Episode 66 – Lyme Disease Aug 12, 2022

Lyme disease

- Lyme disease or Lyme borrelosis is a vector-born disease and the most common tick-borne infection in Canada. [1] [2]
- In Canada, Lyme disease is caused by the bacterium *Borrelia burgdorferi, a* spirochete transmitted through the bite of certain species of infected *Ixodes* ticks.
- Lyme disease is transmitted primarily by four species of *Ixodes* ticks, which are commonly found in temperate regions of North America, Europe, and Asia.
- Ticks feed on a variety of mammals and birds (e.g., deer, rodents, ground foraging birds) and become infected if these hosts are infected with the bacteria.
- Most *B. burgdorferi* infections occur during warmer months. However, Lyme disease cases have been reported throughout the year since ticks can be active whenever the temperature is above freezing and the ground is not snow covered. [1] [3]

Bacterium & ticks associated with Lyme disease [4]

Location	Bacterium	Tick species
Canada	*B. burgdorferi*	*Ixodes scapularis* (blacklegged tick or deer tick) *Ixodes pacificus* (western blacklegged tick)
United States	*B. burgdorferi* *B. mayonii*	*Ixodes scapularis* *Ixodes pacificus*
Europe	*B. burgdorferi* *B. afzelii* *B. garinii*	*Ixodes ricinus* (castor bean tick or sheep tick)
Asia	*B. burgdorferi* *B. afzelii* *B. garinii*	*Ixodes persulcatus* (taiga tick)

Ticks

- There are 2 families of ticks: *Ixodidae* (hard ticks) and *Argasidae* (soft ticks), with 700 species of hard ticks and 200 species of soft ticks found globally. Only a few ticks are known to bite and transmit disease to humans.
- Hard ticks and soft ticks have different life cycles.
- Hard tick life cycle lasts 1-2 years depending on the species. They begin as eggs laid by adult female ticks. Once an egg hatches a larva emerges that must find and feed on a small mammal or bird (host). After feeding it drops from the host to the

ground and goes through a molting process, emerging as a nymph. Nymphs then seek larger hosts, and after feeding drop off and molt into adults.

- Ticks are members of the arachnid family and are unable to jump or fly.
- They thrive in wooded, brushy areas with undergrowth and significant leaf litter that keep the ground damp.
- They find their hosts by detecting animals' breath and body odours, or by sensing body heat, moisture, and vibrations.
- Ticks wait on tips of grasses and shrubs in a "questing" position for a host (person, animal, bird) to pass. While questing, ticks hold onto leaves and grass by their third and fourth pairs of legs and hold the first pair of legs outstretched, waiting to climb onto a host.
- When a host brushes by the waiting tick, the tick quickly climbs aboard. It then finds a suitable place to bite. Ticks can attach to any part of the human body but commonly bite the back of the neck, scalp, armpits, groin, and legs.
- Tick bites are usually painless because they secrete small amounts of saliva with anesthetic properties. They grasp the skin, cut the surface, insert a feeding tube into the skin to feed. The feeding process can last several hours, to days, even weeks.
- Infected blacklegged ticks need to be attached for at least 24 hours to transmit the bacteria that causes Lyme disease.
- Although larvae,[1] nymphs, and adults can bite, nymphs and adult females are thought to be the primary cause of illness in humans.
- Superficially, ticks resemble spiders and, like spiders, have 8 legs at nymph and adult stages (larvae have 6 legs). Ticks can easily be differentiated from spiders by their small size, tear-drop shape, and absence of a "waist" between the abdomen and the rest of the body. Ticks are also very slow moving compared to spiders.
- Adult blacklegged ticks have a reddish-orange to a dark reddish-brown body, black shield (scutum), and dark black legs. Average size is 3mm (size of a sesame seed). As they feed, they become greyish to dark grey-brown and about 10 mm (size of a small corn kernel, egg-shaped) when fully fed.[2]
- Unfed nymphal ticks are very small (~1mm, size of a poppy seed) and grey-brown in colour. As they feed, their stomach enlarges and gets darker, almost black in colour and egg-shaped when fully fed.
- Nymphal stage typically occurs during summer months and is the stage most responsible for human infections since their very small size prevents individuals from noticing them on their body.
- Adult ticks also transmit infection, but are larger and therefore more likely to be discovered and removed before they have had time to transmit the bacteria. [5] [6] [7] [8] [9] [10] [11] [12] [13]

Incidence of Lyme disease

- Reported cases of Lyme disease increased in Canada by over 1,800% between 2009 and 2021, from 144 to 2,851 cases. [14]
- In 2020, there were 834 cases of Lyme disease in Ontario (rate of 5.7 cases per 100,000 people). [15]

[1] Larvae do not transmit disease, they become infected while feeding on an infected host.
[2] Refer to CDC website for images of ticks: https://www.cdc.gov/ticks/tickbornediseases/tickID.html

