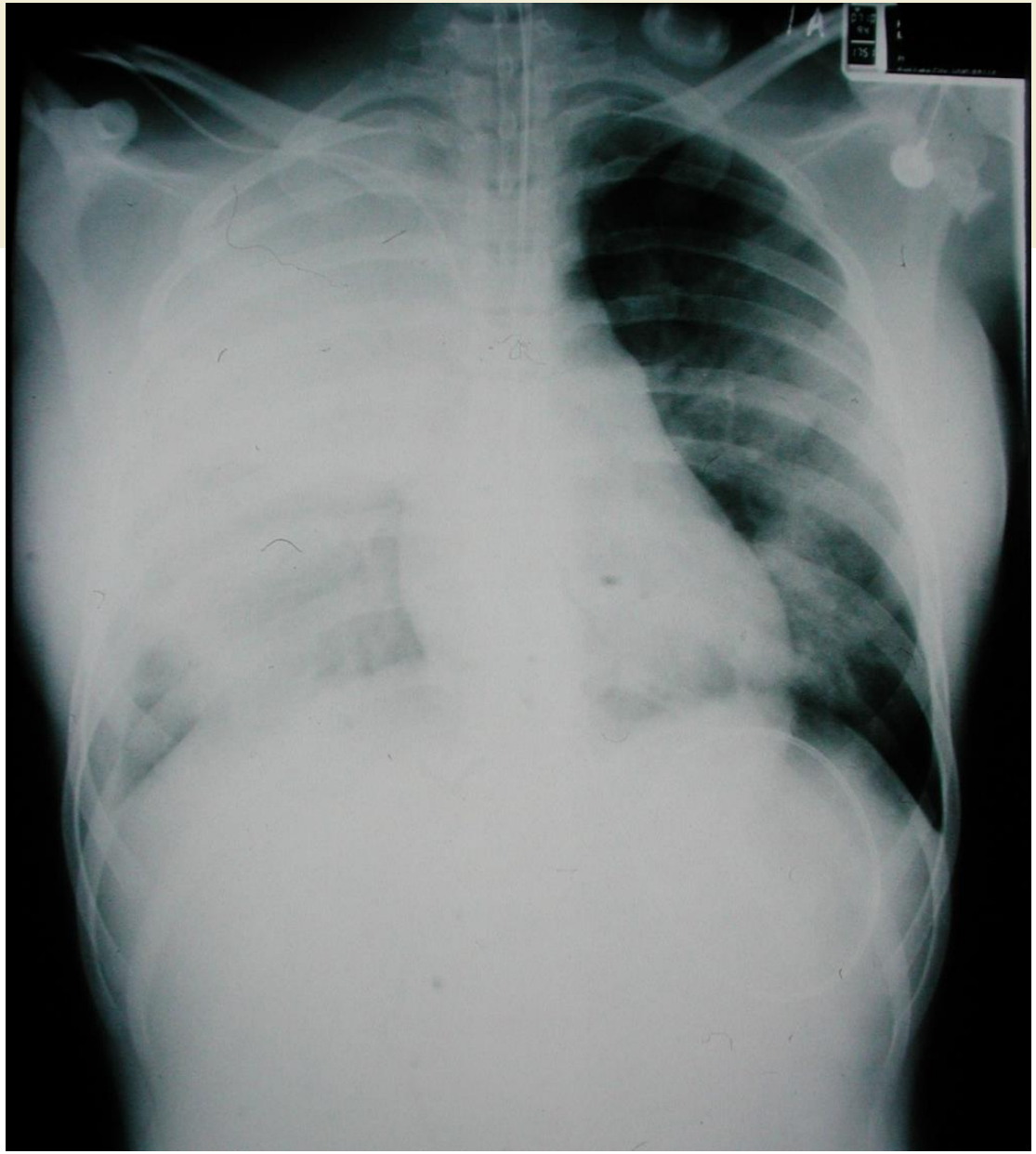
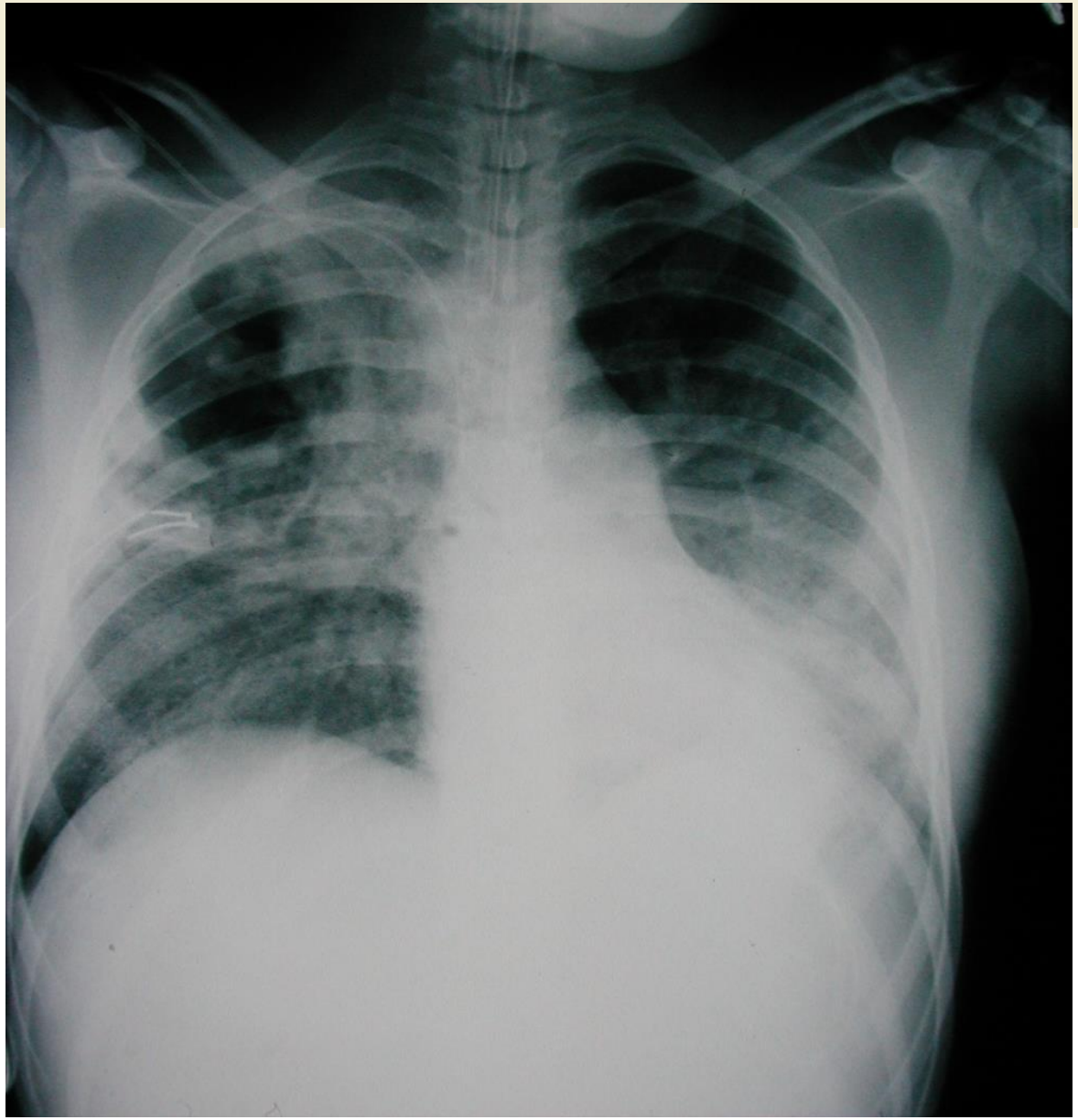
Tularemia: Distinct clinical syndromes

- 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.





