
Tick Talk > Tik Tok
West Virginia Immunization Network (WIN) Webinar Series
Thursday, August 24, 2023

PRESENTERS

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Fellowship: Duke University SOM (Peds ID)
MPH: University of North Carolina (Epidemiology)

DISCLOSURES

- The speakers don’t have any significant disclosures related to today’s presentation

CONTENT OVERVIEW

- Describe Lyme disease and its impact in West Virginia
- Explain Lyme disease transmission and appropriate control measures to mitigate exposure
- State Lyme disease symptoms and management options
- List/briefly describe other tickborne illnesses impacting West Virginia

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Objectives

- Introduce the major tickborne diseases and their tick vectors
- Examine the Lyme disease transmission cycle and show how blacklegged tick (*Ixodes scapularis*) biology explains seasonal activity and spatial distribution of Lyme disease in West Virginia
- Examine different surveillance systems used to monitor Lyme disease
- Compare human incidence of Lyme disease to blacklegged tick (*Ixodes scapularis*) activity
- Discuss tickborne disease prevention and control

Ticks & Public Health

- Loss of blood
- Tick toxicoses
- Tick paralysis
- Disease transmission

WEST VIRGINIA Department of Health & Human Resources BUREAU FOR PUBLIC HEALTH

Tickborne diseases by causative organism(s) and presence of tick vectors in West Virginia

Tick-borne Disease	Pathogen(s)	Tick Vector(s) Present in WV
Tularemia	*Franciscella tularensis*	American dog tick (*Dermacentor variabilis*)
		Lone star tick (*Amblyomma americanum*)
Anaplasmosis	*Anaplasma phagocytophilum* ha	Blacklegged tick (*Ixodes scapularis*)
Ehrlichiosis	*Ehrlichia chaffeensis*	Lone star tick (*Amblyomma americanum*)
	Ehrlichia ewingii	Gulf Coast tick (*Amblyomma maculatum*)
	Panola Mountain *Ehrlichia* sp.	Blacklegged tick (*Ixodes scapularis*)
	Ehrlichia muris-like agent	
Lyme disease	*Borrelia burgdorferi*	Blacklegged tick (*Ixodes scapularis*)
	Borrelia mayonii	
Relapsing fever*	*Borrelia miyamotoi*	Blacklegged tick (*Ixodes scapularis*)
Powassan encephalitis*	Powassan virus	Groundhog tick (*Ixodes cookei*)
		Blacklegged tick (*Ixodes scapularis*)
Babesiosis	*Babesia microti*	Blacklegged tick (*Ixodes scapularis*)
	and other *Babesia* spp.	
Rocky Mountain spotted	*Rickettsia rickettsii*	American dog tick (*Dermacentor variabilis*)
fever and other spotted	(and other spotted	Brown dog tick (*Rhipicephalus sanguineus*)
fever rickettsioses	fever group *Rickettsia*)	Lone star tick (*Amblyomma americanum*)
		Gulf Coast tick (*Amblyomma maculatum*)
		Asian longhorned tick (*Haemaphysalis longicornis*)

*Tickborne disease not detected in West Virginia

Tickborne Disease Surveillance, 2020

Tickborne Disease[a]	# Confirmed and Probable Human Cases
Anaplasmosis	2
Ehrlichiosis	3
Lyme Disease	1065
Spotted Fever Group Rickettioses[b]	5
Total	1075

[a]Table includes confirmed or probable cases reviewed and closed by the OEPS Vectorborne Disease Epidemiologist or State Public Health Entomologist
[b]Includes Rocky Mountain spotted fever

Tickborne Disease Surveillance, 2021

Tickborne Disease[a]	# Confirmed and Probable Human Cases
Anaplasmosis	1
Ehrlichiosis	15
Ehrlichiosis / Anaplasmosis, undetermined	1
Lyme Disease	1724
Q Fever	1
Spotted Fever Rickettsiosis[b]	12
Tularemia	2
Total	1756

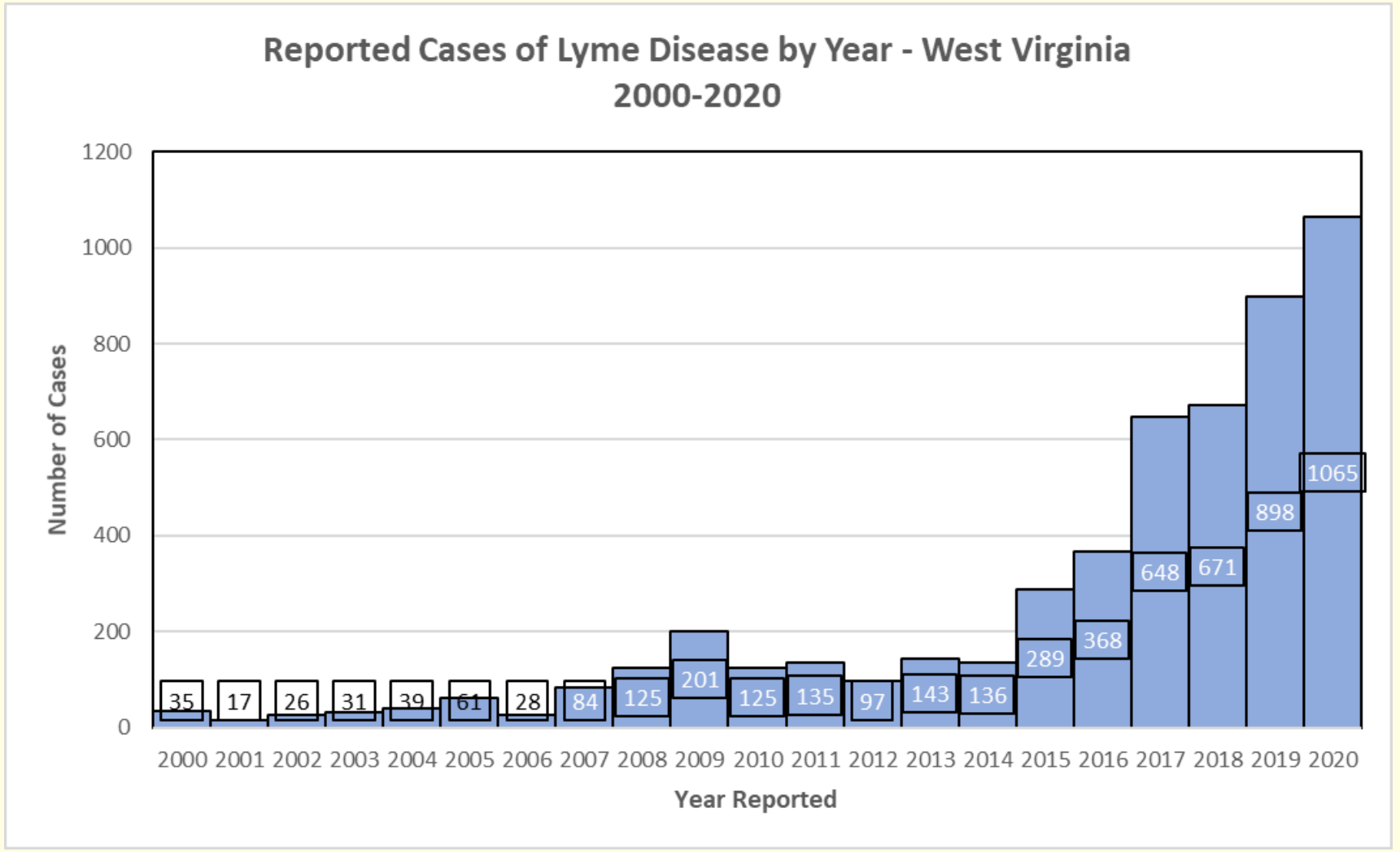
[a]Table includes confirmed or probable cases reviewed and closed by the OEPS Vectorborne Disease Epidemiologist or State Public Health Entomologist
[b]Includes Rocky Mountain spotted fever

Tickborne Disease Surveillance, 2022

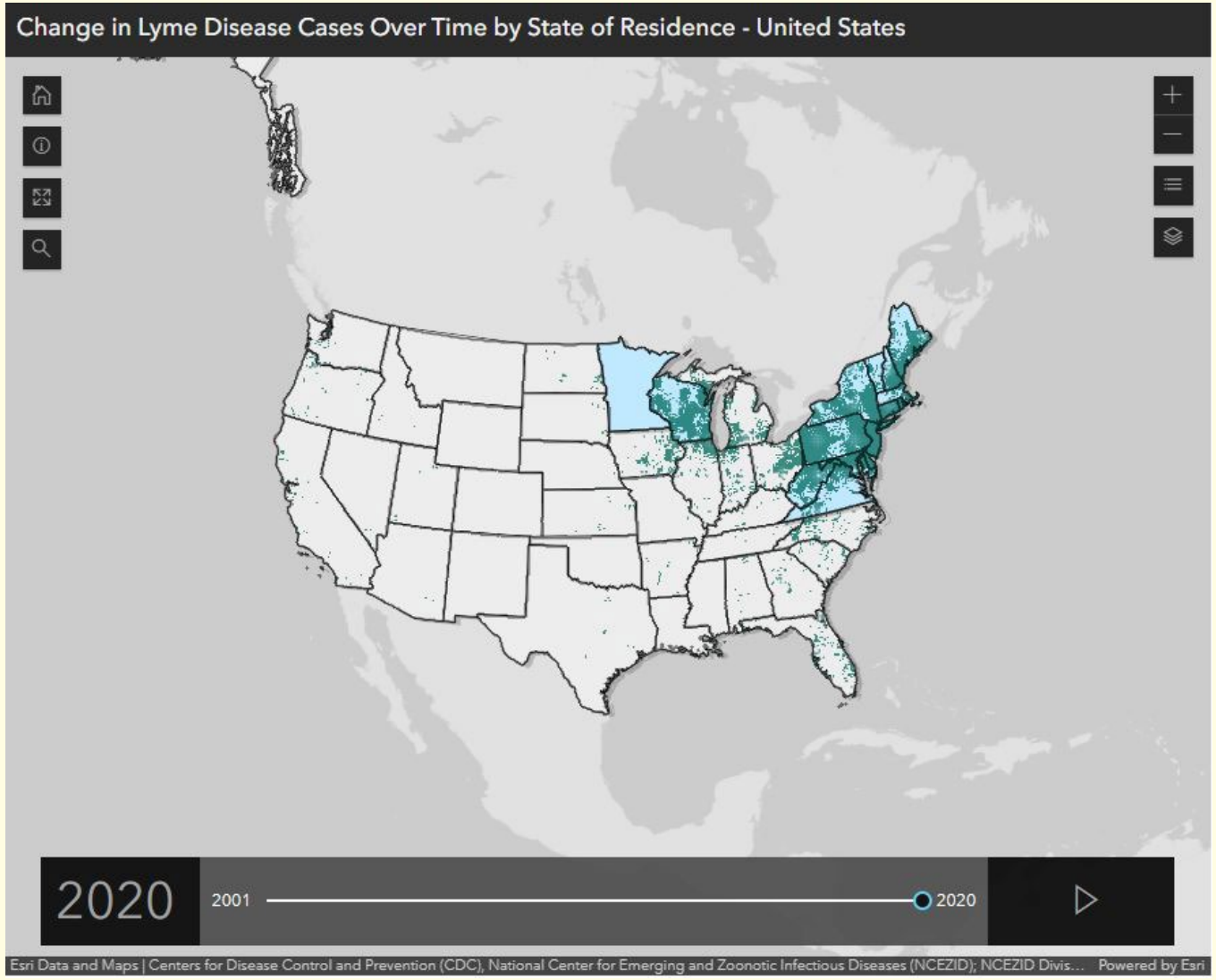
Tickborne Disease[a]	# Confirmed and Probable Human Cases
Anaplasmosis	6
Ehrlichiosis	12
Ehrlichiosis / Anaplasmosis, undetermined	1
Lyme Disease	2449
Q Fever	1
Spotted Fever Rickettsiosis[b]	12
Total	2481

[a]Table includes confirmed or probable cases reviewed and closed by the OEPS Vectorborne Disease Epidemiologist or State Public Health Entomologist
[b]Includes Rocky Mountain spotted fever

Lyme Disease in West Virginia, 2000-2020

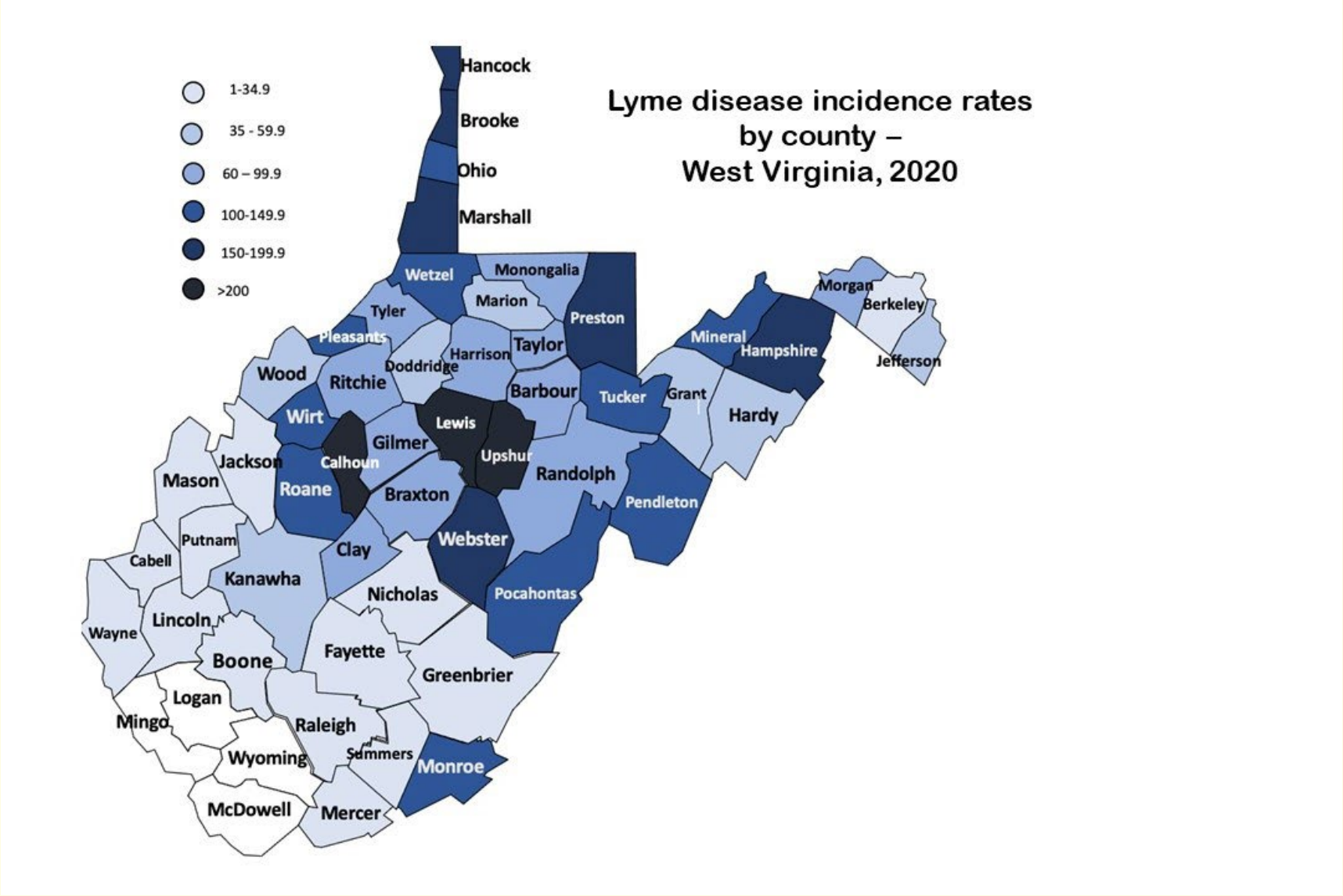


Lyme Disease Surveillance, 2020



https://www.cdc.gov/lyme/datasurveillance/lyme-disease-maps.html

Lyme Disease Surveillance, 2020



Lyme Disease Surveillance, 2020, 2021

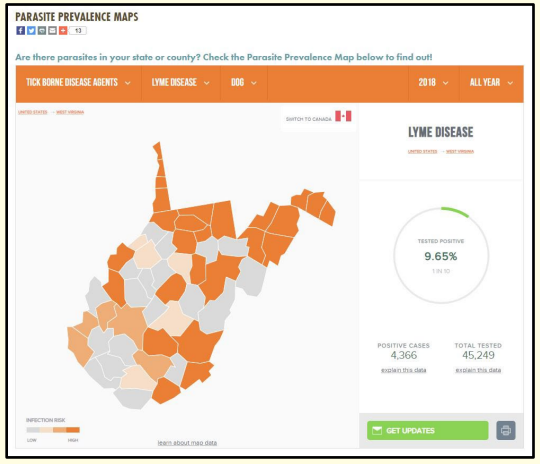
- Human cases of Lyme disease increased from 2020 to 2021 in West Virginia
- Human Lyme disease cases were prevalent in northern West Virginia
- Dramatic proportionate increase in human Lyme disease case counts in southeastern West Virginia

