

## What Wisconsin School Nurses Should Know About Vector-borne Diseases

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## Disclosure

- *I have nothing to disclose...Dr. Xia Lee*
- *I disclose that I have a consulting relationship with the Household & Commercial Products Association, Washington. We never discuss products or brands in our healthcare provider vector-borne disease educational programs....Judi Anderson*

### Learning Objectives

- Learners will understand when and where students are at risk for contracting vector-borne diseases
- Learners will be able to identify key symptoms of vector-borne diseases and counsel students and their families as appropriate
- Learners will understand the importance of prevention and how best to communicate prevention strategies to students, parents, and other stakeholders

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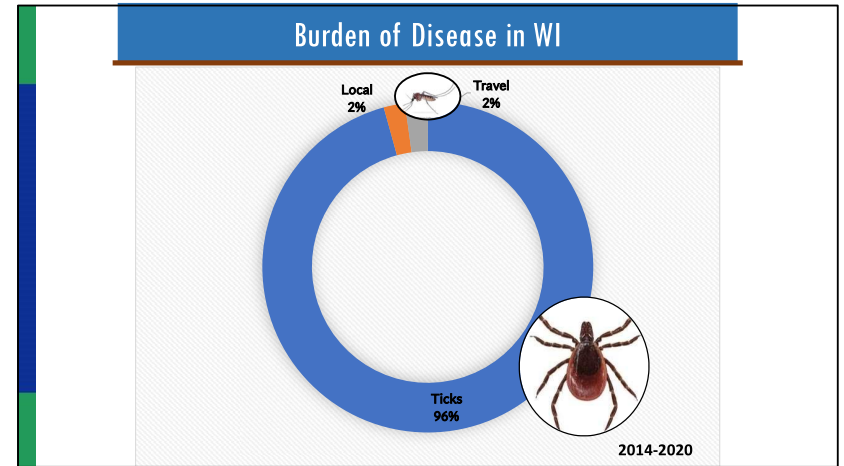
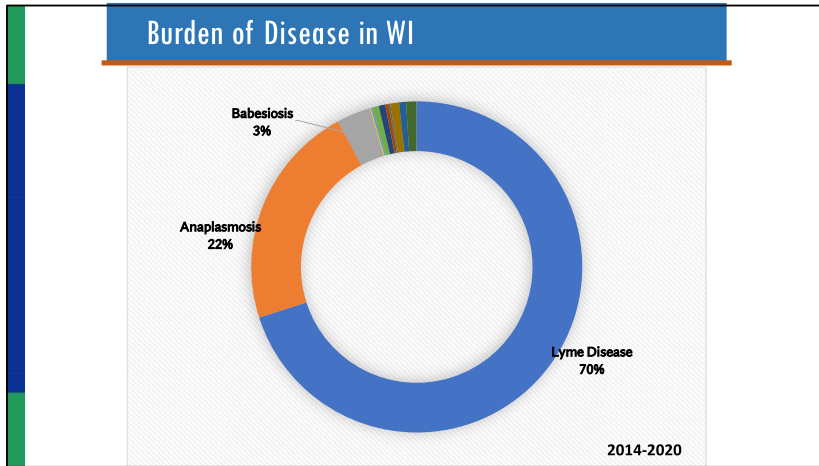
### Reportable Diseases in WI

- Lyme disease
  - Anaplasmosis/Ehrlichiosis
  - Spotted fever rickettsiosis
  - Babesiosis
  - Tularemia
  - Powassan virus
  - Tick-borne relapsing Fever
- 
- Dengue viruses
  - Zika virus
  - Chikungunya
  - La Crosse encephalitis
  - Jamestown Canyon virus
  - Malaria
  - WNV
  - St. Louis encephalitis virus
  - Eastern equine encephalitis virus

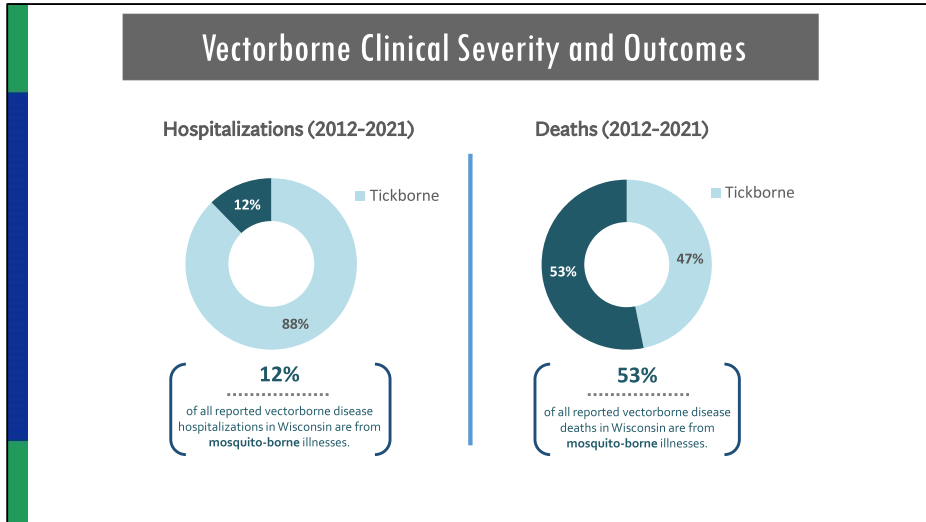


Ixodes female (Image source: Xia Lee)

Mosquito against dark (Image source: Shutterstock ID 200494427)




Tick Image source: Encyclopedia Britannica, Inc.  
<https://www.britannica.com/animal/deer-tick>




### Mosquitoes that may have stolen your blood!

56 recorded species of mosquitoes



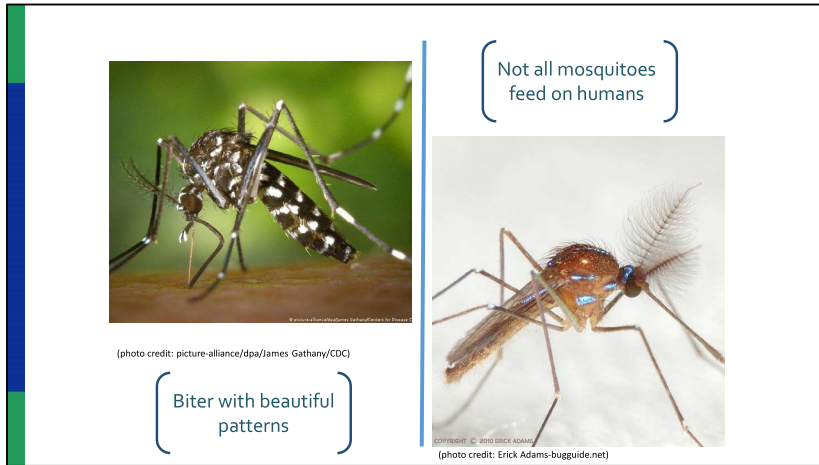
(photo credit: John R. Maxwell-bugguide.net)



(photo credit: Keshava Mysore-bugguide.net)

Aedes vexans (Image source: John R. Maxwell-bugguide.net)

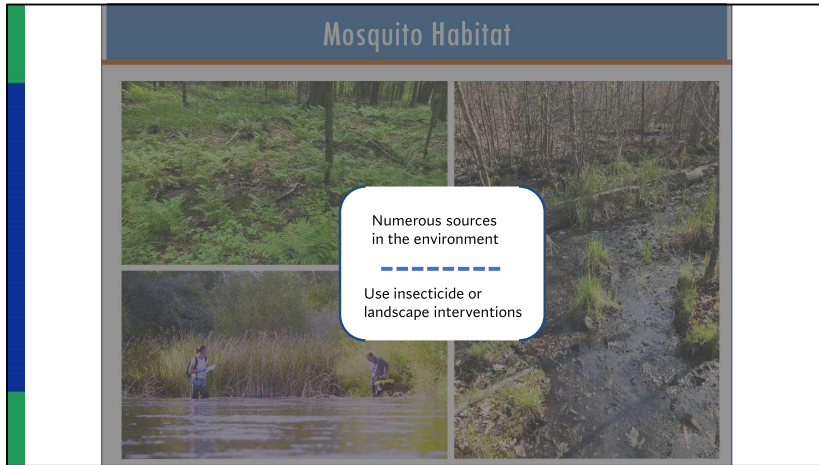
Culex pipiens (Image source: Keshava Mysore-bugguide.net)



Aedes japonicus (Image source: picture-alliance/dpa/James Gathany/CDC)  
Uranotenia sapphirina (Image source: Erick Adams-bugguide.net)



Pool in woods (Image source: Xia Lee)  
Wet woods (Image source: Brad Tucker)  
Man and woman wanders in pond (Image source: Shutterstock ID1185821641)



Pool in woods (Image source: Xia Lee)

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Man and woman wanders in pond (Image source: Shutterstock ID1185821641)



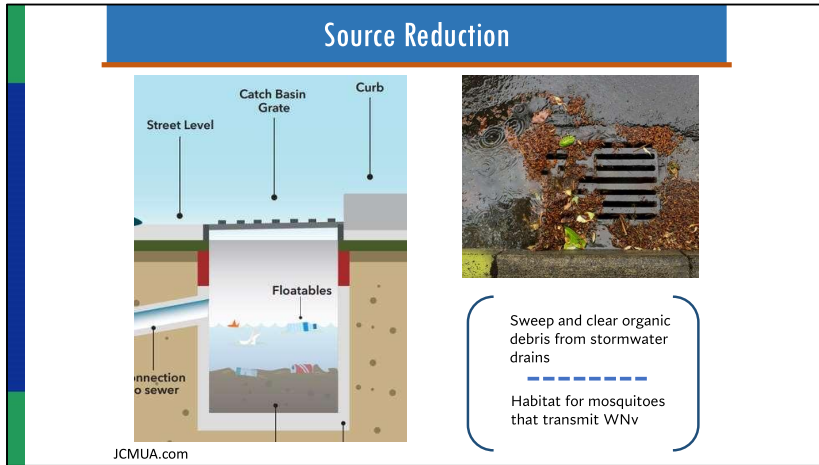
Rain garden (Image source: romi.gov)



Potted-plants-shelves (Image source: Shutterstock ID 393166255)  
Birdbath (Image source: Shutterstock ID 88318048)  
Catch basin (Image source: Xia Lee)



Potted-plants-shelves (Image source: Shutterstock ID 393166255)  
Birdbath (Image source: Shutterstock ID 88318048)  
Catch basin (Image source: Xia Lee)



Catch basin (Image source: nyc.gov)



Image source: Xia Lee



### Ticks of Wisconsin

16 different hard tick species

- *Ixodes scapularis*
- *I. marxi*
- *I. brunneus*
- *I. cookei*
- *I. muris*
- *I. dentatus*
- *I. texanus*
- *I. angustus*
- *I. banksi*
- *I. sculptus*
  
- *Dermacentor variabilis*
- *D. albipictus*

- *Haemaphysalis leporispalustris*
- *H. chordeilis*
- *Amblyomma americanum*
- *Rhipicephalus sanguineus*

<http://labs.russell.wisc.edu/wisconsin-ticks/>

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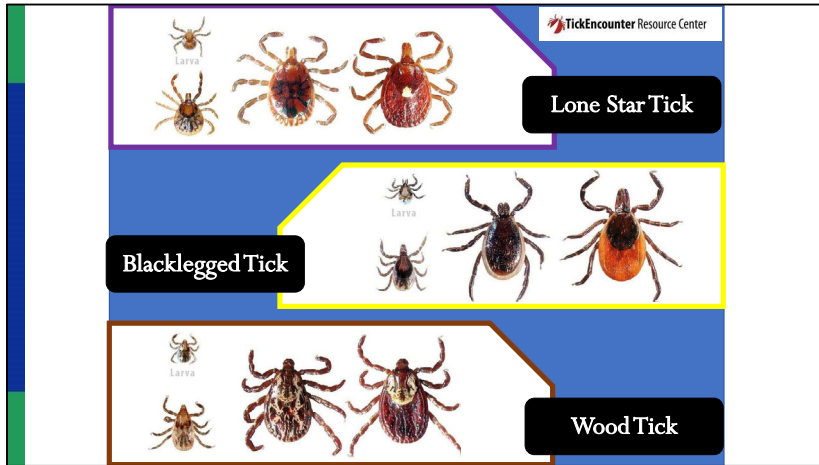


Image Source: TickEncounters

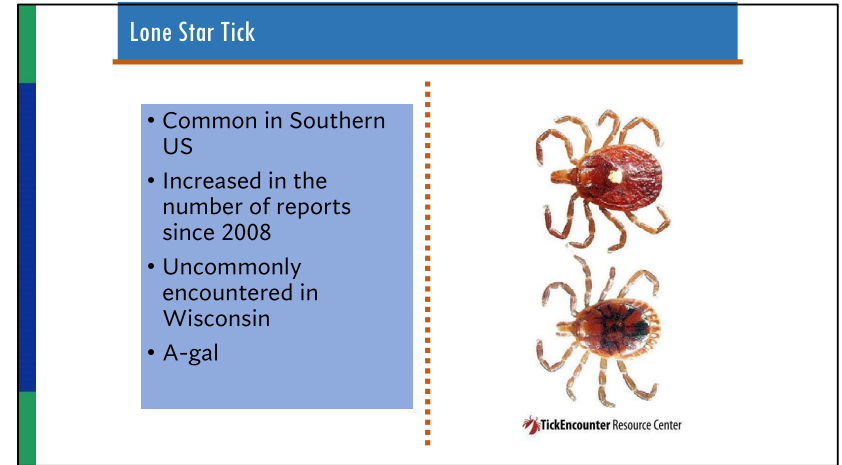
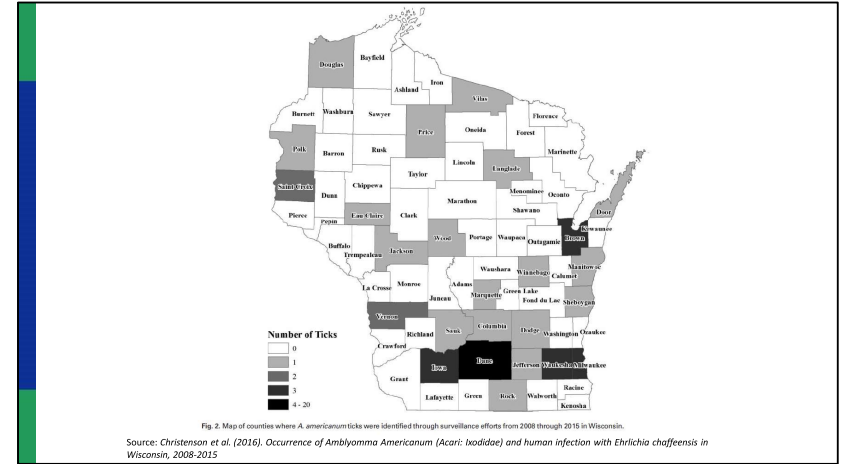


Image Source: TickEncounters




Image Sources: CDC map



### American Dog Tick

- Can transmit
  - Rocky Mountain Spotted Fever
  - Tularemia
- Diseases not commonly found in Wisconsin
- More of a pest/nuisance



TickEncounter

Image Source: TickEncounters



Image Sources: CDC map  
Dermacentor (Image source: Xia Lee)

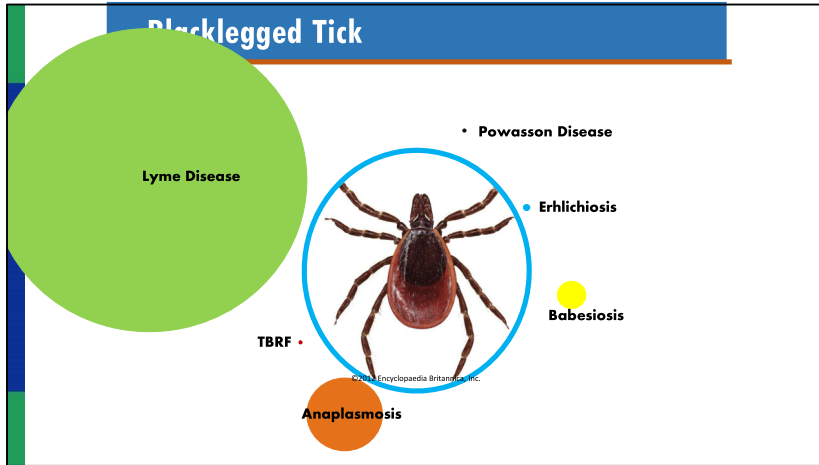


Image Source: Encyclopedia Britannica, Inc.  
<https://www.britannica.com/animal/deer-tick>