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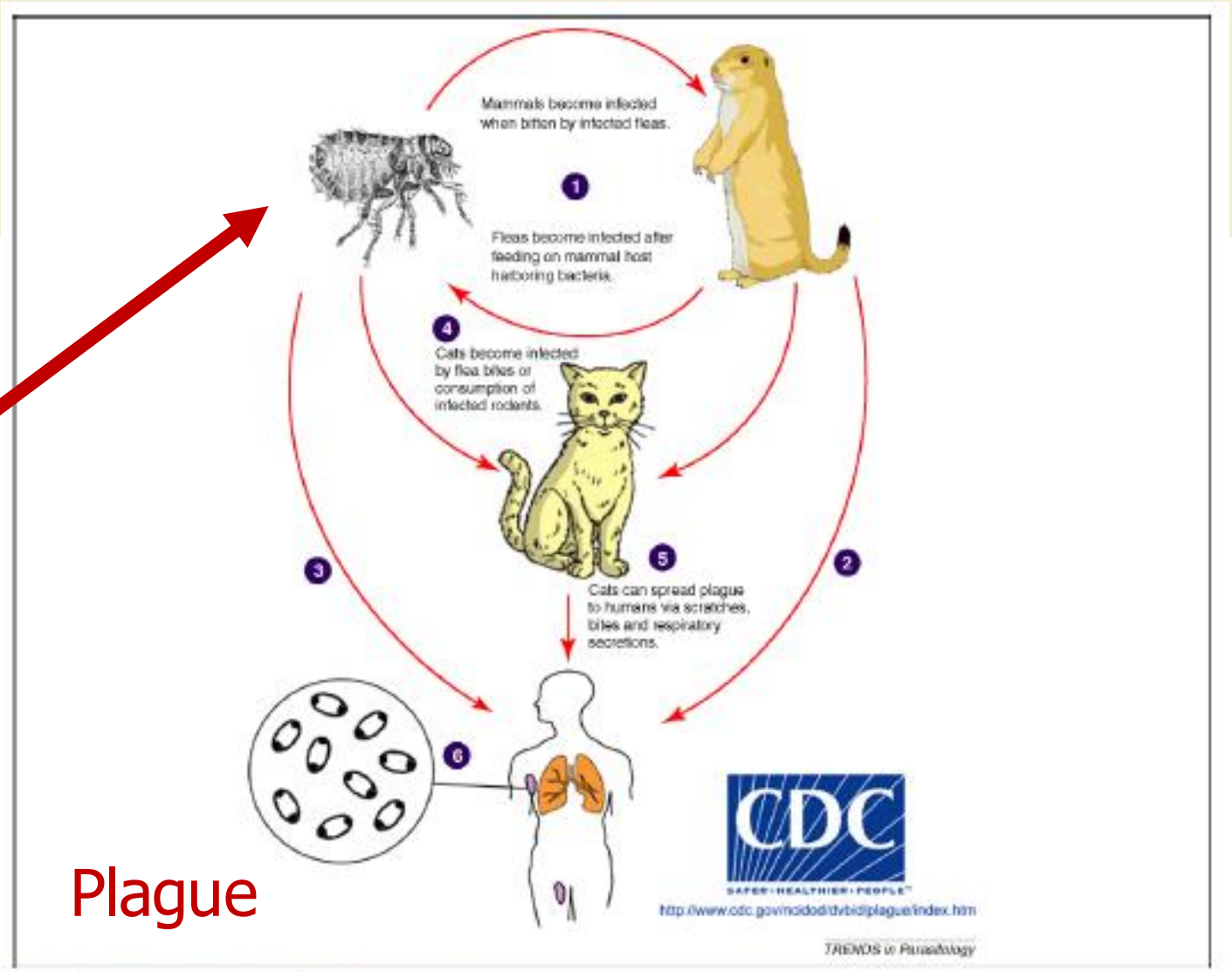
Plague in domestic cats, Idaho, 2016_2

- Cats are highly susceptible to plague illness. 10% have pneumonic plague.
- Can transmit plague to human via exposure to respiratory secretions and infectious body fluids [bites or scratches]. **Fleas** carried inside.
- During 1996-2012: 43% of all primary pneumonic cases of human plague in US had contact with domestic cat.

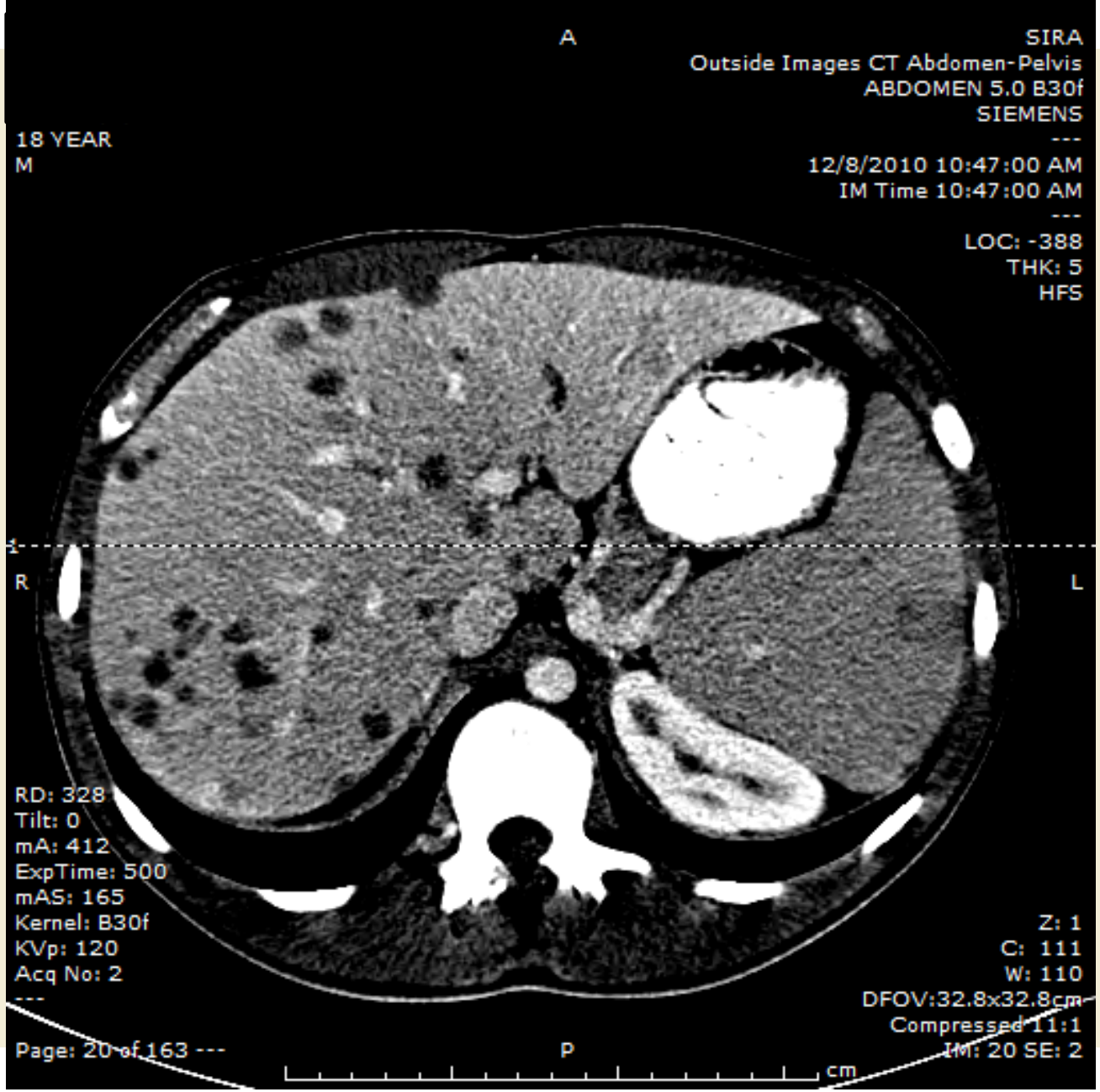
Kassem AM et al. MMWR 2016;65:1378-1379



Plague

Figure 3. Common transmission cycles of plague: *Yersinia pestis*.
Plague, caused by *Yersinia pestis*, is maintained in natural cycles involving rodent hosts and flea vectors (1). Although humans often become infected through direct contact with infected rodents (2) or rodent fleas (3), domestic cats also play an important role in enhancing human exposure. Cats are highly susceptible to plague and can become infected through either flea bites or consumption of infected rodents (4). Once infected, they can transmit *Y. pestis* to humans through bites, scratches and respiratory secretions (5). In addition, cats can indirectly contribute to human infection by transporting infected fleas or rodent carcasses into the home. Diagnosis of plague is made by the isolation of *Y. pestis* from blood, lymph node aspirates, or in cases of pneumonic plague, respiratory secretions (6).

