International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
editorial-office@sciformat.ca

ARTICLE TITLE	LYME DISEASE AS A PUBLIC HEALTH CHALLENGE: A REVIEW OF RECENT EVIDENCE
DOI	https://doi.org/10.31435/ijitss.1(49).2026.4569
RECEIVED	08 January 2026
ACCEPTED	23 March 2026
PUBLISHED	30 March 2026
LICENSE	The article is licensed under a **Creative Commons Attribution 4.0 International License.**

LYME DISEASE AS A PUBLIC HEALTH CHALLENGE: A REVIEW OF RECENT EVIDENCE

Karol Chromiak *(Corresponding Author, Email: chromiakk@onet.pl)*
Internship, 1st Military Clinical Hospital with the Outpatient Clinic, Lublin, Poland
ORCID ID: 0000-0002-4683-5762

Marcelina Podleśna
Doctoral School, Medical University of Lublin, Lublin, Poland
ORCID ID: 0009-0002-2266-3764

Kacper Curzytek
Internship, University Clinical Hospital No. 1 in Lublin, Lublin, Poland
ORCID ID: 0009-0006-3049-0188

Aleksandra Stępień
Internship, Regional Specialist Hospital, Lublin, Poland
ORCID ID: 0009-0004-9258-2294

Kacper Bączek
Internship, University Clinical Centre, Gdańsk, Poland
ORCID ID: 0000-0003-2860-8360

Kacper Bluczak
Medical University of Lublin, Lublin, Poland
ORCID ID: 0009-0009-8258-986X

ABSTRACT

Lyme disease, primarily caused by the spirochete Borrelia burgdorferi transmitted by ticks of the genus Ixodes, is a growing public health problem in many regions of the world. The disease is characterized by a diverse clinical course, including early skin lesions such as erythema migrans, and late joint, neurological, cardiac, and, less frequently, chronic complications. The pathogenesis of Lyme disease is associated with the invasion of tissues by the spirochetes and their ability to evade the host immune response, leading to chronic inflammation. Diagnosis relies on a combination of clinical assessment and serological testing, while considering the limitations of false positive and negative results. Standard treatment includes antibiotic therapy tailored to the stage of disease. Prevention plays a key role and includes the use of repellents, appropriate clothing, environmental monitoring, and public education and awareness in endemic areas. Effective prevention and early diagnosis are essential to reduce morbidity and clinical complications.

KEYWORDS

Lyme Disease, Borrelia Burgdorferi, Tick-Borne Diseases, Ixodes Ticks

CITATION

Karol Chromiak, Marcelina Podleśna, Kacper Curzytek, Aleksandra Stępień, Kacper Bączek, Kacper Bluczak. (2026) Lyme Disease as a Public Health Challenge: A Review of Recent Evidence. *International Journal of Innovative Technologies in Social Science*. 1(49). doi: 10.31435/ijitss.1(49).2026.4569

Introduction

The main pathogens causing Lyme disease are Borrelia burgdorferi, Borrelia garini and Borrelia afzelii. Infected ticks of the genus Ixodes are the main vector through which the disease is transmitted to humans through bites. [1] Erythema migrans, an expanding skin rash that most often appears at the site of a tick bite, is the most common clinical symptom of Lyme disease. The infectious agent can then spread throughout the body, affecting various tissues and organs, leading to symptoms affecting the skin, joints, heart, and nervous system. [2] Antibiotic therapy is the primary treatment for Lyme disease. The most commonly used medications include doxycycline, amoxicillin, cefuroximetil, azithromycin, and penicillin. [3] The aim of this article is to present the current knowledge on the epidemiology, etiology and clinical significance of Lyme disease, because understanding the mechanisms of infection as well as effective methods of prevention and diagnosis of this disease is crucial to limiting its impact on population health.