- Cases have been rising for several years partly due to climate changes, which has contributed to increases in the abundance and geographic range of blacklegged ticks in central and eastern Canada.
- Ticks can also spread by travelling on deer and migratory birds. While the probability is low, it is possible to find an infected tick almost anywhere in Ontario.[3]
- Approximately 70% of all Lyme disease cases are reported in June, July, and August. This peak in cases coincides with greater participation in outdoor activities and increased presence of ticks in the nymph stage of their lifecycle, when they are very tiny and difficult to see. [1] [8]

Clinical manifestations

- Lyme disease can cause a range of clinical manifestations. Some individuals experience no or minimal symptoms, while others have more severe symptoms.
- Incubation period for early localized infection is 3-30 days.
- Note: Individuals who develop symptoms weeks after a tick bite may not remember being bitten or associate symptoms with the bite because nymphs are very small and tick bites are usually painless. [3]

Erythema migrans rash

Erythema migrans (EM)[4] is the most common sign of Lyme disease, classically defined as a mainly flat, localized, expanding, uniformly red rash (with or without central clearing) presenting within 7 days (range 3-30 days) at the site of a tick bite. Additional features of EM include:

- Usually painless and nonpruritic, may feel warm to the touch.
- Expands within 48 hours, usually to >5 cm in diameter; can reach up to 30 cm across its largest diameter.
- Often found near skin folds (e.g., underarm, groin, back of knee).
- May appear more as a bruise on dark skin.
- Usually disappears after ~3-4 weeks without treatment.
- Development of additional EM rashes indicates disseminated stage. [2] [3] [4] [16] [17] [18]

Note: A small, red bump (similar to a mosquito bite bump) often appears at the site of a tick bite or tick removal and resolves over a few days. This normal occurrence does not indicate Lyme disease. [16]

Symptoms indicating a hypersensitivity reaction to a tick bite (not an EM rash) may include:

- Appears within 24 hours after a bite.
- Typically, less than 5 cm in diameter and does not expand over time.
- Is itchy, painful, hot, vesicular, raised, generalized.

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[3] Refer to Ontario Lyme disease Map 2022 for estimated risk areas of infected blacklegged ticks: https://www.publichealthontario.ca/-/media/Documents/O/2022/lyme-disease-risk-area-map-2022.pdf

[4] Refer to Government of Canada website for images of EM rashes: https://www.canada.ca/en/public-health/services/diseases/lyme-disease/health-professionals-lyme-disease.html

- Recedes within 48 hours of its appearance. [2] [3]

Stages of infection [2] [3] [17] [18] [19] [20] [21]

Stage	Onset	Clinical course	Signs & symptoms*
Early localized[5]	3-30 days after infected tick bite	Usually presents as an acute illness that mimics a viral illness	Flu-like symptoms (e.g., fever, malaise, myalgia, headache, neck stiffness, migratory arthralgia) Lymphadenopathy Erythema migrans rash
Early disseminated	1-3 months after infected tick bite	If untreated, bacteria disseminate via bloodstream & lymphatic system to other body sites & cause damage to tissues at those sites, most commonly nervous & musculoskeletal systems	Fatigue & general weakness Headache Arthritis Arthralgia Myalgia Multiple erythema migrans rashes Cranial nerve palsies (e.g., facial palsy [Bell's palsy] Aseptic meningitis Lyme carditis[6] (may cause light-headedness, fainting, shortness of breath, heart palpitations, chest pain) Subtle cognitive difficulties Rare manifestations include: conjunctivitis, keratitis, mild hepatitis, splenomegaly, uveitis
Late disseminated	>3 months after infected tick bite	If remains untreated or inadequately treated, symptoms will worsen & can last months or years. May involve the heart, nervous system, & joints	Arrhythmias, heart block, & sometimes myopericarditis Recurrent arthritis affecting large joints (knees are affected most often, other large joints such as shoulder, ankle, elbow, jaw, wrist, and hip can also be involved) Peripheral neuropathy Central nervous system manifestations, e.g., meningitis; encephalopathy (i.e., behaviour changes, sleep disturbance, headaches) Fatigue

*Clinical manifestations are not necessarily specific to each stage and can overlap in some untreated individuals. Lyme disease may also present in a later stage without history of prior signs or symptoms.

[5] Symptoms generally not associated with early localized Lyme disease include nausea, sore throat, cough, runny nose, & GI symptoms.