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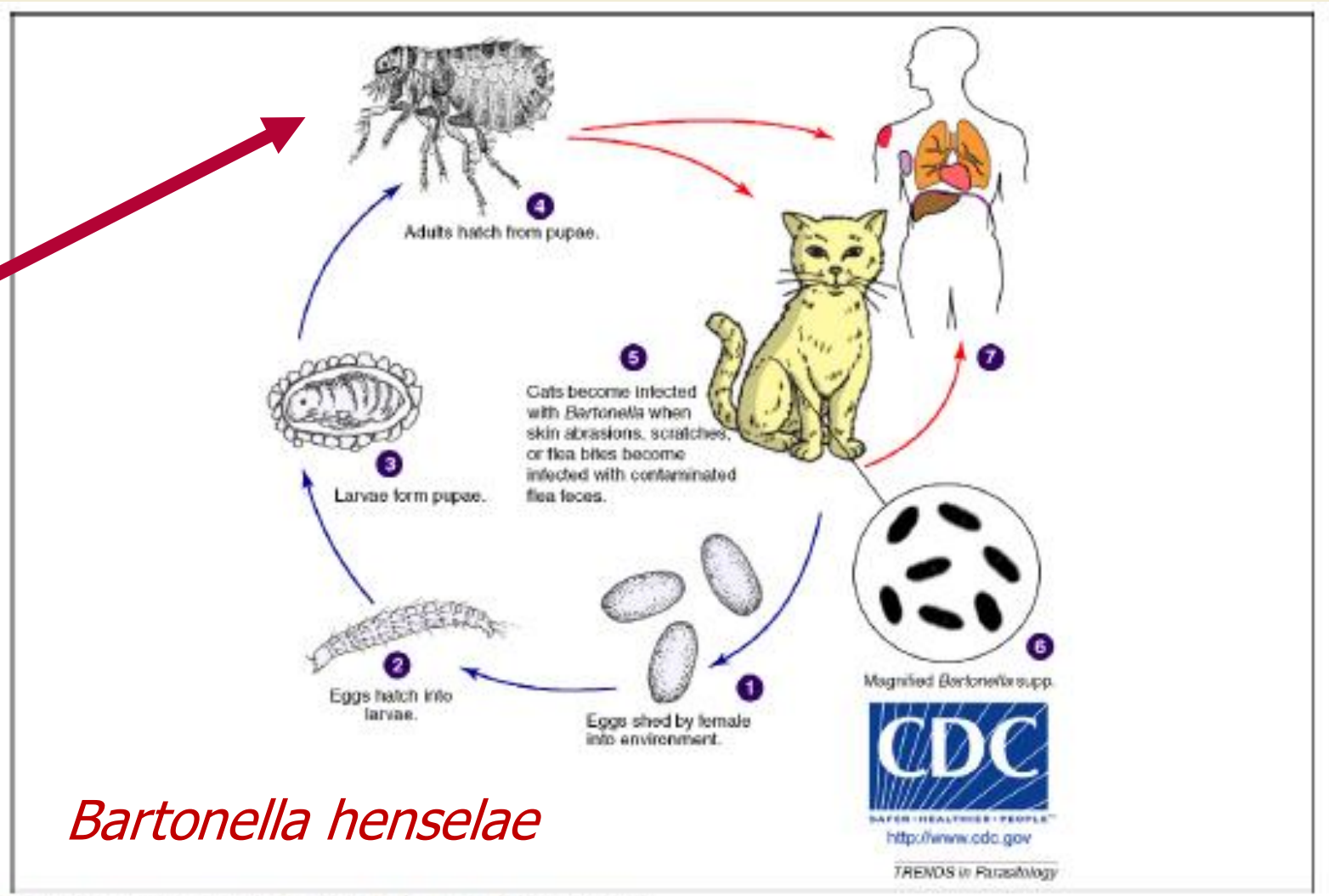


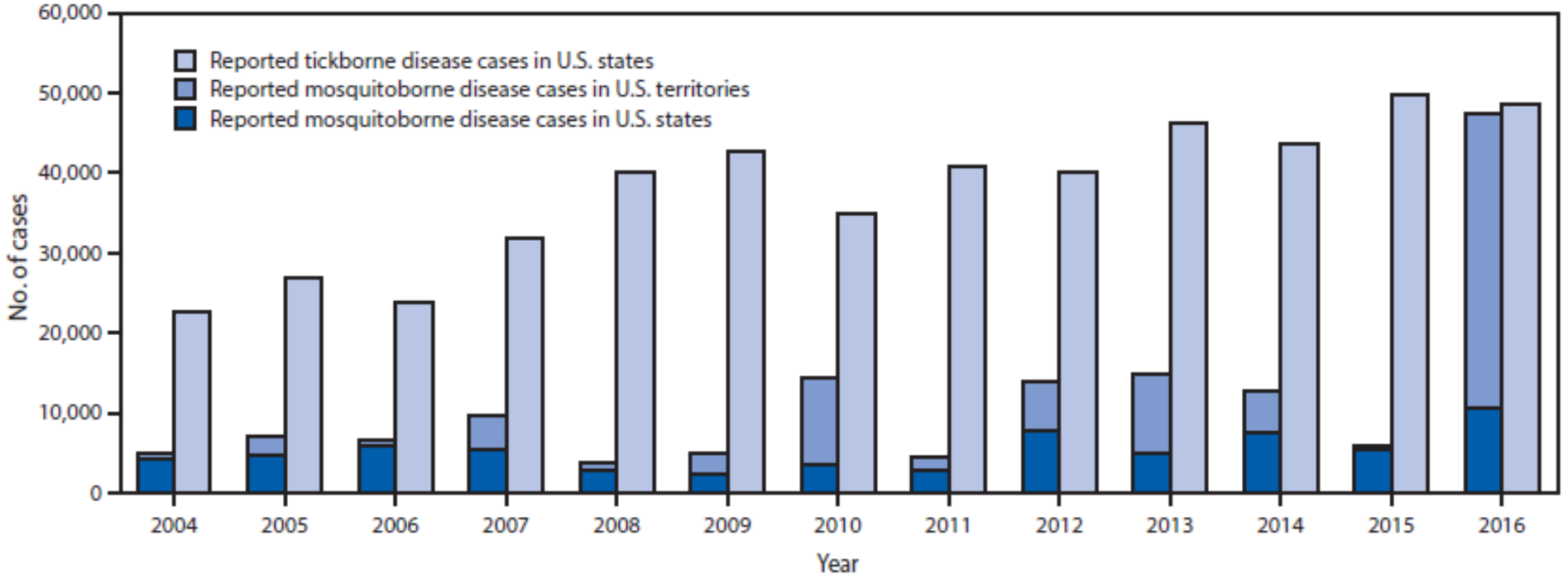
Bartonella henselae

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 (1). Eggs hatch into larvae within two weeks (2) and feed on organic material in the environment. Larvae form pupae, which takes another 1–2 weeks to mature (3). Adults emerge from the pupae (4) 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 (5). Fleas become infected through feeding on bacteremic cats. In cats and other mammalian hosts, the bacteria colonize erythrocytes and endothelial cells after infection (6). 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 (7).

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

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 tickborne diseases in US: Lyme disease
Mosquitoborne epidemics: Dengue, chikungunya, and Zika. PR, AS, and USVI.
West Nile virus is endemic.