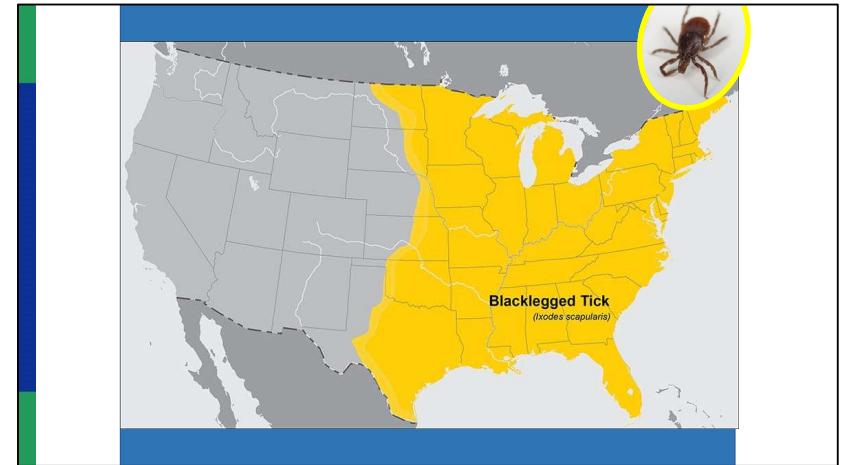


Image Sources: CDC map, Xia Lee

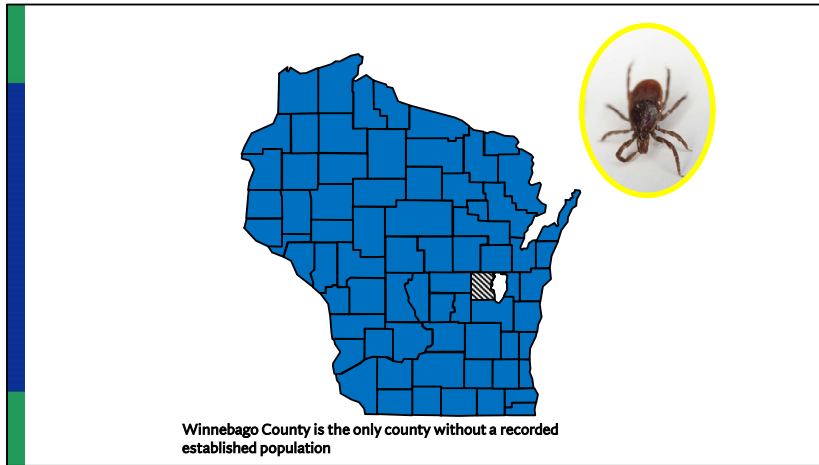
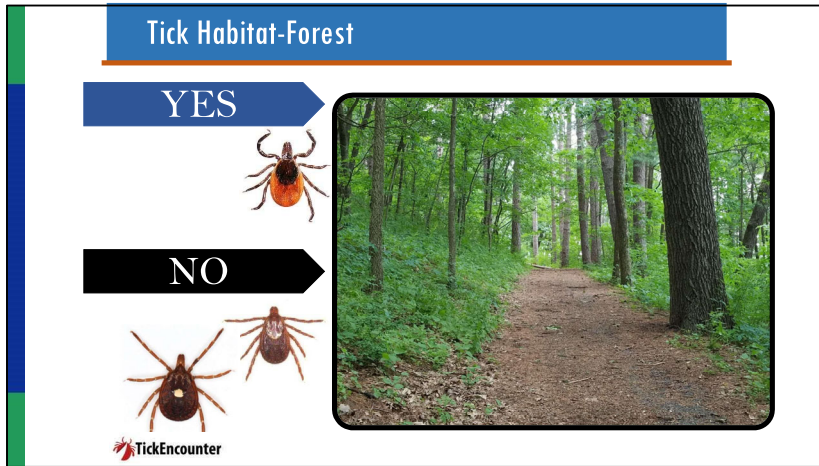


Image Source: Xia Lee



Road (Image source: Shutterstock ID 517961089)  
Ticks (Image source: TickEncounters)



Ticks (Image source: Tick Encounter)  
Pine needle path (Image source: Xia Lee)

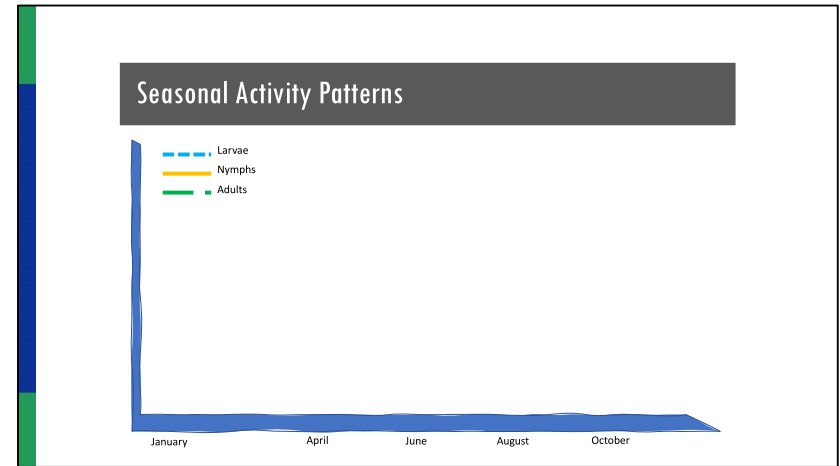


Image: Xia Lee

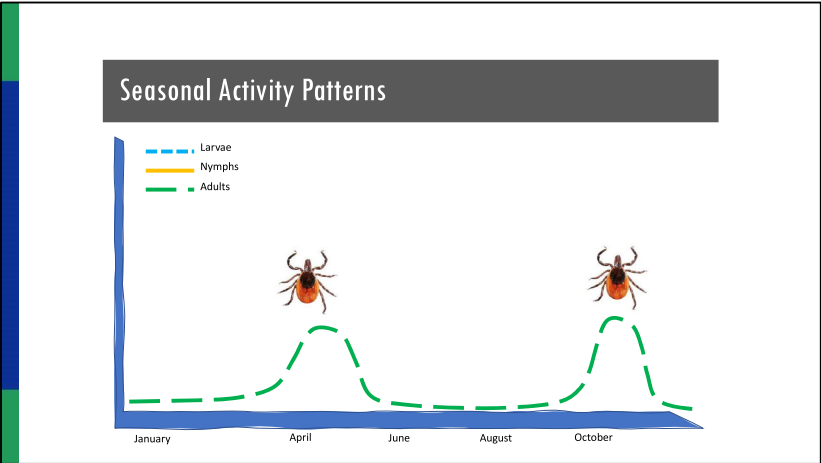


Image: Xia Lee

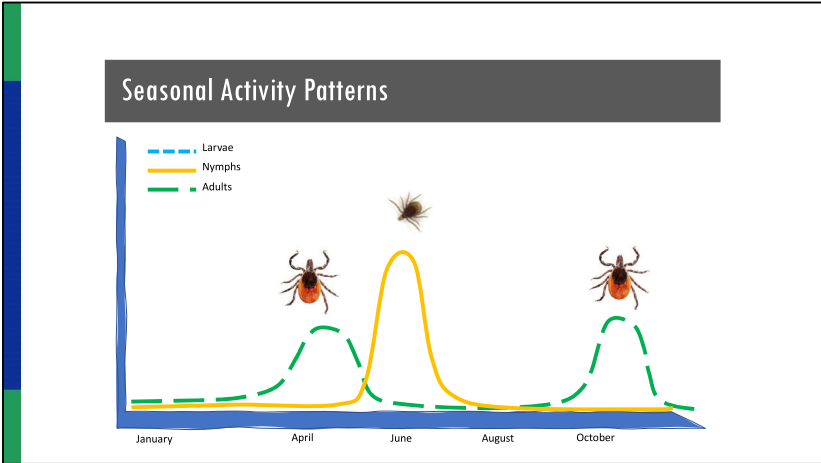


Image: Xia Lee



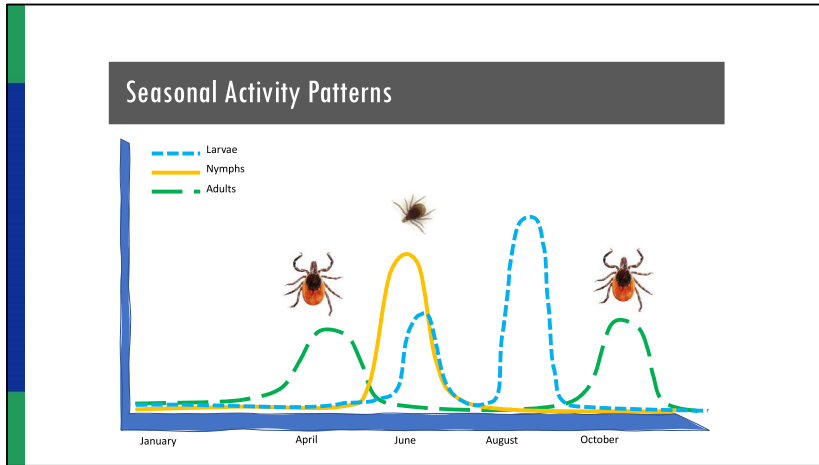
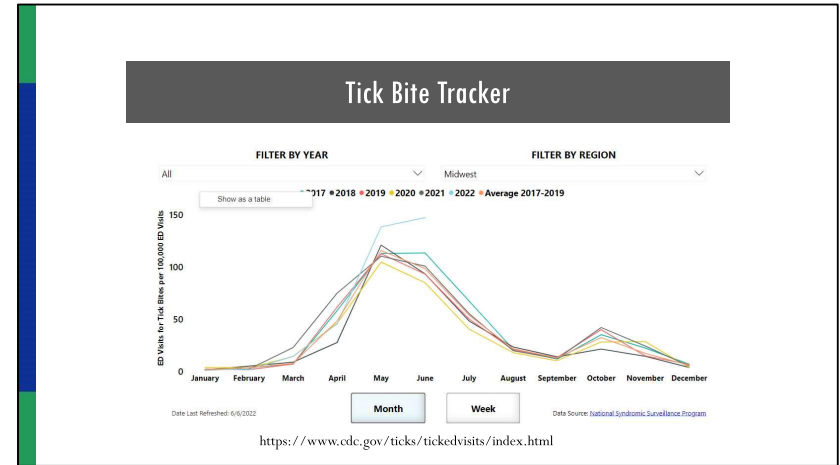
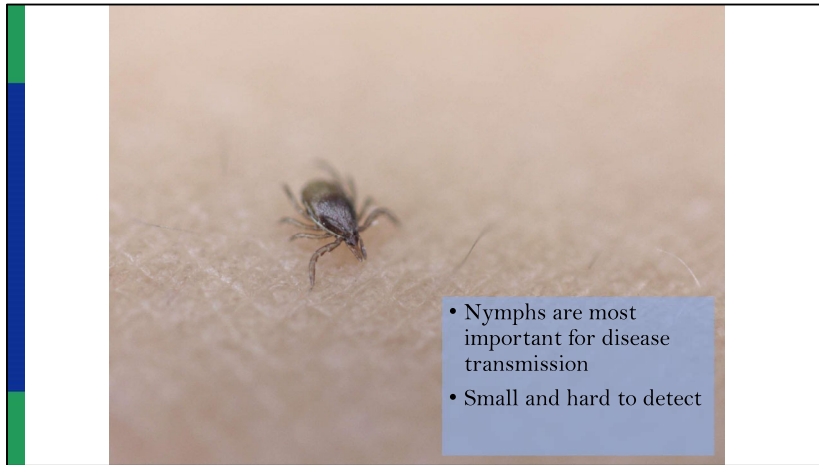


Image: Xia Lee





Nymphal ixodes (Image Source: Xia Lee)

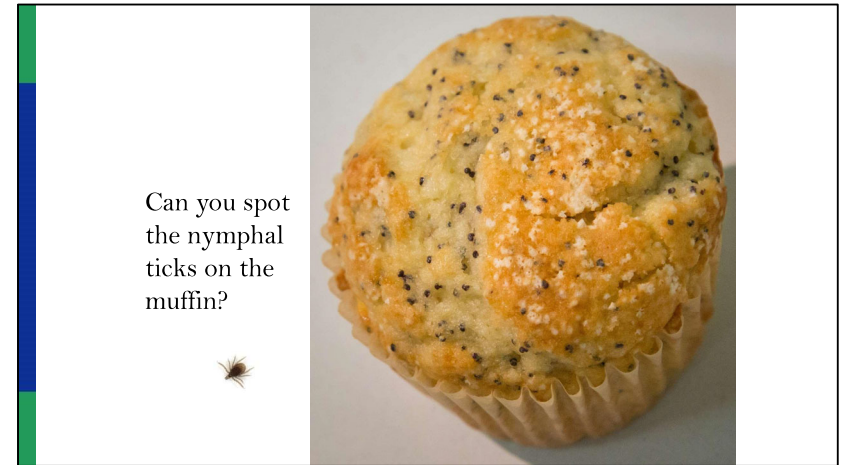


Image Source: CDC

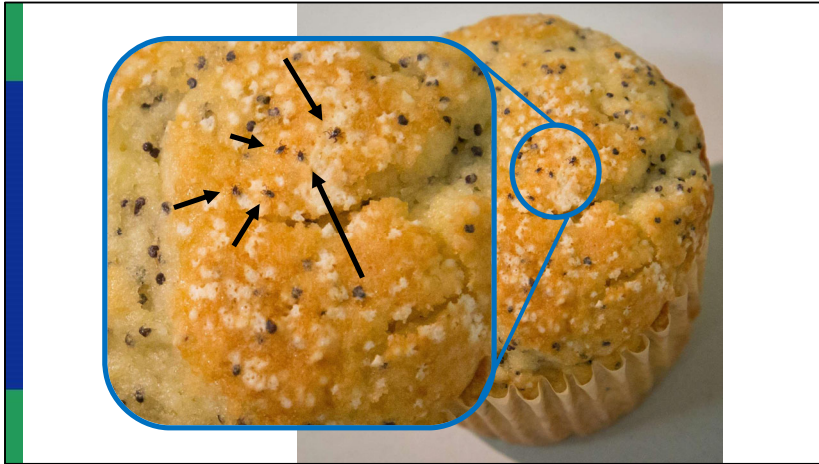
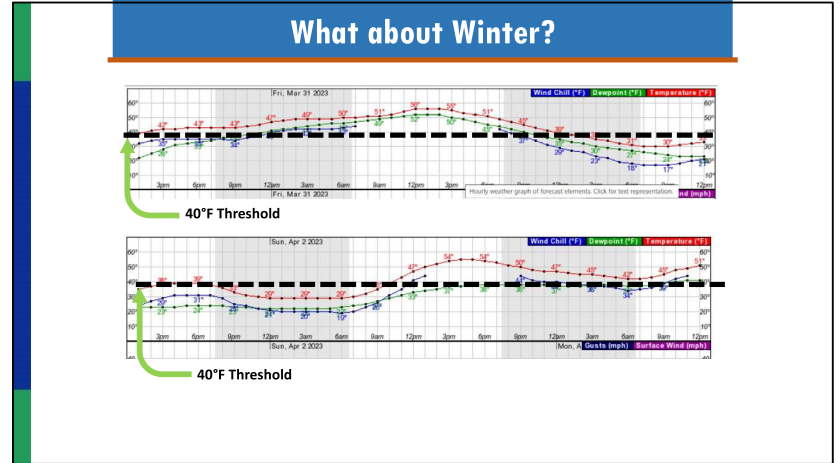
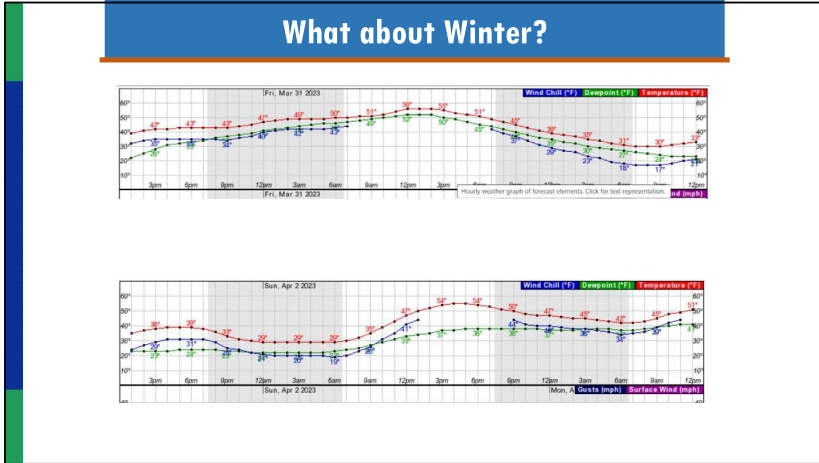


Image Source: CDC



Image Source: Shutterstock 284559365



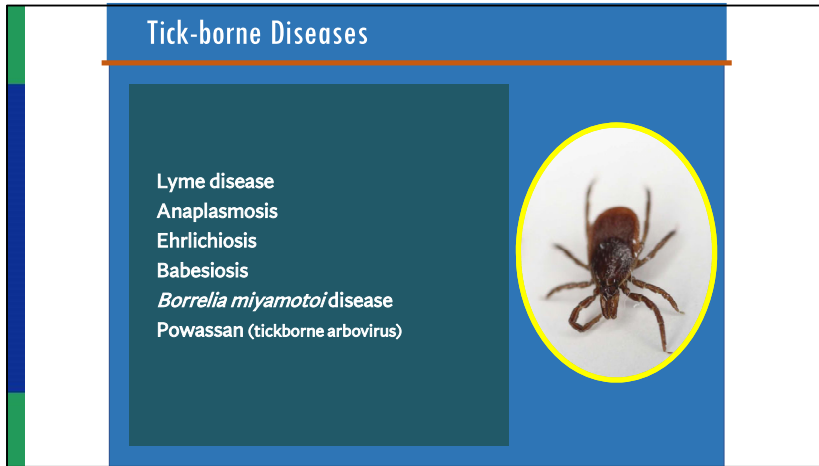
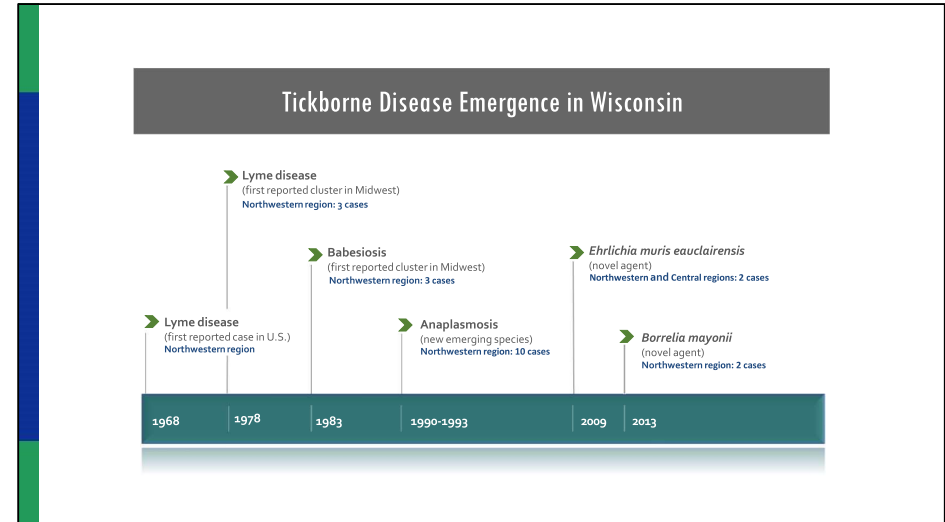


Image Source: Shutterstock 167710664



In addition to being a hotspot for common tickborne disease, Wisconsin has an interesting history of serving as a sort of incubator for emerging tickborne pathogens.