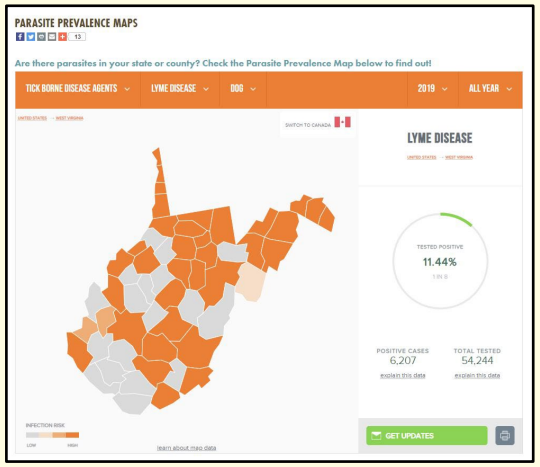
County	2020 Lyme Disease Case Counts	2021 Lyme Disease Case Counts
Barbour,WV	14	44
Berkeley,WV	18	49
Boone,WV	2	6
Braxton,WV	12	15
Brooke,WV	39	52
Cabell,WV	3	11
Calhoun,WV	17	6
Clay,WV	9	7
Doddridge,WV	3	9
Fayette,WV	4	17
Gilmer,WV	7	4
Grant,WV	7	9
Greenbrier,WV	6	41
Hampshire,WV	41	38
Hancock,WV	59	74
Hardy,WV	7	5
Harrison,WV	51	79
Jackson,WV	3	5
Jefferson,WV	23	33
Kanawha,WV	93	111
Lewis,WV	37	32
Lincoln,WV	1	7
Logan, WV	0	1
Marion,WV	11	135
Marshall,WV	66	95
Mason,WV	2	11
McDowell, WV	0	3
Mercer,WV	13	43
Mineral,WV	32	35

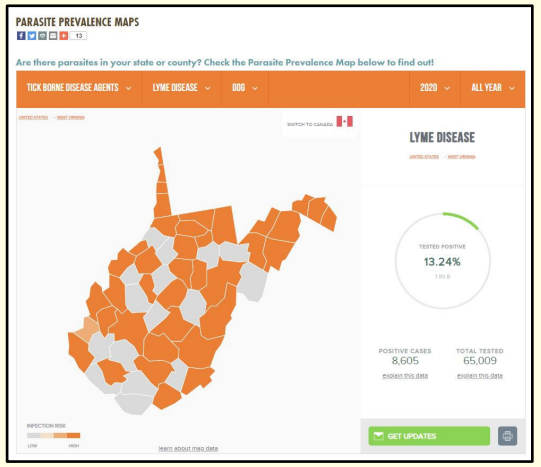
County	2020 Lyme Disease Case Counts	2021 Lyme Disease Case Counts
Mingo, WV	0	1
Monongalia,WV	58	124
Monroe,WV	19	27
Morgan,WV	15	10
Nicholas,WV	6	22
Ohio,WV	48	69
Pendleton,WV	8	14
Pleasants,WV	9	11
Pocahontas,WV	12	13
Preston,WV	62	97
Putnam,WV	7	13
Raleigh,WV	13	26
Randolph,WV	26	57
Ritchie,WV	9	13
Roane,WV	22	10
Summers,WV	2	7
Taylor,WV	13	26
Tucker,WV	9	19
Tyler,WV	9	8
Upshur,WV	59	65
Wayne,WV	3	12
Webster,WV	14	19
Wetzel,WV	20	29
Wirt,WV	6	5
Wood,WV	36	44
Wyoming, WV	0	5

Lyme Disease in Dogs, 2018-2020

- IDEXX developed the SNAP 4DX test to detect heartworm (*Dirofilaria immitis*) antigens and antibodies for Lyme disease (*Borrelia burgdorferi*), ehrlichiosis (*Ehrlichia ewingii*, *Ehrlichia canis*), and anaplasmosis (*Anaplasma phagocytophilum*, *Anaplasma platys*) in dogs
- The PetHealth Network website provides surveillance results from SNAP 4DX tests
- Like humans, Lyme disease infection in dogs is low in southwestern West Virginia
- Lyme disease infection in dogs is increasing in southwestern West Virginia

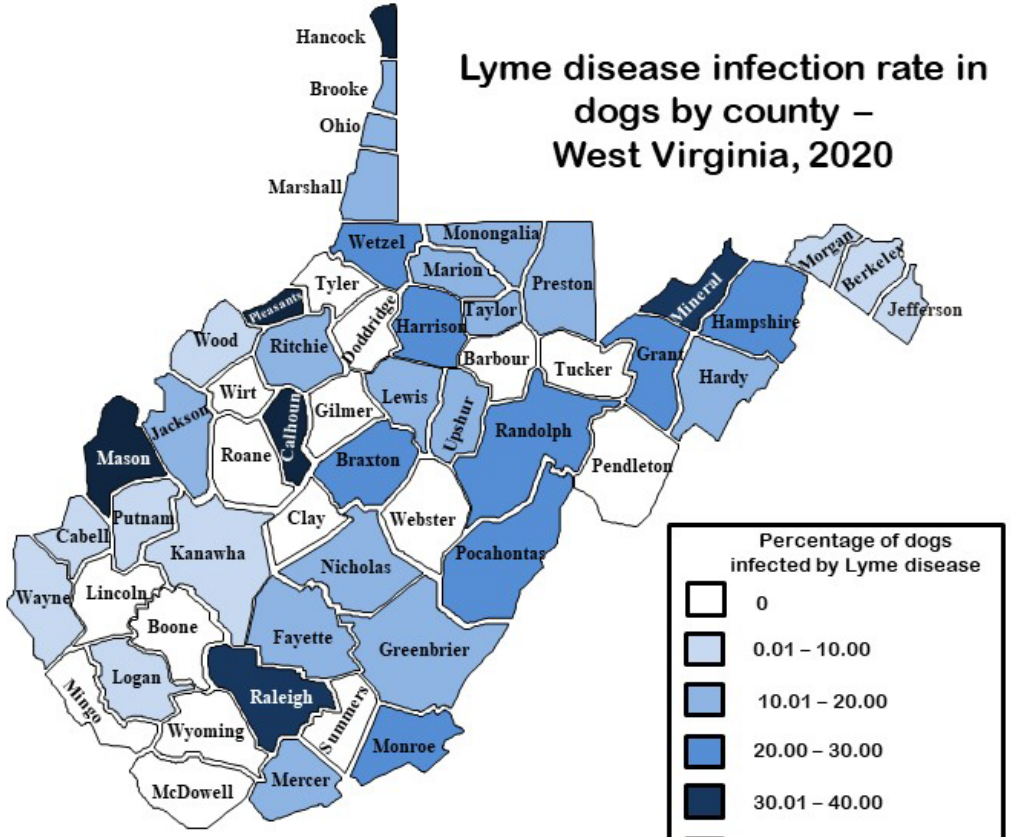






https://www.pethealthnetwork.com/diseases-near-you

Lyme Disease in Dogs, 2020



County	Percentage of Dogs Infected by Lyme Disease
Calhoun	66.67
Hancock	50.00
Mason	50.00
Pleasants	42.86
Mineral	34.70
Raleigh	30.91
Grant	29.45
Monroe	27.22
Randolph	24.63
Pocahontas	24.44
Hampshire	24.38
Wetzel	24.24
Braxton	22.59
Harrison	20.11
Hardy	19.11
Upshur	18.77
Ritchie	18.39
Brooke	17.74
Lewis	17.67
Preston	17.03
Nicholas	16.94
Mercer	16.91
Ohio	16.11
Jackson	15.03
Marion	13.51
Marshall	13.11
Monongalia	13.04
Greenbrier	12.01
Taylor	11.94
Fayette	10.24
Jefferson	9.55
Kanawha	9.43
Berkeley	8.39
Wood	8.04
Wayne	7.25
Morgan	7.11
Putnam	6.51
Logan	5.88
Cabell	4.17
Barbour	0.00
Boone	0.00
Clay	0.00
Doddridge	0.00
Gilmer	0.00
Lincoln	0.00
McDowell	0.00
Mingo	0.00
Pendleton	0.00
Roane	0.00
Summers	0.00
Tucker	0.00
Tyler	0.00
Webster	0.00
Wirt	0.00
Wyoming	0.00

https://www.pethealthnetwork.com/diseases-near-you

Lyme Disease Pathogen

- Pathogen for Lyme disease: *Borrelia burgdorferi*
- Distribution: North and South America, Europe, parts of Asia, and parts of Africa
- United States of America: Mainly northeastern United States and upper Midwest

Lyme Disease Vectors

- Tick vectors for Lyme disease in continental United States
  - *Ixodes scapularis* - blacklegged tick
  - *Ixodes pacificus* - Western blacklegged tick

- *Ixodes scapularis* infected with Lyme disease bacteria are found in West Virginia

Ixodes Species Identification

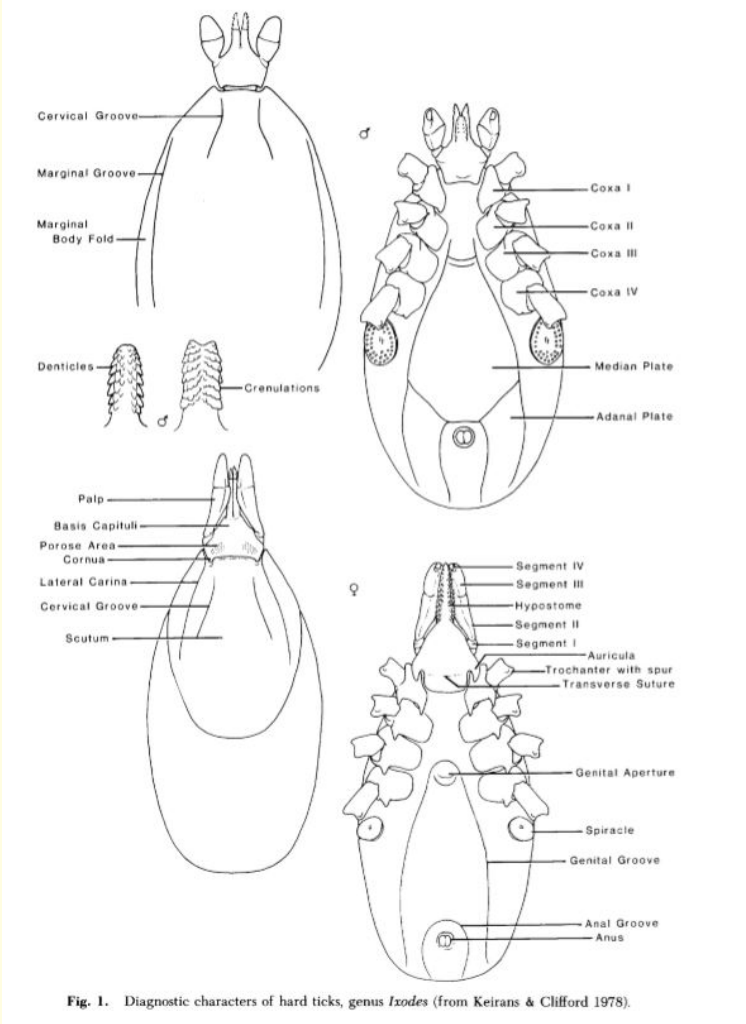
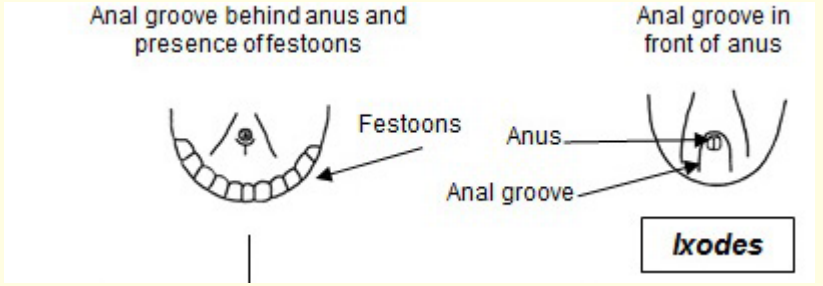


Fig. 1. Diagnostic characters of hard ticks, genus *Ixodes* (from Keirans & Clifford 1978).

Keirans, J. E. & C. M. Clifford. 1978. The genus *Ixodes* in the United States: A scanning electron microscope study and key to the adults. Journal of Medical Entomology Supplement 2.