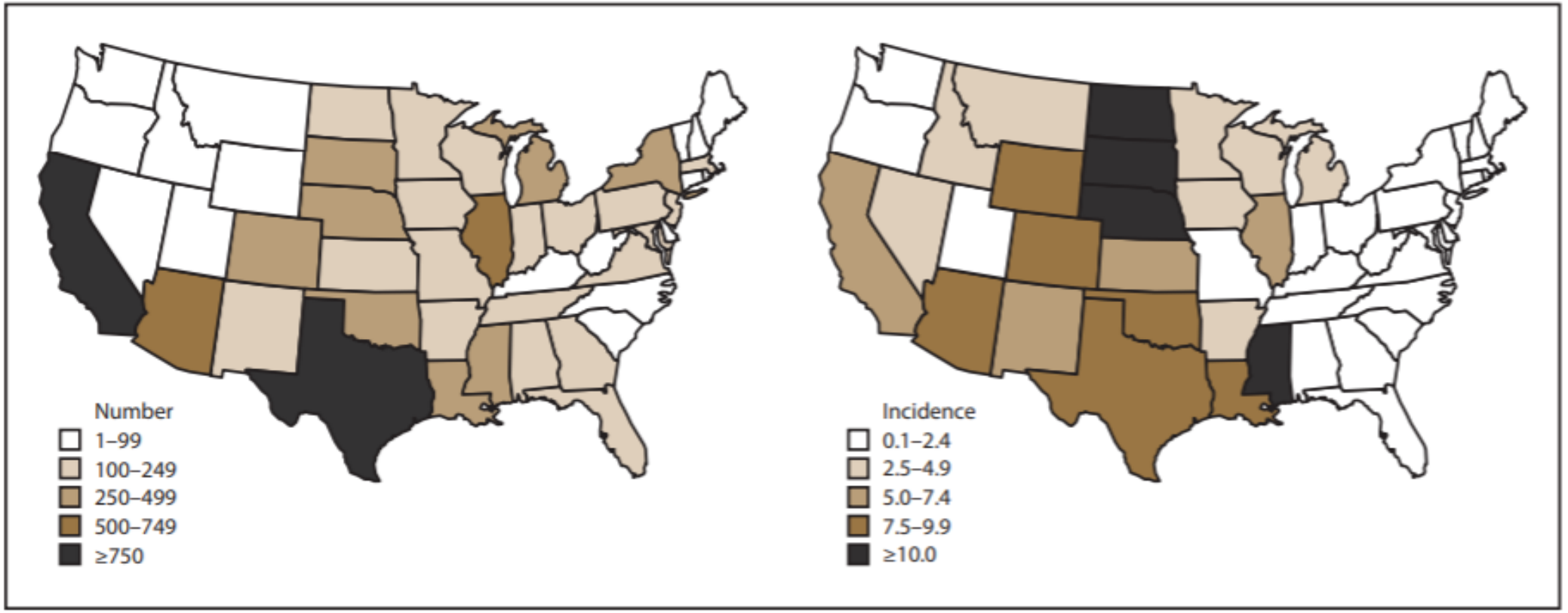
Rosenberg R et al. MMWR 2018;67:496-501. [Public Domain]

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

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

Neuroinvasive arboviral disease in children: US, 2003-2012

- 1217 cases, 22 deaths
- La Crosse virus: 665 cases [55%]

  22 times higher in children. Median age; 7 years. Most disease July-September.

  Most disease: Encephalitis [78%], 20% meningitis, 2% acute flaccid paralysis.
- West Nile virus: 505 cases [41%]
- Eastern equine encephalitis virus: 30 cases [2%], 10 deaths.

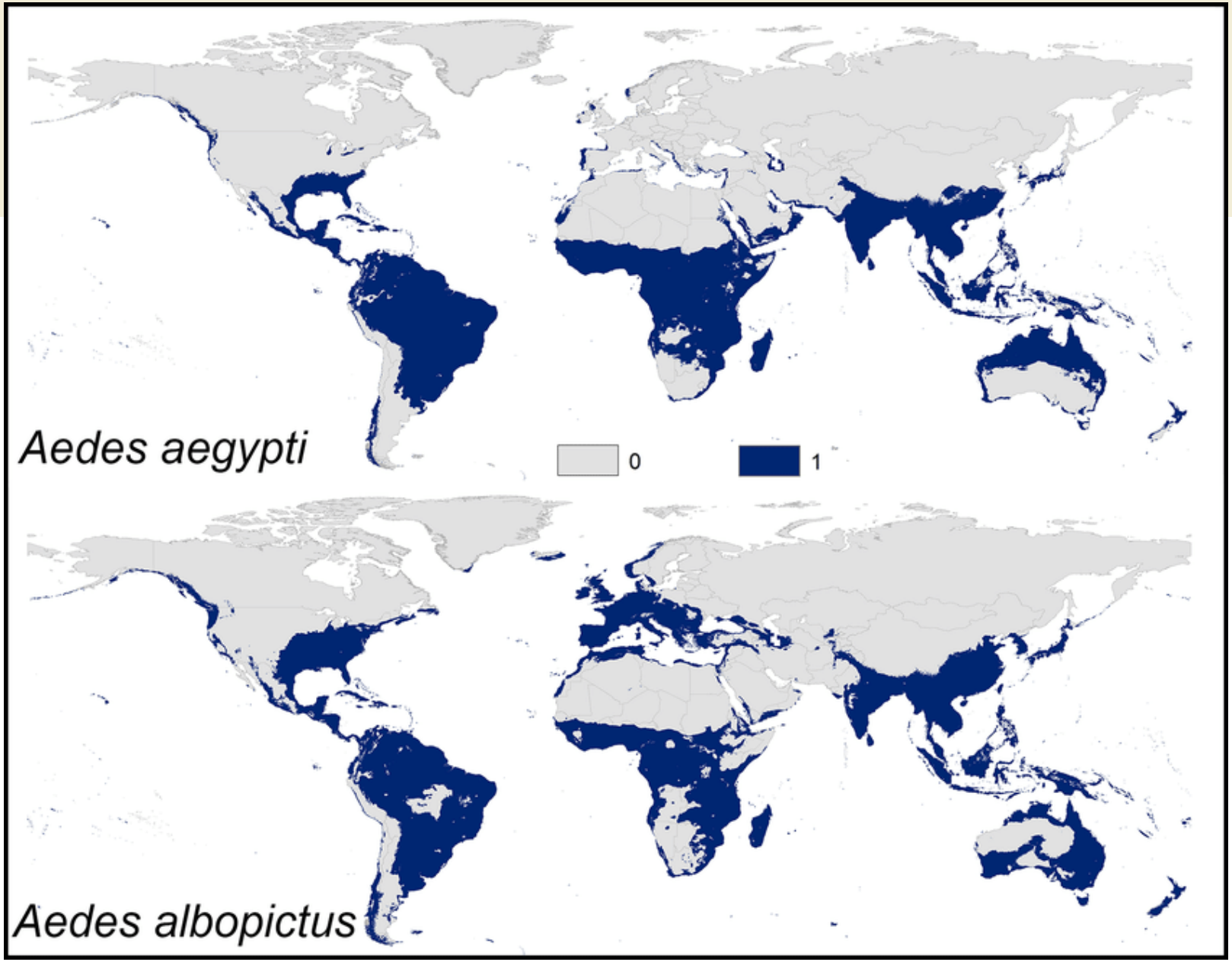
Gaensbauer JT et al. Pediatrics 2014;134:e642-e650