In fact, The first documented case of erythema migrans (or EM rash) in the US was identified in 1968 in Taylor Co. Wisconsin. Followed by the recognition of Lyme disease in 1975 through a cluster of cases identified in the towns of Lyme and Old Lyme Connecticut (which gave the disease its name). The first reported cluster of Lyme disease cases in the Midwest were identified in Barron Co. Wisconsin in 1978. In the 1980s and 90s both Babesiosis and Anaplasmosis emerged in the northwestern region of Wisconsin. In 2009, a novel agent causing Ehrlichiosis was identified in Burnett and Eau Claire counties. You'll notice that these developments were all located in the northwestern part of the state near the shared Minnesota border.

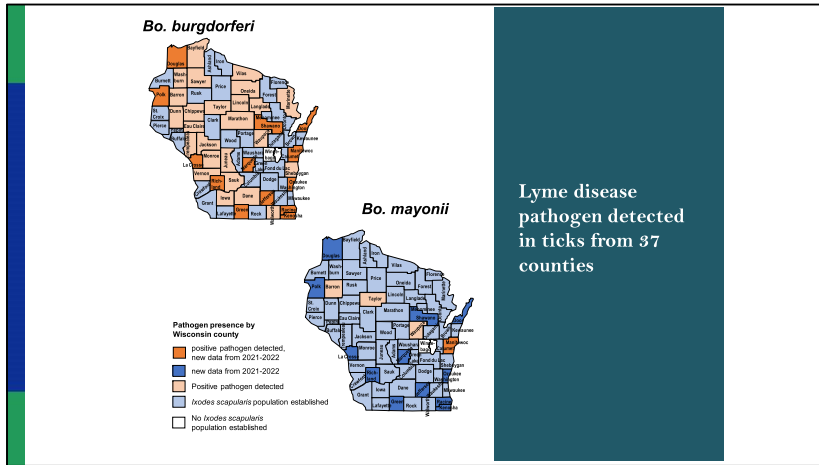


Image Source: Xia Lee



Recreational risk is the old dogma

Image Source: Xia Lee



Peridomestic Risk-Your own backyard!

Image Source: Shutterstock 101933104, Xia Lee

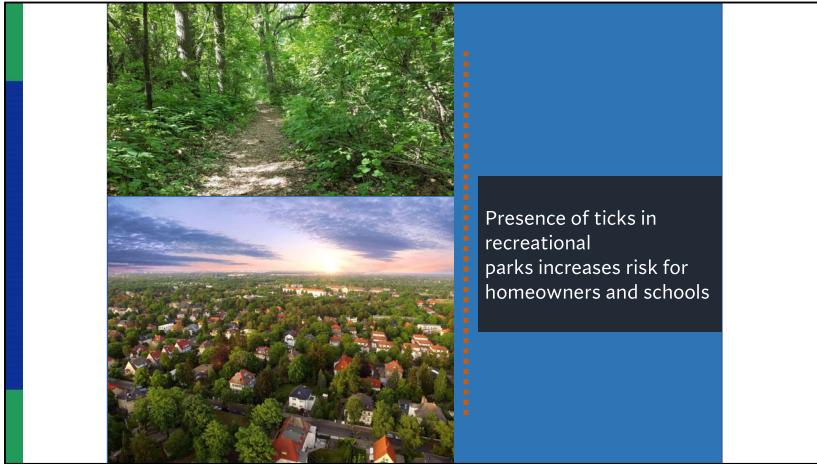


Image Source: Xia Lee, Shutterstock 425561311 (homes)



Image Source: Shutterstock 1021909885



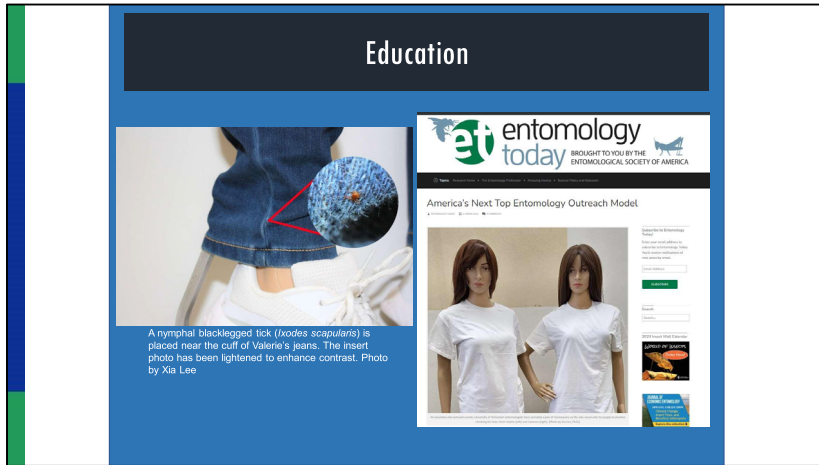


Image source: Xia Lee



Image source: Xia Lee

## Ticks: “The Swiss Army knife of disease vectors”

(National Academy of Sciences)

- More than 90% of nationally notifiable vector borne diseases are linked to ticks\*
- 14 newly recognized TBD have been identified in the last 25 years
- Around since the Jurassic era
- Are opportunistic
- Survive frigid climates
- Don't fall from trees
- **MOST BITES HAPPEN IN OR NEAR YOUR students' OWN YARDS**



\*England Journal of Medicine Bracing for the Worst — Range Expansion of the Lone Star Tick in the Northeastern U.S. DNews 5, 2019

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The tick shown here in amber is from the Jurassic era...a testament to the durability of this dangerous vector.

Rochlin, I. and Toledo, A (2020) Emerging tick-borne pathogens of public health importance: a mini-review. *Journal of Medical Microbiology*, Pathogens transmitted by ticks are responsible for the majority of the vector-borne diseases in temperate North America, Europe and Asia.

Rosenberg et al. (2018) Vital Signs, Trends in Reported Vector borne Disease Cases-US and Territories 2004-2016 *MMWR Morb Mortal Wkly Rep*.

Eisen, L. (2020) Stemming the Rising Tide of Human-Biting Ticks and tickborne Diseases. *Emerg. Infect Dis*; 26(4) Ticks and tick-borne diseases are increasingly problematic. The issues are increasing complex with multiple tick species and more than 10 notable pathogens, with tick species more spatially diffuse including backyards, greens paces and public recreation areas.. Shade and moist habitats and spring early-summer exposures.

Karim et al. (2021) Recent advances in understanding tick and rickettsiae interactions. *Parasite Immunol*. 2021 Mar. Ticks are a major public health threat. Various tick species can transmit 20 emerging and resurgent agents, all capable of causing significant diseases in humans.

## Reported Wisconsin Tick-borne Disease Cases

Tick-borne Disease	2020	2021	2022
Lyme	3,076	4,863	n/a
Babesiosis	58	771	480
Anaplasmosis	335	773	35
Ehrlichiosis	17	33	33
Powassan	4	3	7
Tularemia	2	5	0
Spotted fever rickettsiosis*	3	n/a	n/a

Source: Centers for Disease Control and Prevention and WI Dept of Health Services 52

Case counts: Centers for Disease Control and Prevention. National Notifiable Diseases Surveillance System, Weekly Tables of Infectious Disease Data. Atlanta, GA. CDC Division of Health Informatics and Surveillance. Available at: <https://www.cdc.gov/nndss/data-statistics/index.html> and WI Dept of Health <https://dhs.wisconsin.gov/tick/index.htm>

### Anaplasmosis and ehrlichiosis are under diagnosed.

Dixon, D.M., Branda, J.A., Clark, S> H., Dumler, J.S. Horowitz, H.W., Perdue, S.S., Pritt, B.S., Sexton, D.J., Storch, G.A., & Walker, D.H. (2021) Ehrlichiosis and anaplasmosis subcommittee report to the Tick-borne Disease Working Group. *Ticks and Tick-borne Diseases*, 12(6) 101823. <https://www.sciencedirect.com/science/article/abs/pii/S1877959X2100176X>

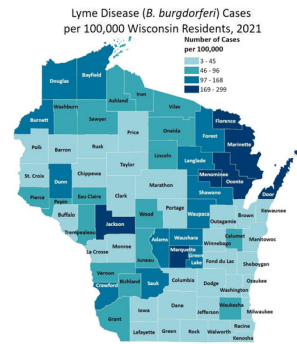
It's important to note that tick-borne diseases tend to be regional. Ticks don't thrive in the desert, but do well in very cold climates, at elevations, and elsewhere. Estimates by the CDC are that Lyme cases are SIGNIFICANTLY higher than are reported in the states where it is endemic.

## Lyme Disease

- Lyme is the #1 vector-borne disease in the U.S. and in Wisconsin
- More than 20% of U.S. cases are children 19 and under
- Some 476,000 U.S. cases annually
  - 10-fold higher than the number of reported cases
  - WI had 4,863 cases in 2021
- Attachment time for transmission = 24-36 hours



Blacklegged (or Deer) Tick



Source: Centers for Disease Control and Prevention and WI Dept of Health Services

\*The number of Lyme disease cases reported in a county does not necessarily represent Lyme disease risk. Data source: Wisconsin Department of Health Services, Division of Public Health, Bureau of Communicable Diseases. Map author: Wisconsin Department of Health Services, Division of Public Health, Bureau of Communicable Diseases.

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More than 20% the cases are in children 19 and under. <https://www.cdc.gov/lyme/datasurveillance/surveillance-data.html>

[https://www.cdc.gov/lyme/datasurveillance/index.html?CDC\\_AA\\_refVal=https%3A%2F%2Fwww.cdc.gov%2Flyme%2Fstats%2Findex.html](https://www.cdc.gov/lyme/datasurveillance/index.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Flyme%2Fstats%2Findex.html)

Kugeler, K et al (2021) Estimating the Frequency of Lyme Disease Diagnoses, United States, 2010–2018 *CDC Emerging Infectious Diseases*, [https://wwwnc.cdc.gov/eid/article/27/2/20-2731\\_article](https://wwwnc.cdc.gov/eid/article/27/2/20-2731_article)

Recent insurance claims suggest that approximately 476,000 people may get Lyme disease each year in the U.S. – CDC: <https://www.cdc.gov/lyme/datasurveillance/index.html>

Nigrovic LE et al. (2019) A minority of children diagnosed with Lyme disease recall a preceding tick bite. *Ticks and Tick-borne Diseases*, Volume 10, Issue 3, 2019, Pages 694-696, ISSN 1877-959X,

Bobbe et al. Recent progress in Lyme Disease and Remaining Challenges. Aug 2021 Vo. 8 *Frontiers in Medicine*

Fuchs, S. (2021) Tick-borne Infections CME Review Article *Pediatric Emergency Care* Vol 37(22) Nov 2021 Many children and/or parents may not realize a tick bite occurred. The geographic region and time of the year along with signs and symptoms often provide sufficient information (for diagnosis).

Lantos PM et al. (2021) [Clinical Practice Guidelines by the Infectious Diseases Society of America \(IDSA\), American Academy of Neurology \(AAN\), and American College of Rheumatology \(ACR\): 2020 Guidelines for the Prevention, Diagnosis and Treatment of Lyme Disease](#). *Clinical Infectious Diseases*, Volume 72, Issue 1, 1 January 2021. This [is an] evidence-based **clinical practice guideline for the prevention, diagnosis, and treatment of Lyme disease** The target audience...includes primary care physicians and specialists caring for this condition such as infectious diseases specialists, emergency physicians, internists, pediatricians, family physicians, neurologists, rheumatologists, cardiologists, and dermatologists

Duration of attachment of a single infected nymphal *I. scapularis* tick required for transmission...for *B. burgdorferi*... is minimal for the first 24 h of attachment, rare up to 48 h, but then increases distinctly by 72 h post attachment.

Dolan et al. (2017) Transmission of the Lyme Disease spirochete *Borrelia mayonii* in relation to duration of attachment by nymphal *Ixodes scapularis*. *Journal of Medical Entomology* 2017 Sep 54(5) 1360-64.

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## Lyme Disease

- Symptom onset 3 - 30 days
- Bull's eye rash occurs in 70-80% of cases
  - Can appear anywhere on the body
  - Expands over several days up to 11" in diameter
  - Warm, painless, doesn't itch
  - Not always a "classic" erythema migrans rash
  - Multiple rashes may appear
  - The most common manifestation in children
- Arthritis is the second most common clinical presentation
  - 67% of kids with arthritis



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Neurologic manifestations occur in 12.5% of confirmed cases.

- Facial nerve palsy is the most common of these, occurring in 8.4% of cases.
- May be accompanied by other symptoms including erythema migrans, malaise, and jaw joint dysfunction..

Lantos PM et al. [Clinical Practice Guidelines by the Infectious Diseases Society of America \(IDSA\), American Academy of Neurology \(AAN\), and American College of Rheumatology \(ACR\): 2020 Guidelines for the Prevention, Diagnosis and Treatment of Lyme Disease](#). *Clinical Infectious Diseases*, Volume 72, Issue 1, 1 January 2021.

Ogden, N.H. et al. (2022). Lyme disease in children: Data from the Canadian Paediatric Surveillance Program. [Ticks and Tick-borne Diseases](#), Volume 11, Issue 2, March 2020, 101347.

Bobbe JR et al. (2021) [Recent Progress in Lyme Disease and Remaining Challenges](#). *Frontiers in Medicine* August 2021, Volume 8, 666554.

The blacklegged tick is responsible for 90% of all reported tick-borne diseases in humans

Yuan et al. (2020) Active surveillance of pathogens from ticks collected in NY State suburban parks and schoolyards. *Zoonoses Public Health* 2020 67: 684-696.

The western black-legged tick (*Ixodes pacificus*) is the most frequently identified human-biting tick species in the western United States and the principal vector of at least three recognized bacterial pathogens of humans.

Paddock, D.C. et al. (2022). Detection and Isolation of *Rickettsia tillamookensis* (Rickettsiales: Rickettsiaceae) From *Ixodes pacificus* (Acari: Ixodidae) From Multiple Regions of California. *Journal of Medical Entomology* Apr 25 2022.

Rochlin, I. and Toledo, A. (2020) Emerging tick-borne pathogens of public health importance: a mini-review. *Journal of Medical Microbiology*, June 2020

McCarthy, C et al. (2022) Lyme Diseases in Children. *Infect Dis Clin N Am* 36 593-603 [https://www.id.theclinics.com/article/S0891-5520\(22\)00032-0/fulltext](https://www.id.theclinics.com/article/S0891-5520(22)00032-0/fulltext)

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## Atypical Lyme Erythema Migrans

Variable	Patients, n (%)
<b>Morphologic characteristics</b>	
<b>Predominant pattern</b>	
Homogeneous	56 (59)
Central erythema	30 (32)
Central clearing	9 (9)
Punctum present	29 (31)
Vesicular or ulcerated	7 (7)
Blue center	2 (2)
<b>Total</b>	<b>95 (100)</b>

\*Smith RP et al. Ann Intern Med 2002

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\*History of a tick bite, clinical manifestations, and presence or absence of a response to LD treatment are ... helpful. -Don Walter Kannangara and Pritiben Patel. *Vector-Borne and Zoonotic Diseases*. Dec 2018.641-652. <http://doi.org/10.1089/vbz.2018.2278>

Lyme Diseases in Children. McCarthy, C et al. *Infect Dis Clin N Am* 36(2022) 593-603

- “The typical rash of Lyme disease, erythema migrans, is the most common manifestation of Lyme Disease in children.”