[6] Lyme carditis occurs when *B. burgdorferi* enters heart tissue causing conduction system disturbances involving the atrioventricular (AV) node resulting in heart block, which can be fatal in rare cases. Lyme carditis can be treated with oral or IV antibiotics, depending on severity. Some individuals may need a temporary pacemaker. Individuals generally recover within 1-6 weeks. [19]

Orofacial manifestations of Lyme disease[7]

Orofacial signs of Lyme disease may include headache, facial palsy (Bell's palsy) on one or both sides of the face, TMJ arthralgia, dysgeusia, sore throat, neck pain and arthralgia, erythema migrans rash on the head and neck, acute parotitis, masticatory myalgia, lymphadenopathy, limitation in jaw opening, and dental pain (e.g., toothache symptoms). [22] [23] [24] [25] [26]

Diagnosis

- Diagnosis of early localized Lyme disease is mainly by the presence of an EM rash, with exposure history to blacklegged ticks.
- History of tick exposure includes a recent tick bite, or living in or having recently visited a Lyme disease endemic area.
- Absence of exposure history does not rule out Lyme disease.
- Misdiagnosis can lead to further disease progression and need for prolonged treatment.
- Note: Lyme disease is a public health reportable disease. [3]

Serological testing [3]

Tick exposure	Serological testing
With erythema migrans rash	Serologic tests are not sensitive at this stage; thus, treatment is recommended without laboratory confirmation.
Without erythema migrans rash	If presents with nonspecific symptoms, such as headache, fever, muscle and joint pain, serological testing is recommended. An acute sample & convalescent sample (2-4 weeks later) may be needed to obtain laboratory confirmation of Lyme disease.

Treatment

- Early Lyme disease can usually be successfully treated with a 21-day course of antibiotics.
- Individuals treated with appropriate antibiotic early in illness tend to recover more quickly than those treated at later stages of disease.
- Doxycycline, cefuroxime axetil, and amoxicillin are the most recommended oral antibiotics.
- Doxycycline is the first-line antibiotic for Lyme disease and is the most effective at preventing severe complications if started in the early stage.
- Following tick exposure, an individual with an EM rash should be treated for Lyme disease promptly, without serological testing. [2] [3]

Lyme disease and pregnancy

- Current evidence is limited on Lyme disease and pregnancy.
- Risk of passing Lyme disease to the baby during pregnancy is considered very low.
- Pregnant individuals can be safely and effectively treated with antibiotics. However, doxycycline is not recommended for pregnant individuals and should not be used for treatment of early Lyme disease in this population. Pregnant individuals should be treated using appropriate antibiotics for their stage of pregnancy.

[7] Refer to Episode 61 for initial discussion on Lyme disease and oral signs.

- Early treatment reduces risk of potential placenta infection and complications. [3]

Persistent symptoms post-treatment

Most individuals with early Lyme disease recover completely after receiving appropriate antibiotics. However, some continue to have persistent symptoms following treatment. Reasons for persistent symptoms may include:

- Coinfection[8] with another pathogen transmitted by *Ixodes* ticks, such as:
    - *Anaplasma phagocytophilum*, which causes anaplasmosis (symptoms may include fever, headache, chills, muscle aches). [27]
    - *Babesia macrotia*, which causes babesiosis (symptoms may include fever, chills, sweats, headache, body aches, loss of appetite, nausea, fatigue). [28]
    - Powassan virus disease (symptoms may range from mild flu-like symptoms to life threatening encephalitis). [29]
    - *Borrelia miyamotoi*, which causes tick-borne relapsing fever (symptoms may include fever, headache, muscle and joint aches, nausea). [30]
- Initial diagnosis of Lyme disease was incorrect.
- Another condition persists (e.g., fibromyalgia, depression, patellofemoral joint disease).
- Permanent tissue damage may have occurred in individuals with previous neurologic involvement. [3]

Post-treatment Lyme disease syndrome

Approximately 10-20% of individuals may experience post-treatment Lyme disease syndrome (PTLDS) where symptoms (e.g., fatigue, headache, joint and muscle aches, impaired cognitive function) last for >6 months following appropriate antibiotic treatment for Lyme disease. It is unknown why some individuals experience PTLDS.

Experts have hypothesized PTLDS may be due to:

- *Borrelia burgdorferi* may trigger an autoimmune response causing symptoms to last well after the infection itself is gone. Autoimmune responses are known to occur following other infections (e.g., campylobacter causing Guillain-Barré syndrome; chlamydia causing reactive arthritis; strep throat causing rheumatic heart disease).
- PTLDS results from a persistent but difficult to detect infection.
- PTLDS symptoms are due to other causes unrelated to the individual's *B. burgdorferi* infection.

There is no proven treatment for PTLDS. Short-term antibiotic treatment is a proven treatment for early Lyme disease. However, studies have found long-term outcomes are not better for individuals who received additional prolonged antibiotic treatment than placebo, but caused significant adverse events including *Clostridioides difficile*, intravenous catheter site infections (when intravenous catheters are used for medication delivery), significant allergic reactions, and death.

[8] Suspected coinfection may need referral to an infectious disease specialist.

Additionally, focusing care on unproven therapies can result in delays in conducting other investigations, identifying the correct diagnoses, and initiating evidence-based treatment to optimize well-being.