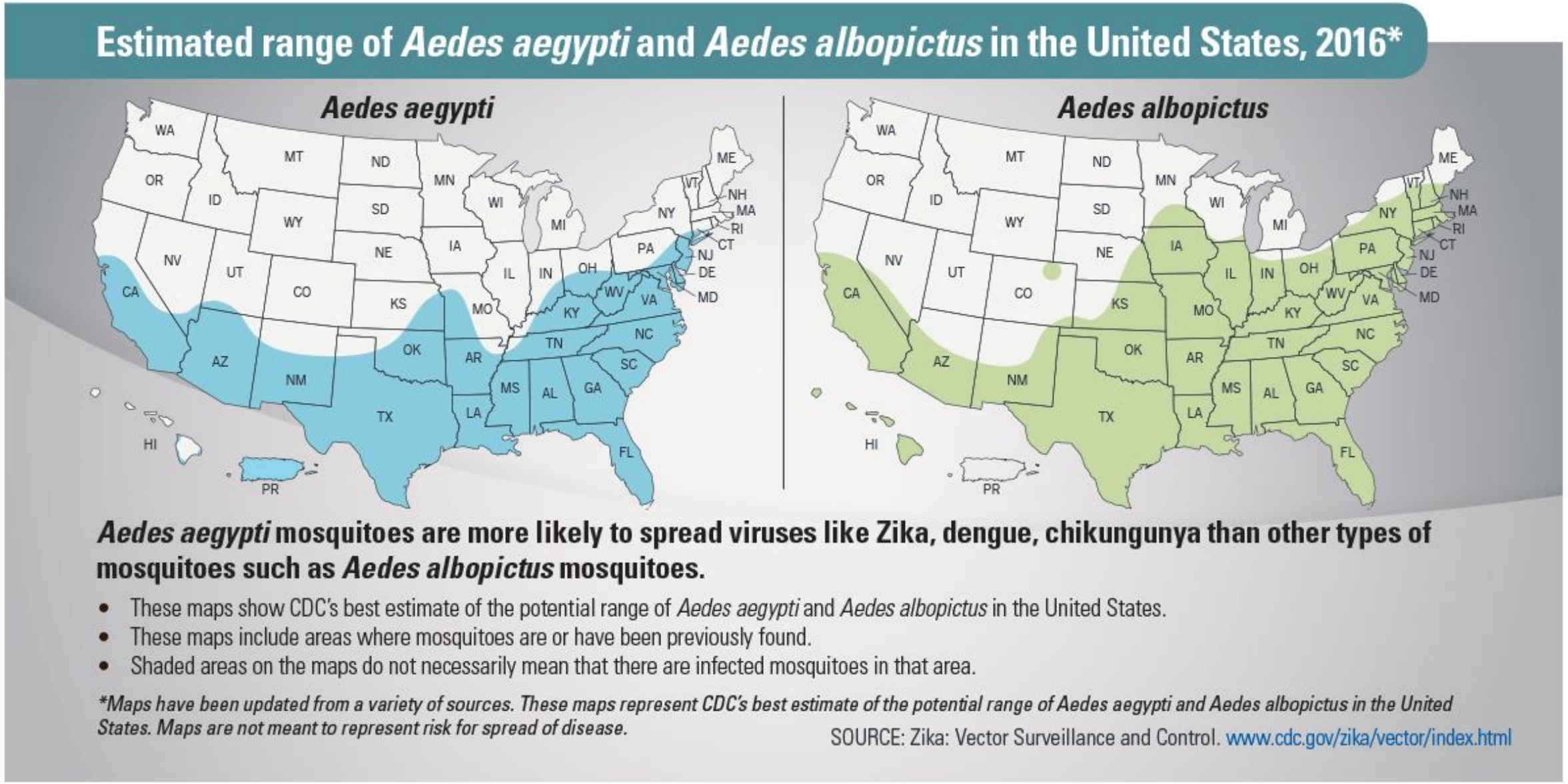
CDC.gov

Aedes aegypti

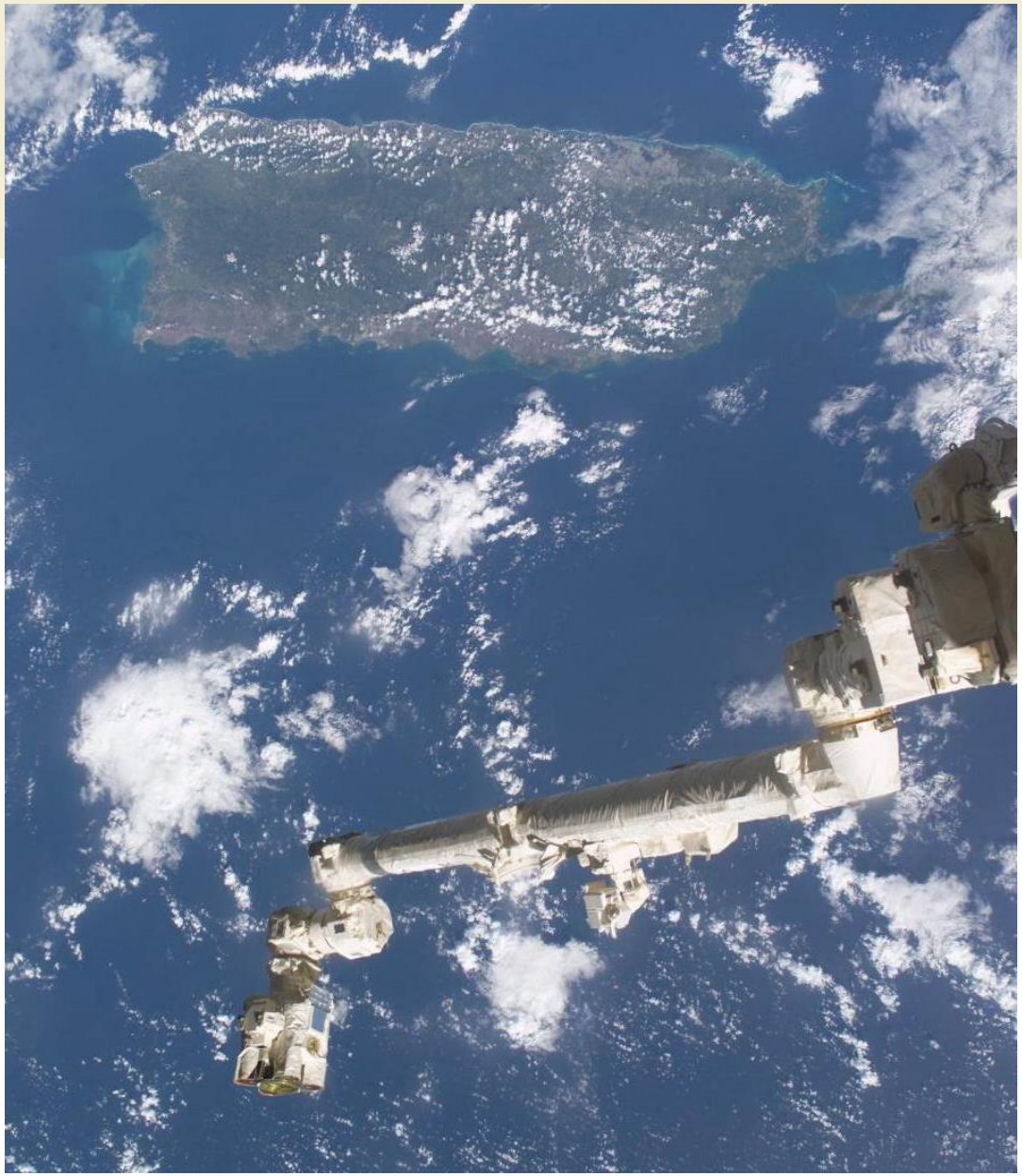
CDC.gov

Aedes albopictus


Aedes aegypti
0
1
Aedes albopictus



CDC.Gov [public domain]



Zika virus: the "new" dengue virus?

- Zika virus [*Flaviviridae*] is an emerging arbovirus. Spread by *Aedes* mosquitoes.
- First discovered in Uganda, 1947. Reaching South America, 2014. Mexico, November 2015. Puerto Rico, December 2015, Florida & Hawaii 2016.
- Dengue-like febrile illness. Fever, chills, arthralgias, maculopapular exanthem.
- Perinatal infections well-documented.
- Recent associations with GBS [Polynesia] and microcephaly [Brazil].