## Babesiosis

**Blacklegged Tick**  
Average Annual Cases of Babesiosis per 100,000 Wisconsin Residents, 2016-2020

- An infection of red blood cells caused by malaria-like parasites
- 2018 – 2022 10,708 U.S. cases reported
  - WI 7<sup>th</sup> highest case count 2018 – 2022 with 364
- Occurs where Lyme is an issue. Can occur as a co-infection
  - 6.5% of the blacklegged ticks in WI are infected
- Transmitted by blacklegged ticks, blood transfusion, congenitally
  - The most common blood transfusion-transmitted pathogen reported in the U.S.
- Transmission peaks in warm months
- Fewer than 5% (2013) are under the age of 18
  - About 40% of children are asymptotically infected compared with about 20% of adults
  - Children have much milder disease, so it's often missed
- U.S. hospitalization rate 50% 2011 - 2015
  - Hospitalization rate 16% among children aged 10–19 years
- Most patients over 50
  - Can be life-threatening esp. for those who are asplenic, immunocompromised, elderly

Source: Centers for Disease Control and Prevention & WI Department of Health Services

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Babesiosis is a malaria-like illness. It is rare and diagnosed by presence of Babesia parasites inside red blood cells. It can be life threatening, particularly for persons who are asplenic, immunocompromised, or elderly. It can be transmitted by blood transfusion.

MMWR Trends in Reported Babesiosis Cases — United States, 2011–2019 Mar 17, 2023

<https://www.cdc.gov/mmwr/volumes/72/wr/mm7211a1.htm>

2011–2015. 7,612 cases in 27 states, 94.5% occurred in seven states [CN, MA, MN, NJ, NY, RI, and WI] Regions in which babesiosis has been endemic for decades (i.e., parts of the Northeast and upper Midwest) accounted for the majority of cases reported for 2011–2015

- Median age 63 years. Hospitalization rates ranged from 16.0% among children aged 10–19 years
- Can be asymptomatic or cause nonspecific influenza-like symptoms. Multiorgan system dysfunction or failure and other potentially life-threatening complications can occur.
- Most human cases in the U.S. are transmitted by *Ixodes scapularis* (blacklegged) ticks. Can be transmitted via blood transfusion or congenitally.
- Hospitalization rates ranged from 16.0% among children aged 10–19 years (16 of 100)
- 70% of patients had symptom onset during June–August. Fever was the most frequently reported clinical manifestation (84.2%), chills (69.5%) thrombocytopenia (68.8)

Kumar, A.; O'Bryan, J.; Krause, P.J. The Global Emergence of Human Babesiosis. *Pathogens* 2021, 10, 1447. <https://doi.org/10.3390/pathogens10111447>

Krause PJ et al *Clinical Practice Guidelines by the Infectious Diseases Society of America (IDSA): 2020 Guideline on Diagnosis and Management of Babesiosis*. *Clinical Infectious Diseases*, Volume 72, Issue 2, 15 January 2021, Pages e49–e64.

Rochlin, I. and Toledo, A. (2020). Emerging tick-borne pathogens of public health importance: a mini-review. *Journal of Medical Microbiology*, June 2020 An emerging tick-borne disease caused by protozoa that share clinical features with malaria parasites.

McCarthy, C et al. (2022) Lyme Diseases in Children. *Infect Dis Clin N Am* 36 593-603 [https://www.id.theclinics.com/article/S0891-5520\(22\)00032-0/fulltext](https://www.id.theclinics.com/article/S0891-5520(22)00032-0/fulltext)

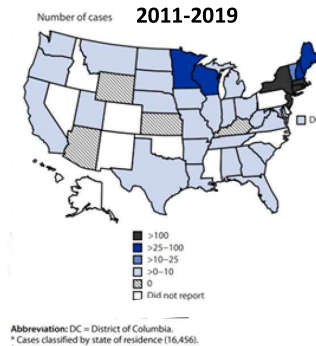
Swanson, M. et al. Trends in Reported Babesiosis Cases — United States, 2011–2019 *MMWR* / March 17, 2023 / Vol. 72 / No. 11. <https://www.cdc.gov/mmwr/volumes/72/wr/pdfs/mm7211a1-H.pdf>

Westwood ML et al Prevalence and coinfection of three tick-borne pathogens in questing adult blacklegged ticks (Vilas County, WI) *Vector-borne and Zoonotic Diseases* 2020

Krause, PJ et al Clinical practice guidelines by IDSA: 2020 Guideline on diagnosis and management of babesiosis. *Clinical Infectious Diseases* 2021:73 (15 Jan) 185

## Babesiosis - Symptoms

- Onset typically June-August
- Underdiagnosed in all age groups
- Symptoms within a week or so after tick bite
- Often nonspecific, flu-like symptoms:
  - Fever, chills
  - Sweats
  - Headache
  - Body aches
  - Loss of appetite
  - Nausea or fatigue
- Symptoms can be severe
  - Can lead to hemolytic anemia, respiratory distress, myocardial infarction, renal failure, hepatic compromise, altered mental status, and death



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Many individuals are asymptomatic. Others have nonspecific flu-like symptoms

- Fever, chills, sweats, headache, body aches, loss of appetite, nausea, or fatigue
- Symptoms can be severe
- It leads to hemolytic anemia and to other complications

Symptoms: [https://www.cdc.gov/parasites/babesiosis/gen\\_info/faqs.html](https://www.cdc.gov/parasites/babesiosis/gen_info/faqs.html)

Those at risk include patients with asplenia, advanced age, and other causes of impaired immune function (e.g., HIV, malignancy, corticosteroid therapy). Some immunosuppressive therapies or conditions may affect the clinical manifestations (e.g., the patient might be afebrile). Severe cases can be associated with marked thrombocytopenia, disseminated intravascular coagulation, hemodynamic instability, acute respiratory distress, myocardial infarction, renal failure, hepatic compromise, altered mental status, and death.

[https://www.cdc.gov/parasites/babesiosis/health\\_professionals/index.html](https://www.cdc.gov/parasites/babesiosis/health_professionals/index.html)

Evan M., Bloch, K., Day, J.R., Krause, P.J., Kjemtrup, A., O'Brien, S.F., Tobian, A.A.R. and Goel, R. (2022). Epidemiology of Hospitalized Patients with Babesiosis, United States, 2010–2016. *Emerging Infectious Diseases*; 28(2):354-362.

*Clinical Infectious Diseases* Clinical Practice Guidelines by the Infectious Diseases Society of America (IDSA): 2020 Guideline on Diagnosis and Management of Babesiosis Jan 15, 2021 ...Guidance for ... effective strategies for the diagnosis and management of babesiosis. ...The target audience ... includes primary care physicians and specialists caring for this condition, such as infectious diseases specialists, emergency physicians, intensivists, internists, pediatricians, hematologists, and transfusion medicine specialists. <https://academic.oup.com/cid/article/72/2/e49/6012666?login=true>

Swanson M, Pickrel A, Williamson J, Montgomery S. Trends in Reported Babesiosis Cases – United States, 2011–2019. *MMWR Morb Mortal Wkly Rep.* Mar 17 2023;72(11):273-277. doi:10.15585/mmwr.mm7211a1

Sam Telford, PHD Tick Talk webinar. 2021

- **Babesiosis 2<sup>nd</sup> most-common blood protozoan in the world**
- Largely asymptomatic. Older people have more serious disease
- The most commonly reported disease in the blood supply

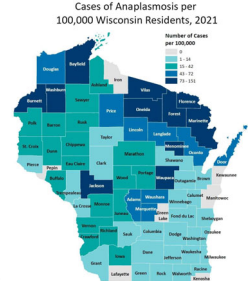
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## Anaplasmosis

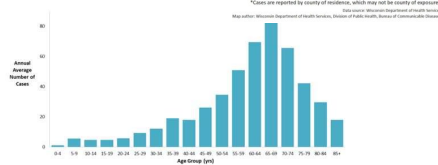
- An emerging public health threat in the U.S. that is under-diagnosed
- 2018-2022: NY, MA, ME, WI, PA account for 72% of cases
  - 18,955 cases reported
  - WI had 2,285 cases
- Can be life-threatening
  - Estimated case fatality of 0.3%
- At highest risk – males, those over 40, those who live near or spend time in known blacklegged tick habitats
- Most cases occur May - August



Blacklegged Tick



Wisconsin 2017-2021 Cases by Age



Source: Centers for Disease Control and Prevention and WI Dept of Health Services

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Case data: Centers for Disease Control and Prevention. National Notifiable Diseases Surveillance System, Weekly Tables of Infectious Disease Data. Atlanta, GA. CDC Division of Health Informatics and Surveillance. Available at: <https://www.cdc.gov/nndss/data-statistics/index.html>.

CDC: <https://www.cdc.gov/anaplasmosis/stats/index.html#geography>

*Ticks and Tick-borne Diseases* Ehrlichiosis and anaplasmosis subcommittee report to the Tick-borne Disease Working Group DOI: <https://doi.org/10.1016/j.ttbdis.2021.101823>

\*\*Anna M Schotthoefer, Matthew C Hall, Satya Vittala, Raza Bajwa, Holly M Frost, Clinical Presentation and Outcomes of Children With Human Granulocytic Anaplasmosis, *Journal of the Pediatric Infectious Diseases Society*, Volume 7, Issue 2, June 2018, Pages e9–e15, <https://doi.org/10.1093/jpids/pix029>

CDC: <https://www.cdc.gov/anaplasmosis/stats/index.html>

[https://www.researchgate.net/publication/7656268\\_Epidemiology\\_of\\_human\\_ehrlichiosis\\_and\\_anaplasmosis\\_in\\_the\\_United\\_States\\_2001-2002](https://www.researchgate.net/publication/7656268_Epidemiology_of_human_ehrlichiosis_and_anaplasmosis_in_the_United_States_2001-2002)

Dixon DM et al. [Ehrlichiosis and anaplasmosis subcommittee report to the Tick-borne Disease Working Group.](https://doi.org/10.1016/j.ttbdis.2021.101823) *Ticks and Tick-borne Diseases* 12 (2021) 101823.

Rochlin, I. and Toledo, A. (2020). Emerging tick-borne pathogens of public health importance: a mini-review. *Journal of Medical Microbiology*, June 2020 <https://www.microbiologyresearch.org/content/journal/jmm/10.1099/jmm.0.001206>

Anaplasmosis attachment time <https://www.health.state.mn.us/diseases/anaplasmosis/basics.html#:~:text=Anaplasmosis%20is%20one%20of%20several,the%20bacteria%20that%20cause%20anaplasmosis.>

McCarthy, C et al. (2022) Lyme Diseases in Children. *Infect Dis Clin N Am* 36 593-603 [https://www.id.theclinics.com/article/S0891-5520\(22\)00032-0/fulltext](https://www.id.theclinics.com/article/S0891-5520(22)00032-0/fulltext)

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## Anaplasmosis -- Symptoms

- Typically begin within 1–2 weeks after the bite of an infected tick
  - **Anaplasmosis typically symptomatic in infected otherwise healthy children**
  - Can cause severe illness if treatment is delayed
    - Advise parents to take student to their healthcare provider
  - Symptoms are non-specific
  - Children often present with stomach pain
  - A higher mortality rate than Lyme
- 
- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li>• <b>Early (1-5 Days)</b></li> <li>• Fever, chills</li> <li>• Severe headache</li> <li>• Muscle aches</li> <li>• Nausea, vomiting, diarrhea, loss of appetite</li> </ul> | <ul style="list-style-type: none"> <li>• <b>Late (5 Days or More)</b></li> <li>• Respiratory failure</li> <li>• Bleeding problems</li> <li>• Organ failure</li> <li>• Death</li> </ul> |
|---|--|

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Symptoms, CDC: <https://www.cdc.gov/anaplasmosis/symptoms/index.html>

Rochlin, I. and Toledo, A. (2020). Emerging tick-borne pathogens of public health importance: a mini-review. *Journal of Medical Microbiology*, June 2020  
<https://www.microbiologyresearch.org/content/journal/jmm/10.1099/jmm.0.001206>

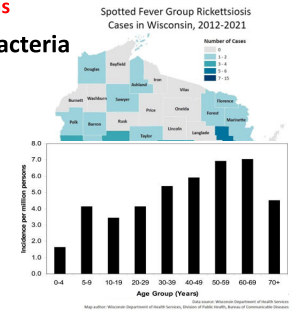
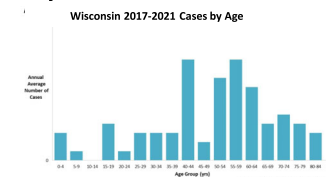
McCarthy, C et al. (2022) Lyme Diseases in Children. *Infect Dis Clin N Am* 36 593-603  
[https://www.id.theclinics.com/article/S0891-5520\(22\)00032-0/fulltext](https://www.id.theclinics.com/article/S0891-5520(22)00032-0/fulltext)

## Spotted Fever Group Rickettsioses

- **2018 – 2019: 10,751 cases reported in the U.S.\*, WI had 3 cases in 2020**
- **Hard to distinguish among the different pathogens**
- **Children <10 years at special risk with Rocky Mountain Spotted Fever**
  - Represent 6% of RMSF diagnoses, but **22% of RMSF deaths**
- **Tick attachment  $\geq 6$  hours required for injection of bacteria**
- **Most cases occur between April – September**
- **Symptom onset 7-14 days after tick bite**



Adult Female  
American Dog Tick



Source: Centers for Disease Control and Prevention & WI Department of Health Services

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\*Centers for Disease Control and Prevention. National Notifiable Diseases Surveillance System, Weekly Tables of Infectious Disease Data. Atlanta, GA. CDC Division of Health Informatics and Surveillance. Available at: <https://www.cdc.gov/nndss/data-statistics/index.html>.

Walker et al. Rickettsiosis subcommittee report to the tick-borne disease working group. *Ticks and Tick-borne Disease* 12 (2022) 101855. 90% of reported cases have onset between April and September...Infection can occur year-round in some areas.

Spotted fever group rickettsioses (spotted fevers) are a group of diseases caused by closely related bacteria spread to people through the bite of infected ticks. The most serious and commonly reported spotted fever group rickettsiosis in the United States is Rocky Mountain spotted fever (RMSF). – CDC: <https://www.cdc.gov/other spotted fever/index.html>

Other causes of spotted fever group rickettsioses (spotted fevers) in the United States include:

- Rickettsia parkeri rickettsiosis, caused by R. parkeri
- Pacific Coast tick fever, caused by Rickettsia species 364D
- Rickettsialpox, caused by Rickettsia akari

Spotted fevers can range from mild to life-threatening. Most people who get sick with a spotted fever other than RMSF will have an eschar (dark scab at the site of tick bite), fever, headache, and rash. Doxycycline is the treatment of choice for all spotted fever infections. – CDC: <https://www.cdc.gov/other spotted fever/index.html>

RMSF can be spread from the female tick to female offspring for up to six generations. (**Vertical transmission – 6 generations=130 quintillion infected ticks from birth.**) If only 10% of the offspring live, that's still a huge number of ticks. Private communication, Wesley Watson, PHD, NC State University.

[Bishop, A. et al. \(2022\). Increasing Incidence of Spotted Fever Group Rickettsioses in the United States, 2010–2018. Vector-Borne And Zoonotic Diseases, 2022 Sep;22\(9\):491-497.](#)

Gottlieb M, Long B, Koyfman (2018) The Evaluation and Management of Rocky Mountain Spotted Fever in the Emergency Department: a Review of the Literature. *Journal of Emergency Medicine*, 55(1):42-50. [https://www.jem-journal.com/article/S0736-4679\(18\)30230-0/fulltext](https://www.jem-journal.com/article/S0736-4679(18)30230-0/fulltext)

Waked, R., Krause, P.J. (2022) Human Babesiosis. *Infectious Disease Clinics*, 36:655–670. [https://www.id.theclinics.com/article/S0891-5520\(22\)00030-7/fulltext](https://www.id.theclinics.com/article/S0891-5520(22)00030-7/fulltext)

Bishop, A., Borski, J., Wang, H.H., Donaldson, T.G., Michalk, A., Montgomery, A., Heldman, S., Mogg, M., Derouen, Z., Grant, W.E., Teel, P.D.. (2022). [Increasing Incidence of Spotted Fever Group Rickettsioses in the United States, 2010–2018. Vector Borne Zoonotic Dis. 2022 Sep;22\(9\):491-497. doi: 10.1089/vbz.2022.0021.](#)

## RMSF Symptoms

- Early signs/symptoms not specific to RMSF (including fever and headache)
- Rapid progression to serious, life-threatening illness if treatment is not started promptly
- Symptoms may include:
  - Fever
  - Headache
  - Rash
  - Nausea, Vomiting
  - Stomach pain
  - Muscle pain
  - Lack of appetite
- Children report nausea, vomiting, loss of appetite, and rash
  - Are less likely to report headache
  - Abdominal pain, altered mental status
  - Edema involving the dorsum of the hands or around the eyes
- **“If you don’t treat by Day 5, they may be DEAD by Day 8”—CDC MD**
- Laboratory diagnostics are usually ineffective for establishing an acute diagnosis

Source: Centers for Disease Control and Prevention

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This family of diseases is widespread in the U.S. The most serious and commonly reported spotted fever group rickettsiosis in the United States is [Rocky Mountain spotted fever \(RMSF\)](#). This group also includes *R. parkeri* rickettsiosis, Pacific Coast Tick fever, and rickettsial pox. These are less severe than RMSF <https://www.cdc.gov/rmsf/>

Diagnosis can be challenging even in areas with more frequent RMSF, as the clinical presentation can resemble that of many other infectious and non-infectious conditions. Can occur in urban areas. Many patients will not have the classic rash progression...Salje J, et al. (2021) Rickettsial infections: A blind spot in our view of neglected tropical diseases. *PLoS Negl Trop Dis* 15(5): e0009353. <https://doi.org/10.1371/journal.pntd.0009353>

Rhodes, SD, et al. (2020) Brain death secondary to RMSF Encephalitis. *Case Reports in Critical Care* Vol 2020.