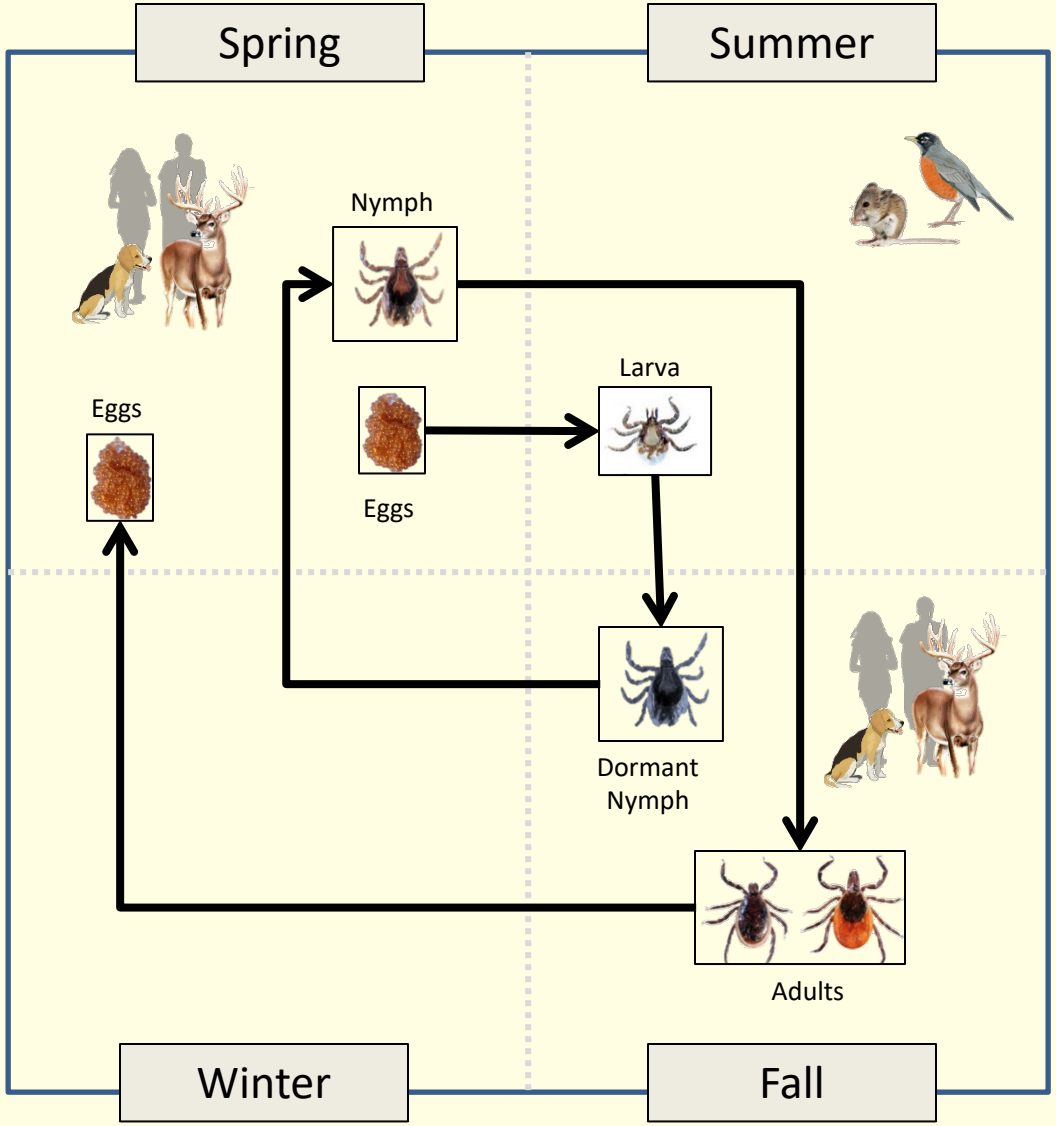
- *Ixodes* ticks differentiated from other tick species by anal groove in front of anus

Blacklegged tick (*Ixodes scapularis*)

Ixodes scapularis

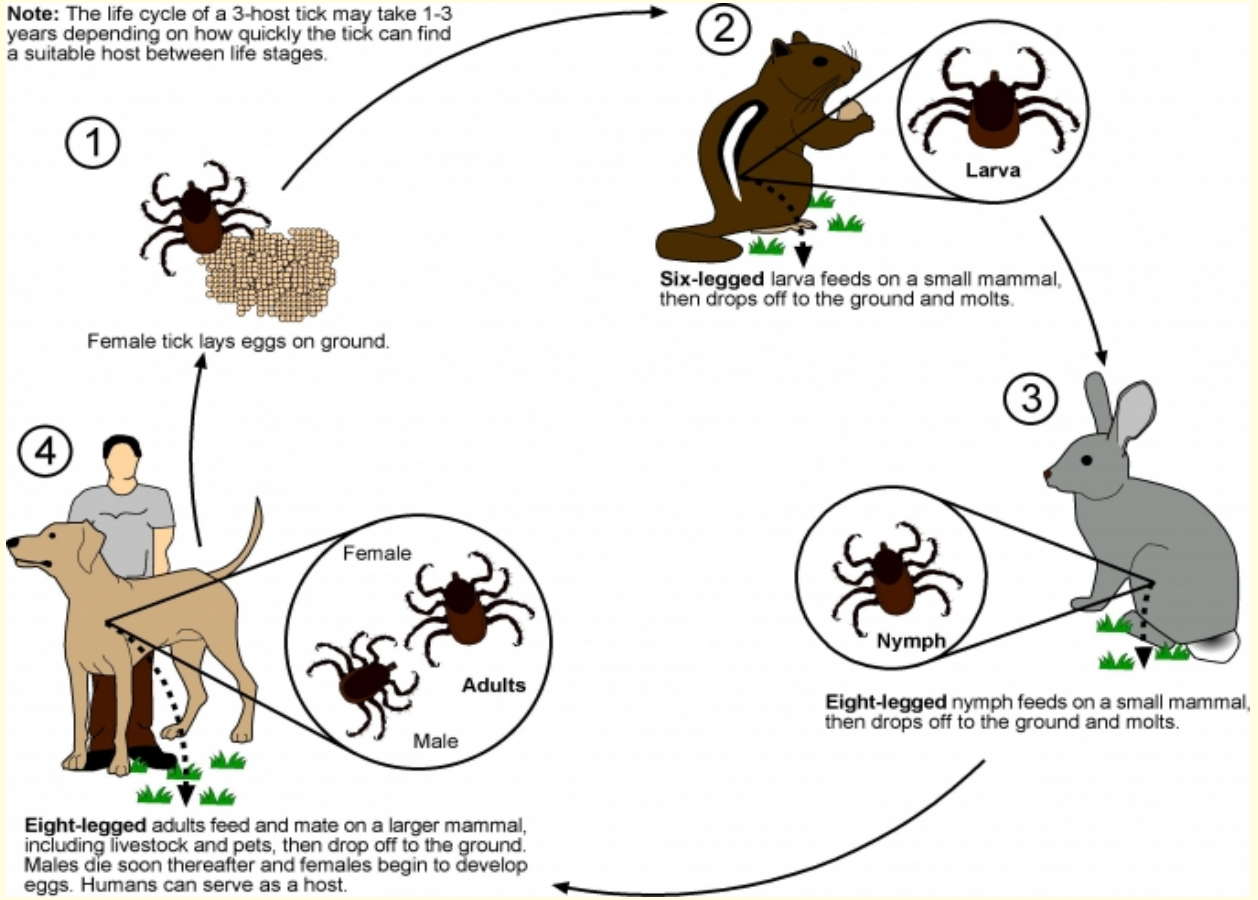
http://www.cdc.gov/ticks/geographic_distribution.html

Ixodes scapularis Life Cycle



Ixodes scapularis Life Cycle (cont'd)

- *Ixodes scapularis* follows the three host life cycle
- Each stage feeds once on a different vertebrate host

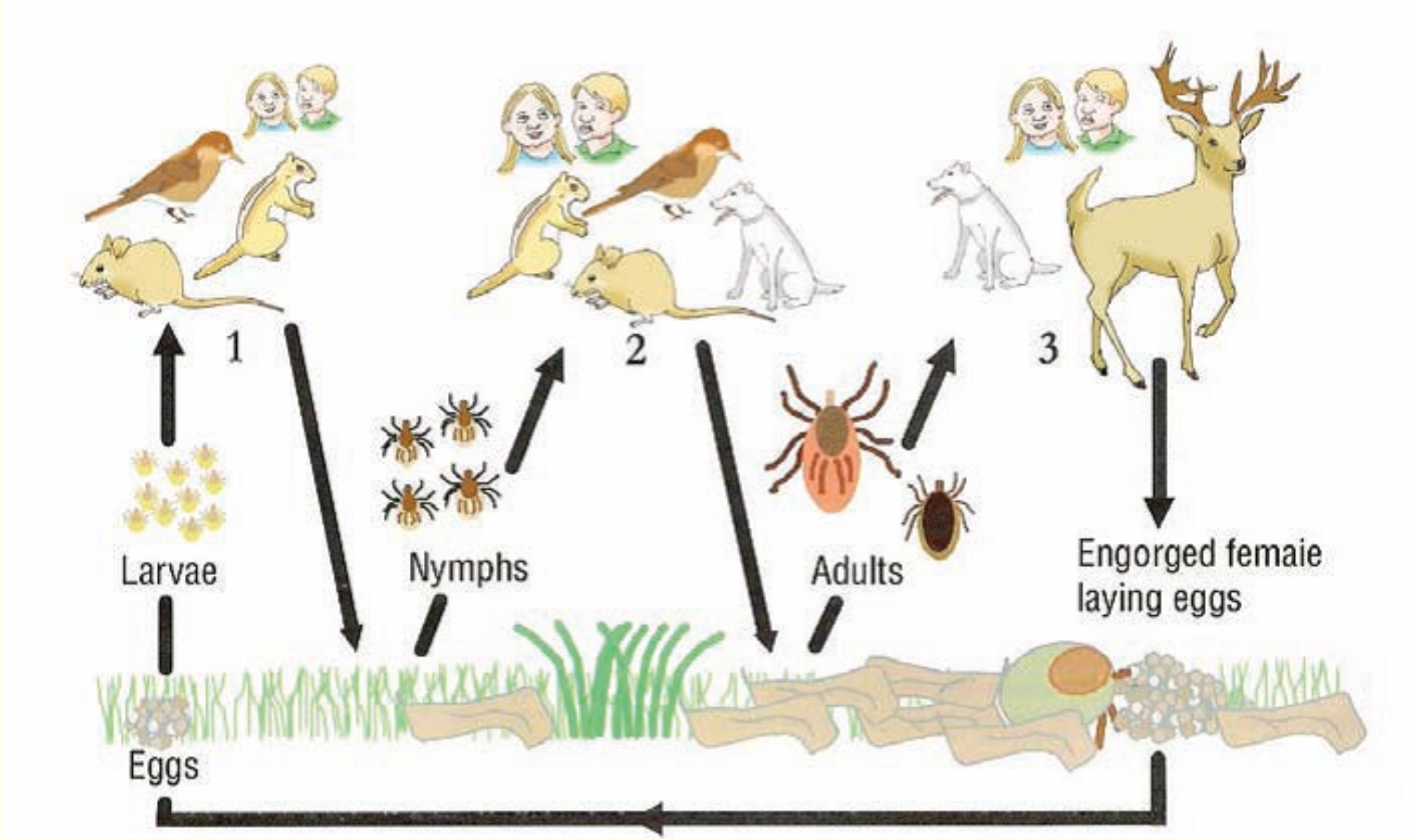


Vertebrate Hosts

- Hosts of *Ixodes scapularis*
  - Field mice, chipmunks, birds, lizards: Larvae, nymphs
  - Raccoon, opossum, humans: Nymphs
  - White-tailed deer, humans: Adults

Vertebrate Hosts (cont'd)

- Different tick life stages feed on different vertebrate hosts
- Younger tick life stages feed on smaller hosts closer to the ground



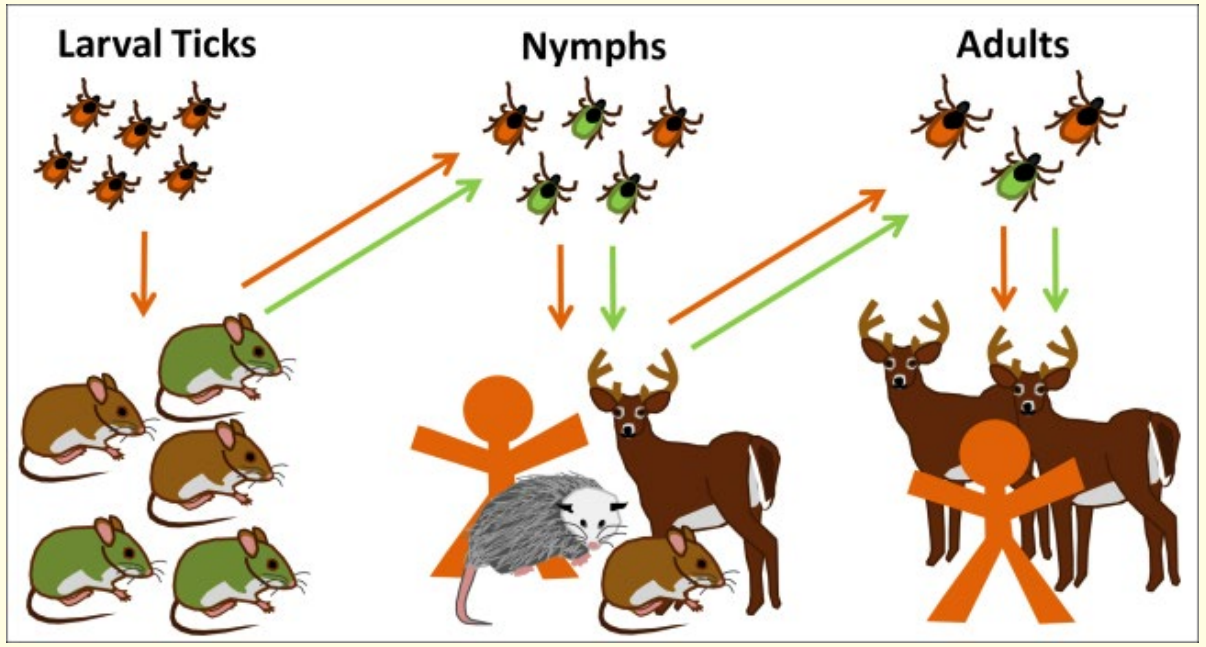
Lyme Disease Transmission Cycle

- Hosts of *Borrelia burgdorferi*
  - Field mice, chipmunks
  - Raccoon, opossum, rabbits
  - Birds

Lyme Disease Transmission Cycle (cont'd)

- Uninfected larval ticks (brown) acquire Lyme disease (become green) from infected (green) field mice

- Nymph and adult ticks transmit Lyme disease to humans and other mammals



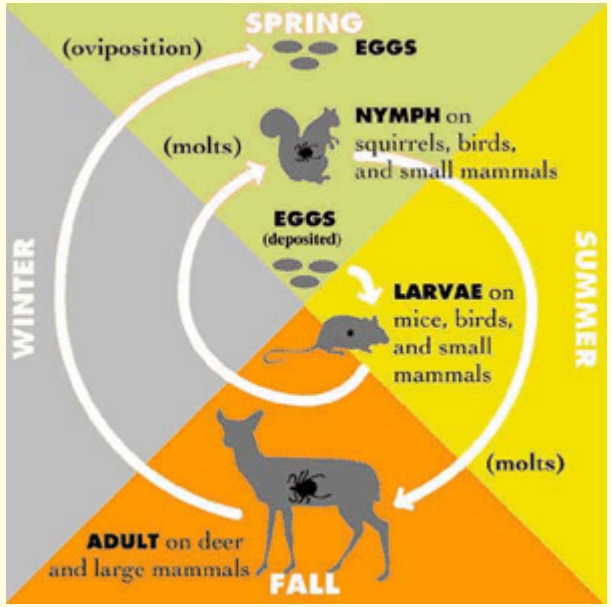
Lyme Disease Transmission

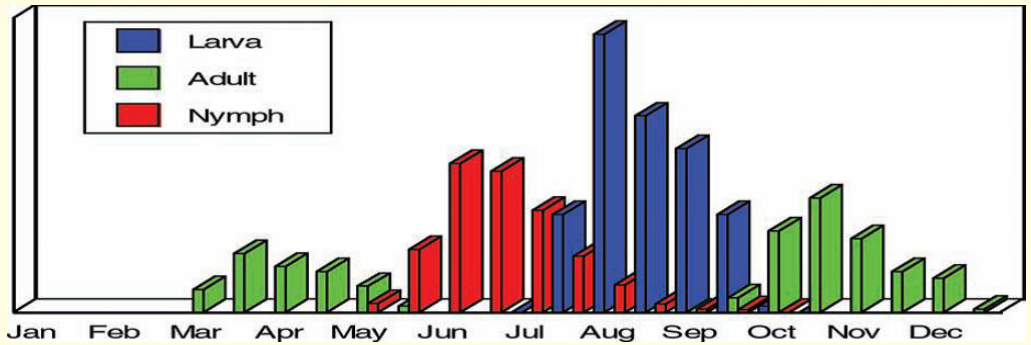
- Ticks can attach to any part of the human body
  - Often found in hard-to-see areas such as the groin, armpits, and scalp

- In most cases, the tick must be attached for 36-48 hours or more before the Lyme disease bacterium can be transmitted
  - Nymphs are hard to see and able to stay on host long enough to transmit disease

Lyme Disease Transmission (cont'd)

- Nymphs are active during the late spring through summer
- Nymphs become adults from fall until following spring