Epidemiology

Lyme disease is mainly endemic in regions with a temperate climate. Depending on the habitat range of Ixodes ticks, Lyme disease is also endemic in certain regions of North America, Europe, the Middle East, Australia, Southeast Asia, and areas of Russia. [1] Lyme disease cases are being reported more and more frequently on various continents, with a relatively high incidence of antibodies against Borrelia being observed in Central Europe and Western and Eastern Asia. [2] This upward trend is associated with reforestation, increases in deer and tick populations, and increased human exposure to ticks due to increased migration into forested areas and deer habitats. The risk of contracting Lyme disease is particularly high for people traveling to endemic regions, as well as for those who work in forests, nature parks or meadows, and for hikers who spend a lot of time in green areas. [1] In Asia, the main vector of Lyme disease is Ixodes persulcatus, on the Pacific coast I. pacificus, in Europe I. ricinus, and in the northeastern and central regions of the United States and in Canada I. scapularis. [4]

Pathogenesis

Lyme disease is a zoonotic disease transmitted from animals to humans. The etiological agent is the spirochete Borrelia burgdorferi, which inhabits the intestine of the Ixodes tick, which serves as the infection vector. The natural reservoir of the pathogen in the environment is small mammals, primarily mice, shrews, squirrels, and other small animal species. Human infection occurs as a result of tick nymphs attaching to the skin, which feed by sucking blood, and their greatest activity occurs in late spring and summer, which determines the seasonal nature of Lyme disease cases. [5]

After biting, an infected tick injects Borrelia burgdorferi subcutaneously. In the first 24 hours after the bite, the risk of transmitting the infection is negligible, while effective transmission of the pathogen usually occurs around the third day of the tick's feeding. In Europe and Asia, there is a certain risk of infection transmission already within the first 24 hours after tick attachment, which is related to the presence of the species Ixodes ricinus and Ixodes persulcatus, which transmit different genospecies of spirochetes — Borrelia garinii and Borrelia afzelii. [6] As the tick feeds, its saliva, injected into the tissues along with the spirochete, modulates the host's local immune response, creating favorable conditions for the pathogen to multiply. The spirochetes multiply and migrate within the dermis, and skin lesions resulting from the host's inflammatory response, known as erythema migrans, are a characteristic symptom of infection. [5] The spirochetes show tropism not only for the joints, nervous system, heart and eyes, but their presence has also been confirmed in the lymph nodes, bone marrow, liver, spleen, testicles and placenta, which indicates their ability to disseminate early via the bloodstream. The detection of Borrelia burgdorferi or its genetic material in the blood or cerebrospinal fluid (CSF) in approximately 10% of patients with erythema migrans (EM) without systemic symptoms confirms the occurrence of spirochetemia and early penetration of the central nervous system. [7] Only a limited number of Borrelia burgdorferi genotypes are responsible for most cases of disseminated or chronic Lyme disease. Clinically, B. afzelii is most often associated with acrodermatitis chronica atrophicans (ACA), while B. garinii has a particular tropism for the nervous system, leading to neurological symptoms. Arthritis and neuroborreliosis are most often associated with B. burgdorferi infection. As a result of molecular mimicry, an autoimmune inflammatory reaction occurs, caused by cross-interaction of antibodies directed against membrane epitopes of spirochete proteins with antigens present in nervous and connective tissues. [1]

Clinical Picture

Three characteristic clinical stages – early localized, early disseminated, and late – constitute the typical developmental course of Lyme disease. [8] Although the morphology of erythema migrans can be variable, a central brightening is often observed, giving the lesion a characteristic "bull's-eye" appearance. This erythema, typical of the early localized phase of Lyme disease, usually develops at the site of a tick bite. It begins as a small red spot that appears 2 to 30 days after exposure and then gradually enlarges over the following days or weeks, reaching a diameter of 5 to 60 cm and forming a ring-shaped skin lesion. Although the skin lesion usually resolves spontaneously within a few weeks or months, it may recur in about 20% of patients, and if left untreated, about 75% of patients develop further symptoms of early disseminated or late Lyme disease. [1,5] Flu-like symptoms such as fatigue, headache and general malaise may accompany the early, localized stage of infection. [5] Musculoskeletal and neurological symptoms predominate in the early disseminated form of Lyme disease, which typically develops 3–10 weeks after the tick bite, whereas dermatological and cardiac symptoms are relatively less common. [1] In 17%–57% of patients, secondary erythema migrans (EM) lesions are observed in locations distant from the tick bite, suggesting hematogenous or lymphatic dissemination. Compared with primary EM, secondary lesions are multiple, usually similar in size and shape, occur in one or two body regions, and are characterized by less swelling, central pallor, and milder local symptoms. [9,10]. In a small number of patients, the disease may present only as isolated erythema migrans (EM), whereas mild fever and regional lymph node enlargement are relatively common. [7] The most characteristic symptom of late-stage Lyme disease is arthritis, which in approximately 60% of untreated patients usually develops several months after the first symptoms appear. After a tick bite, B. burgdorferi spirochetes can spread throughout the body and settle in synovial joints, triggering an inflammatory response in the synovial tissue, including synovial hyperplasia, vascular proliferation, and mononuclear cell infiltration. [5]