Soto RA, Hughes ML, Staples JE, Lindsey NP. West Nile Virus and Other Domestic Nationally Notifiable Arboviral Diseases - United States, 2020. *MMWR Morb Mortal Wkly Rep.* 2022 May 6;71(18):628-632.

Spotted fevers can range from mild to life-threatening. Most people who get sick with a spotted fever other than RMSF will have an eschar (dark scab at the site of tick or mite bite), fever, headache, and rash. Doxycycline is the treatment of choice for all spotted fever infections. – CDC: <https://www.cdc.gov/otherspottedfever/index.html>

Knowledge and awareness of laboratory diagnostics and appropriate treatment by many physicians is lacking. Diagnosis based on clinical manifestations early in the course of illness is difficult. Rickettsial diseases have varied signs, symptoms and severity which often make them difficult to distinguish from other infections. **There is low awareness of rickettsial disease by physicians.** Current diagnostic tests for rickettsioses have many limitations.. The clinical diagnosis of RMSF is hampered by appearance of rash that may not appear until two-five days after onset of fever...Symptoms may mimic a variety of other syndromes. The highest incidences of human infection...occurs in the so-called RMSF belt (NC to OK). Sporadic cases of SFR occur throughout the continental US and clinicians in areas of low endemicity may be less familiar with the presentation.. Atypical presentations (acute abdomen and meningoencephalitis) are not infrequent. Walker et al. (2022). Rickettsiosis subcommittee report to the tick-borne disease working group. *Ticks and Tick-borne Disease* 12 101855

Jibbe, A., Neill, B., & Tolkachjov, S. (2021). Rocky Mountain Spotted Fever Misdiagnosed as an Acute Drug Reaction: Diagnostic Clues and Evaluation Recommendations: Rocky Mountain Spotted Fever. *Kansas Journal of Medicine*, 14(2), 186–187. <https://doi.org/10.17161/kjm.vol1415223>

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## RMSF Rash

Early (day 2-4)



Late (>day 4)



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Rash is not always present, especially in children, so don't rely on that for a definitive diagnosis. By the time "late" rashes show up, it may be too late to save the student.

### Symptoms:

- Fever and chills
- The spotted rash can occur earlier in children than in adults, usually a few days after the fever begins. Rash is absent or atypical in up to 20% of cases. Appears on palms and soles of feet 30% of the time. May cover entire body late in the progression of illness.
- Myalgia (calf and back pain is common)
- Headache in 60%, often severe. Younger children are less likely to report headache – be sure to ask them.
- Sore throat, cough, difficulty breathing
- Stomach pain, nausea, vomiting, diarrhea, loss of appetite
- Altered mental status

CDC: <https://www.cdc.gov/rmsf/symptoms/index.html>

Symptoms typically begin 2-14 days after the bite of an infected tick. About half of those who develop RMSF do not remember being bitten. Children ages 0-9 and Native Americans have an increased risk of fatal outcomes. Incidence is higher among males. The disease frequently begins as a sudden onset of fever and headache. Most people visit a healthcare provider during the first few days of symptoms. Because early symptoms may be non-specific, several visits may occur before the diagnosis of RMSF is made and correct treatment begins. Before the use of current antibiotics, fatality rates were as high as 65-80%.

Children have a lower incidence rate compared to adults, but have highest risk of fatal outcome.

Walker et al. Rickettsiosis subcommittee report to the tick-borne disease working group. *Ticks and Tick-borne Disease* 12 (2022) 101855 50% of patients will have a rash by days 2-4 of illness (macular lesions around ankles and wrists). By days 5-7 rash becomes petechial and generalized.

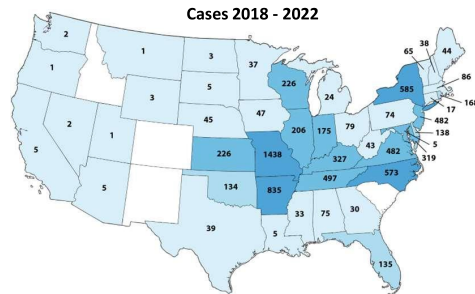
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## Ehrlichiosis



Lone Star Tick

- **Caused by bacteria**
  - *Ehrlichia chaffeensis* (most common outside of Wisconsin)
  - *E. ewingii*
  - *E. muris eauclairensis* (most likely culprit in Wisconsin)
- **2018 – 2022 = 7,760 reported U.S. cases**
  - More than 50% of *chaffeensis* ehrlichiosis cases occurred in 5 states (MO, AR, NY, NC, TN)
- **Underdiagnosed**
- **57% of patients require hospitalization**
- **11% develop life-threatening complications**
- **12% of U.S. cases in children 18 or younger**



Source: Centers for Disease Control and Prevention & WI Department of Health Services

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\*Centers for Disease Control and Prevention. National Notifiable Diseases Surveillance System, Weekly Tables of Infectious Disease Data. Atlanta, GA. CDC Division of Health Informatics and Surveillance. Available at: <https://www.cdc.gov/nndss/data-statistics/index.html>.

Underreported in heavy Lyme areas— estimated 1 case for every 2 Lyme cases based on a study done in New Jersey. The lower-than-expected number of reported ehrlichiosis cases is likely attributed to a lack of awareness about ehrlichial disease by the public and by physicians, leading to misdiagnosis and underreporting. Another explanation could be the existence of asymptomatic infections. Blood donors could pass the infection to immunocompromised patients. Sulfa drugs for unrelated ailments could cause worsened disease presentation in children. *Emerging Infectious Diseases* 2017 [https://wwwnc.cdc.gov/eid/article/23/6/16-0528\\_article](https://wwwnc.cdc.gov/eid/article/23/6/16-0528_article)

Kuriakose K et al. Assessment of Risk Factors and Outcomes of Severe Ehrlichiosis Infection *JAMA Network Open* 2020 <https://jamanetwork.com/journals/jamanetworkopen/article-abstract/2773048>

Dixon DM et al. (2021) *Ehrlichiosis and anaplasmosis subcommittee report to the Tick-borne Disease Working Group*. *Ticks and Tick-borne Diseases* 12 101823.

Rochlin, I. and Toledo, A. (2020). Emerging tick-borne pathogens of public health importance: a mini-review. *Journal of Medical Microbiology*, Volume 69, Issue 6 <https://www.microbiologyresearch.org/content/journal/jmm/10.1099/jmm.0.001206>

*Ticks and Tick Borne Diseases* Ehrlichiosis and anaplasmosis subcommittee report to the Tick-borne Disease Working Group Sept 4 2021.. Currently available laboratory diagnostic methods are poorly utilized, and with the exception of nucleic acid amplification tests are not useful for diagnosis during the acute stage of illness when timely treatment is needed. The Ehrlichiosis and Anaplasmosis Subcommittee of the Tick-Borne Disease Working Group recommended ... enhanced education of primary medical caregivers and the public regarding these diseases. <https://doi.org/10.1016/j.ttbdis.2021.101823>

## Ehrlichiosis Symptoms

Tests are not useful for diagnosis during the acute stage of illness when timely treatment is needed

- It has a higher mortality rate than Lyme

### Early signs (1-2 weeks after bite)

- Fever, chills
- Severe headache
- Muscle aches
- Nausea, vomiting, diarrhea, loss of appetite
- Confusion
- Rash (more common in children)

### Severe / Late Stage

- Meningoencephalitis
- Respiratory failure
- Uncontrolled bleeding
- Organ failure
- Death – U.S.
  - 1% fatality rate in adults
  - For children younger than 5 years old, reported fatality rate is 4%

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Symptoms <https://www.cdc.gov/ehrlichiosis/symptoms/index.html>

Snowden, J et al. Ehrlichiosis *StatPearls* 2020 <https://www.ncbi.nlm.nih.gov/books/NBK441966/>

Kuriakose K et al. Assessment of Risk Factors and Outcomes of Severe Ehrlichiosis Infection *JAMA Network Open* 2020 <https://jamanetwork.com/journals/jamanetworkopen/article-abstract/2773048>

Heitman KN et al. Increasing Incidence of Ehrlichiosis in the United States: A Summary of National Surveillance of Ehrlichia chaffeensis and Ehrlichia ewingii Infections in the United States, 2008–2012 *The American Journal of Tropical Medicine and Hygiene* 2016

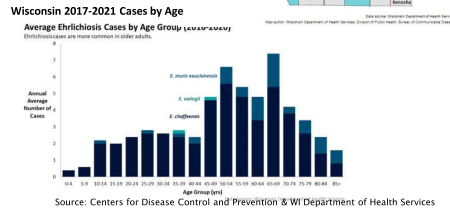
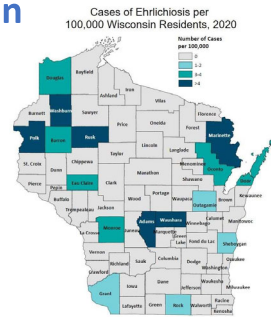


## Ehrlichiosis in Wisconsin

- **Caused by bacteria**
- *E. muris eauclairensis*
- **2018 – 2022 WI had 226 cases**
- **First isolated in 2009 from an Eau Claire resident**
- **Cases limited to individuals from MN or WI or to those who have travelled here**
- **Symptoms, similar to ehrlichiosis caused by other Ehrlichiae**
- **Fever**
- **Headache**
- **Myalgia**
- **Malaise**
- **Anemia**
- **No fatalities have been reported**



Black-legged tick



Source: Centers for Disease Control and Prevention & WI Department of Health Services

\*Centers for Disease Control and Prevention. National Notifiable Diseases Surveillance System, Weekly Tables of Infectious Disease Data. Atlanta, GA. CDC Division of Health Informatics and Surveillance. Available at: <https://www.cdc.gov/nndss/data-statistics/index.html>.

Underreported in heavy Lyme areas—estimated 1 case for every 2 Lyme cases based on a study done in New Jersey. The lower-than-expected number of reported ehrlichiosis cases is likely attributed to a lack of awareness about ehrlichial disease by the public and by physicians, leading to misdiagnosis and underreporting. Another explanation could be the existence of asymptomatic infections. Blood donors could pass the infection to immunocompromised patients. Sulfa drugs for unrelated ailments could cause worsened disease presentation in children. *Emerging Infectious Diseases* 2017 [https://wwwnc.cdc.gov/eid/article/23/6/16-0528\\_article](https://wwwnc.cdc.gov/eid/article/23/6/16-0528_article)

Kuriakose K et al. Assessment of Risk Factors and Outcomes of Severe Ehrlichiosis Infection *JAMA Network Open* 2020 <https://jamanetwork.com/journals/jamanetworkopen/article-abstract/2773048>

Dixon DM et al. (2021) *Ehrlichiosis and anaplasmosis subcommittee report to the Tick-borne Disease Working Group. Ticks and Tick-borne Diseases* 12 101823.

Rochlin, I. and Toledo, A. (2020). Emerging tick-borne pathogens of public health importance: a mini-review. *Journal of Medical Microbiology*, Volume 69, Issue 6 <https://www.microbiologyresearch.org/content/journal/jmm/10.1099/jmm.0.001206>

*Ticks and Tick Borne Diseases* Ehrlichiosis and anaplasmosis subcommittee report to the Tick-borne Disease Working Group Sept 4 2021.. Currently available laboratory diagnostic methods are poorly utilized, and with the exception of nucleic acid amplification tests are not useful for diagnosis during the acute stage of illness when timely treatment is needed. The Ehrlichiosis and Anaplasmosis Subcommittee of the Tick-Borne Disease Working Group recommended ... enhanced education of primary medical caregivers and the public regarding these diseases. <https://doi.org/10.1016/j.ttbdis.2021.101823>

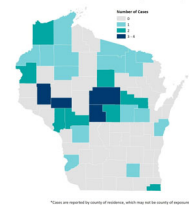
## Powassan -- Another Concerning Virus Delivered by Blacklegged Ticks

- **Causes a rare and potentially life-threatening neuroinvasive disease**
  - **123 neuroinvasive cases between 2018 - 2021 in the U.S.**
  - **WI had 24 cases in the same time period – 2<sup>nd</sup> highest in U.S.**
  - **Same states as Lyme**
- **Up to 17% of U.S. cases in children**
  - **13% in children 19 and under in WI (2003-2021)**
- **Transmission - Late spring through mid-fall**
- **Transmission within 15 minutes of tick attachment**
- **10% fatality rate for severe disease**
- **50% of survivors have lasting neuro symptoms**

Blacklegged (Deer) Tick



Powassan Virus Cases in Wisconsin (2003-2021)



Source: Centers for Disease Control and Prevention & WI Department of Health Services

Transmission occurs within 15 minutes of attachment - Columbia University Irving Medical Center: <https://www.columbia-lyme.org/powassan-virus>

Powassan is carried by blacklegged ticks in the states where Lyme is a serious issue.

- Viral—so not treatable with antibiotics
- No vaccine, no cure
- Rare, but now being studied
- The first case was in a child

Frost HM, Schotthoef AM, Thomm AM, et al. Serologic Evidence of Powassan Virus Infection in Patients with Suspected Lyme Disease. *Emerg Infect Dis.* 2017;23(8):1384-1388. [https://wwwnc.cdc.gov/eid/article/23/8/16-1971\\_article](https://wwwnc.cdc.gov/eid/article/23/8/16-1971_article)

Koester TM et al. Suspected Neuro-invasive Powassan Virus Infection in a Pediatric Patient. *Clinical Medicine & Research* Volume 18, Number 2-3: 95-98. Feb 14, 2020

10% of those infected have died. 50% of survivors have long-term WNV-like neurological sequelae. This virus is related to WNV that is transmitted by mosquitoes. There is no cure. Hassett, E.M.; Thangamani, S. Ecology of Powassan Virus in the United States. *Microorganisms* 2021, 9, 2317. <https://doi.org/10.3390/microorganisms9112317> <https://www.cdc.gov/powassan/>

Based on the years 2006-2016 11% of the reported cases were among children under the age of 19. Krow-Lucal, ER et al. Powassan Virus Disease in the United States, 2006–2016 *Vector-Borne & Zoonotic Diseases* 2017 <https://www.liebertpub.com/doi/pdf/10.1089/vbz.2017.2239>

Hassett EM, Thangamani S. Ecology of Powassan Virus in the United States. *Microorganisms* 2021, 9, 2317.

Rochlin, I. and Toledo, A. (2020). Emerging tick-borne pathogens of public health importance: a mini-review. *Journal of Medical Microbiology*, June 2020 Powassan can be fatal or leave the patient with permanent cognitive impairment.

*Wilderness & Environmental Medicine* Underrecognized Tickborne Illnesses: Borrelia Miyamotoi and Powassan Virus April 7 2021. ... Borrelia miyamotoi and Powassan virus... have a significant impact on humans, yet are underdiagnosed compared to most other tickborne diseases. ...Powassan virus disease appears to have an asymptomatic or minimally symptomatic presentation in most people but can cause devastating and fatal encephalitis. The Powassan virus may be transmitted in less than 15 minutes of tick feeding. Powassan virus disease is a difficult diagnosis because testing capabilities are limited and because there may be co-infection with other tickborne pathogens. [https://www.wemjournal.org/article/S1080-6032\(21\)00010-7/fulltext](https://www.wemjournal.org/article/S1080-6032(21)00010-7/fulltext)

Hasset, EM and Thangamani, S. (2021) Ecology of Powassan Virus in the United States *Microorganisms* 2021 Nov; 9(11):2317

Raney, WR et al. (2022) Horizontal and Vertical Transmission of Powassan Virus by the Invasive Asian Longhorned Tick... Under laboratory conditions. *Front Cell Infect Microbiol* 2022 July 1:12

Dias, JH Emerging Tickborne Viral Infections: What Wilderness Medicine Providers Need to Know *Wilderness and Environmental Medicine* 2020

[https://www.wemjournal.org/article/S1080-6032\(20\)30121-6/fulltext](https://www.wemjournal.org/article/S1080-6032(20)30121-6/fulltext)

Taylor, I. et al. Powassan Virus Infection Likely Acquired Through Blood Transfusion Presenting as Encephalitis in a Kidney Transplant Recipient *Clinical Infectious Diseases* 2020

<https://academic.oup.com/cid/advance-article-abstract/doi/10.1093/cid/ciaa738/5857602>

Jameson Canyon & Powassan viruses - USA: (NH) coinfection, RFI <https://wwwnc.cdc.gov/eid/article/2003/09/03-0903a1>

Feder, HM et al. Powassan Virus Encephalitis Following Brief Attachment of Connecticut Deer Ticks *Clinical Infectious Diseases* 2020 ciaa1183, <https://doi.org/10.1093/cid/ciaa1183> *J Neuroopathol Exp Neurol* A Fatal Case of Powassan Virus Encephalitis Oct 5 2020 <https://pubmed.ncbi.nlm.nih.gov/33020816/>

Fleishman AC, Foster E, Maes SE and Eisen RJ *Reported County-Level Distribution of Seven Human Pathogens Detected in Host-Seeking Ixodes scapularis and Ixodes pacificus (Acari: Ixodidae) in the Contiguous United States* *Journal of Medical Entomology*, 2022.