Vaccination recommended
Vaccination generally not recommended[1]
Vaccination not recommended
Tourist Destination
BRAZIL
VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA
COLOMBIA
ECUADOR
PERU
BOLIVIA
PARAGUAY
CHILE
ARGENTINA
URUGUAY
AMAZONAS
PARÁ
AMAPÁ
RORAIMA
ACRE
RONDÔNIA
MATO GROSSO
TOCANTINS
MARANHÃO
PIAUÍ
CEARÁ
RIO GRANDE DO NORTE
PARAÍBA
PERNAMBUCO
ALAGOAS
SERGIPE
BAHIA
DISTRITO FEDERAL
GOIÁS
MINAS GERAIS
ESPÍRITO SANTO
SÃO PAULO
RIO DE JANEIRO
PARANÁ
SANTA CATARINA
RIO GRANDE DO SUL
MATO GROSSO DO SUL
Medellin
Manizales
Bogota
Puerto Ayacucho
Cali
Pasto
Mitu
Boa Vista
Paramaribo
Cayenne
Macapá
Quito
Guayaquil
Iquitos
Leticia
Manaus
Santarem
Belém
São Luís
Fortaleza
Caxias
Teresina
Natal
Recife
Maraba
Piura
Trujillo
Chimbote
Pucallpa
Cruzeiro do Sul
Rio Branco
Porto Velho
Riberalta
Ji-Parana
Vilhena
Alta Floresta
Colider
Petrolina
Barreiras
Talismã
Feira de Santana
Salvador
Vitoria da Conquista
Lima
Huancayo
Ica
Cusco
Arequipa
Tacna
Arica
Iquique
Antofagasta
La Paz
Sucre
Santa Cruz
Trinidad
Cuiaba
Goiania
Brasília
Monte Claros
Campo Grande
Uberlandia
Belo Horizonte
Vila Velha
Tarija
Salta
Asuncion
Ciudad del Este
Iguaçu Falls
Ponta Grossa
Sorocaba
Campinas
São Paulo
Rio de Janeiro
Curitiba
Florianópolis
Posadas
Formosa
Tucumán
Copiapo
La Serena
Córdoba
Santa Fe
San Juan
Rosario
Mendoza
Valparaiso
Santiago
Buenos Aires
Durazno
Porto Alegre
PACIFIC OCEAN
ATLANTIC OCEAN
Amazon
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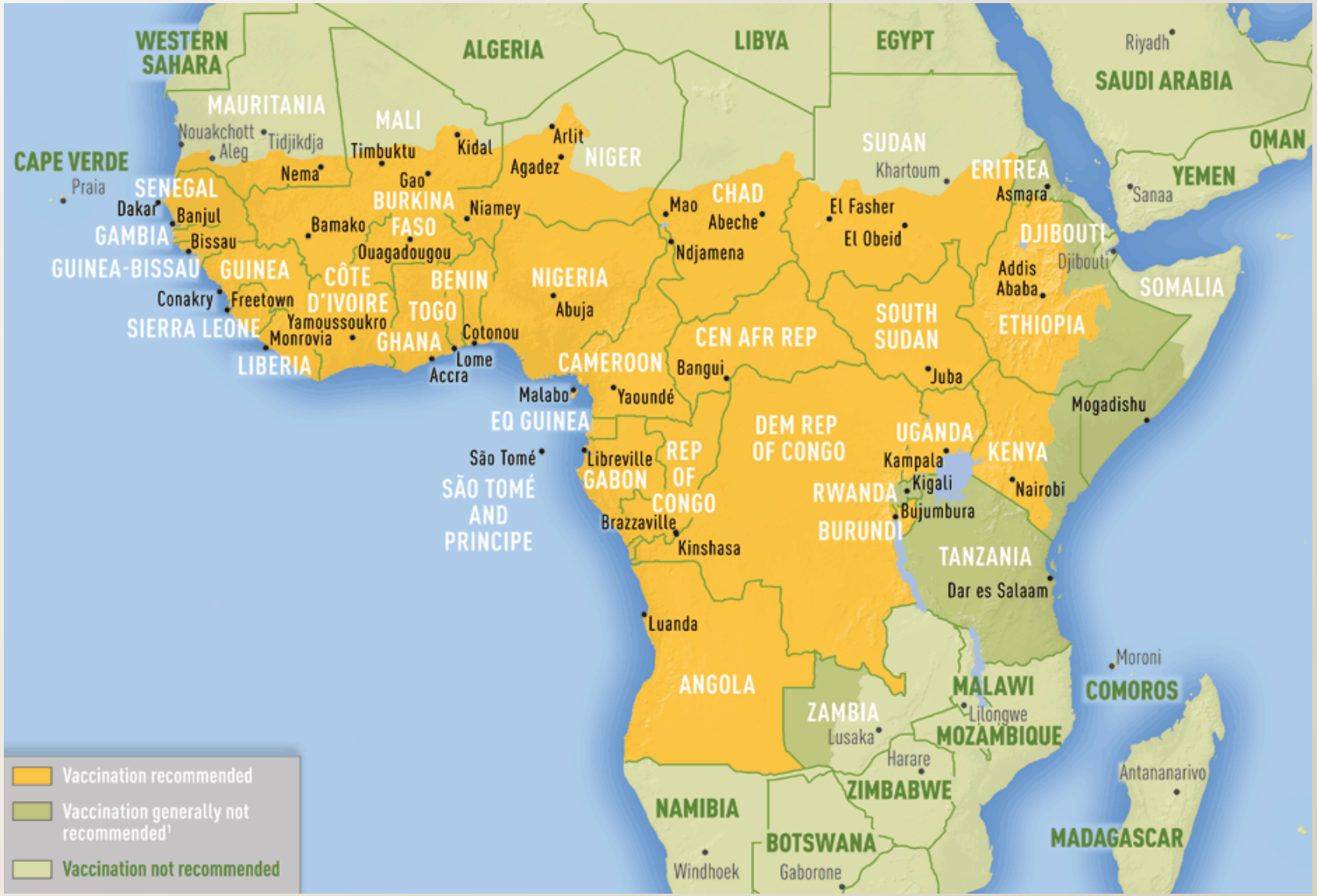
CDC


WESTERN SAHARA
ALGERIA
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EGYPT
Riyadh
SAUDI ARABIA
MAURITANIA
MALI
Nouakchott
Aleg
Tidjikdja
Timbuktu
Kidal
Arlit
Agadez
NIGER
SUDAN
Khartoum
ERITREA
Asmara
OMAN
YEMEN
Sanaa
CAPE VERDE
Praia
SENEGAL
Dakar
Banjul
GAMBIA
Bissau
Nema
Gao
BURKINA FASO
Niamey
Bamako
Ouagadougou
Mao
Abeche
CHAD
Ndjamena
El Fasher
El Obeid
DJIBOUTI
Djibouti
Addis Ababa
SOMALIA
GUINEA-BISSAU
GUINEA
Conakry
Freetown
SIERRA LEONE
Monrovia
CÔTE D'IVOIRE
Yamoussoukro
BENIN
TOGO
Cotonou
GHANA
Lome
Accra
LIBERIA
NIGERIA
Abuja
CEN AFR REP
Bangui
CAMEROON
Yaoundé
Malabo
EQ GUINEA
SOUTH SUDAN
Juba
ETHIOPIA
Mogadishu
São Tomé
SÃO TOMÉ AND PRINCIPE
Libreville
GABON
REP OF CONGO
Brazzaville
Kinshasa
DEM REP OF CONGO
UGANDA
Kampala
KENYA
Nairobi
RWANDA
Kigali
Bujumbura
BURUNDI
TANZANIA
Dar es Salaam
Luanda
ANGOLA
ZAMBIA
Lusaka
MALAWI
Lilongwe
MOZAMBIQUE
Moroni
COMOROS
Harare
ZIMBABWE
Antananarivo
NAMIBIA
Windhoek
BOTSWANA
Gaborone
MADAGASCAR
Vaccination recommended
Vaccination generally not recommended[1]
Vaccination not recommended

CDC

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.

Fever and a rash: Part 2

- **14 year-old** male is admitted to Riley Hospital for Children on July 18, 2019. He is the **brother** of the prior patient.
- Same flight back home. Sick on the plane, fever 104. Sore throat, cough.
- Day of admission: Abdominal pain, listlessness, fevers.
- WBC is 2700. Hemoglobin: 11.9. Platelets: 152,000. ALT: 182. AST 211. Total bilirubin, 0.5.
- 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 ~15 years.
- Ate local food. No insect repellent. No vaccines.

- 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.