Individuals with PTLDS usually get better over time, but it can take many months to feel completely well. Individuals who still feel unwell after Lyme disease treatment, should see a medical practitioner to discuss symptom management options. [4] [18] [31] [32]

Tick removal

Remove attached ticks as soon as possible to reduce chance of infection.

- Use clean, fine-tipped tweezers to grasp the head as close to the skin as possible.
- Slowly pull the tick straight out, gently but firmly. Ticks firmly attach their mouthparts into the skin requiring slow but firm traction to remove them.
- Do not crush, squeeze, or damage the tick because it may result in the disease-causing bacteria to pass from the tick into the bloodstream.
- Do not jerk or twist the tweezers while pulling the tick out, which may cause mouthparts to remain embedded. If mouthparts remain in the skin, remove with tweezers. If unable to remove embedded pieces or a tick that is deep in the skin, visit a medical healthcare provider as soon as possible to remove.
- Place tick in a sealable plastic bag or container (e.g., pill bottle).
- Wash the bite area with soap and water or alcohol-based sanitizer and clean hands thoroughly.
- Record date, geographic location, and part of the body that was bitten (e.g., on calendar, phone). Take a photo of the tick to help you or your healthcare provider determine the type of tick and risk of disease transmission (e.g., submission on a tick identifying platform)
- Monitor for signs and symptoms for the next 30 days.
- Note: Tick testing is only done with ticks collected by local public health units using a method called tick dragging. These test results are used to monitor where infected and uninfected ticks live. Tick testing is not used to diagnose Lyme disease in humans. [11] [12] [13]

<u>Do not try to remove a tick by</u>:

- Burning it (e.g., with a lit match or cigarette)
- Smothering it with nail polish, nail polish remover, essential oils, petroleum jelly, liquid soap, or kerosene.

This can cause the tick to release its stomach contents into the bite area, increasing infection risk. [11] [12]

Postexposure prophylaxis

Postexposure prophylaxis (i.e., single dose of oral doxycycline) may be recommended for asymptomatic individuals if all the following criteria are met:

1. Blacklegged tick was attached for >24 hours;
2. Prophylaxis can be started within 72 hours of tick removal;
3. Tick was acquired in an area with a prevalence of ticks infected with *Borrelia burgdorferi* is >20% (e.g., Rouge National Urban Park and Morningside Park in the

Greater Toronto Area, Brighton, Kingston and surrounding areas, Thousand Islands, Brockville, Perth-Smiths Falls and surrounding areas, Ottawa and surrounding areas, Rondeau Provincial Park in Morpeth, etc.);[9] and
4. Doxycycline is not contraindicated.

Other antibiotics such as amoxicillin have not been proven effective for postexposure prophylaxis. Unlike treatment for early Lyme disease in pregnant individuals, recent research suggests a single dose of doxycycline is safe for pregnant individuals as postexposure prophylaxis. [2] [18] [33]

Individuals who receive postexposure prophylaxis should still monitor for signs and symptoms as postexposure prophylaxis may not be 100% effective. [2]

Tick identification
To determine if a tick is a blacklegged tick, contact a local public health unit[10] or a medical practitioner, or upload a photo of the tick for identification to the eTick website or mobile app. [8]

eTick[11]
eTick is a free publicly available tick identification platform for ticks found on a person, pet, or in the environment. Members of the public and healthcare providers can submit a photo and receive species identification results within 48 hours. The website offers tips on how to take photos for submission (e.g., placing tick in closed container in freezer for 10-30 minutes to immobilize it; placing tick near a ruler or coin for measurement purposes). Keep the tick for a period of at least 5 days following photo submission in case additional photos are required to complete the identification. [34]

Disposing of ticks
Ticks should be killed before disposal by placing in rubbing alcohol or by freezing for several days. Avoid squashing ticks with bare fingers as infection may enter through breaks in skin. Ticks can be disposed of in household garbage once they are dead. [11]

Prevention
Avoiding tick bites is the best prevention against Lyme disease, strategies include:
- Use insect repellent containing DEET or icaridin[12]; follow manufacturer's instructions.

[9] Refer to Ontario Lyme disease Map 2022 for additional areas: https://www.publichealthontario.ca/-/media/Documents/O/2022/lyme-disease-risk-area-map-2022.pdf
[10] Public Health Units https://www.health.gov.on.ca/en/common/system/services/phu/locations.aspx
[11] eTick website: https://www.etick.ca/
[12] Icaridin, also known as picaridin, is a synthetic compound made to resemble the natural compound piperine, which is found in the group of plants used to produce black pepper. Icaridin repels insects and makes them less likely to bite. [39]