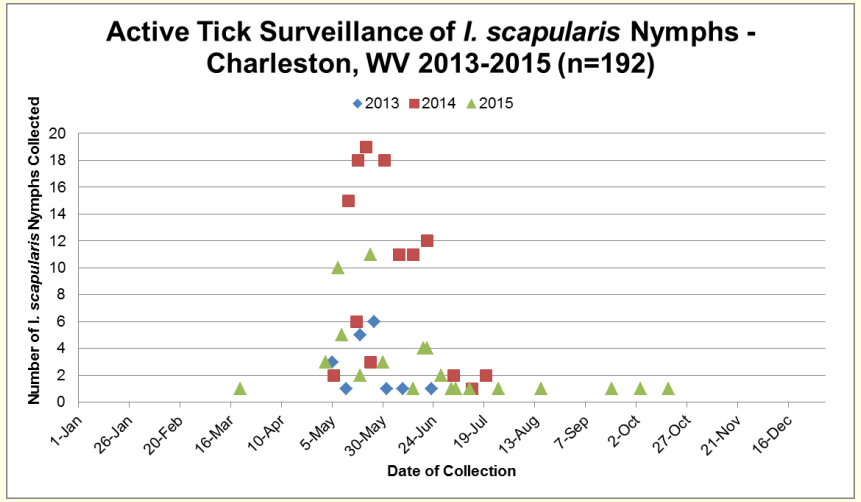


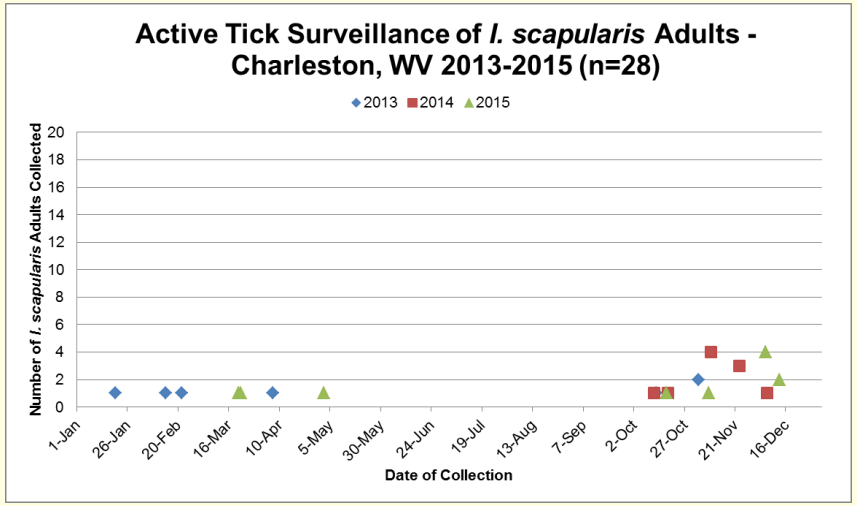


Ixodes scapularis Seasonal Activity

- Peak tick activity occurs in late spring through early summer

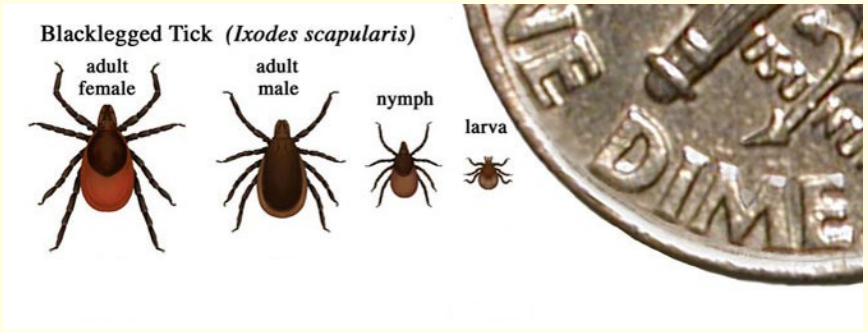
- Nymphs are the most common life stage during late spring through early summer





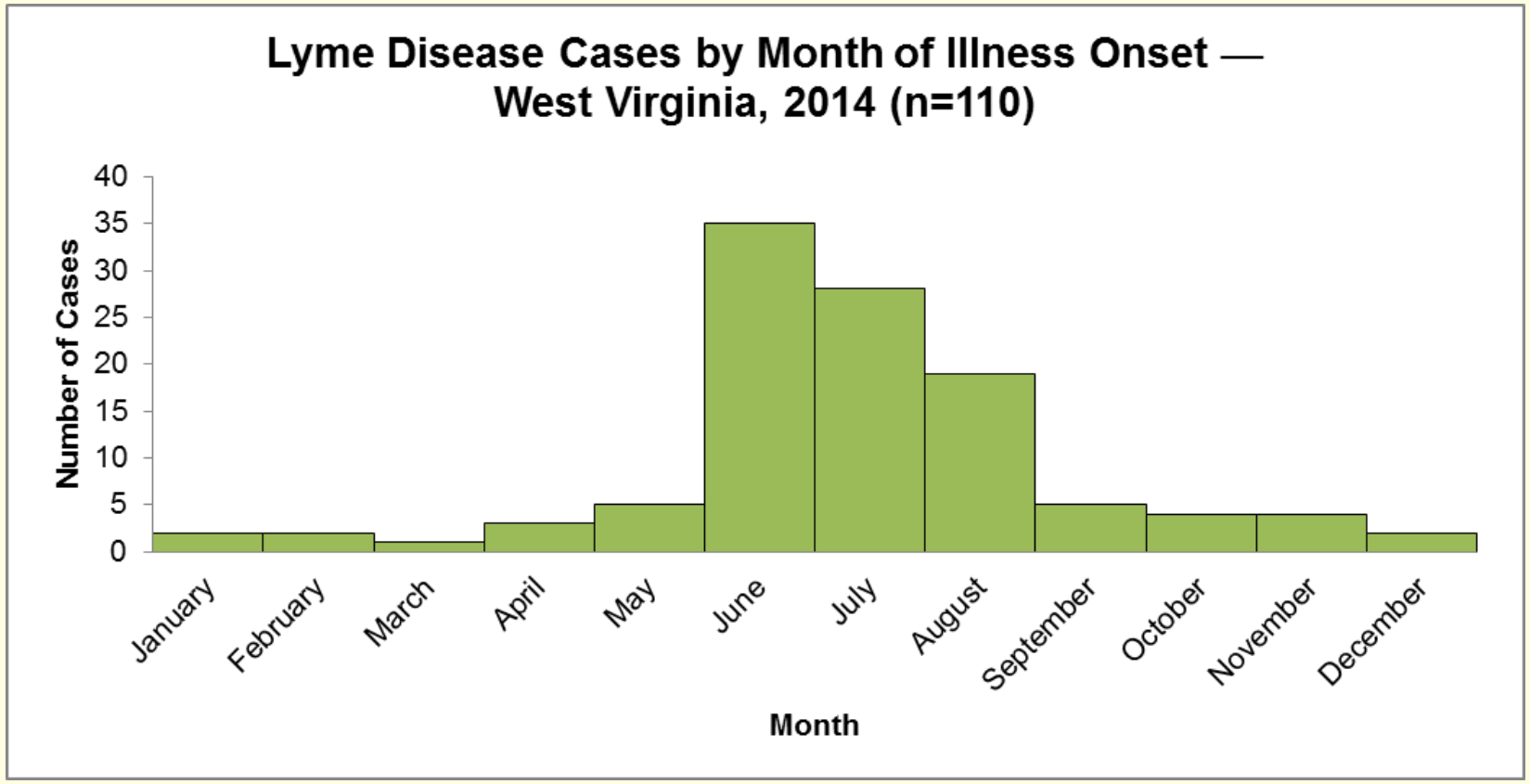
Ixodes scapularis Seasonal Activity (cont'd)

- Nymphs are the primary life stage transmitting Lyme disease to humans
  - Harder to see nymphs than adults
  - Nymphs have shorter attachment time than adults
  - There are more nymphs in late spring – early summer than adults in fall through early spring
  - Humans are more active in tick habitats during late spring – early summer



Lyme Disease Seasonal Activity

- Most human Lyme disease cases occur in early to mid-summer when tick nymphs are most active

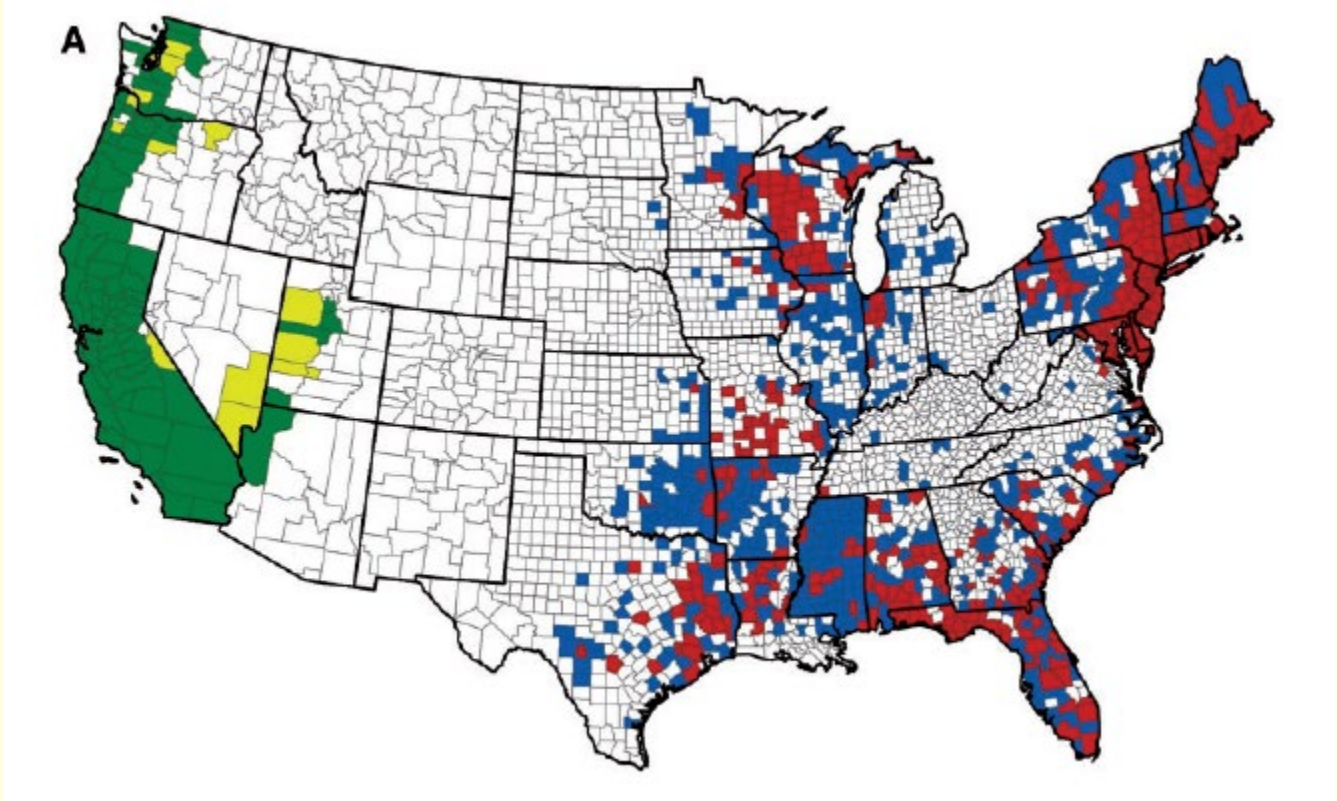


Ixodes scapularis & Lyme Disease Habitat

- Habitat conducive to *Ixodes scapularis*
  - Deciduous forest
  - Canopy closure
  - Deciduous leaf litter
  - Mild, moist conditions
  - White-tailed deer
  - Japanese barberry
  - Winterberry holly
  - Eurasian honeysuckle
- Habitat conducive to Lyme disease cases
  - Close proximity to deciduous forest

Lyme Disease Vector Geographic Distribution

Lyme Disease Vector Distribution 1907-1998

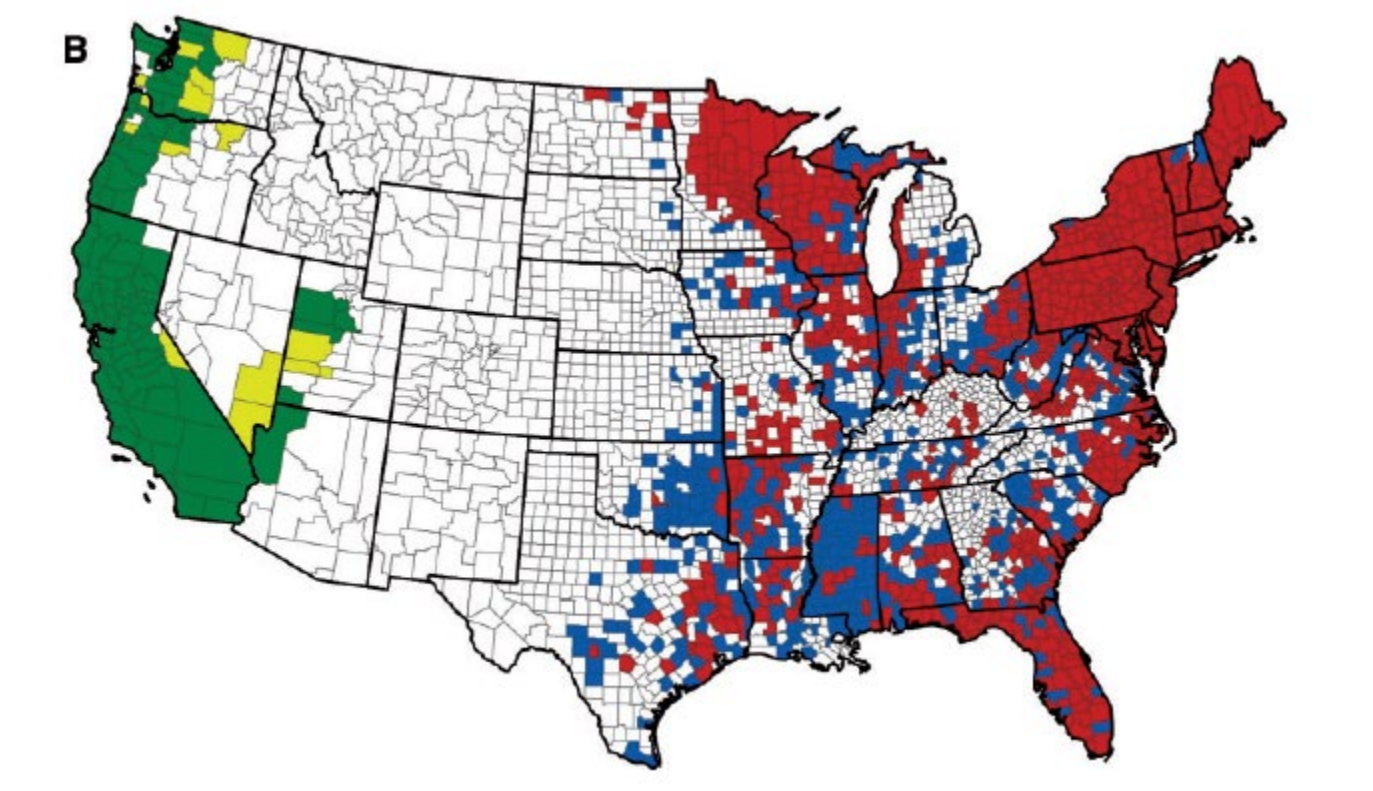


Ixodes scapularis reported (blue) or established (red) in county
Ixodes pacificus reported (yellow) or established (green) in county

Dennis, D. T., T. S. Nekomoto, J. C. Victor, W. S. Paul & J. Piesman. 1998. Reported distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the United States. *Journal of Medical Entomology* **35** (**5**): 629-638.