Borrelia lymphocytoma is a lesion that rarely occurs in the early stages of disseminated disease and usually appears 30–45 days after the tick bite, although it can occur earlier or up to six months after infection. In children, the lesion is primarily located on the earlobe, appearing as a single bluish-red nodule or plaque ranging from one to several centimeters in diameter. In adults, lesions may appear on the nipple, sometimes with mild pain, but rarely involve the scrotum, nose, or limbs. The lesion resolves within approximately 3 weeks after antibiotic therapy, but the differential diagnosis should include lymphoma, leukemic infiltrates, lupus erythematosus, sarcoidosis, facial granuloma, and polymorphic light rash. [9]

The most common neurological symptom in early Lyme disease is facial nerve palsy, occurring in approximately 3% of patients, particularly in children with meningeal symptoms. Cranial neuropathies are observed in a total of 5–20% of patients with this form of infection. If left untreated, some patients develop migratory enthesitis, which initially affects polyarticular joints and then, within 1–2 days, transforms into a monoarticular form, most often affecting the knee, ankle, or wrist joints. Inflammatory episodes typically last about a week and may recur every 2–3 months, but tend to resolve spontaneously over time—over a period of approximately 10 years. [1,11,12]

Neurological symptoms occur in approximately 15% of untreated patients and include lymphocytic meningitis, cranial neuropathies, primarily unilateral facial nerve palsy, less frequently bilateral, motor or sensory radiculoneuropathy, mononeuritis multiplex, cerebellar ataxia, and myelitis. Patients may report headaches, neck stiffness, and altered mental status. The classic triad of neurological symptoms includes meningitis, cranial neuropathy, and radiculoneuropathy, although all these elements do not occur simultaneously. In endemic regions, Lyme disease should be considered in the differential diagnosis of unilateral seventh nerve palsy, also known as Bell's palsy. Rarely, late-onset disease manifests as subacute encephalopathy or axonal polyneuropathy, usually accompanied by disturbances of consciousness, cognitive function, insomnia, or personality changes. [13]

Clinical cardiac involvement in Lyme disease patients occurs in 4–10% of patients, of whom 90% develop myocarditis. Physical examination reveals bradycardia in approximately 35% of patients and tachycardia in approximately 15%. Typical symptoms include dyspnea, chest pain, irregular heartbeat, and syncopal episodes. The most common forms of cardiac involvement include atrioventricular conduction and rhythm disturbances, pericarditis, and postural orthostatic tachycardia syndrome. [4]

Symptoms of meningitis typically develop between 2 and 10 weeks after infection. If eye problems, such as double vision, occur, they are most often caused by cranial neuropathy. Inflammation of the cornea or iris, on the other hand, leads to eye pain and blurred vision. Typically, after several months, and sometimes only years, after infection, borreliosis encephalopathy becomes apparent, which is a late complication of the disease. [1] Late, or chronic, Lyme disease typically develops after a long latency period, spanning months or

years after the initial infection. This stage is characterized by persistent nonspecific symptoms that may or may not be reflected in clinical and laboratory tests. [7,13]

Marques divides chronic Lyme disease into four categories. Category 1 includes symptoms of unknown cause, with no evidence of *Borrelia burgdorferi* infection. Category 2 refers to a well-defined illness unrelated to *B. burgdorferi* infection. Category 3 encompasses symptoms of unknown cause in patients who have antibodies against *B. burgdorferi* but no history of objective clinical findings consistent with Lyme disease. Finally, Category 4 corresponds to post-Lyme disease syndrome. In clinical practice, most patients described as having "chronic Lyme disease" fall into categories 1 and 2. [14]