- Wear proper clothing (e.g., light-coloured clothing to see ticks easier), closed-toed shoes, long-sleeved shirts, long pants tucked into socks, special clothing designed to repel ticks (e.g., permethrin-treated clothing[13]).
- Walk in the centre of trails.
- Check for ticks on yourself and your children after being outdoors (e.g., full body and head, including in and around hair, legs, back of knees, inside belly button, in and around ears, groin area, underarm area, between toes, back of body [use a mirror or someone else checks]).
- Shower as soon as possible after spending time outdoors to wash off any ticks (ticks often remain on skin for hours before attaching themselves).
- Remove ticks as soon as possible after bites.
- Check pets for ticks after being outdoors (e.g., in and around ears, around eyes and tail, between toes and back legs, under their collar and front legs); remove any ticks found. Tick removal for pets is the same as for humans. Pets cannot spread Lyme disease directly to humans, but they can carry infected ticks into the home and yard. Monitor pets for signs of Lyme disease (e.g., sore muscles and joints, fever, fatigue, changes in behaviour or appetite). Signs of tickborne disease may not appear for 7-21 days or longer after a tick bite. Consult a veterinarian about tick prevention (e.g., oral or topical acaricides) or if the pet develops symptoms.
- Check clothing and gear (e.g., boots, daypacks, tents) for ticks. Ticks may be carried into the house on clothing and gear. Remove any ticks found. Tumble dry clothes in a dryer on high heat for 10 minutes to kill ticks on dry clothing. If clothes are damp, additional time may be needed. If the clothes require washing first, hot water is recommended. Cold and medium temperature water will not kill ticks.
- Remove tick habitats from around the home, strategies include:
    - Keep grass mowed short
    - Remove leaf litter, brush, weeds from edge of lawn, stone walls, wood piles.
    - Trim bushes and tree branches to let in sunlight (ticks avoid hot, dry locations).
    - Stack firewood neatly and in a dry area.
    - Create a border of gravel or woodchips 1 metre or wider around the yard if next to a wooded area or an area with tall grasses.
    - Move children's swing sets and sandboxes away from woodland's edge, consider placing them on a woodchip or mulch foundation.
- Discourage rodents by sealing stonewalls and small openings around the yard. Use plantings that do not attract deer or exclude deer by fencing. Keep bird feeders away from the house.
- Note: Individuals do not become immune to Lyme disease and can be reinfected from another tick bite. Follow precautions to prevent another bite. [7] [12] [13] [15] [35] [36] [37]

[13] Permethrin-treated clothing is approved by Health Canada for persons >16 years, including pregnant individuals. Permethrin is a synthetic insecticide similar to pyrethrum, a natural insecticide found in chrysanthemums. Permethrin irritates ticks causing them to move away before they can bite. Permethrin-treated clothing does not provide complete protection and should be layered with other prevention measures. Follow label instructions. This clothing has not been evaluated for pet safety in Canada, avoid prolonged contact between clothing and pets. [41] [42]

Risk factors

Risk factors for Lyme disease include:

- Outside activities that increase tick exposure (e.g., gardening, hiking, camping, golfing) in an area where Lyme disease occurs (e.g., wooded or grassy areas).
- Having a pet that may carry infected ticks home.
- Walking in high grasses in areas where Lyme disease occurs, including city gardens and parks.
- Not removing ticks promptly or properly.
- The greatest risk occurs in regions where populations of ticks carrying *B. burgdorferi* have become established. [1] [12] [16] [38]

Take home messages

- With the increasing number of Lyme disease cases, it is vital for oral health professionals to be familiar with signs and symptoms of all stages of illness to better educate clients and support early detection of the disease.
- Client education should include tick bite prevention as well as signs and symptoms of Lyme disease and to seek medical guidance accordingly.
- Orofacial manifestations of Lyme disease affect head and neck anatomical areas routinely examined by oral health professionals.
- Oral health professionals should consider Lyme disease when clients present with unexplained facial paralysis, neck stiffness, headache, TMJ pain, altered taste, sore throat, and neck pain when a clinical examination fails to identify a specific oral pathology and refer for medical consultation.
- Information to obtain from clients that may assist oral health professionals when undiagnosed Lyme disease is suspected include: if they have noticed a red, circular skin rash; the geographic area they live; have they worked, played, or travelled to an outdoor area in the previous weeks or months (e.g., camping, visited wooded areas, public parks, or gardens); recollection of a recent insect bite; and do they own pets that venture outside.
- Refer for medical consultation when Lyme disease is suspected. Obtaining early diagnosis through interprofessional care is critical since most cases of Lyme disease can be managed successfully with timely diagnosis and appropriate treatment.
- Additional research is needed to help all clinicians understand orofacial symptoms associated with Lyme disease to improve health outcomes for clients with the illness.

References

[1] Government of Canada, "Lyme disease surveillance in Canada: Preliminary annual report 2019," 8 January 2022. [Online]. Available: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/lyme-disease-surveillance-report-2019.html. [Accessed 1 August 2022].

[2] Centre for Effective Practice, "Early Lyme Disease Management in Primary Care," February 2020. [Online]. Available: https://cep.health/media/uploaded/CEP_EarlyLymeDisease_Provider_2020.pdf. [Accessed 1 August 2022].