## Powassan Symptoms

- Many people asymptomatic
- Symptoms (if present) begin a week to one month after bite
- Initially fever, headache, vomiting, weakness
- Severe disease - encephalitis or meningitis
  - Confusion, loss of coordination, difficulty speaking, seizures
- There is no treatment

Centers for Disease Control and Prevention

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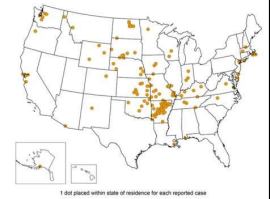
Wisconsin Department of Health Services: **Powassan Virus**

<https://www.dhs.wisconsin.gov/tick/powassan-about.htm>

## Tularemia-Rare

- A bio-terrorism organism
- 440 reported U.S. cases 2020 - 2022
  - WI reported 7 cases in the same time period
- A bacterium transmitted by tick or deer fly bites and from handling carcasses of infected animals, dust inhalation or water contamination
- Hunters and farmers are often exposed
- 23% of U.S. cases occur in children 19 or younger
- Symptoms vary based on the mode of transmission
  - Fever up to 104°F
- Skin lesion is most common with tick bite

2020 Reported Cases



1 dot placed within state of residence for each reported case



North Central  
American Dog Tick



Lone Star Tick



Source: Centers for Disease Control and Prevention &amp; WI Department of Health Services

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Tularemia is a highly infectious bacterial disease that can infect animals and people. Rabbits, hares, and rodents are especially susceptible and often die in large numbers during outbreaks. <https://www.cdc.gov/Tularemia/>

Because it's rare and because it shares symptoms with other diseases, tularemia may be difficult to diagnose. <https://www.cdc.gov/tularemia/diagnosistreatment/index.html>

Symptoms vary based on how the bacteria enter the body. They appear 3-5 days after exposure, but can take up to two weeks. Sudden fever, chills, headaches, joint and muscle pain, dry cough, progressive weakness.

**Ulceroglandular** This is the most common form of tularemia and usually occurs following a tick or deer fly bite or after handling of an infected animal. A skin ulcer appears at the site where the bacteria entered the body. The ulcer is accompanied by swelling of regional lymph glands, usually in the armpit or groin.

**Glandular** Similar to ulceroglandular tularemia but without an ulcer. Also generally acquired through the bite of an infected tick or deer fly or from handling sick or dead animals.

**Oculoglandular** This form occurs when the bacteria enter through the eye. This can occur when a person is butchering an infected animal and touches his or her eyes. Symptoms include irritation and inflammation of the eye and swelling of lymph glands in front of the ear.

**Oropharyngeal** This form results from eating or drinking contaminated food or water. Patients with oropharyngeal tularemia may have sore throat, mouth ulcers, tonsillitis, and swelling of lymph glands in the neck.

**Pneumonic** This is the most serious form of tularemia. Symptoms include cough, chest pain, and difficulty breathing. This form results from breathing dusts or aerosols containing the organism. It can also occur when other forms of tularemia (e.g. ulceroglandular) are left untreated and the bacteria spread through the bloodstream to the lungs.

**Typhoidal** This form is characterized by any combination of the general symptoms (without the localizing symptoms of other syndromes)

<https://www.cdc.gov/tularemia/signssymptoms/index.html>

Kelson, M et al. (2022) Tularemia: The resurgence of a diagnostic challenge and clinical dilemma in the US. *Cureus* [https://assets.cureus.com/uploads/case\\_report/pdf/106909/20220826-23399-y0k01k.pdf](https://assets.cureus.com/uploads/case_report/pdf/106909/20220826-23399-y0k01k.pdf)

Stringham S et al. (2020) Disseminated Tularemia: Finding the Needle in the Haystack, *Jnl of the Pediatric Infectious Disease Society*, Volume 10, Issue 3, March 2021, Pages 376–378, <https://doi.org/10.1093/jpids/piaa066>

Darmon-Curti, A et al. (2020) Tularemia: A Case Series of Patients Diagnosed at the National Reference Center for Rickettsioses from 2008-2017 *Open Forum Infectious Diseases* (IDSA) Volume 7, Issue 11, November 2020, ofaa440, <https://doi.org/10.1093/ofid/ofaa440>

## Hard Tick Relapsing Fever *Borrelia miyamotoi* Disease

- An emerging tick-borne illness wherever Lyme occurs
- May be spread by larval blacklegged ticks
- Occurs July/August
- Symptoms
  - Recurring febrile episodes that last ~3 days, separated by afebrile periods of ~7 days duration
  - Students may experience a wide range of non-specific symptoms
- This is not a reportable disease but WI Department of Health Services knows of 5 cases in 2021 and 1 in 2020
  - Between 2016-2021 only one case was reported in a child 19 and under

Source: Centers for Disease Control and Prevention & WI Department of Health Services

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Hoonstra, D et al. (2022) The Prevalence of *Borrelia miyamotoi* in *Ixodes* Ticks and Humans in the Northern Hemisphere: A Systematic Review and Meta-Analysis. <http://dx.doi.org/10.2139/ssrn.4008931>

Cutter S et al. A new *Borrelia* on the block: *Borrelia miyamotoi* – a human health risk? *Euro Surveill.* 2019 May 2; 24(18): 1800170. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6505184/>

**Bio Med Central (BMC) - Spatial and temporal patterns of the emerging tick-borne pathogen *Borrelia miyamotoi* in blacklegged ticks (*Ixodes scapularis*) in New York** Jan 14 2021. ... One of the newer tick-borne pathogens in the United States is *Borrelia miyamotoi*..., a bacterium that causes relapsing fever, found in ixodid ticks throughout the northern hemisphere. ...Overall infection prevalence of questing nymphal ticks across all sites was ~ 1%, but prevalence at individual sites was as high as 9.1%. .... Only 0.4% of questing larval ticks were infected. .... The locally high prevalence of *B. miyamotoi* in the New York/New England landscape suggests the importance of vigilance by health practitioners and the public <https://parasitesandvectors.biomedcentral.com/articles/10.1186/s13071-020-04569-2>

**Wilderness & Environmental Medicine Underrecognized Tickborne Illnesses: *Borrelia Miyamotoi* and Powassan Virus** April 7 2021. .... *Borrelia miyamotoi* and Powassan virus... have a significant impact on humans, yet are underdiagnosed compared to most other tickborne diseases. ...*Borrelia miyamotoi* ...infects and co-infects ticks along with other pathogens, including *Borrelia burgdorferi*. .... *B. miyamotoi* infection may be underdiagnosed... First, a presumptive treatment approach to Lyme disease may result in *B. miyamotoi* infection treatment without identification of the actual cause. Second, the absence of readily available testing and diagnostic criteria makes it difficult to diagnose *B. miyamotoi* infection. ....[https://www.wemjournal.org/article/S1080-6032\(21\)00010-7/fulltext](https://www.wemjournal.org/article/S1080-6032(21)00010-7/fulltext)

Mitchell, PG et al. (2023) Relapsing Fever: A Rare Cause of Pediatric Fever of Unknown Origin. *Clinical Pediatrics* <https://journals.sagepub.com/doi/abs/10.1177/00099228231154129?journalCode=cjpa>

Karim et al. Recent advances in understanding tick and rickettsiae interactions. *Parasite Immunol.* 2021 Mar. <https://onlinelibrary.wiley.com/doi/full/10.1111/pim.12830>

## Tick-Associated Red Meat Allergy Lone Star Ticks are the Culprits

- Galactose-alpha 1,3-galactose (alpha gal) present in tick saliva and red meat
  - Allergic reaction to meat consumption (beef, pork, lamb, wild game,) and mammalian products (dairy, gelatin, vaccines)
- About half of the children with alpha gal end up in ER
- Delayed anaphylaxis, hives
  - May be fat-content related, so risk with milk may be less
- Allergy may wane if mammalian products and future tick bites are avoided
  - To date, just 8% of patients have recovered



Lone Star Tick



\*Scott Commins, MD, PhD, Assoc. Prof of Med.UNC and first to report Alpha Gal

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Maccougall JD, Thomas KO, Iweala OI. The Meat of the Matter: Understanding and Managing Alpha-Gal Syndrome. *Immunotargets Ther.* 2022;11:37-54 <https://doi.org/10.2147/ITT.S276872>

Mathew, S. Alpha Gal Syndrome *Journal for International Medical Graduates* Sep. 2022.

Symptoms: Hives or skin rash, nausea, stomach cramps, indigestion, vomiting, diarrhea; Stuffy/runny nose, sneezing, bronchospasm, headaches, anaphylaxis <https://www.cdc.gov/ticks/alpha-gal/>

A 'life-changing' diagnosis - The impact of AGS appears to be ongoing, with 37% of patients reporting having 15 or more reactions prior to diagnosis, 25% still reacting at least once a month and 39% having visited the ED due to a reaction. Only 8% of patients reported having had their symptoms resolve over time. Patients with alpha-gal syndrome report 'wide range' of previously undocumented symptoms: <https://www.healio.com/news/allergy-asthma/20220301/patients-with-alphagal-syndrome-report-wide-range-of-previously-undocumented-symptoms>

Bianchi JR, et al. Abstract 608. Presented at: AAAAI Annual Meeting; Feb. 25-28, 2022; Phoenix (hybrid meeting). Hees-Doon A, et al. Abstract CA04. Presented at: AAAAI Annual Meeting; Feb. 25-28, 2022; Phoenix (hybrid meeting). Platt J, et al. Abstract L29. Presented at: AAAAI Annual Meeting; Feb. 25-28, 2022; Phoenix (hybrid meeting).

Young I, Prematunge C, Pussegoda K, Corrin T, Waddell L. Tick exposures and alpha-gal syndrome: A systematic review of the evidence. *Ticks and Tick-borne Diseases.* 2021 May;12(3):101674.

*Journal of Allergy and Clinical Immunology* On the cause and consequences of IgE to galactose- $\alpha$ -1,3-galactose: A report from the National Institute of Allergy and Infectious Diseases Workshop on Understanding IgE-Mediated Mammalian Meat Allergy April 2021. ...This publication is a summary of the workshop. Panel recommendations are presented herein. <https://doi.org/10.1016/j.jaci.2020.01.047>

Saretta F, Giovannini M, Mori F, Arasi S, Liotti L, Pecoraro L, Barni S, Castagnoli R, Mastrorilli C, Caminiti L, Marseglia GL and Novembre E (2021) Alpha-Gal Syndrome in Children: Peculiarities of a "Tick-Borne" Allergic Disease. *Front. Pediatr.* 9:801753

## Alpha-Gal Allergy



Map showing incidence of alpha-gal in the US, as reported by patients (Zee Maps, March 2017)

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Alpha gal is not reportable.

In some areas of Virginia, as many as 15 percent of children were shown to have allergy antibodies to this sugar (called alpha-gal), which can be found in beef, pork, lamb, wild game and even cow's milk. Kennedy, JL et al. **Galactose- $\alpha$ -1,3-galactose and Delayed Anaphylaxis, Angioedema, and Urticaria in Children** *Pediatrics* 2013 <https://www.publications.aap.org/pediatrics/article-abstract/131/5/e1545/31281/Galactose-1-3-galactose-and-Delayed-Anaphylaxis?redirectedFrom=fulltext>

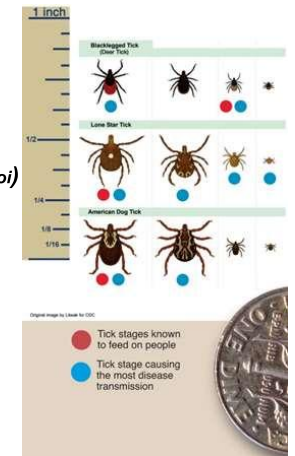
**Expert Review of Clinical Immunology Diagnosis & management of alpha-gal syndrome: lessons from 2,500 patients** Jul 8, 2020 Alpha-gal Syndrome (AGS) is a **unique allergy to non-primate mammalian meat (and derived-products)** that is associated with tick bites and is due to a specific IgE antibody to the oligosaccharide galactose- $\alpha$ -1,3-galactose (alpha-gal). AGS ... **reactions are delayed 3–6 hours after exposure and patients have frequently tolerated red meat for many years prior to the development of allergic reactions. Due to the ubiquitous inclusion of mammal-derived materials in foods, medications, personal products and stabilizing compounds, full avoidance is difficult to achieve.**

<https://www.tandfonline.com/doi/full/10.1080/1744666X.2020.1782745?scroll=top&needAccess=true>

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## Co-infections

- **Blacklegged Ticks**
  - Anaplasmosis
  - Babesiosis
  - Ehrlichiosis
  - Lyme
  - Powassan
  - **Relapsing Fever (*Borrelia miyamotoi*)**
- **Lone Star Tick**
  - Alpha-gal
  - Bourbon
  - Ehrlichiosis
  - Heartland
  - STARI
  - Tularemia
- **American Dog Tick**
  - RMSF
  - Tularemia



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Ticks are often co-infected with more than one pathogen. **The black legged tick transmits the greatest diversity of pathogens of any tick within the U.S.** Combined, **these pathogens account for >90% of all reported tick-borne diseases.** In NY and CT Lyme disease was detected in 56.3% of ticks. Powassan was present in 3.6%. 19% of ticks were co-infected with two to three pathogens. The chart shows blacklegged, Lone star and American dog ticks at their different life stages. Compared to the dime, they are very small. The red dots refer to those ticks known to feed on people. The blue dots indicate which life stage causes disease transmission.

In 197 ticks, Lyme was present in 65.3%, Anaplasmosis in 10.6% and Powassan in 3.6%. Babesias were in 7.6%. *Borrelia miyamotoi* in 5%.

Tokarz et al (2019). Microbiome analysis of Ixodes scapularis ticks from NY and CT. *Ticks and tick-borne Diseases* 10.

In MA where they track coinfection of Lyme with Babesiosis, the greatest number of coinfecting symptomatic cases between the years of 2009 – 2013, was in children under 10 years of age (35%). MA also tracks Lyme with Anaplasmosis, between the years of 2009 – 2013, the largest number of cases was also with children under 10 (13%). <https://www.mass.gov/lists/tick-borne-disease-surveillance-summaries-and-data>.

Coinfection rates were as high as 36% in NY

Yuan et al Active surveillance of pathogens from ticks collected in NY State suburban parks and schoolyards. *Zoonoses Public health* 2020 67: 684-696.

Co-infections with Lyme disease are on the rise and increasingly recognized as serious health threats. Eisen, L. (2020). Stemming the Rising Tide of Human-Biting Ticks and tickborne Diseases. *Emerg. Infect Dis*; 26(4)

Coinfection with multiple Ixodes-borne pathogens may increase severity of disease and complicate diagnosis and treatment. Coinfections are more common and higher than expected in the Northeast. 18% of nymphs and 38% of adults blacklegged ticks tested positive for Lyme.. Incidence of co-infections in humans is not monitored nationally.

Lehane et al. (2021). Prevalence of single and coinfections of human pathogens in Ixodes ticks from five geographical regions in the US. 2013-2019 *Ticks and Tick-borne Diseases* 12 (2021).

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## Tick-Bite Prevention Messages

- When coming inside, put clothing in the dryer on high heat for 20 minutes
- Do a tick-check when you're in the shower
  - Check all nooks and crannies
  - Look for moving freckles
- **Estimated disease transmission time**
  - 36-48 hours
  - Anaplasmosis 12-24 hours
  - Rocky Mountain Fever 6 hours
  - Powassan 15 minutes



Source: Centers for Disease Control and Prevention 73

Ticks will survive a trip through the washing machine...but not the dryer. So as soon as you return indoors, put everything you're wearing into the dryer on high for 20 minutes.



This diagram shows likely tick attachment locations. Ticks move up from the ground—they do not drop from trees, so preventing them from getting onto skin by covering up with clothing is important.

Experts suggest tucking pants into socks when outside to keep ticks from getting inside pants legs. Use a repellent on shoes, socks, clothing and exposed skin.

Personal protection, vector control and accurate diagnosis and treatment will remain the cornerstones of coping with tick-borne disease in the foreseeable future  
Rochlin, I. and Toledo, A. (2020). Emerging tick-borne pathogens of public health importance: a mini-review. *Journal of Medical Microbiology*, June 2020

## Tick Removal

The tick's "mouth" penetrates skin and is cemented into place

### What TO DO

- REMOVE the tick ASAP
  - Time is of the essence
- Clean wound area with soap and water, antiseptic
- Put the tick in alcohol to kill it

### What NOT to do...

- Burn it (gasoline, kerosene)
- Smother it (petroleum jelly)
- Poison it (fingernail polish)
- Annihilate it (hot match tip)
- Crush it
- Use Dawn soap

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The photo at the top left is a magnified image of the part of the tick that gets inserted into the skin...it's like a swordfish's bill...with sharp barbs. It's cemented into place.

The "What NOT to DO list" is here because these aggressive actions are sometimes taken to try to get the tick to release and back out. The tick is incapable of backing out until she gets a complete blood meal. Until then, she is cemented into the wound and no matter what you do, she cannot back out.

There is a school of thought that suggests that irritating her, causes her to regurgitate the contents of her stomach into the wound. So, the best approach is just to yank her out as shown in this diagram.