Regional variations of disease$_3$

- Dermatologic: Latin America
- Diarrheal disorders: Middle East & North Africa
- Systemic febrile illnesses: Sub-Saharan Africa & Asia

Asia:

Enteric fever:	19%
Dengue fever:	17%
Malaria:	9%

Africa:

Malaria:	64% [*P. falciparum*, 56%]

Hagman S et al. Pediatrics 2010;125:e1072-e1080

Acute undifferentiated febrile illness, Thailand

- Prospective hospital-based study. Bangkok Hospital for Tropical Diseases, 2013-2015. 397 adults.
- Etiologies of acute undifferentiated fevers: 271 [**68.3%**]. Most common causes:

Dengue: 157 [39.6%]

Murine typhus: 20 [5.0%]

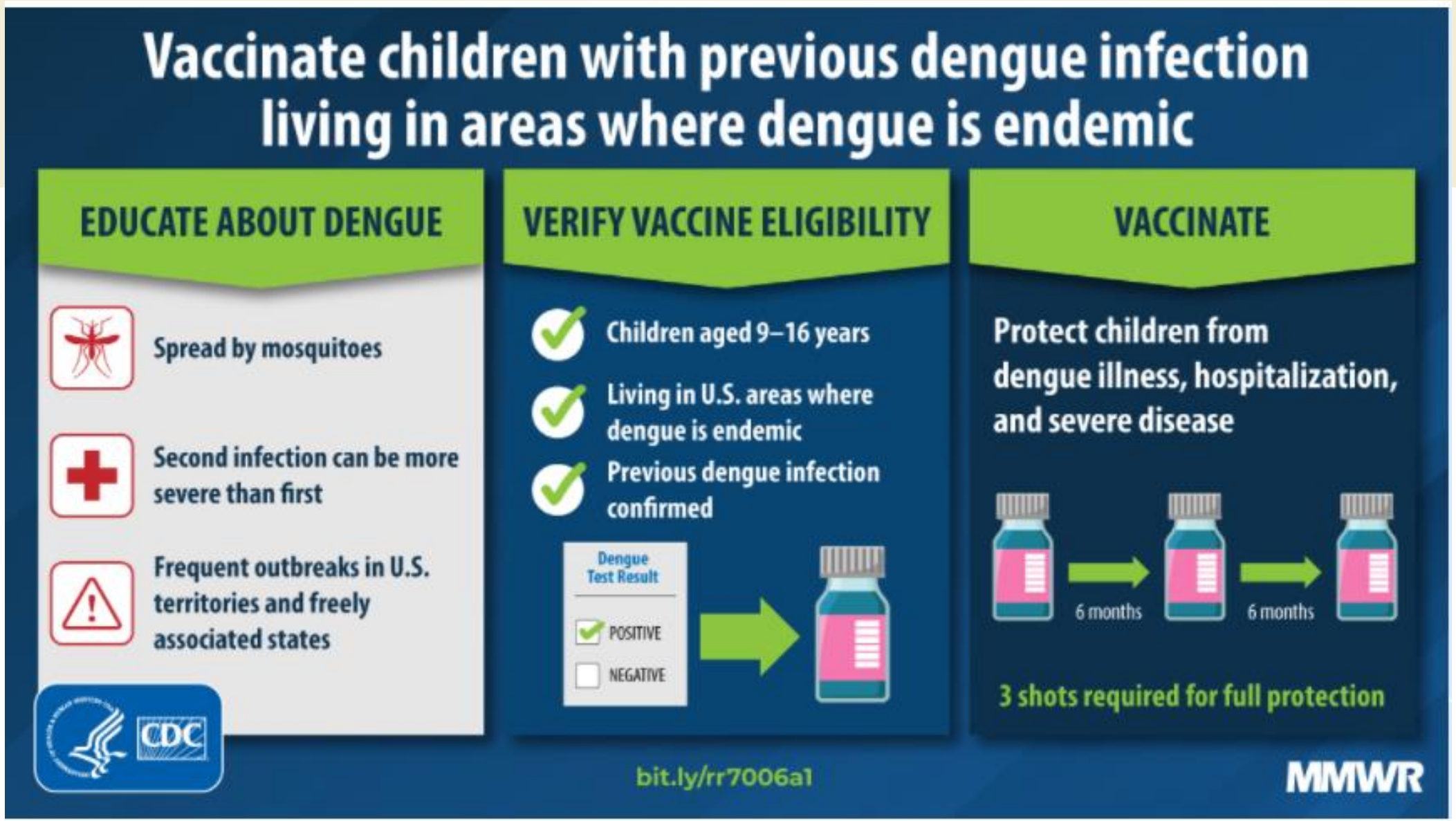
Leptospirosis: 16 [4.0%]

Influenza: 14 [3.5%]

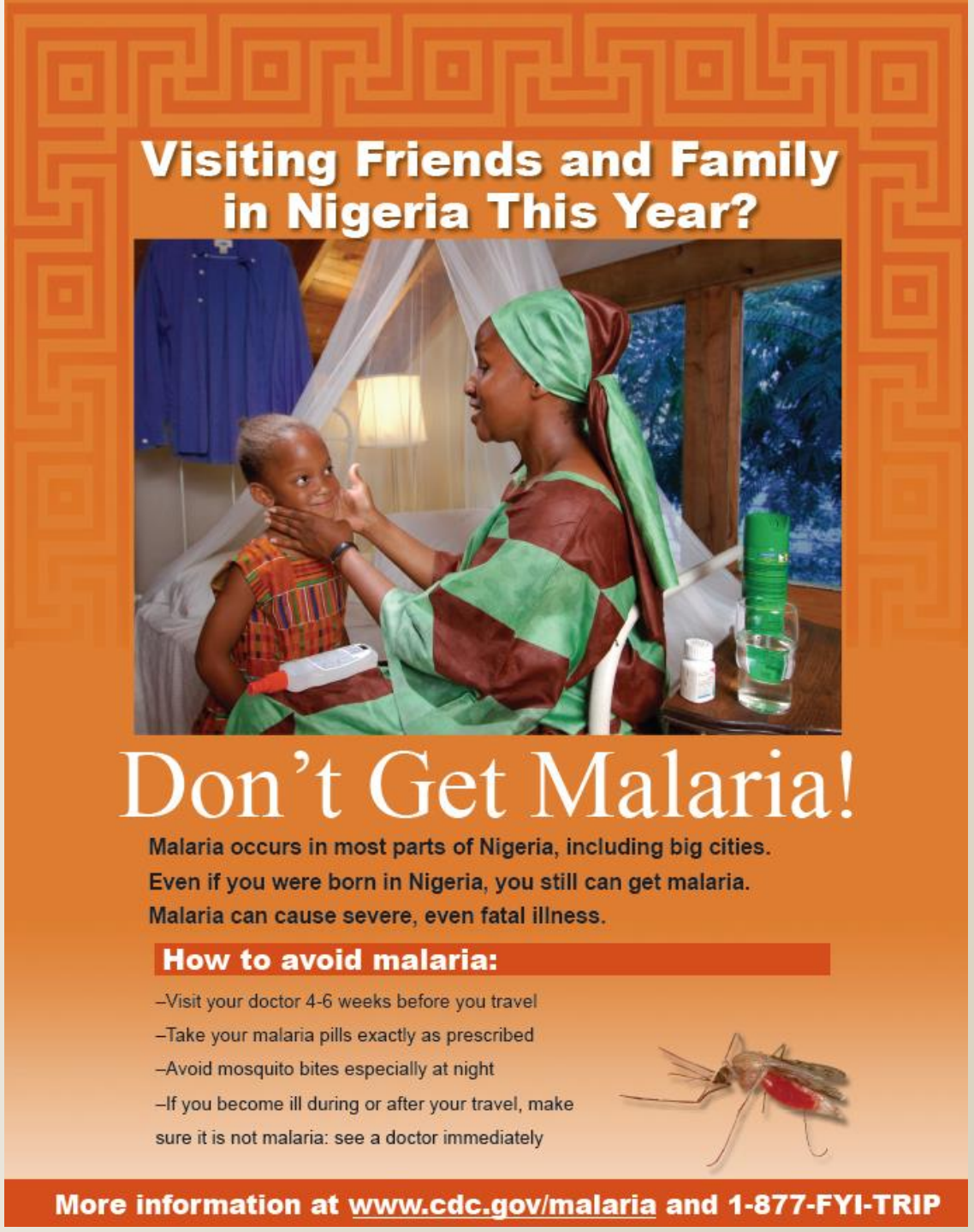
Bacteremia: 6 [1.5%]

Concurrent infections, ≥2 pathogens: 37 [9.3%].
Mostly dengue plus.