[3] Government of Canada, "Lyme disease: For health professionals," 28 January 2022. [Online]. Available: https://www.canada.ca/en/public-

health/services/diseases/lyme-disease/health-professionals-lyme-disease.html. [Accessed 1 August 2022].

[4] L. Bush and M. Vazquez-Pertejo, "Lyme Disease," Merck Manual Professional Version, November 2020. [Online]. Available: https://www.merckmanuals.com/en-ca/professional/infectious-diseases/spirochetes/lyme-disease. [Accessed 1 August 2022].

[5] LymeDisease.org, "Types of Ticks," 2022. [Online]. Available: https://www.lymedisease.org/types-of-ticks/. [Accessed 7 August 2022].

[6] Centers for Disease Control and Prevention, "How ticks survive," 21 September 2022. [Online]. Available: https://www.cdc.gov/ticks/life_cycle_and_hosts.html. [Accessed 1 August 2022].

[7] City of Toronto, "Lyme Disease," 2022. [Online]. Available: https://www.toronto.ca/community-people/health-wellness-care/health-programs-advice/lyme-disease/. [Accessed 1 August 2022].

[8] Public Health Ontario, "Let's Talk About Ticks!," 18 July 2022. [Online]. Available: https://www.publichealthontario.ca/en/About/News/2022/Tick-Season. [Accessed 2 August 2022].

[9] etick.ca, "How to recognize a tick," [Online]. Available: https://www.etick.ca/wordpress/wp-content/uploads/2017/03/How-to-recognize-a-tick.pdf. [Accessed 2 August 2022].

[10] Government of Canada, "Blacklegged (deer) ticks," 4 June 2015. [Online]. Available: https://www.canada.ca/en/health-canada/services/pest-control-tips/blacklegged-deer-ticks.html. [Accessed 2 August 2022].

[11] Government of Canada, "Lyme disease: How to remove and identify a tick," 10 January 2022. [Online]. Available: https://www.canada.ca/en/public-health/services/diseases/lyme-disease/removing-submitting-ticks-testing.html. [Accessed 2 August 2022].

[12] Government of Ontario, "Lyme disease," 20 April 2022. [Online]. Available: https://www.ontario.ca/page/lyme-disease. [Accessed 2 August 2022].

[13] Centre for Effective Practice, "Ticks and Early Lyme Disease: Information for Patients," February 2020. [Online]. Available: https://cep.health/media/uploaded/CEP_Early_Lyme_Disease_Patient_2020.pdf. [Accessed 3 August 2022].

[14] Government of Canada, "Lyme disease: Monitoring," 1 April 2022. [Online]. Available: https://www.canada.ca/en/public-health/services/diseases/lyme-disease/surveillance-lyme-disease.html. [Accessed 3 August 2022].

[15] Public Health Ontario, "2020 Lyme disease Data at a Glance," 2020. [Online]. Available: https://www.publichealthontario.ca/en/diseases-and-conditions/infectious-diseases/vector-borne-zoonotic-diseases/lyme-disease. [Accessed 3 August 2022].

[16] Mayo Clinic, "Lyme disease," 24 October 2020. [Online]. Available: https://www.mayoclinic.org/diseases-conditions/lyme-disease/symptoms-causes/syc-20374651. [Accessed 3 August 2022].

[17] Government of Canada, "Lyme disease: Symptoms and treatment," 10 January 2022. [Online]. Available: https://www.canada.ca/en/public-health/services/diseases/lyme-disease.html. [Accessed 4 August 2022].

[18] City of Toronto, "Lyme Disease Information for Health Professionals," July 2022. [Online]. Available: https://www.toronto.ca/community-people/health-wellness-care/information-for-healthcare-professionals/environmental-health-infomation-for-health-professionals/lyme-disease-info-for-health-professionals/. [Accessed 5 August 2022].

[19] Centers for Disease Control and Prevention, "What is Lyme carditis?," 24 February 2022. [Online]. Available: https://www.cdc.gov/lyme/treatment/lymecarditis.html. [Accessed 5 August 2022].

[20] O. Rivera and V. Nookala, "Lyme Carditis," National Library of Medicine, 15 February 2022. [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK546587/. [Accessed 5 August 2022].

[21] Centers for Disease Control and Prevention, "What is Lyme arthritis?," 7 October 2021. [Online]. Available: https://www.cdc.gov/lyme/treatment/LymeArthritis.html. [Accessed 5 August 2022].

[22] B. Bradshaw, K. Jones and G. H. Westerdale-McInnis, "Orofacial manifestations of Lyme disease: A systematic review," *Journal of Dental Hygiene,* vol. 95, no. 4, pp. 23-31, August 2021.

[23] CDHO, "Lyme Disease," CDHO, Toronto, 2014.

[24] Centers for Disease Control and Prevention, "What is neurologic Lyme disease?," 11 August 2021. [Online]. Available: https://www.cdc.gov/lyme/treatment/NeurologicLyme.html. [Accessed 6 August 2022].