Lyme Disease Vector Geographic Distribution (cont'd)

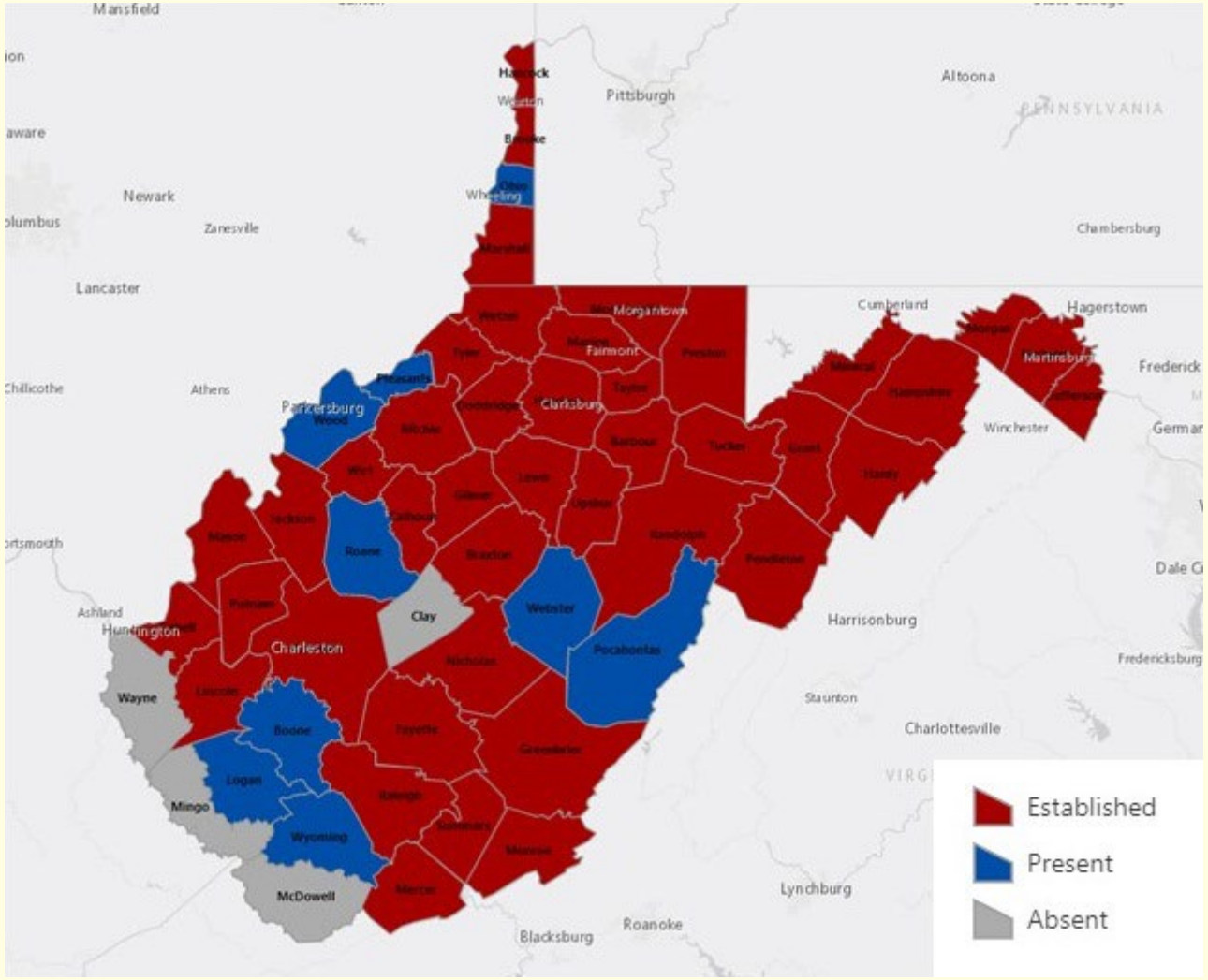
Lyme Disease Vector Distribution 1907-2015



Ixodes scapularis reported (blue) or established (red) in county
Ixodes pacificus reported (yellow) or established (green) in county

Eisen, R. J., L. Eisen & C. B. Beard. 2016. County-scale distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the continental United States. *Journal of Medical Entomology* **53** (**2**): 349-386.

Ixodes scapularis Distribution - West Virginia, (2019)

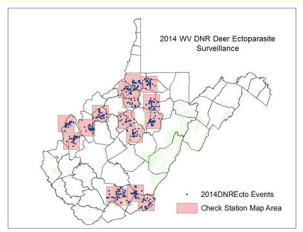


Tick Surveillance

- Completed distribution and seasonal phenology of *I. scapularis*
- Need to determine presence/prevalence of human pathogens in *I. scapularis*
- Need to determine density of *I. scapularis* nymphs and adult females
- Need to determine density of infected *I. scapularis* nymphs and adult females

Table 2. Summary of tick collection methods that are acceptable or unacceptable for each surveillance objective.

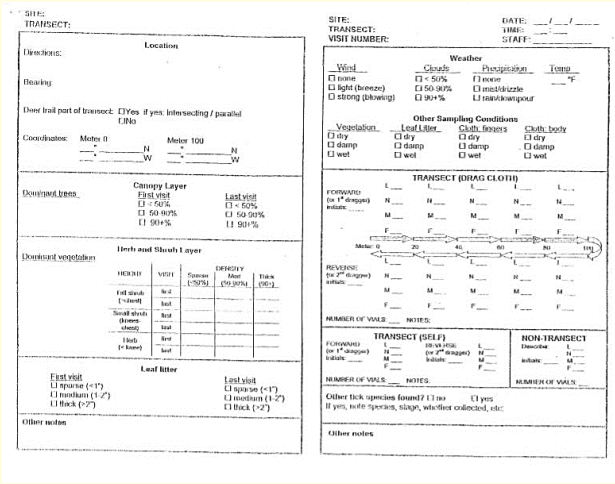
Collection Method	Objective: Classify county status	Objective: Presence/Prevalence of pathogens in ticks	Objective: DON/DIN or DOF/DIF	Objective: Phenology
Dragging/Flagging	Acceptable	Acceptable	Acceptable	Acceptable
Walking	Acceptable	Acceptable	Not Acceptable	Acceptable
CO2 traps	Acceptable	Acceptable for presence, but not prevalence	Not Acceptable	Not Acceptable
Ticks collected from deer	Acceptable	Acceptable for presence, but not prevalence	Not Acceptable	Not Acceptable
Ticks collected from small- or medium-sized mammals, birds, lizards	Acceptable	Acceptable for presence, but not prevalence	Not Acceptable	Acceptable
Ticks from people/pets	Acceptable, if travel history is accounted for	Acceptable for presence, but not prevalence	Not Acceptable	Not Acceptable



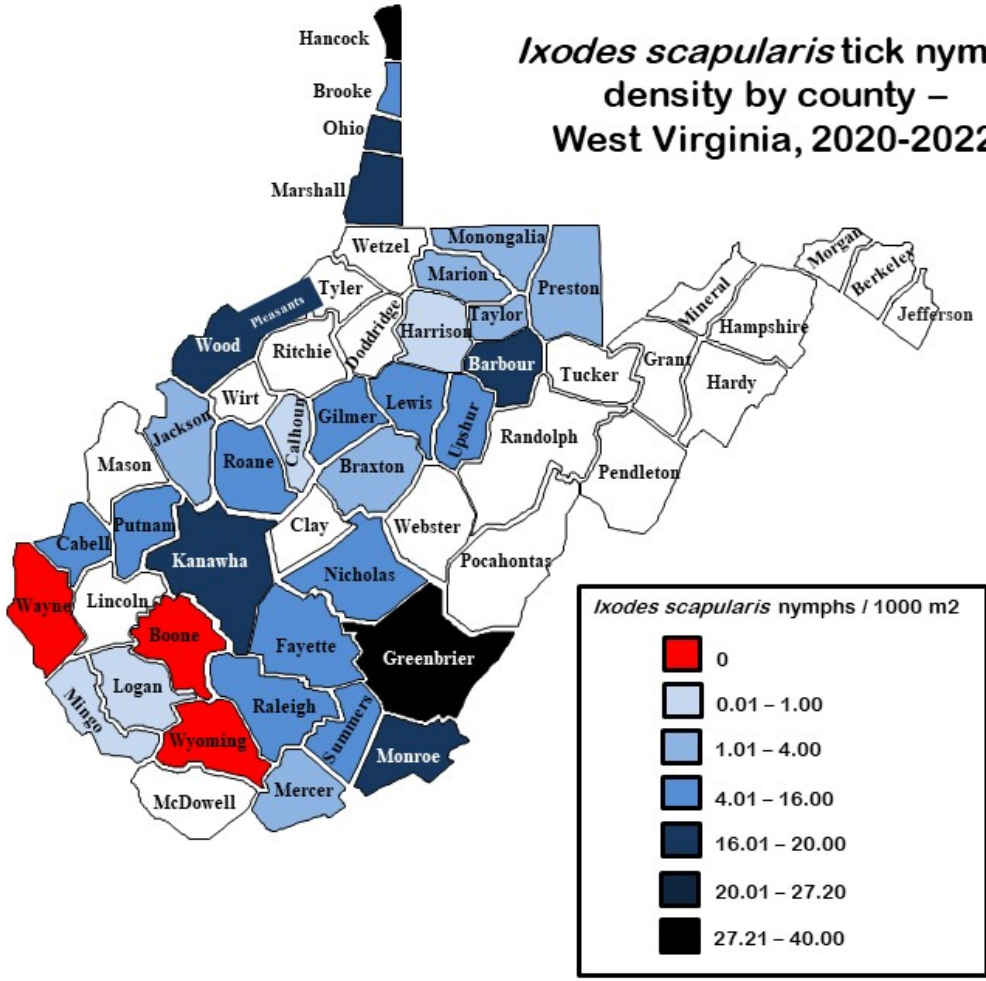
Eisen, R. *et al*. 2019. Surveillance for *Ixodes scapularis* and pathogens found in this tick species in the United States.

Tick Surveillance, 2020-2022

- Active tick surveillance activities focused on blacklegged tick (*Ixodes scapularis*), lone star tick (*Amblyomma americanum*), and Asian longhorned tick (*Haemaphysalis longicornis*)
- Active tick surveillance conducted in 65 localities in 19 counties (2020), 32 localities in 22 counties (2021), and 21 localities in 18 counties (2022)
- Ticks collected using the tick drag method over minimum of 750 m^2 area (2020, 2021) or 1000 m^2 area (2022)
- Passive tick surveillance with West Virginia Veterinary Tick Submission Project and public submissions


SITE:
TRANSECT:
Location
Directions:
Bearing:
Deer trail part of transect: ☐Yes if yes: Intersecting / parallel ☐No
Coordinates: Meter 0 Meter 100
Canopy Layer
Dominant trees
First visit
☐ < 50%
☐ 50-90%
☐ 90+%
Last visit
☐ < 50%
☐ 50-90%
☐ 90+%
Herb and Shrub Layer
Dominant vegetation
HEIGHT
VISIT
DENSITY
Sparse (<50%)
Med (50-90%)
Thick (90+)
Leaf litter
First visit
☐ sparse (<1")
☐ medium (1-2")
☐ thick (>2")
Last visit
☐ sparse (<1")
☐ medium (1-2")
☐ thick (>2")
Other notes
SITE:
TRANSECT:
VISIT NUMBER:
DATE: ___/___/____
TIME:
STAFF:
Weather
Wind
☐ none
☐ light (breeze)
☐ strong (blowing)
Clouds
☐ < 50%
☐ 50-90%
☐ 90+%
Precipitation
☐ none
☐ mist/drizzle
☐ rain/downpour
Temp
____ °F
Other Sampling Conditions
Vegetation
☐ dry
☐ damp
☐ wet
Leaf Litter
☐ dry
☐ damp
☐ wet
Cloth: fingers
☐ dry
☐ damp
☐ wet
Cloth: body
☐ dry
☐ damp
☐ wet
TRANSECT (DRAG CLOTH)
FORWARD (or 1st dragged)
Initials: ____
Meter: 0 20 40 60 80 100
REVERSE (or 2nd dragged)
Initials: ____
NUMBER OF VIALS: ____ NOTES:
TRANSECT (SELF)
FORWARD (or 1st dragged)
Initials: ____
REVERSE (or 2nd dragged)
Initials: ____
NUMBER OF VIALS: ____ NOTES:
NON-TRANSECT
Describe:
Initials: ____
NUMBER OF VIALS: ____
Other tick species found? ☐ no ☐ yes
If yes, note species, stage, whether collected, etc:
Other notes

Ixodes scapularis Surveillance, 2020-2022



County	Tick Nymphs / 1000 m2
Hancock	40.00
Greenbrier	27.20
Monroe	26.00
Barbour	21.33
Kanawha	20.00
Wood	20.00
Pleasants	20.00
Ohio	18.75
Marshall	16.25
Raleigh	16.00
Brooke	13.75
Gilmer	12.00
Fayette	10.00
Lewis	9.33
Summers	8.57
Nicholas	8.49
Roane	7.33
Cabell	6.40
Putnam	4.57
Jackson	4.00
Braxton	4.00
Upshur	4.00
Monongalia	3.63
Marion	3.33
Mercer	3.00
Taylor	2.86
Preston	1.50
Harrison	0.67
Calhoun	0.67
Logan	0.67
Mingo	0.40
Wayne	0.00
Boone	0.00
Wyoming	0.00

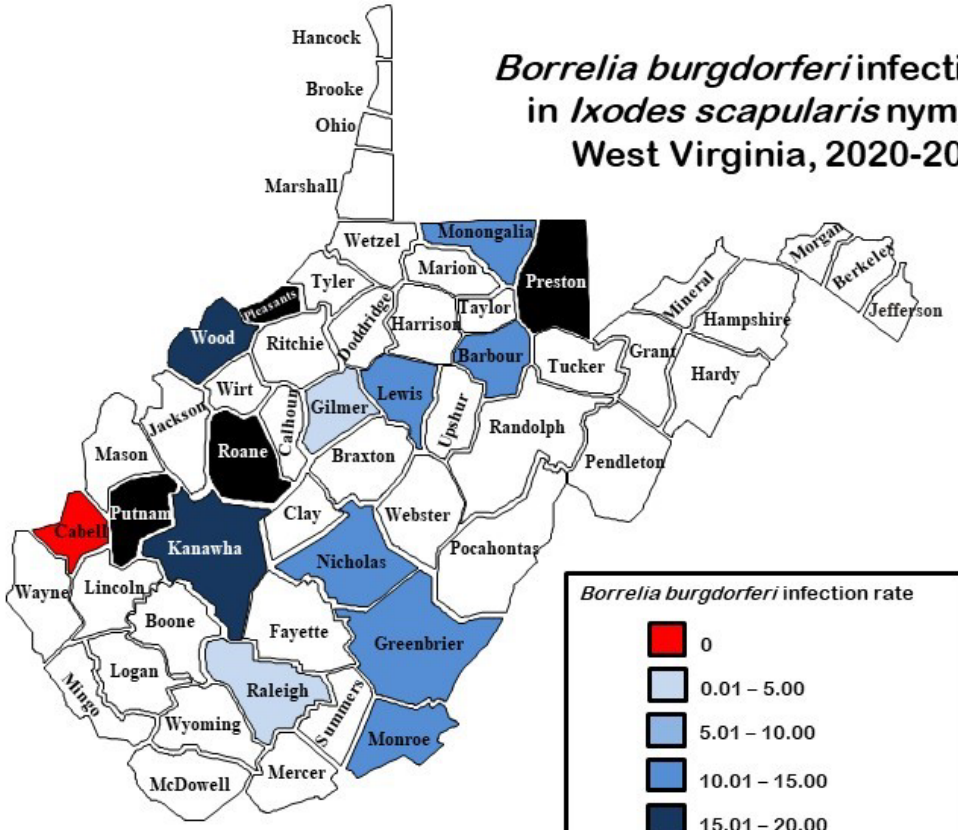
Ixodes scapularis Surveillance, 2020-2022 (cont'd)