Neurological and rheumatological manifestations, as well as atrophic dermatitis chronica atrophica (ACA), are the most typical manifestations of this phase of the disease.[9]

Chronic atrophic dermatitis of the extremities (ACA) is a late manifestation of Lyme disease, developing months or years after infection, primarily in older adults due to persistent infection with the spirochete Borrelia. Lesions typically occur on the distal limbs, particularly around bony prominences, reflecting the pathogen's preference for cooler skin areas. The disease pathogenesis involves a chronic inflammatory response mediated by T lymphocytes and limited cytokine expression, with concomitant downregulation of MHC class II molecules on Langerhans cells.[15,16]

In the advanced stage of chronic atrophic dermatitis of the extremities (ACA), extensive lesions occur covering large areas of the skin, characterized by induration, hypersensitivity, and a tendency to develop ulcers that are difficult to heal. In rare cases, malignant transformation in the form of squamous cell carcinoma or sarcoma may occur. The atrophic phase develops gradually over many years, leading to thinning, dryness, and translucency of the skin with visible superficial vessels. The disease—unlike other forms of Lyme disease—does not tend to resolve spontaneously. The most common extracutaneous manifestation is peripheral neuropathy. In the earlier, inflammatory phase of ACA, poorly defined, blue-red patches appear, which gradually expand peripherally, forming well-defined plaques. Occasionally, papules, nodules, or swelling are present, and linear fibrous nodules are observed near joints—most commonly elbows and knees—which may coincide with or precede ACA lesions. Some patients also experience enlarged lymph nodes. [9] Borrelia burgdorferi spirochetes can be isolated from skin lesions in chronic atrophic dermatitis of the extremities (ACA) up to 10 years after the onset of symptoms, and the presence of numerous plasma cells in sclerotic skin infiltrates is a significant diagnostic clue suggesting this condition. In the atrophic phase, epidermal thinning, vasodilation, and lymphocyte and plasma cell infiltration in the upper dermis are observed. In the inflammatory phase, a dense perivascular and periadnexal infiltrate composed of lymphocytes, histiocytes, and plasma cells occurs, accompanied by edema and homogenization of collagen fibers. Skin lesions of ACA, particularly on the lower extremities, may clinically resemble venous or arterial insufficiency, eczema, localized scleroderma, lichen sclerosus and atrophic lichen (LSA), or posttraumatic or post-cold exposure lesions. [17]

Diagnosis:

Confirming the presence of Borrelia burgdorferi in the affected organ is difficult due to the limited yield of laboratory culture, the diagnosis of Lyme borreliosis relies primarily on characteristic clinical symptoms, positive serological tests, and epidemiological history, including a tick bite or travel to an endemic area. In the initial phase of the disease, only 25–30% of patients remember a tick bite, highlighting the importance of the epidemiological context. Standard laboratory tests rarely provide definitive confirmation of infection: white blood cell counts may remain normal or slightly elevated, while hemoglobin, hematocrit, creatinine, and urinalysis are usually within the reference range; serum aminotransferases may show a slight increase, and rheumatoid factor and ANA tests remain negative, while the erythrocyte sedimentation rate (ESR) is often elevated. If indicated, diagnostics include additional tests such as an electrocardiogram, echocardiogram, cerebrospinal fluid analysis, or imaging studies. In patients without obvious skin lesions, important diagnostic indications include cranial neuritis, lymphocytic meningitis, radicular pain with dermatomal sensorimotor neuropathy, as well as carditis or joint swelling, which should be confirmed by a positive serological test or immunoblot. [1,7,9] A definite diagnosis of Lyme neuroborreliosis is made when the patient has compatible neurological symptoms, lymphocytic pleocytosis in the cerebrospinal fluid, and the presence of antibodies against B. burgdorferi in the intrathecal space. [18]

When cardiac involvement is suspected in patients with Lyme disease, a complete cardiac evaluation is recommended, including a 12-lead ECG and 24-hour Holter monitoring to analyze the rhythm, PQ interval, QRS width, and ectopic beats. Additionally, a chest X-ray and echocardiography are performed to assess ejection fraction, wall motion, and the presence of pericardial effusion. In selected cases, cardiac magnetic

resonance imaging (MRI) or myocardial biopsy for histological examination and Borrelia culture are indicated. Electrophysiological testing is used only in specific situations due to its invasive nature and the potential risk of arrhythmia. [4]