[25] O. Gnatovych and V. Benvenuto, "The Manifestations of Lyme Disease," 11 February 2020. [Online]. Available: https://dimensionsofdentalhygiene.com/article/manifestations-lyme-disease/. [Accessed 6 August 2022].

[26] D. Goldfarb and R. Sataloff, "Lyme disease: A review for the otolaryngologist," *ENT Journal,* vol. 73, no. 11, pp. 824-829, 1994.

[27] Centers for Disease Control and Prevention, "Anaplasmosis," 9 May 2022. [Online]. Available: https://www.cdc.gov/anaplasmosis/index.html. [Accessed 5 August 2022].

[28] Centers for Disease Control and Prevention, "Parasites - Babesiosis," 17 May 2018. [Online]. Available: https://www.cdc.gov/parasites/babesiosis/disease.html. [Accessed 5 August 2022].

[29] Government of Canada, "Symptoms of Powassan virus disease," 31 October 2017. [Online]. Available: https://www.canada.ca/en/public-health/services/diseases/powassan-virus/symptoms.html. [Accessed 5 August 2022].

[30] Centers for Disease Control and Prevention, "Tick-borne Relapsing Fever," 10 September 2015. [Online]. Available: https://www.cdc.gov/relapsing-fever/. [Accessed 5 August 2022].

[31] Centers for Disease Control and Prevention, "Post-Treatment Lyme Disease Syndrome," 10 January 2022. [Online]. Available: https://www.cdc.gov/lyme/postlds/index.html. [Accessed 5 August 2022].

[32] Association of Medical Microbiology and Infectionous Disease Canada, "AMMI Canada position statement on the diagnosis and treatment of people with persistent symptoms that have been attributed to Lyme disease," *JAMMI,* vol. 4, no. 2, pp. 43-46, June 2019.

[33] Health Quality Ontario, "Management of Tick Bites and Investigation of Early Localized Lyme Disease," 2018. [Online]. Available: https://www.hqontario.ca/Portals/0/documents/evidence/qs-clinical-guidance-lyme-disease-en.pdf. [Accessed 5 June 2022].

[34] eTick, "eTick," 2021. [Online]. Available: https://www.etick.ca/. [Accessed 4 August 2022].

[35] Centers for Disease Control and Prevention, "Ticks on pets," 10 January 2019. [Online]. Available: https://www.cdc.gov/ticks/avoid/on_pets.html. [Accessed 5 August 2022].

[36] Government of Canada, "Pamphlet: Enjoy the outdoors, without a tick," 15 June 2020. [Online]. Available: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/lyme-pamphlet.html. [Accessed 5 August 2022].

[37] Centers for Disease Control and Prevention, "Ticks on people," 1 July 2020. [Online]. Available: https://www.cdc.gov/ticks/avoid/on_people.html. [Accessed 5 August 2022].

[38] U.S. National Library of Medicine, "Lyme disease," MedlinePlus, 2021. [Online]. Available: https://medlineplus.gov/ency/article/001319.htm. [Accessed 3 August 2022].

[39] National Pesticide Information Center, "Picaridin," December 2009. [Online]. Available: http://npic.orst.edu/factsheets/PicaridinGen.html. [Accessed 5 August 2022].

[40] I. Mello, J. Peters and C. Lee, "Neuropathy mimicking dental pain in a patient diagnosed with Lyme disease," *Journal of Endodontics,* vol. 46, no. 9, pp. 1337-1339, 1 September 2020.

[41] Government of Canada, "Permethrin-treated clothing," 14 August 2020. [Online]. Available: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/permethrin-treated-clothing.html. [Accessed 5 August 2022].

[42] Florida Department of Agriculture & Consumer Services, "Frequently Asked Questions about Permethrin," 20 March 2013. [Online]. Available: https://www.fdacs.gov/content/download/3188/file/Permethrin%2520QA%25203-20-13.pdf. [Accessed 6 August 2022].

Client resources

Factsheet: Ticks & Lyme Disease How to prevent tick bites when outdoors, Government of Ontario, 2016
https://files.ontario.ca/moh-lyme-en-factsheet-2019-11-20.pdf

Poster: Protect yourself from Lyme disease, Government of Ontario, October 2019
https://files.ontario.ca/moh-lyme-en-poster-2019-11-20.pdf

Factsheet: The Facts: Ticks and Lyme Disease, Government of Ontario, 2017
https://www.health.gov.on.ca/en/ms/lyme/pdf/lyme_factsheet_en.pdf

Factsheet: Ticks and Lyme Disease, Government of Ontario, 2016
https://www.health.gov.on.ca/en/ms/lyme/pdf/lyme_factsheet_07072016_en.pdf