- Most of the collecting localities with the highest *Ixodes scapularis* nymph densities were in northern and eastern West Virginia
- *Ixodes scapularis* was not active in many collecting localities in southwestern West Virginia
- The *I. scapularis* nymph density in central West Virginia was less than the high tick nymph densities in northern and southeastern West Virginia but greater than the low tick nymph densities in southwestern West Virginia
- Many sites with high tick density are near human habitation

Human Pathogen Testing in *Ixodes scapularis*

- Submitted *I. scapularis* nymphs actively collected to CDC for human pathogen testing (*Borrelia burgdorferi*, *Borrelia mayonii*, *Borrelia miyamotoi*, *Anaplasma phagocytophilum*, *Babesia microti*)
- *Borrelia miyamotoi* has been found in neighboring states (Pennsylvania, Maryland, Virginia) but not West Virginia

Human Pathogen Testing in *Ixodes scapularis* (cont'd)



Borrelia burgdorferi infection rate in *Ixodes scapularis* nymphs – West Virginia, 2020-2022

Borrelia burgdorferi infection rate

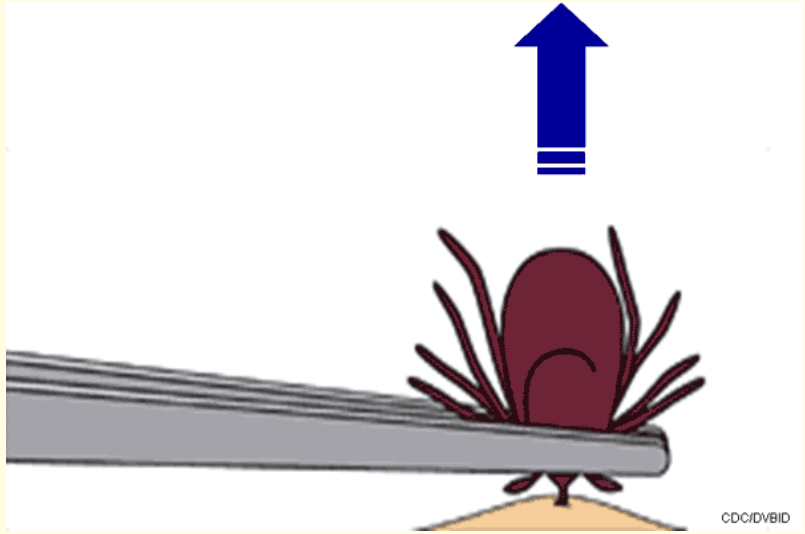
- 0
- 0.01 – 5.00
- 5.01 – 10.00
- 10.01 – 15.00
- 15.01 – 20.00
- 20.01 – 25.00
- >25.00

County	*Borrelia burgdorferi* infection rate
Roane	31.03
Pleasants	29.03
Putnam	28.57
Preston*	27.27
Wood	17.07
Kanawha	16.00
Monongalia	14.29
Greenbrier	13.04
Barbour	12.12
Lewis	11.76
Nicholas	10.71
Monroe	10.35
Gilmer	4.08
Raleigh	3.57
Cabell*	0.00

* Less then recommended 25 ticks tested from surveillance site

Tick Management (Personal Protection)

- Repellent (DEET) – up to 25%
- Long-trousers and light-colored clothing
- Permethrin-impregnated clothing
- Self-examination
- Gentle removal of tick with mouthparts



Tick Management (Physical Control)

- Cattle quarantine
- Burning or clearing vegetation
- Pasture rotation
- Elimination of deer

Tick Management (Chemical Control)

- Dipping, dust bags, power drench, pour-on, plastic collars, ear tags, permethrin impregnated cotton balls

Summary

- The blacklegged tick, *Ixodes scapularis*, is a competent vector for *Borrelia burgdorferi*, the causative agent for Lyme disease in West Virginia
- Most human Lyme disease cases occur in early to mid-summer when tick nymphs are most active
- *Ixodes scapularis* live in deciduous forest ecosystems
- Lyme disease is following the southwestward migration of *Ixodes scapularis* across West Virginia
- The density of *I. scapularis* nymphs was lower in low Lyme disease incidence counties in southwestern West Virginia
- Distribution of Lyme disease infection in the human population corresponds to the distribution of *Borrelia burgdorferi* infection in *Ixodes scapularis* and companion animals in West Virginia

CONTENT OVERVIEW

- Describe Lyme disease and its impact in West Virginia
- Explain Lyme disease transmission and appropriate control measures to mitigate exposure
- State Lyme disease symptoms and management options
- List/briefly describe other tickborne illnesses impacting West Virginia

CLINICAL VIGNETTE

- A 20-year-old female presents to your clinic approximately 4-weeks after spending a weekend with her boyfriend, with who she is sexually active, exploring and camping in the United State's newest national park, the New River Gorge National Park and Preserve. She states that when she awoke this morning, she noticed a new rash (as described in the image). Rash is non-pruritic and not painful to touch. She mentions some general fatigue and body aches over the past week or so, including some headache and "sore shoulders." Further history reveals anaphylactoid allergy to all beta-lactams.

- What test might you consider ordering before prescribing the recommended first-line therapy for this patient's history & clinical condition?

Patient's rash

Reference: RedBook. Report of the Committee on Infectious Diseases. Lyme Disease. 2021-2024 (32nd ed).

CLINICAL VIGNETTE (CONTD.)

- A 20-year-old female presents to your clinic approximately 4-weeks after spending a weekend with her boyfriend, with who she is sexually active, exploring and camping in the United State's newest national park, the New River Gorge National Park and Preserve. She states that when she awoke this morning, she noticed a new rash (as described in the image). Rash is non-pruritic and not painful to touch. She mentions some general fatigue and body aches over the past week or so, including some headache and "sore shoulders." Further history reveals anaphylactoid allergy to all beta-lactams.

- What test might you consider ordering before prescribing the recommended first-line therapy for this patient's history & clinical condition?

    - **Dx:** Lyme Disease; rash is pathognomonic (no Lyme testing needed)
    - **1st-line therapy:** doxycycline
    - **Preferred test:** pregnancy test (tetracyclines – class D drugs, contraindicated in pregnancy)

Patient's rash

Reference: RedBook. Report of the Committee on Infectious Diseases. Lyme Disease. 2021-2024 (32nd ed).

LYME DISEASE STAGES: EARLY

A. **Early localized (3-32 days after bite)**
   - Erythema migrans (EM) rash
     - Target lesion (≥5 cm diameter) = "Bulls-eye" rash; painless / non-pruritic
     - Typically occurs in 70-80% of patients
     - Without treatment, lesion resolves in 1–2 wks.
   - Constitutional symptoms: fever, headache (HA), malaise

B. **Early disseminated (1-2 weeks after localized disease)**
   - Secondary EM lesions (smaller than primary)
   - Constitutional symptoms, lymphadenopathy
   - Cranial nerve palsies (CN VII = Bell's)
   - Carditis (myocarditis, AV heart block)
   - CNS findings (neuropathy, lymphocytic meningitis)

Erythema migrans rash

Reference: RedBook. Report of the Committee on Infectious Diseases. Lyme Disease. 2021-2024 (32nd ed).

LYME DISEASE STAGES: LATE

- Months after initial tick bite (may not have findings of early Lyme disease)

- Children = arthritis (with arthralgia)
    - Affecting large joints (e.g. hip, knee)
    - Can wax & wane (weeks not days)
    - Swelling/effusion typically out of proportion to pain or disability + lower peripheral neutrophilia and inflammatory marker elevation (e.g. CRP & ESR)

- Adults = variable
    - Arthritis
    - Polyneuropathy
    - Encephalopathy/encephalitis
    - Conjunctivitis/keratitis/uveitis
    - Optic neuritis

Knee swelling associated with Lyme arthritis

Reference: RedBook. Report of the Committee on Infectious Diseases. Lyme Disease. 2021-2024 (32nd ed).

LYME DISEASE STAGES: LATE

- Months to years after initial tick bite (may not have findings of early Lyme disease)

- Children = arthritis (with arthralgia)
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Stages of Lyme Disease

Early localized stage
(3-30 days post-tick bite)

- Erythema migrans (EM) (also called Bull's eye rash)
- Fever, malaise, headache, stiff neck, muscle and joint aches, and swollen lymph nodes

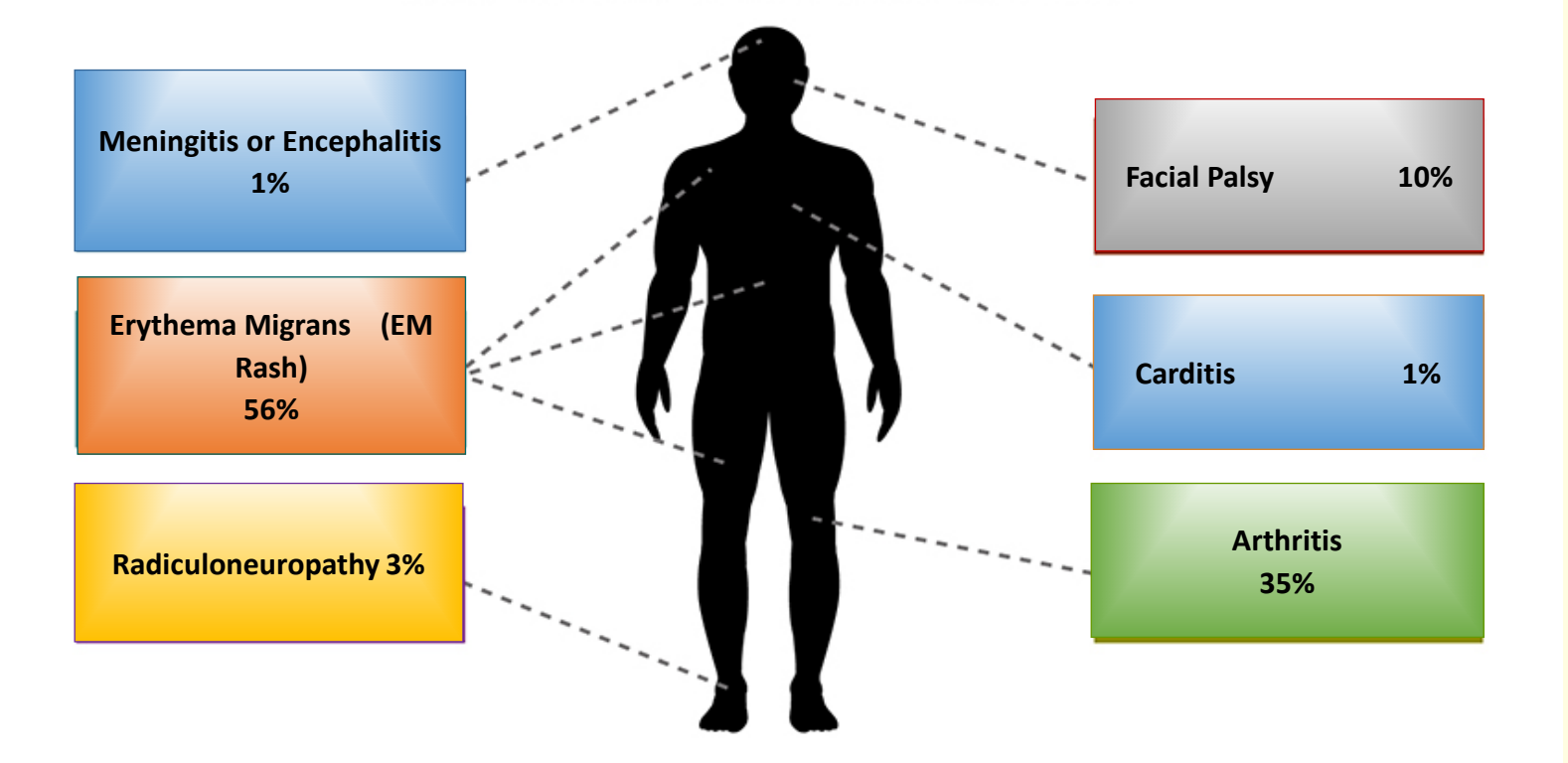
Early disseminated stage
(days to weeks post-tick bite)

- Additional EM lesions
- Facial or Bell's palsy
- Headache and stiff neck due to meningitis
- Pain and swelling of joints
- Heart block and dizziness

Late disseminated stage
(months to years post-tick bite)

- Arthritis that affects large joints (particularly knees)
- Chronic neurological complications (e.g., shooting pains, numbness, and tingling in hands and feet)

Lyme Disease Symptoms



Frequency of clinical features of Lyme disease among confirmed cases – West Virginia, 2020

LYME DISEASE STAGES

- Persistent post-treatment symptoms
  - Some patients have prolonged symptoms despite treatment
  - "*Antibiotic-refractory Lyme arthritis*" → discussed in a minute
  - Persistent, treatment-refractory infection with *B. burgdorferi* ("chronic Lyme disease") has not been substantiated
  - These patients usually respond to symptomatic treatment and cover gradually
  - Double-blinded, RCTs have not found that retreatment offers benefit and can be associated with increased harm
  - Retreatment is recommended for repeat infection

Reference: RedBook. Report of the Committee on Infectious Diseases. Lyme Disease. 2021-2024 (32nd ed).

Lyme Diagnosis

- No definitive test(s)
- Primarily clinical, based on history + rash
- Two-tiered testing (standard):
  - Quantitative ELISA test
  - Confirmatory Western blot if ELISA positive or equivocal
  - Testing preferred within an appropriate window of time
- Joint fluid diagnostics