In the diagnosis of arthritis caused by Lyme disease, it is crucial to identify typical clinical symptoms, take into account the history of exposure to the pathogen in endemic regions, and confirm the infection with serological tests. [19]

Serologic and molecular diagnostic methods

Laboratory serological confirmation of the presence of specific antibodies is based on a two-step diagnostic algorithm. The first step involves screening using enzyme-linked immunosorbent assays (ELISA, EIA, ELFA), as well as chemiluminescent immunoassays (CLIA) or fluoroimmunoassays (FIA). Positive or borderline results require further verification in the second step, performed using a confirmatory Western immunoblot assay. [4] The sensitivity of serology in Lyme disease depends significantly on the clinical presentation, reaching an average of approximately 50% in patients with erythema migrans, 77% in neuroborreliosis, and up to 97% in patients with atrophic dermatitis atrophica (ACA). The immune response also progresses in stages: IgM antibodies to B. burgdorferi usually appear within 2–4 weeks of the onset of skin lesions, while an increase in IgG antibody concentration is observed approximately 4–6 weeks after infection. IgG levels peak within the first six months and may remain elevated for many months or even years. [1,9] False positive results may occur in the course of mononucleosis, syphilis or autoimmune diseases, while false negative results are often observed in the early stages of Lyme disease. [9] Recent years have seen the development of new commercial serological tests for detecting Borrelia, including the TickPlex ELISA-based test, which additionally utilizes an antigen for round (perisister) Borrelia. An improved version of this test allows for the simultaneous detection of IgM and IgG antibodies to several tick-borne bacterial and viral pathogens, and reports indicate its usefulness in various stages of Lyme borreliosis. [4] For the diagnosis of neuroborreliosis, the Infectious Diseases Society of America prefers assessing intrathecal antibody production in cerebrospinal fluid samples, considering it more reliable than direct detection of the pathogen. PCR testing can be used in selected patients with late-stage arthritis or neuroborreliosis, especially since it demonstrates the highest sensitivity in synovial fluid samples from individuals with untreated late-stage arthritis. However, urine antigen testing has a high false-positive rate and is generally inaccurate. [13]

Treatment

The best treatment results are achieved when therapy is started at an early stage of the disease. Treatment of late stages of the disease, especially those with neurological or rheumatological manifestations, is less effective, and the response to antibiotic therapy may be limited. [9] Prevention of the development of the disease can be effective if the tick is removed within 24 hours of attachment, using precise, fine-tipped gripping tools placed directly on the skin surface, taking care to avoid pressure on the tick's body. In the case of early, limited stage of Lyme disease, oral treatment is recommended, with therapeutic management focused primarily on the clinical manifestations of the disease. Indications for intravenous treatment include patients with symptomatic involvement of the nervous or cardiovascular system and refractory arthritis. [1,7]

In the treatment of Lyme disease, doxycycline is the drug of first choice; in the case of early erythema migrans (EM) the recommended dose is 100 mg administered orally twice daily for 14–21 days, while in the course of BL and ACA the duration of therapy should be 3–4 weeks.

In the treatment of erythema migrans (EM), several studies have shown that azithromycin administered initially at a dose of 500 mg twice daily on the first day, followed by 500 mg once daily for the next four days, achieves efficacy comparable to other treatment methods. [20]

Borrelia lymphocytoma, the early form of disseminated Lyme disease, is primarily treated with oral antibiotics: doxycycline (100–200 mg/day), amoxicillin (500 mg three times a day), or cefuroxime (500 mg twice a day) for 14–21 days. Alternatively, azithromycin is used for 5 days. In the case of systemic symptoms or failure of oral treatment, intravenous treatment with ceftriaxone or cefotaxime is indicated. Therapy usually lasts 2–3 weeks, and efficacy is assessed by the resolution of skin lesions. [1] Lyme arthritis is treated orally with doxycycline 100 mg twice daily, amoxicillin 500 mg three times daily, or cefuroxime axetil 500 mg twice daily for 28 days. In refractory or severe cases, intravenous ceftriaxone 2 g daily is used for 2–4 weeks. The effectiveness of therapy is assessed by the resolution of joint symptoms. [1,5] Alternatively, amoxicillin, cefuroxime, or erythromycin can be used to treat Lyme disease. In cases with multiple erythema migrans lesions, in pregnant women, or in immunocompromised patients, parenteral therapy may be more appropriate:

intravenous (IV) ceftriaxone 2 g once daily or IV penicillin G 18–24 million units daily administered every four hours for 10–14 days. [21] In cases of persistent ACA, it may be necessary to use the same therapeutic regimens. The daily dose of antibiotics in children under 8 years of age is: cefuroxime 30–40 mg/kg, amoxicillin 25–50 mg/kg and azithromycin 20 mg/kg on the first day, then 10 mg/kg for the following days, with the duration of treatment being the same as in adults. [9] During pregnancy, the first-line drugs are amoxicillin, azithromycin, and third-generation cephalosporins, administered in the same doses and for the same duration as in non-pregnant women, while doxycycline is contraindicated in pregnant and breastfeeding women and in children under 8 years of age. [22] Elevated levels of IgM and IgG antibodies against B. burgdorferi may persist for a long time after successfully completed therapy, but this does not indicate either ineffective treatment or persistent infection. Therefore, current guidelines emphasize that serological tests should not be repeated to confirm treatment efficacy or document recovery. Nevertheless, serological results are sometimes misinterpreted—their limitations, including the possibility of false-positive or false-negative results, can lead to unnecessary diagnosis and unjustified antimicrobial treatment. A new IgG enzyme immunoassay based on C6 peptide has also emerged in diagnostics, with sensitivity and specificity similar to the standard two-step protocol. However, further studies assessing the usefulness of this test are needed before its optimal diagnostic role can be clearly determined. [13]

Risk Reduction

Tick-borne disease prevention encompasses a range of measures to reduce the risk of exposure to vectors. One key element is reducing tick populations through the use of acaricides such as carbaryl and deltamethrin, as well as controlling the animal reservoirs that support their life cycle. Equally important is the use of personal protective equipment, including repellents applied to both skin and clothing, which effectively reduce the likelihood of infection. Appropriate clothing also plays a crucial role – wearing long pants and long-sleeved clothing reduces the area of exposed skin, and regular, thorough body checks allow for rapid detection and removal of ticks. Avoiding environments typical of tick habitats remains the primary form of protection. For pharmacological prevention, a single dose of 200 mg of doxycycline administered orally within 72 hours of tick contact is being considered, although this approach is still under debate and is not a definitively accepted strategy. [23] Vaccines targeting protein A (OspA), found on the outer surface of Borrelia burgdorferi, are considered a promising strategy for Lyme disease prevention. The most advanced vaccine of this type was LYMErix—a recombinant lipoprotein OspA—which, after demonstrating 70–80% protective efficacy after three doses, was approved for clinical use by the FDA/USFDA in individuals over 16 years of age. However, it was subsequently withdrawn from the market in 2002 due to reports of adverse events, particularly arthritis, although the causal relationship remained controversial. Intensive work is currently underway on second-generation vaccines based on updated antigens and improved immunization platforms, aimed at improving the safety and effectiveness of Lyme disease prevention. [1,9,24,25,26]

Conclusions

Lyme disease, although traditionally associated with endemic regions, is increasingly being diagnosed outside of these regions. Early implementation of appropriate antibiotic therapy is usually associated with a good prognosis, although recurrence of infection cannot be ruled out. However, early diagnosis can be significantly challenging, especially in the absence of a clear epidemiological context, typical clinical symptoms, or readily available, inexpensive, and highly sensitive diagnostic tests. Therefore, increasing public awareness and strengthening public health surveillance of this disease are crucial. Making Lyme disease a mandatory notifiable entity—as proposed in India, among others—could be a significant step toward improving monitoring and early case detection. Although Lyme disease is a fully treatable disease, it remains frequently underdiagnosed in primary care. Its early cutaneous manifestations are particularly significant, as they can precede more severe complications such as arthritis, neurological, or cardiac disorders. Proper identification of skin lesions can therefore enable earlier diagnosis of the disease and prevent progression to more advanced stages. Therefore, raising awareness among both the public and family physicians is crucial to improving early diagnosis of Lyme disease and reducing its late clinical consequences.