Luvira V et al. Am J Trop Med Hyg 2019;100:622-629


Vaccinate children with previous dengue infection living in areas where dengue is endemic
EDUCATE ABOUT DENGUE
Spread by mosquitoes
Second infection can be more severe than first
Frequent outbreaks in U.S. territories and freely associated states
CDC
VERIFY VACCINE ELIGIBILITY
Children aged 9–16 years
Living in U.S. areas where dengue is endemic
Previous dengue infection confirmed
Dengue Test Result
POSITIVE
NEGATIVE
VACCINATE
Protect children from dengue illness, hospitalization, and severe disease
6 months
6 months
3 shots required for full protection
bit.ly/rr7006a1
MMWR

CDC


Visiting Friends and Family in Nigeria This Year?
Don't Get Malaria!
Malaria occurs in most parts of Nigeria, including big cities.
Even if you were born in Nigeria, you still can get malaria.
Malaria can cause severe, even fatal illness.
How to avoid malaria:
–Visit your doctor 4-6 weeks before you travel
–Take your malaria pills exactly as prescribed
–Avoid mosquito bites especially at night
–If you become ill during or after your travel, make sure it is not malaria: see a doctor immediately
More information at www.cdc.gov/malaria and 1-877-FYI-TRIP

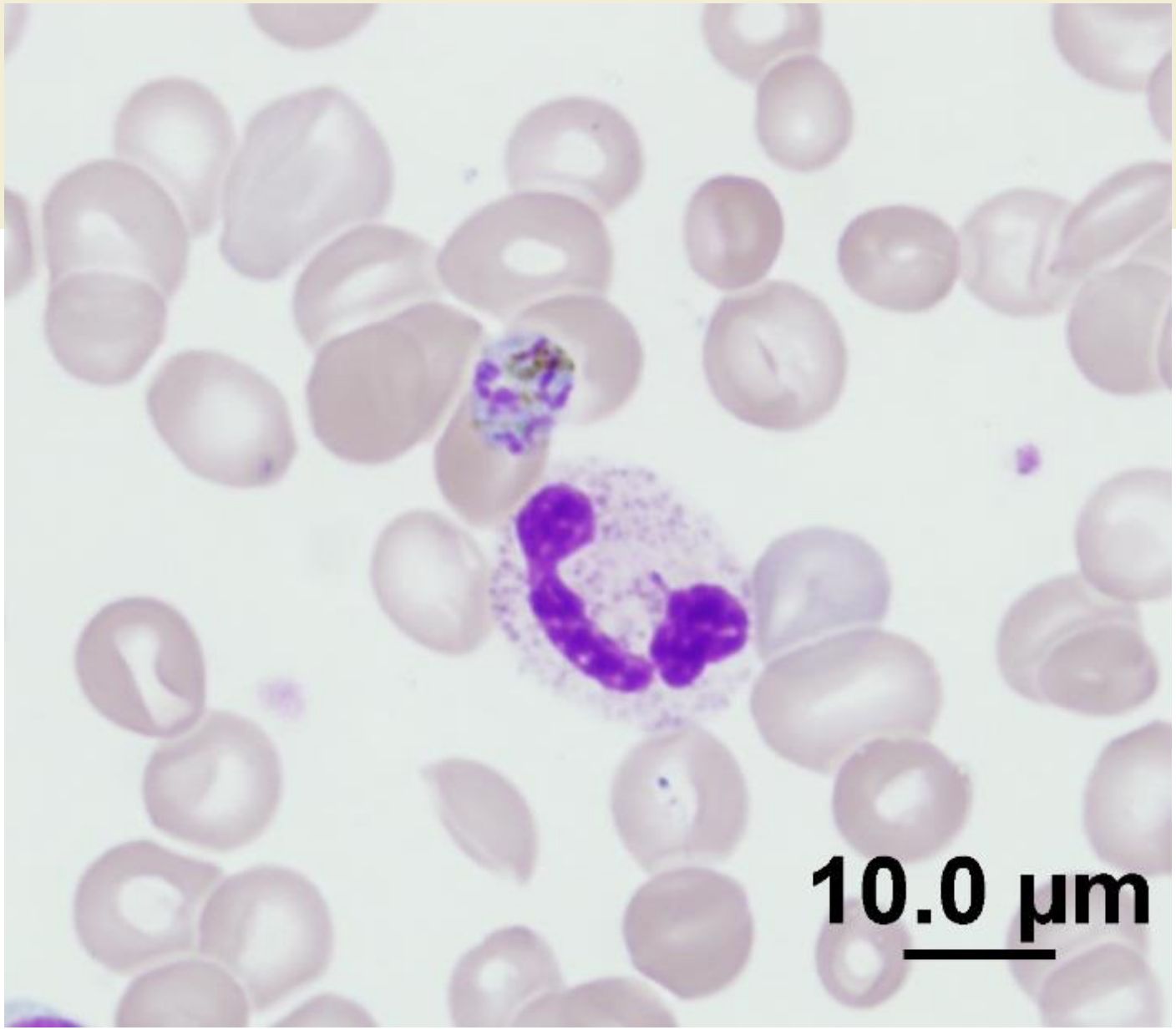

10.0 µm

TABLE 4. Number and percentage of imported malaria cases among U.S residents and non-U.S. residents, by region of acquisition — United States, 2017

Area or region	U.S. residents No. (%)	Non-U.S. residents No. (%)	Total No. (%)
Africa	1,181 (90.3)	397 (77.1)	**1,578 (86.6)**
Asia	59 (4.5)	89 (17.3)	**148 (8.1)**
South America	21 (1.6)	13 (2.5)	**34 (1.9)**
Central America/ Caribbean	18 (1.4)	10 (1.9)	**28 (1.5)**
Oceania	4 (0.3)	2 (0.4)	**6 (0.3)**
Unknown	25 (1.9)	4 (0.8)	**29 (1.6)**
Total	**1,308 (100)**	**515 (100)**	1,823 (100)

CDC. MMWR 2021;70[SS-2];19
March 2021

TABLE 5. Number and percentage of imported malaria cases, by *Plasmodium* species* and interval between date of arrival in the United States and onset of illness — United States, 2017

	P. falciparum	P. vivax	P. ovale	P. malariae	Mixed	Total
Interval (days)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
<0†	159 (13.2)	10 (7.0)	4 (5.0)	0 (0)	4 (22.2)	177 (12.0)
0–29	1,001 (83.2)	75 (52.5)	34 (42.5)	17 (54.8)	7 (38.9)	1,134 (76.9)
30–89	35 (2.9)	22 (15.4)	16 (20.0)	11 (35.5)	4 (22.2)	88 (6.0)
90–179	4 (0.3)	19 (13.3)	9 (11.3)	2 (6.5)	3 (16.7)	37 (2.5)
180–364	3 (0.3)	15 (10.5)	11 (13.8)	1 (3.2)	0 (0)	30 (2.0)
≥365	1 (0.1)	2 (1.4)	6 (7.5)	0 (0)	0 (0)	9 (0.6)
Total	1,203 (100.0)	143 (100.0)	80 (100.0)	31 (100.0)	18 (100.0)	1,475 (100.0)

* Persons for whom *Plasmodium* species, date of arrival in the United States, or date of onset of illness is unknown are not included.
† Cases in this row are among patients who had onset of illness before arriving in the United States.

- Among US residents with malaria: **93%** did not take chemoprophylaxis or adhere to CDC-recommended regimen.
- **71.7%** did not take chemoprophylaxis.
- Those taking chemoprophylaxis: **57.3%** missing doses.
- Prematurely stopping after leaving endemic region: **30.7%**
- Forgetting to take medication: **28%**
- Stopping because of side effect: **12%**
- Did not need to take: **12%**

Riley Hospital for Children
Indiana University Health

Mace KE et al. MMWR 2021;70 [Surveillance Sum];1-35

SCHOOL OF MEDICINE
INDIANA UNIVERSITY

Riley Hospital for Children
Indiana University Health

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INDIANA UNIVERSITY

Insect repellents: The basics$_1$

- DEET [*N,N*-diethyl-*m*-toluamide] and picaridin are the **most protective** compounds. **DEET** [5-100%], **picaridin** [5-20%].
- Higher concentrations provide longer protection. DEET: No greater efficacy >50%.
- Duration of protection: 12 seconds-12 hours.
- Long-acting polymers or liposomal DEET preparations [Sawyer Ultra 30® Liposome Controlled Release, 3M Ultrathon®] 30-34%: Protection, 11-12 hours.

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.

Insect repellents and children

- DEET [*N, N*-diethyl-*m*-toluamide] products are safe in children if applied correctly.
- Products >50% are not necessary.
- Do not spray directly on child.
- Only application of thin "layer" is needed.
- Do not apply DEET underneath clothes.
- Do not apply DEET on hands of young children, around eyes and mouth.

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. 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.

- Avoid tick-infested areas
- Inspection after returning from outdoors
- Use of protective clothing
- Insect repellents: DEET, picaridin, permethrin
- Careful removal of ticks


FotoSolis

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

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