- Put ticks in alcohol to kill them (hand sanitizer works)
- Use an antibiotic ointment/spray on the bite area
- Wash your hands thoroughly after handling a tick.
  - Most healthcare organizations won't test the tick
  - Take a photo of the tick if you want a record of it
- Don't crush the tick (spreads pathogens)

Antibiotic treatment is NOT needed UNLESS the child has symptoms. If the child is symptomatic within 14 days of the tick bite, have the parents get medical attention for him/her as soon as possible.

**If the head remains after tick removal, don't panic...the body is the part that really matters**

**If there are NO symptoms after a tick bite, there is no need for antibiotics**

Many fearful of tick-borne disease do so anyway

## Tick Summary

- Children may present different symptoms than adults to the same tick-borne disease
- Lyme is the most commonly-reported tick-borne disease in the U.S. and in Wisconsin
- Powassan virus infection has no cure
  - Transmission occurs within 15 minutes
- Ehrlichioses and RMSF can be fatal without prompt treatment
- Remove ticks ASAP—Estimated disease transmission time 24-36 hours
  - Powassan 15 minutes
  - Rocky Mountain Spotted Fever 6 hours



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Many infectious disease experts treat patients with doxycycline immediately based on the suspicion of tick-borne disease. If there is a quick drop in fever, that's a strong indication that they have correctly diagnosed a tick-borne disease (even though they may not know precisely WHICH disease). If fever does not resolve quickly, they know they need to pursue another diagnosis.

## Mosquitoes

- The most important vector of infectious disease agents in humans
- 2,500 species worldwide
- 200 species in the U.S.
  - Only a few bite humans and transmit disease



*Culex pipiens*— Common House Mosquito

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Number of species in U.S.

<https://www.cdc.gov/mosquitoes/about/mosquitoes-in-the-us.html>

### Reported Wisconsin Mosquito-borne Disease Cases

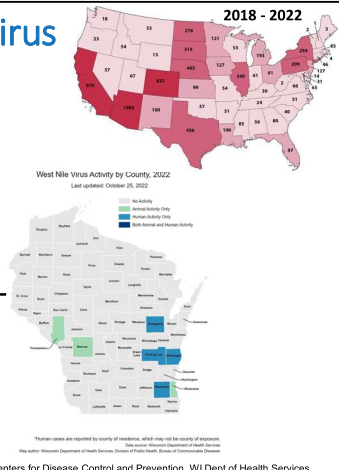
Mosquito-borne Disease	2020	2021	2022
West Nile Virus	11	27	34
Jamestown Canyon Virus	15	4	10
La Crosse Encephalitis	4	3	7
St Louis Encephalitis	5	8	5
Eastern Equine Encephalitis	2	1	1
Travel Related Cases	2020	2021	2022
Dengue	8	3	8
Malaria	0	17	0
Chikungunya	2	0	0

Source: Centers for Disease Control and Prevention and WI Dept of Health Services 77

Case counts: Centers for Disease Control and Prevention. National Notifiable Diseases Surveillance System, Weekly Tables of Infectious Disease Data. Atlanta, GA. CDC Division of Health Informatics and Surveillance. Available at: <https://www.cdc.gov/nndss/data-statistics/index.html> and WI Dept of Health <https://dhs.wisconsin.gov/tick/index.htm>

### West Nile Virus

- WNV: the leading mosquito-borne virus infection in the U.S.
  - The most common cause of viral encephalitis in the U.S.
  - Endemic throughout the “lower 48”
- More cases in children than for ALL AGES for SLE, LAC, EEE and WEE combined
- 89% of all patients have illness onset July-September
- Human illness is cyclic, geography shifts
  - 2018 – 2022 = 8,259 reported U.S. cases
  - AZ, CA, CO had the most cases
  - WI had 53 in the same time period



Source: Centers for Disease Control and Prevention, WI Dept of Health Services 78

Pediatric WNV-Associated Neuroinvasive Disease: A Review of the Literature. Herring et al. *Pediatric Neurology* 2019 <https://www.sciencedirect.com/science/article/abs/pii/S0887899418300626>

Soto RA, Hughes ML, Staples JE, Lindsey NP. West Nile Virus and Other Domestic Nationally Notifiable Arboviral Diseases - United States, 2020. *MMWR Morb Mortal Wkly Rep.* 2022 May 6;71(18):628-632.

*PLoS Pathogens* Twenty years of West Nile virus spread and evolution in the Americas visualized by Nextstrain Oct 31, 2019 ...Endemic to the U.S., with an estimated 7 million human infections ..., making it the leading mosquito-borne virus infection and the most common cause of viral encephalitis in the country. <https://journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1008042>

Shannon, R., et al., Cumulative Incidence of West Nile Virus Infection, Continental United States, 1999–2016, Center for Disease Control and Prevention, February, 2019 [https://wwwnc.cdc.gov/eid/article/25/2/18-0765\\_article](https://wwwnc.cdc.gov/eid/article/25/2/18-0765_article) Severe manifestations of WNV infection are far more common in adults than in children

3% of the cases are among children 18 and under.

Vahey GM, et al. (2021) West Nile Virus and Other Domestic Nationally Notifiable Arboviral Diseases - United States, 2019. *MMWR Morb Mortal Wkly Rep.* 2021 Aug 13;70(32):1069-1074. doi: 10.15585/mmwr.mm7032a1. Erratum in: *MMWR Morb Mortal Wkly Rep.* 2021 Aug 27;70(34):1180. [West Nile Virus and Other Domestic Nationally Notifiable Arboviral Diseases — United States, 2019 | MMWR \(cdc.gov\)](https://www.cdc.gov/mmwr/preview/mmwrhtml/7034a1.htm)

\*\*Herring R, Desai N, Parnes M, Jarjour I. Pediatric West Nile Virus-Associated Neuroinvasive Disease: A Review of the Literature. *Pediatric Neurology* 2019 Mar;92:16-25. DOI: <https://doi.org/10.1016/j.pediatrneurol.2018.07.019>

Clé M [Neurocognitive impacts of arbovirus infections](#) *Journal of Neuroinflammation* 2020 Aug 10;17(1):233.

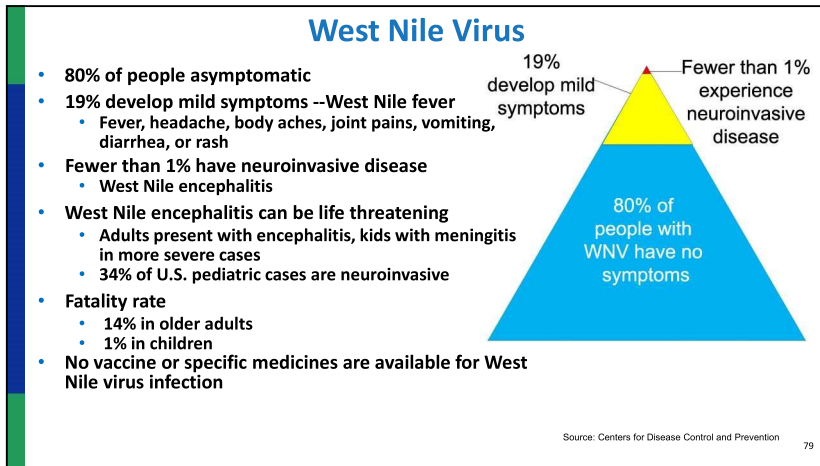
McDonald E, et al. (2021) Surveillance for West Nile virus disease — United States, 2009–2018. *Am J Transplant.*;21:1959–1974.

Humphreys, J.M. et al. (2021) Vector Surveillance, Host Species Richness, and Demographic Factors as West Nile Disease Risk Indicators. *Viruses* 2021, 13, 934.

Keyel AC et al. (2021) A proposed framework for the development and qualitative evaluation of West Nile virus models and their application to local public health decision-making. *PLoS Negl Trop Dis* 15(9): e0009653.

East of the Mississippi River, mostly *Culex pipiens* L. complex mosquitoes drive intense enzootic transmission with relatively small numbers of human cases. Westward, the presence of highly competent *Culex tarsalis* (Coquillett) ... defines the regions with the highest human risk. West Nile virus human risk distribution is not uniform geographically or temporally within all regions. **Notable geographic ‘hotspots’ persist with occasional severe outbreaks.**

Rochlin, I et al. (2019) West Nile Virus Mosquito Vectors in North America *Journal of Medical Entomology* Oct 24, 2019 <https://academic.oup.com/jme/article-abstract/56/6/1475/5572131?redirectedFrom=fulltext>



<https://www.cdc.gov/westnile/symptoms/index.html>

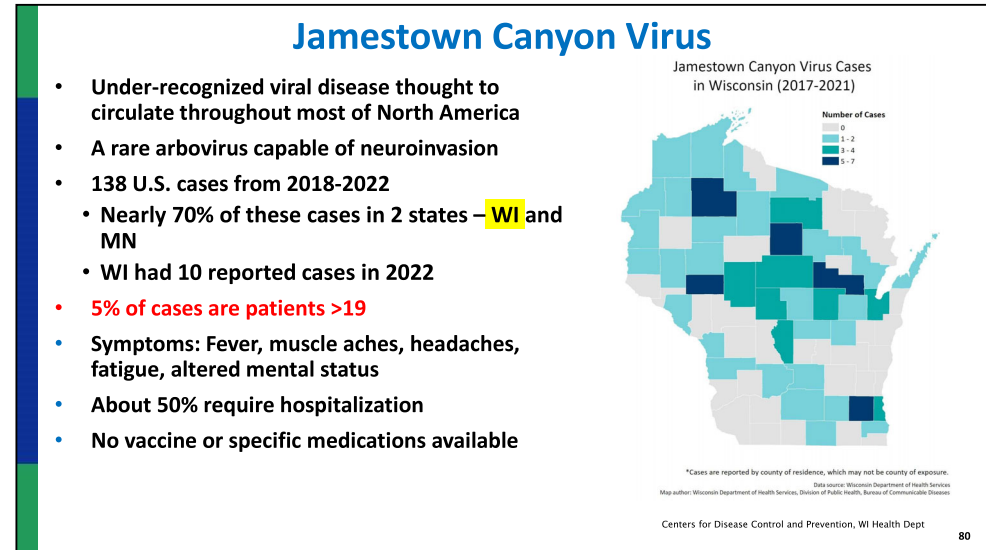
Children are more likely to present with meningitis rather than encephalitis which is seen in adults.

Herring R et al., (2018) Pediatric West Nile Virus-Associated Neuroinvasive Disease: A Review of the Literature, *Pediatric Neurology, Journal of Medical Entomology*, 92, P16-25, MAR 2019 <https://doi.org/10.1016/j.pediatrneurol.2018.07.019>

Children’s Hospital of Philadelphia, West Nile Virus in Children <https://www.chop.edu/conditions-diseases/west-nile-virus-children>

- No vaccine or specific antiviral treatments for West Nile virus infection
- Over-the-counter pain relievers -- to reduce fever and some symptoms
- In severe cases, patients are hospitalized to receive supportive treatment

[Centers for Disease Control and Prevention West Nile Virus](https://www.cdc.gov/westnile/symptoms/index.html)



- Many people infected with Jamestown Canyon virus are asymptomatic.
- For those who are symptomatic, the time from mosquito bite to disease onset ranges from a few days to 2 weeks.
- Initial symptoms can include fever, fatigue, and headache. Some people also have respiratory symptoms such as cough, sore throat, or runny nose.
- Jamestown Canyon virus can cause severe disease, encephalitis or meningitis.
- Symptoms include stiff neck, confusion, loss of coordination, difficulty speaking, or seizures.
- About half of patients reported with Jamestown Canyon virus disease are hospitalized.
- Deaths associated with Jamestown Canyon virus infection are rare.

<https://www.cdc.gov/jamestown-canyon/symptoms/index.html>

•Case data\_Centers for Disease Control and Prevention. National Notifiable Diseases Surveillance System, Weekly Tables of Infectious Disease Data. Atlanta, GA. CDC Division of Health Informatics and Surveillance. Available at: <https://www.cdc.gov/nndss/data-statistics/index.html>.

Five rare emerging or reemerging arboviruses are capable of neuroinvasion..... Cache Valley and Jamestown Canyon viruses likely circulate throughout most of North America, while eastern equine encephalitis and Powassan viruses typically circulate in the eastern half. Usutu ...has the potential to be introduced in the future ....To prevent neuroinvasive arboviral diseases, use of insect repellent and other mosquito and tick bite prevention strategies are key. Gill, C.M. (2019) Five Emerging Neuroinvasive Arboviral Diseases: Cache Valley, Eastern Equine Encephalitis, Jamestown Canyon, Powassan, and Usutu. *Seminars in Neurology* 39(04): 419-427. <https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0039-1687839>



### La Crosse Encephalitis

- The leading cause of pediatric viral encephalitis in North America
- Transmission - late spring through early fall
- 88% of people are 19 and younger (2000-2013)
- WV, NC, TN, and OH 80% of cases
- WI had 10 cases 2021-2022




Photo: Lynn Bergen

**Eastern Treehole Mosquito**  
Bites early mornings and late afternoons

La Crosse Encephalitis Virus  
Cases in Wisconsin (2012-2021)

Number of Cases

\*Cases are reported by county of residence, which may not be county of exposure.  
Data source: Wisconsin Department of Health Services  
Map author: Wisconsin Department of Health Services, Division of Public Health, Bureau of Communicable Diseases

Centers for Disease Control and Prevention, WI Dept of Health Services 81

Day CA, Odoi A, Trout Fryxell RT (2023) Geographically persistent clusters of La Crosse virus disease in the Appalachian region of the United States from 2003 to 2021. *PLoS Negl Trop Dis* 17(1): e0011065. <https://doi.org/10.1371/journal.pntd.0011065>.

States with highest incidences  
Vahey GM et al La Crosse Virus Disease in the United States, 2003-2019 *Am. J. Trop. Med. Hyg.*, 105(3), 2021, pp. 807-812

2003-2013 Data showed 88% of the cases were 19 and under.  
Pastula, DM et al. (2015) Jamestown Canyon Virus Disease in the United States—2000–2013 *American Journal of Tropical Medicine and Hygiene* 2015  
[https://www.ajtmh.org/content/journals/10.4269/ajtmh.15-0196#html\\_fulltext](https://www.ajtmh.org/content/journals/10.4269/ajtmh.15-0196#html_fulltext)


La Crosse virus (LACV) is the **leading cause of pediatric viral encephalitis in North America**, .... Wilson, S.N. et al. (2021) La Crosse Virus Shows Strain-Specific Differences in Pathogenesis *Pathogens* March 19 2021. <https://doi.org/10.3390/pathogens10040400>

**IndeOnline.com** Massillon OH Stark family warns of dangerous mosquito virus after rare diagnosis Oct 7, 2018 <https://www.indeonline.com/news/20181007/stark-family-warns-of-dangerous-mosquito-virus-after-rare-diagnosis>

La Crosse encephalitis, a rare and dangerous virus, is on the increase. ...Transmitted by infected eastern treehole mosquitoes, it has a 5-15 day incubation period, with most severe cases often found in children under 16. It can cause seizures and, in some cases, coma and paralysis. It strikes **boys 5-9** in particular. Though most patients recover, it **can cause cognitive and neuro-behavioral problems** that require occupational therapy. There is no cure, however, symptoms are treatable. Severe neurological cases occur, mainly in pre-school age children. They are seldom fatal, but prolonged hospitalization and sequelae including personality changes, may occur. See a summary of LACV ... at <https://www.cdc.gov/lac/tech/epi.html>.

### Eastern Equine Encephalitis

- 30% fatality rate for patients with severe form of the disease
  - 50% of survivors have neurological complications\*
- 140 cases reported in the U.S. from 2009 - 2021
  - 4 cases reported in Wisconsin in this time period, 1 in 2022
- Symptoms:
  - Systemic: Fever, chills, fatigue, arthralgia and/or myalgia 1–2 weeks in duration with recovery
  - Encephalitic: 5% of infections—fever, headache, neck stiffness, irritability, focal weakness, cranial nerve palsies, seizures and/or altered mental status\*\*
- Those under age 15 or over 50 most likely to develop encephalitic EEE virus disease\*\*



\*The American Journal of Tropical Medicine and Hygiene Eastern Equine Encephalitis Virus in the United States, 2003-2016  
\*\*Five Emerging Arboviral Disease Gill et al. *Semin Neurol* 2019

Centers for Disease Control and Prevention, WI Health Dept 82

\* Lindsey, N.P. et al. (2018). Eastern Equine Encephalitis Virus in the United States. *The American Journal of Tropical Medicine and Hygiene*, 2003–2016 DOI: <https://doi.org/10.4269/ajtmh.17-0927>

\*\* <https://www.cdc.gov/easternequineencephalitis/symptoms-diagnosis-treatment/index.html>

\*\*\* *Seminars in Neurology* Gill, C.M. (2019) Five Emerging Neuroinvasive Arboviral Diseases: Cache Valley, Eastern Equine Encephalitis, Jamestown Canyon, Powassan, and Usutu. *Seminars in Neurology* 2019. <https://www.thieme-connect.com/products/ejournals/abstract/10.1055/s-0039-1687839>

Kills 30% of victims

New England and Michigan highest incidence in 2019  
Four children (5-11) infected, 2 died

Symptoms are:

- Neurologic - fever, headache, vomiting, diarrhea, seizures, behavioral changes, drowsiness, coma
- In infants, neurologic disease often occurs soon after onset; in older children and adults, after several days of systemic illness
- Systemic illness- fever, chills, malaise, arthralgia, myalgia
- 80% of survivors-permanent neuro damage

<https://www.cdc.gov/easternequineencephalitis/healthcare-providers/clinical-evaluation-disease.html>

Younger patients develop signs earlier during acute disease.. Patients under 5 and over 50 are more likely to develop severe illness..