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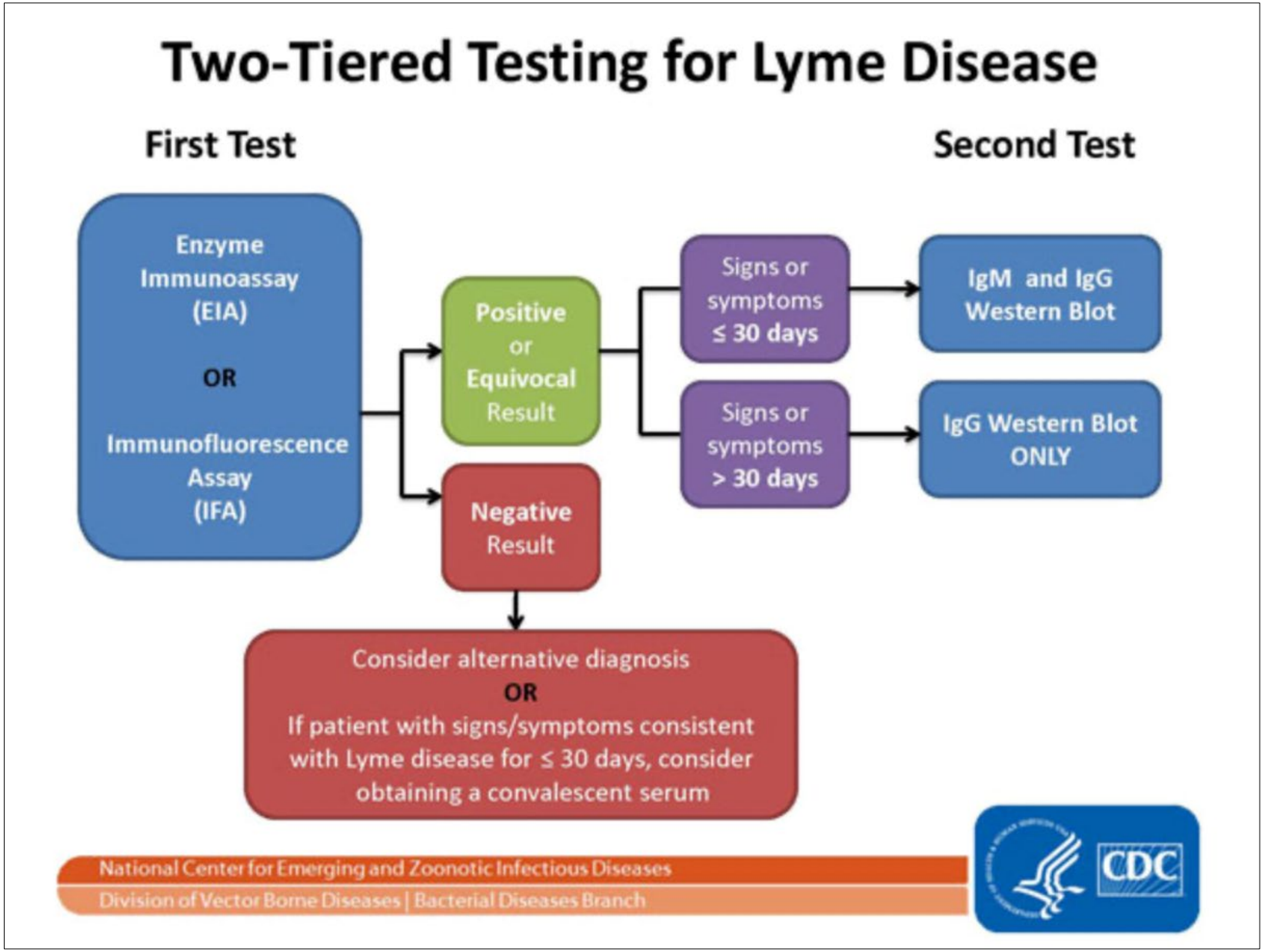
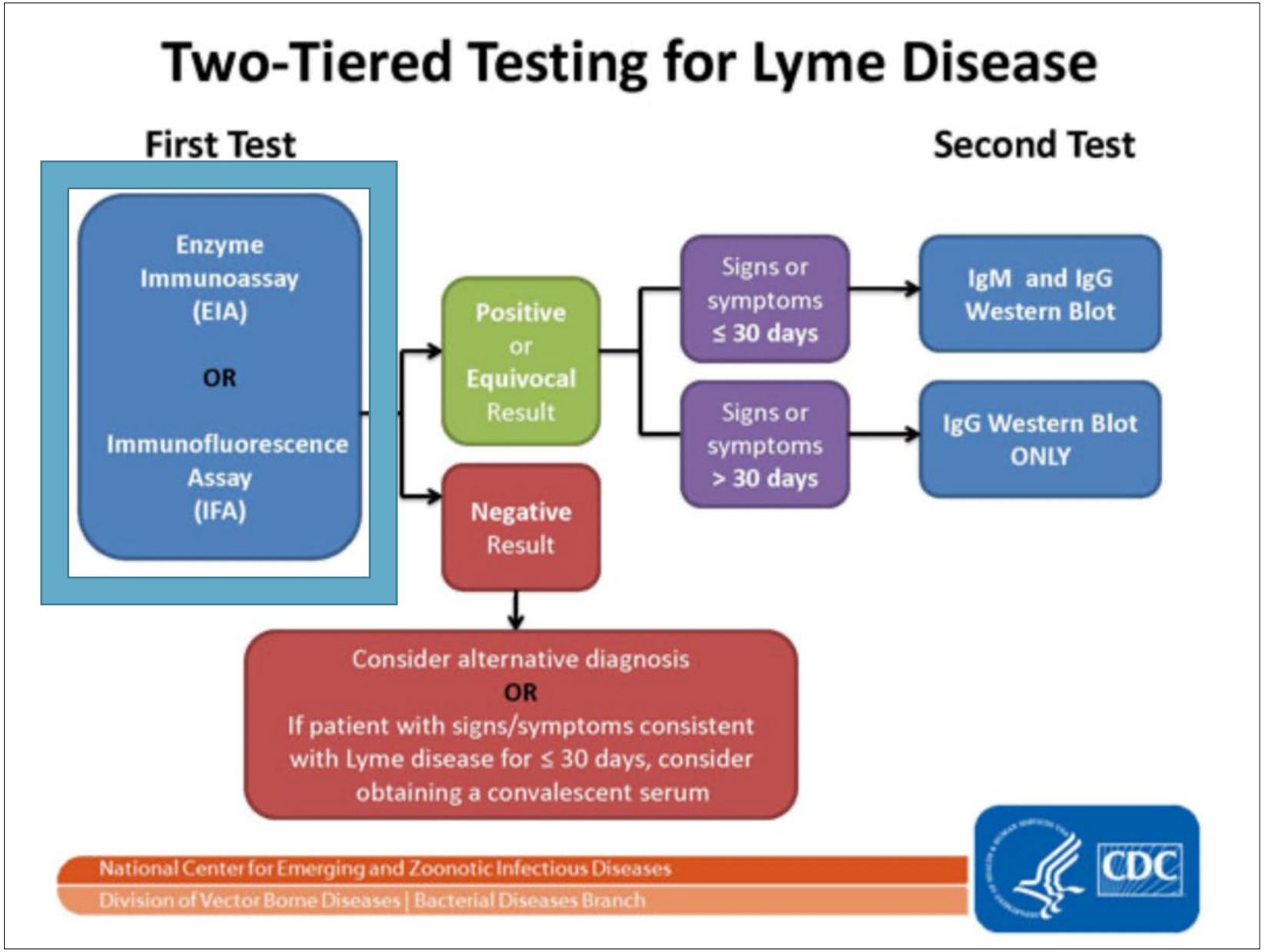


The Two-tier Testing Decision Tree describes the steps required to properly test for Lyme disease. The first required test is the Enzyme Immunoassay (EIA) or Immunofluorescence Assay (IFA). If this test yields negative results, the provider should consider an alternative diagnosis; or in cases where the patient with has had symptoms for less than or equal to 30 days, the provider may treat the patient and follow up with a convalescent serum. If the first test yields positive or equivocal results, two options are available: 1) If the patient has had symptoms for less than or equal to 30 days, an IgM Western Blot is performed; 2) if the patient has had symptoms for more than 30 days, the IgG Western Blot is performed. The IgM should not be used if the patient has been ill for more than 30 days.

Lyme Diagnosis



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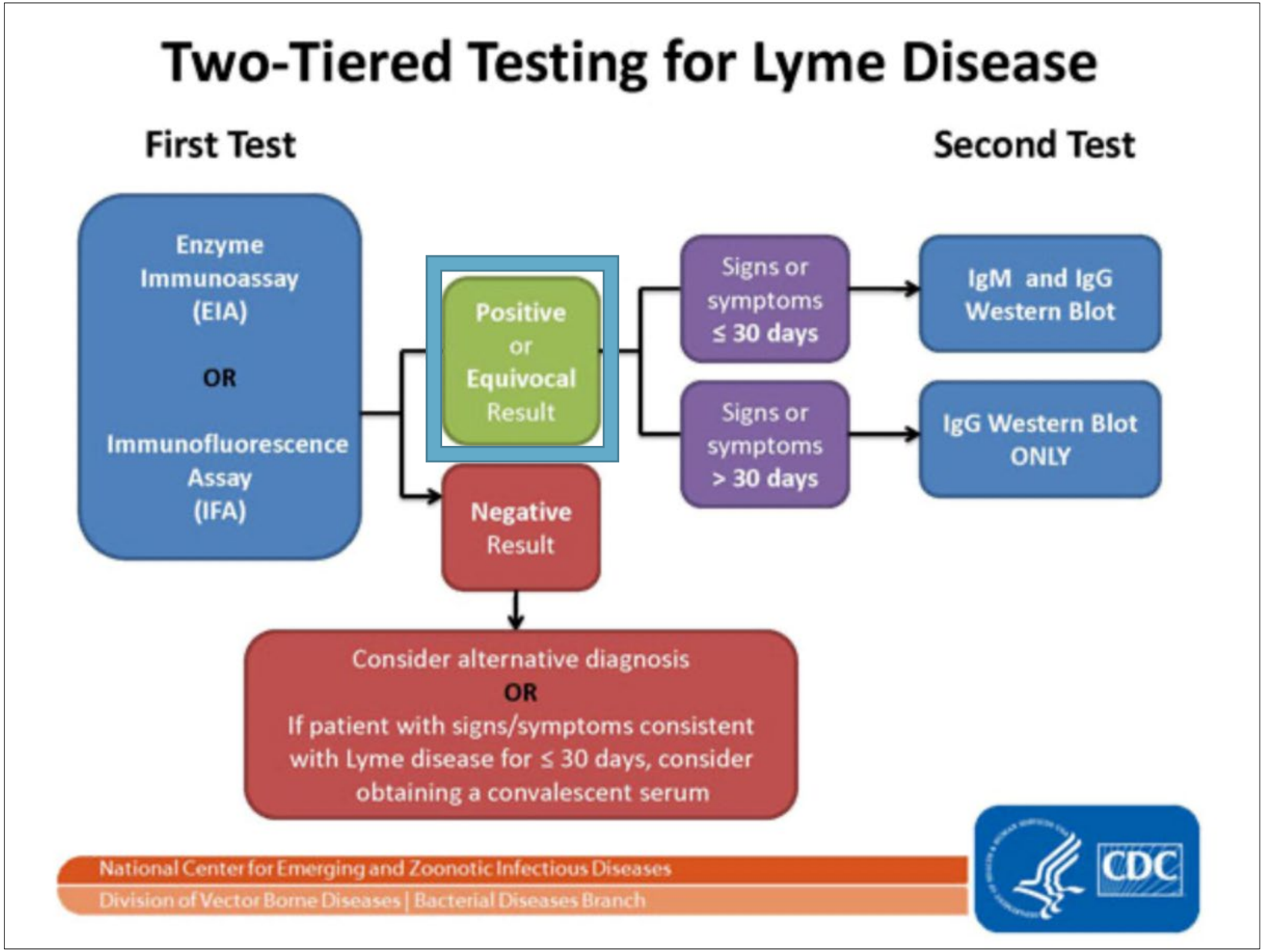

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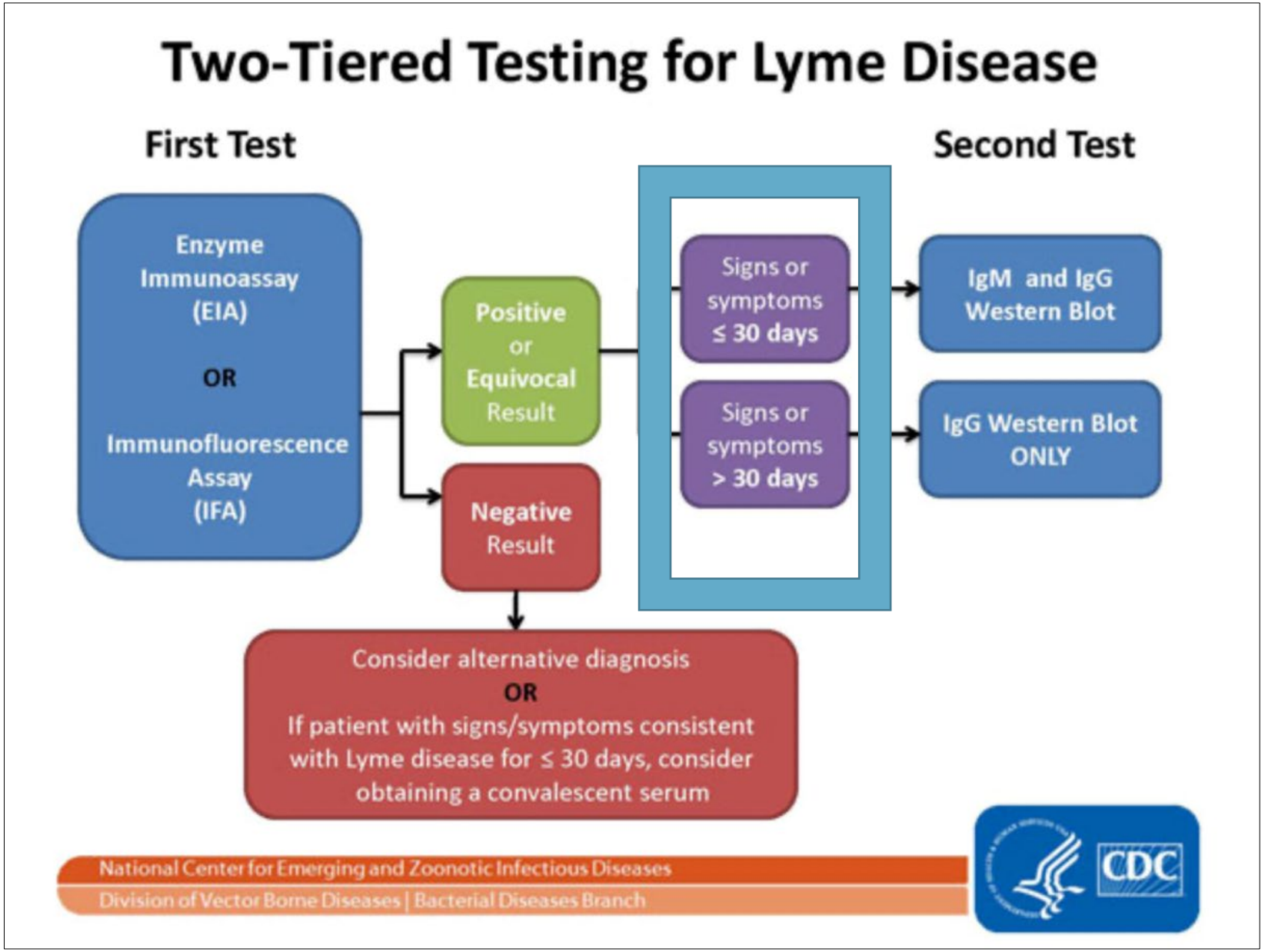

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Lyme Diagnosis

- A positive IgM immuoblot is useful for patients only within first 4 weeks after symptom onset
- Try not to order alone with symptoms >4 weeks or symptoms consistent with late Lyme disease (e.g. monoarticular arthritis). Why?