Funding Statement: The article did not receive any funding.
Institutional Review and Board Statement: Not applicable.
Informed Consent Statement: Not applicable.
Data Availability Statement: Not applicable.
Conflict of Interest Statement: No conflicts of interest to declare.

REFERENCES

1. Mahajan, V. K. (2023). Lyme disease: An overview. *Indian Dermatology Online Journal, 14*(5), 594–604. https://doi.org/10.4103/idoj.idoj_418_22
2. Dong, Y., Zhou, G., Cao, W., Xu, X., Zhang, Y., Ji, Z., Yang, J., Chen, J., Liu, M., Fan, Y., Kong, J., Wen, S., Li, B., Yue, P., Liu, A., & Bao, F. (2022). Global seroprevalence and sociodemographic characteristics of *Borrelia burgdorferi* sensu lato in human populations: A systematic review and meta-analysis. *BMJ Global Health, 7*(6), e007744. https://doi.org/10.1136/bmjgh-2021-007744
3. Torbahn, G., Hofmann, H., Allert, R., Freitag, M. H., Dersch, R., Fingerle, V., Sommer, H., Motschall, E., Meerpohl, J. J., & Schmucker, C. (2016). Efficacy and safety of pharmacological agents in the treatment of erythema migrans in early Lyme borreliosis: Systematic review protocol. *Systematic Reviews, 5*, 73. https://doi.org/10.1186/s13643-016-0251-3
4. Trevisan, G., Bonin, S., & Ruscio, M. (2020). A practical approach to the diagnosis of Lyme borreliosis: From clinical heterogeneity to laboratory methods. *Frontiers in Medicine, 7*, 265. https://doi.org/10.3389/fmed.2020.00265
5. Smith, B. G., Cruz, A. I., Jr., Milewski, M. D., & Shapiro, E. D. (2011). Lyme disease and the orthopaedic implications of Lyme arthritis. *Journal of the American Academy of Orthopaedic Surgeons, 19*(2), 91–100. https://doi.org/10.5435/00124635-201102000-00004
6. Fikrig, E., & Narasimhan, S. (2006). *Borrelia burgdorferi*: Traveling incognito? *Microbes and Infection, 8*(5), 1390–1399. https://doi.org/10.1016/j.micinf.2005.12.022
7. Wormser, G. P., McKenna, D., Carlin, J., Nadelman, R. B., Cavaliere, L. F., Holmgren, D., Byrne, D. W., & Nowakowski, J. (2005). Brief communication: Hematogenous dissemination in early Lyme disease. *Annals of Internal Medicine, 142*(9), 751–755. https://doi.org/10.7326/0003-4819-142-9-200505030-00011
8. Feder, H. M., Jr. (2008). Lyme disease in children. *Infectious Disease Clinics of North America, 22*(2), 315–vii. https://doi.org/10.1016/j.idc.2007.12.007
9. Vasudevan, B., & Chatterjee, M. (2013). Lyme borreliosis and skin. *Indian Journal of Dermatology, 58*(3), 167–174. https://doi.org/10.4103/0019-5154.110822
10. Stanek, G., & Strle, F. (2008). Lyme disease: European perspective. *Infectious Disease Clinics of North America, 22*(2), 327–vii. https://doi.org/10.1016/j.idc.2008.01.001
11. Bacon, R. M., Kugeler, K. J., Mead, P. S., & Centers for Disease Control and Prevention. (2008). Surveillance for Lyme disease—United States, 1992–2006. *Morbidity and Mortality Weekly Report: Surveillance Summaries, 57*(10), 1–9.
12. Nigrovic, L. E., Thompson, A. D., Fine, A. M., & Kimia, A. (2008). Clinical predictors of Lyme disease among children with a peripheral facial palsy at an emergency department in a Lyme disease-endemic area. *Pediatrics, 122*(5), e1080–e1085. https://doi.org/10.1542/peds.2008-1273
13. Wright, W. F., Riedel, D. J., Talwani, R., & Gilliam, B. L. (2012). Diagnosis and management of Lyme disease. *American Family Physician, 85*(11), 1086–1093.
14. Marques, A. (2008). Chronic Lyme disease: A review. *Infectious Disease Clinics of North America, 22*(2), 341–viii. https://doi.org/10.1016/j.idc.2007.12.011
15. Buechner, S. A., Rufli, T., & Erb, P. (1993). Acrodermatitis chronica atrophicans: A chronic T-cell-mediated immune reaction against *Borrelia burgdorferi*? Clinical, histologic, and immunohistochemical study of five cases. *Journal of the American Academy of Dermatology, 28*(3), 399–405. https://doi.org/10.1016/0190-9622(93)70058-2
16. Silberer, M., Koszik, F., Stingl, G., & Aberer, E. (2000). Downregulation of class II molecules on epidermal Langerhans cells in Lyme borreliosis. *British Journal of Dermatology, 143*(4), 786–794. https://doi.org/10.1046/j.1365-2133.2000.03776.x
17. Asbrink, E., & Hovmark, A. (1985). Successful cultivation of spirochetes from skin lesions of patients with erythema chronicum migrans Afzelius and acrodermatitis chronica atrophicans. *Acta Pathologica, Microbiologica, et Immunologica Scandinavica Section B: Microbiology, 93*(2), 161–163. https://doi.org/10.1111/j.1699-0463.1985.tb02870.x
18. Mygland, A., Ljøstad, U., Fingerle, V., Rupprecht, T., Schmutzhard, E., Steiner, I., & European Federation of Neurological Societies. (2010). EFNS guidelines on the diagnosis and management of European Lyme neuroborreliosis. *European Journal of Neurology, 17*(1), 8–e4. https://doi.org/10.1111/j.1468-1331.2009.02862.x
19. Steere, A. C. (2001). Lyme disease. *New England Journal of Medicine, 345*(2), 115–125. https://doi.org/10.1056/NEJM200107123450207
20. Barsic, B., Maretic, T., Majerus, L., & Strugar, J. (2000). Comparison of azithromycin and doxycycline in the treatment of erythema migrans. *Infection, 28*(3), 153–156. https://doi.org/10.1007/s150100050069
21. Maraspin, V., Cimperman, J., Lotric-Furlan, S., Pleterski-Rigler, D., & Strle, F. (1996). Treatment of erythema migrans in pregnancy. *Clinical Infectious Diseases, 22*(5), 788–793. https://doi.org/10.1093/clinids/22.5.788
22. Steere, A. C. (1989). Lyme disease. *New England Journal of Medicine, 321*(9), 586–596. https://doi.org/10.1056/NEJM198908313210906