At least half or as high as 90% of neurologic cases develop lasting sequelae.

Only about 5% of infections result in reported diseases.

An estimated 30% of cases are fatal.

Symptoms: vomiting seizures, diarrhea, fever, headache, coma drowsiness, behavioral changes  
Reyna, R.A. and Weaver, S.C. Sequelae and Animal Modeling of Encephalitic Alphavirus Infections. *Viruses* 2023 15, 382.

## Key Mosquito Messages

- **WNV: most common mosquito-borne disease in the U.S.**
- **Other infections widely endemic around the world**
  - Malaria, Chikungunya, Dengue, Zika virus
  - Know where your students are going for breaks, vacations, business trips
- **Elsewhere in the U.S., other mosquito-borne diseases are possible**
- **Bite prevention is essential**
  - Use EPA-registered repellent
  - Dress appropriately



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While we have focused mainly on the mosquito-borne diseases in the U.S. and tropical destinations, West Nile occurs in Europe, as do many other vector-borne diseases. Consulting with travel medicine experts before trips is highly recommended. In the U.S., other mosquito-borne diseases include St. Louis Encephalitis, La Crosse Encephalitis, Jamestown Canyon virus and Western Equine encephalitis. Keystone virus (rare) also circulates in Florida.

## Why Care About Repellents?

- **VBDs are becoming more prevalent**
- **For many VBDs, the *only* option is to avoid bites**
- **Emerging and known diseases and their vectors are expanding territories**
- **Personal protection for those at home/traveling is crucial**

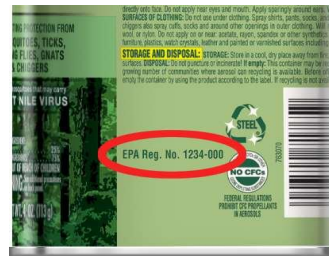


84

Lantos, P., et al. (2021) Clinical Practice Guidelines by the Infectious Diseases Society of America...for Prevention, Diagnosis and Treatment of Lyme Disease *Arthritis & Rheumatology* Vol 73, No 1, Jan 2021 pp 12-20.

## Repellents

- Always use a repellent with an EPA-registered active ingredient
- Tested for safety and efficacy
- Tested for *specific* vectors
- EPA has **NO** age limitations on any of the registered actives
  - **EXCEPT** Oil of Lemon Eucalyptus
  - Children must be **3 years** of age



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Knowing more about repellents helps parents make better choices about prevention strategies.

The Environmental Work Group says this:

“...DEET...is widely used but much maligned.

...[Its] Safety profile is better than many people assume.

...[Its] Effectiveness at preventing bites is approached by only a few other repellent ingredients.

DEET isn't a perfect choice nor the only choice. But weighed against the consequences of Lyme disease and West Nile virus, it is believed it is a reasonable one.”

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## Concentration is the Key

- Concentration is the amount of active ingredient in the product
- It's always on the label
- The higher the concentration the **LONGER** the repellent helps protect against bites
- More isn't “Better,” it's “Longer”



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As concentration increases in a product, the duration of efficacy does as well, leveling off at about 30%.

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## Repellent Use for Mosquitoes

- All concentrations help provide protection
- Pick one that matches the length of exposure
  - 10%=@90 minutes
  - 30%=@ 8 hours
  - Use a 25% or higher product for *Aedes* species (found in subtropical and tropical areas. In the U.S., Texas to California as far north as SFO. See map at very end of presentation.
- Apply sparingly to clothing if mosquitoes can bite through fabric (*Aedes* can)



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Special species like the *Aedes* mosquitoes are very hard to repel, so experts recommend starting with a 25% product if you are in areas where these mosquitoes are located. *Aedes* can bite through lighter fabrics, so a quick spritz on the clothing or under clothing is advisable.

Repellents are water soluble, so reapply if needed after swimming, when perspiring, or after rain exposure.

Typical MOSQUITO Protection Times (DEET-based Products)

- 100% = @12 hours
- 50% = 10 hours
- 34.5% sustained release = @12 hours
- 30% = up to 8 hours
- 25% = up to 6+ hours
- 15% = up to 4+ hours
- 10% = up to 2+ hours
- 5% DEET-based product = @ 90 min

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## It's *DIFFERENT* for Ticks

- LOWER concentrations may not work well or very long – some experts recommend products starting with a 20% concentration EPA-registered active ingredient product
- Apply to exposed skin AND clothing, shoes, socks, pants
- Use permethrin-treated clothing and gear—kills on contact
- Duration of efficacy may be *shorter* for ticks than it is for mosquitoes
- Dress appropriately—long pants tucked into socks



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Ticks are hard to repel. Experts suggest starting with a 20% concentration product when in tick territory.

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## HOW You Apply Is Important



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Many people believe spraying randomly around themselves provides protection. It doesn't. Repellent needs to be applied sparingly and then smoothed on as you would sunscreen.

## Application Information

- Follow application directions
- Smooth on exposed skin
- Spray lightly on clothing (shoes, socks, pants, tops)
- Use permethrin-treated clothing
  - It's an insecticide and kills on contact
  - Repellents don't kill ticks or mosquitoes
- Repellent washes off with perspiration/swimming/rain, so reapply as needed



Adobe Stock

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Ticks are hard to repel. Experts suggest starting with a 20% concentration product when in tick territory.

Permethrin—not the products used for head lice—is sold in sporting goods stores for use on clothing. This should NEVER be used on skin. It's an insecticide that kills ticks and mosquitoes when they contact the clothing. Pre-treated clothing is also sold in sporting goods stores. Follow label instructions.

## Guidance For Use On Children

- Since 2003 Am. Academy of Pediatrics
  - Use DEET, picaridin, IR3535 on kids as young as 2 MONTHS of age in concentrations up to 30%
- Parents should apply to their own hands and smooth onto the child's exposed skin
- Read and follow label directions

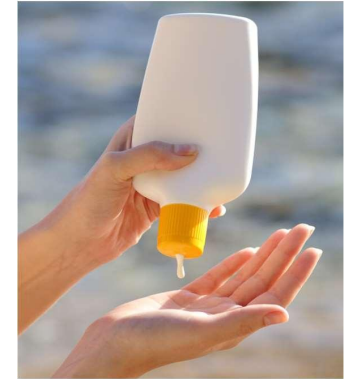


Adobe Stock

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## Sunscreen and Repellent

- Apply sunscreen first, then repellent
- Reapply sunscreen often and liberally
- Reapply repellent sparingly when bugs return



Courtesy of FamilyEducation.com

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Children 2+ months can use DEET-based repellents in concentrations up to 30%

This has been AAP Guidance since 2003

- Reviewed all safety data
- Same for picaridin and IR3535

MUST BE 3+ years for Oil Of Lemon Eucalyptus/PMD (EPA REGULATION)

### EPA-Registered Repellents

- DEET -500 products
- Picaridin—40 products
- IR 3535—45 products
- Oil of Lemon Eucalyptus— 10 products
- Catnip Oil—4 products
- BLOUD—1 product
- Oil of Citronella—3

## Resources

- American Mosquito Control Association
- Northeast Regional Center for Excellence Cornell University
- Wisconsin Department of Health Services
- University of Massachusetts Amherst
- CDC.gov
- [www.RepellentInfo.org](http://www.RepellentInfo.org)

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## QUESTIONS ???



Scan here for free student  
brochures and more  
information

## Questions?



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## The *Aedes* Mosquitoes Are Different Important for Travelers to Know

- Important to know mosquito behavior
  - Daytime biters
  - Sip biters/Stealth biters
  - Knees to ankles
- Live in urban settings
- Difficult to repel
- AGGRESSIVE
  - Prefer people
- *Aedes aegypti*
  - Zika, Dengue, Chikungunya
  - Yellow Fever

Yellow Fever Mosquito (*Aedes aegypti*)



Photo by James Gathany, Center for Disease Control Public Health Image Library

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<https://health.mo.gov/living/healthcondiseases/communicable/zika/local.php>

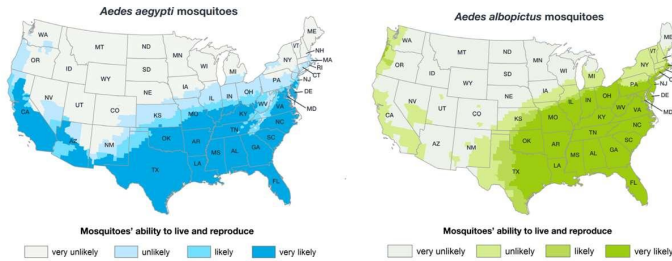
<https://www.intechopen.com/chapters/74041>

These mosquitoes can breed in a bottle cap of water. They never go more than 500 feet from the water in which they were larvae. They are “cosmopolitan”, living in and around people. They may be co-infected with yellow fever, dengue and CHIKV.

We focus on this mosquito because its behavior is quite different from that of OTHER mosquitoes that can infect humans with vector-borne diseases.



## ESTIMATED Potential Range of *Aedes Aegypti* and *Aedes Albopictus*



Centers for Disease Control and Prevention

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These maps are from 2017 and they may have spread farther.

Experts have evaluated the likelihood of *Aedes aegypti* and *Aedes albopictus* being able to survive in various areas of the U.S.

### *Aedes aegypti*

These mosquitoes live in tropical, subtropical, and in some temperate climates. They are the main type of mosquito that spread Zika, Dengue, Chikungunya, and other viruses.

Because *Ae. aegypti* mosquitoes live near and prefer to feed on people, they are more likely to spread these viruses than other types of mosquitoes.

### *Aedes albopictus*

These mosquitoes live tropical, subtropical, and temperate climates, but can live in a broader temperature range and at cooler temperatures than *Ae. aegypti*.

Because these mosquitoes feed on animals as well as people, they are less likely to spread viruses like Zika, dengue, chikungunya and other viruses.

<https://www.cdc.gov/zika/vector/range.html>

## Travel-Related Diseases (Imports)

- **Malaria: 6,425 U.S. cases from 2018-2022, WI had 0 cases in 2022, 16 in 2021**
  - 17% children (<18 years)
  - Severe infection with end organ damage more common in children 5 years old or younger
  - Symptoms include fever and flu-like illness, including shaking chills, headache, muscle aches, and tiredness. Nausea, vomiting, and diarrhea may also occur and may cause anemia and jaundice
- **Dengue: 3,261 U.S. cases from 2018-2022, WI had 8 cases in 2022, 3 in 2021**
  - Local dengue cases have been reported in multiple states in recent years, including 70 cases in Florida in 2020
  - 40% of the world's population is at risk
  - Most common symptom of dengue is fever with any of the following: nausea, vomiting, rash, aches and pain (eye pain, typically behind the eyes, muscle, joint, or bone pain)
- **Chikungunya: 404 U.S. cases from 2018-2022, WI had no cases in 2022 or 2021 but 2 in 2020**
  - Musculoskeletal symptoms with a chronic polyarthrits
  - May resemble autoimmune inflammatory arthritis
  - CHIKV infection should always be suspected in a returning traveler presenting with fever, skin rash and arthralgia
- **Zika: About 105 U.S. cases from 2018-2022, no vaccine or treatment, WI had no cases in 2022 or 2021**
  - The most common symptoms of Zika are fever, rash, headache, joint pain, conjunctivitis and muscle pain

Source: Centers for Disease Control and Prevention

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\*Malaria: CDC - <https://www.cdc.gov/malaria/about/index.html>

Early symptoms:

fever, chills, sweats, headaches, muscle pains, nausea, vomiting

In severe cases:

confusion, coma, neurologic focal signs, severe anemia, respiratory difficulties

Treatment depends on:

Patient's clinical status, the species of the infecting parasite

Where infection acquired and its drug-resistance status

Pregnancy status

Drug allergies, other medications

\*\*Dengue - Widespread in tropical climates

• No cure

• Can be fatal

• In Philippines in 2019, 17% of cases were in children

• Dengue local cases source: Wong JM et al. Dengue: A Growing Problem With New Interventions. *Pediatrics* Volume 149, number 6, June 2022:e202105532

<https://journals.sagepub.com/doi/10.1177/0883334920909406>

NOTE: Hawaii had the largest outbreak of locally transmitted dengue since 1944. ...Of 264 persons with confirmed dengue, 238 (90.2%) were Hawaii residents. Thirty-seven (14.0%) persons required hospitalization. 21% of the cases were under 18.

<https://health.hawaii.gov/dood/dengue-outbreak-2015/>

\*\*\*Chikungunya: CHIKV is a mosquito-borne disease (the *Aedes* mosquitoes, again) that causes severe joint pain that requires hospitalization. There are imported cases in the U.S., with widespread cases in tropical and subtropical climates. These may be locations where patients go for business, travel, church mission trips, and the like. There's no cure so prevention is essential.

As of January 9, 2020, a U.S. total of 134 chikungunya virus disease cases with illness onset in 2019 have been reported to ArboNET from 26 U.S. states. All reported cases occurred in travelers returning from affected areas. No locally-transmitted cases have been reported from U.S. states. (CDC)

\*\*\*Zika:

If returning from an area that has Zika, to protect sexual partners:

• Men should use condoms—or not have sex—for at least 3 months after travel

• Women should use condoms or abstain for at least 2 months after travel

• If you and your partner travel together, use condoms for at least 3 months after your return.

• If you or your partner are pregnant, use condoms for the rest of the pregnancy.

<https://www.cdc.gov/travel/zika/zika-information>

<https://www.cdc.gov/immization-prevention.html>

U.S. statistical reports on Dengue and other VBD's can be found at:

<https://wonder.cdc.gov/ndds/cstat/2010/2/2012.5?table=11.html>

<https://www.cdc.gov/diseases/statistics/mwsp/2020.html>

Dealing with Travelers to Endemic Areas

CDC: <https://www.cdc.gov/travel/faqbook/2020/posttravel-evaluation/eneral-approach-to-the-returned-traveler>

**National Library of Medicine Measuring the global burden of chikungunya and Zika viruses: A systematic review**

March 4 2021. ...Chikungunya virus (CHIKV) and Zika virus (ZIKV) infections have spread globally, causing a spectrum of disease that ranges from self-limited febrile illness to permanent severe disability, congenital anomalies, and early death. ...Both...caused substantially more burden in the Americas than in any other WHO region...and ... represent a significant cause of morbidity ... not included in current disease burden reports. ...<https://pubmed.ncbi.nlm.nih.gov/33561908/>

University of Minnesota Center for Infectious Disease Research and Policy Zika roadmap outlines steps toward diagnostics, treatment, vaccines Feb 26 2021....

Zika ... affecting a total of 87 countries and territories as of July 2019.... The ... outbreak in the Americas involved more than 700,000 cases. Zika infection, while normally mild, can lead to Zika congenital disease, whose symptoms may include microcephaly in infants. The WHO has also linked it to health problems such as Guillain-Barré syndrome, neuropathy, and spinal cord inflammation. ...A 2018 study by researchers from the US Centers for Disease Control and Prevention looked at 1,450 children in US territories whose mothers had Zika during pregnancy. ... 14% had birth defects associated with the virus and 6% had microcephaly.

<https://www.cidrap.umn.edu/news-perspective/2021/02/zika-roadmap-outlines-steps-toward-diagnostics-treatment-vaccines>

## Dealing with Travelers to Endemic Areas Outside the U.S.

- Zika, dengue, chikungunya and malaria are travel-related diseases – rarely locally transmitted
- People traveling “home” to an endemic country may not consider the potential of a vector-borne disease, don’t use personal protection
- When returning to the U.S., they may be asymptomatic, but can be bitten by local mosquitoes, starting local transmission
- For Zika, transmitted sexually, there are more cautions
- See the CDC website for more information

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If returning from an area that has Zika, to protect sexual partners:

- Men should use condoms—or not have sex—for at least 3 months after travel
- Women should use condoms or abstain for at least 2 months after travel
- If you and your partner travel together, use condoms for at least 3 months after your return.
- If you or your partner are pregnant, use condoms for the rest of the pregnancy.

<https://wwwnc.cdc.gov/travel/page/zika-information>

<https://www.cdc.gov/zika/prevention/sexual-transmission-prevention.html>

## More on Removal

- If the head remains after tick removal, don’t panic...the body is the part that really matters
- If there are NO symptoms after a tick bite, there is no need for the student to seek treatment and no need for antibiotics

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0

## Ticks and Tick-borne Diseases (TBDs)

- **Worldwide, ticks are second only to mosquitoes as the most important vector of infectious disease agents in humans**
  - Transmit a greater diversity of viral, bacterial and protozoan infections than any other arthropod on earth
- **In many regions of the world, including Europe and the U.S., TBDs are the most widespread and medically important of all vector-borne infections**
  - TBDs have expanded worldwide both in the U.S. and Europe
- **14 newly recognized TBD have been identified in the last 25 years**
- **Minimizing the risk of tick bites remains the most important measure to reduce the risk of TBD**
  - Wear long pants tucked into boots
  - Apply an EPA-registered repellent to exposed skin and clothing and permethrin **ONLY** on clothing
  - Inspect for and remove attached ticks as soon as possible

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***Travel Medicine and Infectious Disease*** Travel and tick-borne diseases: Lyme disease and beyond. Nov/Dec. 2019. <https://hal.archives-ouvertes.fr/hal-01970230/document>