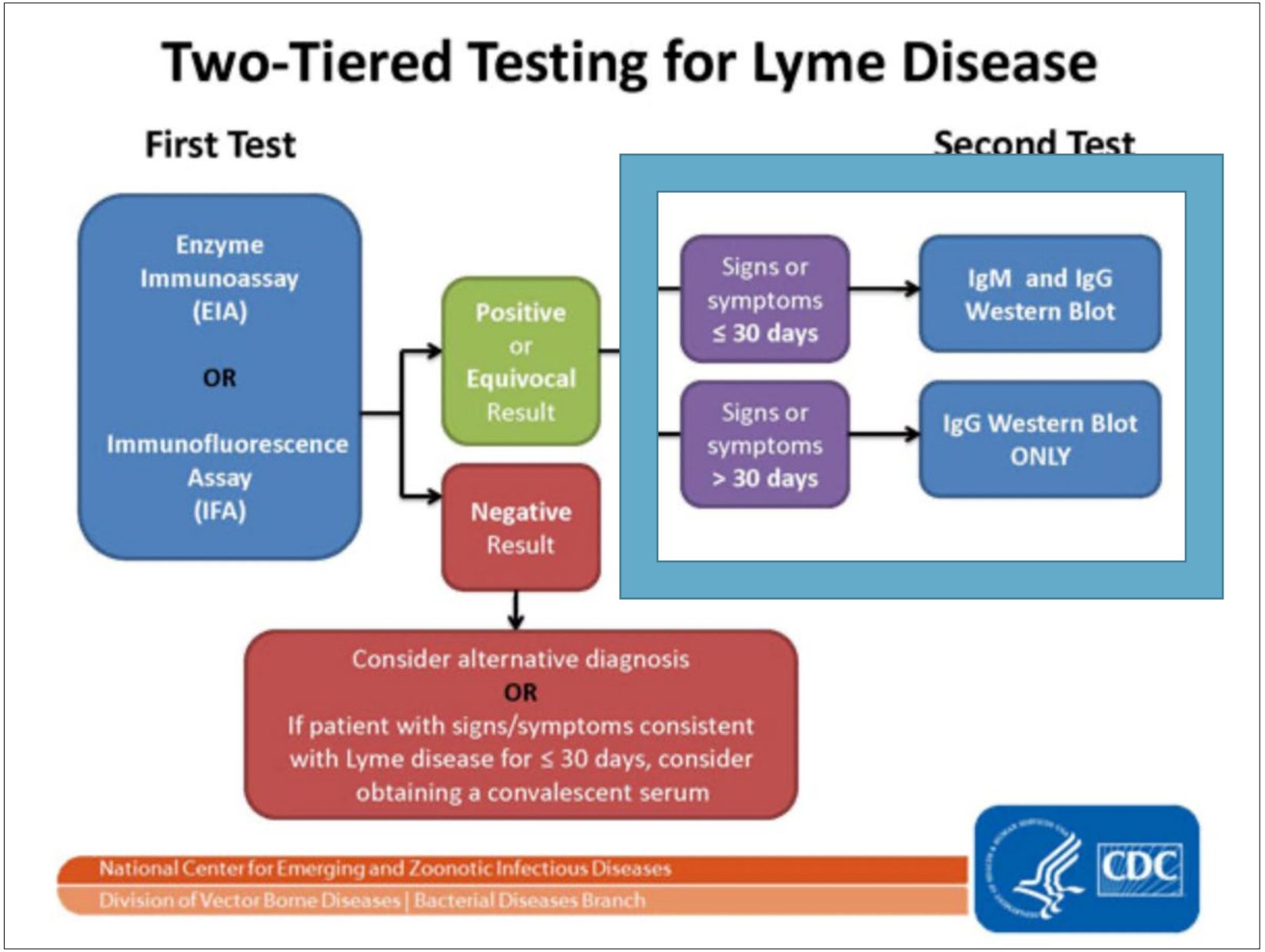
Lyme Diagnosis

- A positive IgM immuoblot is useful for patients only within first 4 weeks after symptom onset

- Try not to order alone with symptoms >4 weeks or symptoms consistent with late Lyme disease (e.g. monoarticular arthritis). Why?
  - *Because false-positive IgM assay results are common and most untreated patients with disseminated Lyme disease will have positive IgG result by week 4 of symptoms.*

Reference: RedBook. Report of the Committee on Infectious Diseases. Lyme Disease. 2021-2024 (32nd ed).

Lyme Diagnosis



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Lyme Diagnosis

- Interpreting Western Blot results (never alone)
  - Tests for presence of antibodies to specific *B. burgdorferi* antigens, including immunoglobulin (Ig) M antibodies to 3 spirochetal antigens (the 23/24, 39, and 41 kDa polypeptides) & IgG to 10 spirochetal antigens (the 18, 23/24, 28, 30, 39, 41, 45, 60, 66, and 93 kDA polypeptides)
  - **Positive result:** at least 2 IgM bands or 5 IgG bands
  - Note: IgG antibodies to flagella protein, the p41 band, are present in 30-50% of healthy, non-infected individuals

Reference: RedBook. Report of the Committee on Infectious Diseases. Lyme Disease. 2021-2024 (32nd ed).

Lyme Diagnosis

- No definitive test(s)
- Primarily clinical, based on history + rash
- Two-tiered testing:
  - Quantitative ELISA test
  - Confirmatory Western blot if ELISA positive or equivocal
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- Joint fluid diagnostics

JOINT FLUID DIAGNOSTICS

- Appearance: yellow & cloudy
- Edema/effusion out of proportion of expected
- Joint WBC typically <50,000
- WBC differential typically lymphocytes (some PMNs)
- Like CSF, joint fluid aseptic

Reference: RedBook. Report of the Committee on Infectious Diseases. Lyme Disease. 2021-2024 (32nd ed).

LYME DISEASE TREATMENT

Disease Category	Drug(s) and Dose
Erythema migrans (single or multiple) (any age)	Doxycycline, 4.4 mg/kg per day, orally, divided into 2 doses (maximum 200 mg/day) for 10 days **OR** Amoxicillin, 50 mg/kg per day, orally, divided into 3 doses (maximum 1.5 g/day) for 14 days **OR** Cefuroxime, 30 mg/kg per day, orally, in 2 divided doses (maximum 1 g/day) for 14 days **OR,** for a patient unable to take a beta-lactam or doxycycline, Azithromycin, 10 mg/kg/day, orally, once daily for 7 days
Isolated facial palsy	Doxycycline, 4.4 mg/kg per day, orally, divided into 2 doses (maximum 200 mg/day), for 14 days[a]
Arthritis	An oral agent as for early localized disease, for 28 days[b]
Persistent arthritis after first course of therapy	Retreat using an oral agent as for first-episode arthritis for 28 days[b] **OR** Ceftriaxone sodium, 50–75 mg/kg, IV, once a day (maximum 2 g/day) for 14–28 days
Atrioventricular heart block or carditis	An oral agent as for early localized disease, for 14 days (range 14–21 days) **OR** Ceftriaxone sodium, 50–75 mg/kg, IV, once a day (maximum 2 g/day) for 14 days (range 14–21 days for a hospitalized patient); oral therapy (using an agent as for early localized disease) can be substituted when the patient is stabilized or discharged, to complete the 14- to 21-day course
Meningitis	Doxycycline, 4.4 mg/kg per day, orally, divided into 1 or 2 doses (maximum 200 mg/day) for 14 days **OR** Ceftriaxone sodium, 50–75 mg/kg, IV, once a day (maximum 2 g/day) for 14 days

Reference: RedBook. Report of the Committee on Infectious Diseases. Lyme Disease. 2021-2024 (32nd ed).

IV indicates intravenously.

[a]Corticosteroids should not be given. Use of amoxicillin for facial palsy in children has not been studied. Treatment has no effect on the resolution of facial nerve palsy; its purpose is to prevent late disease.

[b]There are limited safety data on the use of doxycycline for >21 days in children <8 years of age.

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LYME DISEASE TREATMENT (ERYTHEMA MIGRANS)

Referencehttps://www.cdc.gov/lyme/treatment/erythema-migrans-rash.html

Age Category	Drug	Dosage	Maximum	Duration, Days*	References
Adults	Doxycycline OR	100 mg, twice per day orally	N/A	10-14	1 – 6
	Amoxicillin OR	500 mg, three times per day orally	N/A	14	1, 3, 6
	Cefuroxime	500 mg, twice per day orally	N/A	14	6, 10, 11
Children	Doxycycline OR	4.4 mg/kg per day orally, divided into 2 doses	100 mg per dose	10–14	7,9
	Amoxicillin OR	50 mg/kg per day orally, divided into 3 doses	500 mg per dose	14	7,8
	Cefuroxime	30 mg/kg per day orally, divided into 2 doses	500 mg per dose	14	8, 10, 11

*When different durations of antibiotics are shown to be effective for the treatment of Lyme disease, the shorter duration is preferred to minimize adverse effects, including infectious diarrhea and antimicrobial resistance.

NOTE: For people intolerant of amoxicillin, doxycycline, and cefuroxime, the macrolide azithromycin may be used, although it is less effective. People treated with azithromycin should be closely monitored to ensure that symptoms resolve.

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DOXYCYCLINE DOGMA RELATED TO PEDIATRIC USAGE

- The CDC recommends “doxycycline as the treatment of choice for children of all ages with suspected tickborne rickettsial disease” noting that “Previous concerns about tooth staining in children aged <8 years stem from older tetracycline-class drugs that bind more readily to calcium than newer members of the drug class, such as doxycycline” [MMWR Recomm Rep. 2016;65(No. RR-2):1-44].

- The 2018 AAP Red Book states that “doxycycline can be used for short durations (ie, 21 days or less) without regard to patient age….”

- Tetracyclines are considered first-line therapy for a number of infections, including those caused by *Rickettsia* (most notably Rocky Mountain spotted fever), *Ehrlichia* and *Anaplasma* spp., as well as for tularemia, brucellosis, cholera, *Chlamydia* genital infections, post-exposure prophylaxis following anthrax exposure and malaria prophylaxis.

- Doxycycline also is used for prophylaxis and treatment of Lyme disease caused by *Borrelia burgdorferi*.

LYME DISEASE CHEMOPROPHYLAXIS

- Recommended in areas of high endemicity = West Virginia
- After a high-risk deer tick bite, defined as an engorged tick that has fed for >72 hours as the risk of infection may be 25% in an area with hyperendemic disease. The risk is extremely low after brief attachment, defined as <36 hours (eg, a flat, non-engorged deer tick is found).
- Benefits of prophylaxis may outweigh risks when the tick is engorged (ie, has been attached for at least 36 hours based on exposure history) and prophylaxis can be started within 72 hours of tick removal.
- Studies of doxycycline prophylaxis have been conducted in adults and older children (≥12 years). In areas of high risk, a single prophylactic 200 mg dose (or 4.4 mg/kg for children weighing less than 45 kg) of doxycycline can be used in children of any age to reduce risk of acquiring Lyme disease after the bite of an infected *I. scapularis* tick.
- Amoxicillin prophylaxis has not been studied sufficiently, but likely would require a longer course than doxycycline because of its shorter half-life and is not recommended.
- There are no clinical data to support antibiotic prophylaxis for anaplasmosis, ehrlichiosis, babesiosis or Rocky Mountain Spotted Fever after tickbite exposure.

LYME DISEASE CHEMOPROPHYLAXIS

- Recommended in areas of high endemicity = West Virginia
- After a high-risk deer tick bite, defined as an engorged tick that has fed for >72 hours as the risk of infection may be 25% in an area with hyperendemic disease. The risk is extremely low after brief attachment, defined as <36 hours (eg, a flat, non-engorged deer tick is found).
- Benefits of prophylaxis may outweigh risks when the tick is engorged (ie, has been attached for at least 36 hours based on exposure history) and prophylaxis can be started within 72 hours of tick removal.
- Studies of doxycycline prophylaxis have been conducted in adults and older children (≥12 years). In areas of high risk, a single prophylactic 200 mg dose (or 4.4 mg/kg for children weighing less than 45 kg) of doxycycline can be used in children of any age to reduce risk of acquiring Lyme disease after the bite of an infected *I. scapularis* tick.
- Amoxicillin prophylaxis has not been studied sufficiently, but likely would require a longer course than doxycycline because of its shorter half-life and is not recommended.
- There are no clinical data to support antibiotic prophylaxis for anaplasmosis, ehrlichiosis, babesiosis or Rocky Mountain Spotted Fever after tickbite exposure.

LYME DISEASE

- Prognosis:
  - Excellent (children) = cure
  - Despite adequate treatment, can get recurrent arthritis that is non-infectious (immune-mediated) = “antibiotic refractory Lyme arthritis”
    - 10-15% develop persistent synovitis that can last for months to years → various theories including missed diagnosis
    - Strongly HLA-associated
    - Initial management: NSAIDs
    - Ongoing management: steroid injections, DMARDs

Reference: RedBook. Report of the Committee on Infectious Diseases. Lyme Disease. 2021-2024 (32nd ed).

Did you know?

True

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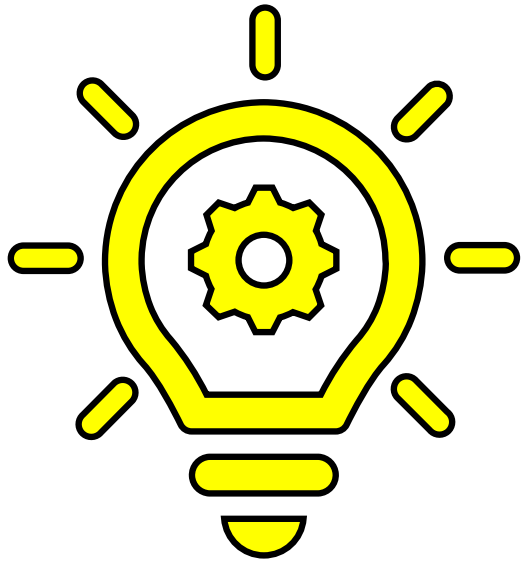

Did you know?

- Those treated with appropriate antimicrobial agents in the early stage of disease rarely develop late manifestations (query compliance, tolerance, etc.).

- No causal relationship between maternal Lyme disease and abnormalities of pregnancy or congenital disease has been documented. Thus, Lyme disease is not thought to produce a congenital infection syndrome.

- No evidence to support Lyme disease transmission via break milk.

- No documented cases of Lyme disease transmission have occurred to date as a result of blood transfusion, but due to potential risk, recommendation is to not donate blood while acutely infected.

- Testing of the tick for spirochete infection has a poor predictive value and is not recommended.

- Lyme disease vaccine licensed by FDA in 1998 (15-70 years of age); withdrawn in 2002 → poor sales, unsubstantiated claims of adverse effects; phase I/II trials of a new vaccine ongoing.

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CONTENT OVERVIEW

- Describe Lyme disease and its impact in West Virginia.
- Explain Lyme disease transmission and appropriate control measures to mitigate exposure.
- State Lyme disease symptoms and management options.
- List/briefly describe other tickborne illnesses impacting West Virginia.

Tickborne diseases by causative organism(s) and presence of tick vectors in West Virginia

Tick-borne Disease	Pathogen(s)	Tick Vector(s) Present in WV
Tularemia	*Franciscella tularensis*	American dog tick (*Dermacentor variabilis*)
		Lone star tick (*Amblyomma americanum*)
Anaplasmosis	*Anaplasma phagocytophilum* ha	Blacklegged tick (*Ixodes scapularis*)
Ehrlichiosis	*Ehrlichia chaffeensis*	Lone star tick (*Amblyomma americanum*)
	Ehrlichia ewingii	Gulf Coast tick (*Amblyomma maculatum*)
	Panola Mountain *Ehrlichia* sp.	Blacklegged tick (*Ixodes scapularis*)
	Ehrlichia muris-like agent	
Lyme disease	*Borrelia burgdorferi*	Blacklegged tick (*Ixodes scapularis*)
	Borrelia mayonii	
Relapsing fever*	*Borrelia miyamotoi*	Blacklegged tick (*Ixodes scapularis*)
Powassan encephalitis*	Powassan virus	Groundhog tick (*Ixodes cookei*)
		Blacklegged tick (*Ixodes scapularis*)
Babesiosis	*Babesia microti*	Blacklegged tick (*Ixodes scapularis*)
	and other *Babesia* spp.	
Rocky Mountain spotted	*Rickettsia rickettsii*	American dog tick (*Dermacentor variabilis*)
fever and other spotted	(and other spotted	Brown dog tick (*Rhipicephalus sanguineus*)
fever rickettsioses	fever group *Rickettsia*)	Lone star tick (*Amblyomma americanum*)
		Gulf Coast tick (*Amblyomma maculatum*)
		Asian longhorned tick (*Haemaphysalis longicornis*)

*Tickborne disease not detected in West Virginia

NOTABLE TICKBORNE DISEASES REFERENCES

STATEWIDE

HTTPS://OEPS.WV.GOV/ZOONOTIC/PAGES/DEFAULT.ASPX

HTTPS://OEPS.WV.GOV/ARBOVIRAL/PAGES/TBD.ASPX

HTTPS://OEPS.WV.GOV/LYME/PAGES/DEFAULT.ASPX

HTTPS://OEPS.WV.GOV/ARBOVIRAL/PAGES/DEFAULT.ASPX

NATIONAL

HTTPS://WWW.CDC.GOV/TICKS/TICKBORNEDISEASES/INDEX.HTML

HTTPS://PUBLICATIONS.AAP.ORG/REDBOOK?AUTOLOGINCHECK=REDIRECTED

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MANY THANKS!

ALL INQUIRIES WELCOMED

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