23. Nadelman, R. B., Nowakowski, J., Fish, D., Falco, R. C., Freeman, K., McKenna, D., Welch, P., Marcus, R., Agüero-Rosenfeld, M. E., Dennis, D. T., Wormser, G. P., & Tick Bite Study Group. (2001). Prophylaxis with single-dose doxycycline for the prevention of Lyme disease after an *Ixodes scapularis* tick bite. *New England Journal of Medicine, 345*(2), 79–84. https://doi.org/10.1056/NEJM200107123450201
24. Steere, A. C., Sikand, V. K., Meurice, F., Parenti, D. L., Fikrig, E., Schoen, R. T., Nowakowski, J., Schmid, C. H., Laukamp, S., Buscarino, C., & Krause, D. S. (1998). Vaccination against Lyme disease with recombinant *Borrelia burgdorferi* outer-surface lipoprotein A with adjuvant. *New England Journal of Medicine, 339*(4), 209–215. https://doi.org/10.1056/NEJM199807233390401
25. Wallich, R., Jahraus, O., Stehle, T., Tran, T. T., Brenner, C., Hofmann, H., Gern, L., & Simon, M. M. (2003). Artificial-infection protocols allow immunodetection of novel *Borrelia burgdorferi* antigens suitable as vaccine candidates against Lyme disease. *European Journal of Immunology, 33*(3), 708–719. https://doi.org/10.1002/eji.200323620
26. Clark, R. P., & Hu, L. T. (2008). Prevention of Lyme disease and other tick-borne infections. *Infectious Disease Clinics of North America, 22*(3), 381–vii. https://doi.org/10.1016/j.idc.2008.03.007