Poster: Top 10 tick hiding spots on your body, Government of Canada, June 15, 2020
Available in 11 different languages
https://www.canada.ca/en/public-health/services/publications/diseases-conditions/top-10-tick-hiding-spots-body-poster.html

Pamphlet: Enjoy the outdoors, without a tick, Government of Canada, June 15, 2020
Available in 11 different languages
https://www.canada.ca/en/public-health/services/publications/diseases-conditions/lyme-pamphlet.html

Wallet card: How to check for ticks, Government of Canada, June 15, 2020
Available in 11 different languages
https://www.canada.ca/en/public-health/services/publications/diseases-conditions/how-to-check-for-ticks-wallet-card.html

Poster and postcard: Enjoy the outdoors, without a tick, Government of Canada, June 15, 2020
Available in 11 different languages
https://www.canada.ca/en/public-health/services/publications/diseases-conditions/lyme-disease-posters.html

Lyme disease, Government of Ontario, April 2022
https://www.ontario.ca/page/lyme-disease

Lyme disease video: How to properly remove a tick, Government of Canada, June 11, 2021
https://www.canada.ca/en/public-health/services/video/lyme-disease-properly-remove-tick.html

Lyme disease video: How to reduce ticks around your home, Government of Canada, June 11, 2021
https://www.canada.ca/en/public-health/services/video/lyme-disease-reduce-ticks-around-your-home.html

Lyme disease video: Enjoy the outdoors, without a tick, Government of Canada, April 13, 2018
https://www.canada.ca/en/public-health/services/video/lyme-disease-enjoy-outdoors-without-tick.html

Lyme disease video: Stay tick-free, Government of Canada, May 30, 2017
https://www.canada.ca/en/public-health/services/video/lyme-disease-stay-tick-free.html

Ticks and Early Lyme Disease: Information for Patients, Centre for Effective Practice, February 2020, p 1-4
https://cep.health/media/uploaded/CEP_Early_Lyme_Disease_Patient_2020.pdf

Additional Resources

Lyme disease: For health professionals, Government of Canada, January 28, 2022
https://www.canada.ca/en/public-health/services/diseases/lyme-disease/health-professionals-lyme-disease.html

Lyme disease, CDHO factsheet, September 11, 2014, p 1-3
https://www.cdho.org/Advisories/CDHO_Factsheet_Lyme_Disease.pdf

Ontario Lyme disease map 2022: Estimated risk areas, Public Health Ontario, 2022, p 1-5
https://www.publichealthontario.ca/-/media/Documents/O/2022/lyme-disease-risk-area-map-2022.pdf

Early Lyme disease management in primary care, Centre for Effective Practice, February 2020, p 1-11
https://cep.health/media/uploaded/CEP_EarlyLymeDisease_Provider_2020.pdf

Management of tick bites and investigation of early localized Lyme disease, Clinical Guidance Document, Health Quality Ontario, 2018, p 1-2
https://www.hqontario.ca/Portals/0/documents/evidence/qs-clinical-guidance-lyme-disease-en.pdf

Lyme disease information for health professionals, City of Toronto, July 2022
https://www.toronto.ca/community-people/health-wellness-care/information-for-healthcare-professionals/environmental-health-infomation-for-health-professionals/lyme-disease-info-for-health-professionals/

Lyme Disease, Bush, L; Vazquez-Pertejo, M. Merck Manual Professional Version, November 2020
https://www.merckmanuals.com/en-ca/professional/infectious-diseases/spirochetes/lyme-disease

The manifestations of Lyme disease, Gnatovych, O; Benvenuto, V. *Dimensions of Dental Hygiene*, February 11, 2020
https://dimensionsofdentalhygiene.com/article/manifestations-lyme-disease/

Orofacial manifestations of Lyme disease: A systematic review, Bradshaw, B; Jones, K; Westerdale-McInnis, J; Gaff, H. *Journal of Dental Hygiene*, Volume 95, Issue 4, August 2021, p 23-31
https://jdh.adha.org/content/95/4/23

Report of the pathogenesis and pathophysiology of Lyme disease Subcommittee of the HHS Tick Borne Disease Working Group, Donta, S; States, L; Adams, W; et al. *Frontiers in Medicine*, Volume 8, Article 643235, June 7, 2021, p 1-8
https://www.frontiersin.org/articles/10.3389/fmed.2021.643235/full

Post-treatment Lyme disease as a model for persistent symptoms in Lyme disease, Rebman, A; Aucott, J. *Frontiers in Medicine*, Volume 7, Article 57, February 25, 2020, p 1-16
https://www.frontiersin.org/articles/10.3389/fmed.2020.00057/full

The clinical, symptom, and quality-of-life characterization of a well-defined group of patients with posttreatment Lyme disease syndrome, Rebman, A; Bechtold, K; Yang, T; et al. *Frontiers in Medicine*, Volume 4, Article 224, December 14, 2017, p 1-10
https://www.frontiersin.org/articles/10.3389/fmed.2017.00224/full