Domestic Dogs as Sentinels for Lyme Disease: A One Health Approach

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Abstract

Lyme disease is the most common vector-borne illness in the United States, threatening the lives of both humans and animals. With domestic dogs being present in 68 million US households, they are not only ideal companion animals but also serve as potential early indicators of disease risk. This research explores the role of domestic dogs as effective early warning signals, also known as sentinel species, for tracking the spread of Lyme disease. This technique would be effective to combat underreporting in regions with high disease prevalence, such as the Northeast and Midwest. By analyzing studies that demonstrate the correlation between Lyme bacteria (Borrelia burgdorferi) exposure in dogs and reported human cases, this review highlights how veterinary testing data can enhance public health surveillance. The findings show a clear link between canine Lyme disease seroprevalence and human disease incidence, increasing understanding of the environmental risk present in an area. Applying a One Health approach, this research emphasizes the importance of collaboration between veterinarians and public health departments to enhance early detection, fill surveillance gaps, and improve prevention strategies against Lyme disease.

Introduction

Lyme disease, a bacterial infection caused by *Borrelia burgdorferi*, is the most common vector-borne illness in the United States. It is spread by the bite of an infected black-legged tick (*Ixodes scapularis*). Lyme disease used to be limited to certain endemic regions of the United States, but due to various factors, including ecological changes, urbanization in natural habitats, and climate change, its range and incidence rates have expanded rapidly. As the threat grows, protecting humans and animals requires early detection and efficient surveillance. Recent data from The Centers for Disease Control and Prevention (CDC) report that in 2022, there were over 60,000 reported cases of Lyme disease, a 68% increase from the average of roughly 37,000 cases annually from 2017 to 2019. Changes to the 2022 surveillance case definition, which permitted reporting based only on laboratory evidence in high-incidence states, are primarily responsible for this sharp rise. Additionally, according to CDC preliminary data, over 80,000 cases were reported in 2023, highlighting the disease's ongoing growth. Even so, there remains a lack of knowledge regarding the temporal and spatial dynamics of human exposure to Lyme disease and changes to the environment that affect the interactions between humans, animals, and ticks.

Using domestic dogs as sentinel species, which serve as early indicators of disease risk in a particular area, is the most effective method for identifying new Lyme disease hotspots. In regions with high prevalence, previous research has shown a strong correlation between human and dog cases. Given that 68 million households in the United States own a dog, we must consider their potential as sentinel species for monitoring Lyme disease (Martyn, 2025). They are critical early indicators of tick-borne disease exposures because of their close contact with people, their status as the most common domestic animal in the nation, and their frequent interaction with natural environments. Canine surveillance data has shown the predictive value in identifying Lyme disease in high-risk areas; however, the use of this approach depends not only on veterinary testing but also on the collaboration between veterinarians and public health departments, a concept central to the One Health framework, which promotes integrated efforts across human, animal, and environmental health sectors. Strategic collaboration between these experts and public health officials can enhance disease surveillance, facilitate early detection, fill surveillance gaps, and inform more effective prevention strategies. The objective of this review is to assess the use of domestic dogs as sentinel species for Lyme disease surveillance, identify logistical gaps in surveillance systems, and integrate One Health strategies that utilize veterinary and public health partnerships in emerging Lyme disease hotspots.

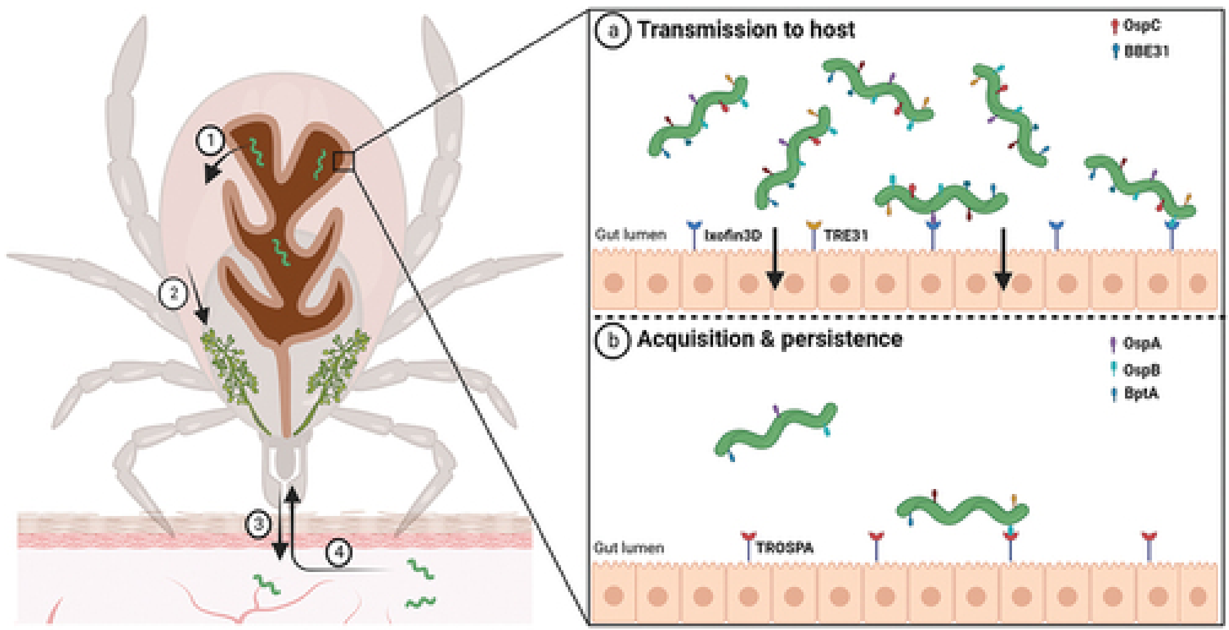

Figure 1. Molecular interactions at the tick midgut luminal interface involved in transmission and acquisition/persistence of *B. burgdorferi* in ticks
Illustration of when an infected tick feeds. Borrelia spirochetes multiply within the tick, change their surface proteins to escape the tick gut, invade the salivary glands, and then transmit to the host.
Note. Adapted from Pathogenicity and virulence of *Borrelia burgdorferi*. By Strnad, M., Rudenko, N., & Rego, R. O. M. (2023).

Scientific Justification for Using Dogs as Sentinels

To understand why domestic dogs are effective sentinels for Lyme disease, it is essential to examine their susceptibility to infection and the environments they share with humans. An essential factor when dogs are infected is that they may not show symptoms but still test positive because the antibodies are present. Most dogs roam around in grassy areas where ticks live, and even if your dog is primarily indoor, there is still a risk of Lyme disease, as ticks can be carried into the home. The Merck Veterinary Manual (2025) states that diagnosis is challenging since many infected animals are asymptomatic but seropositive. They do not exhibit symptoms, and a positive test does not always indicate that current clinical signs are caused by infection, or if the animal will develop illness in the future. So, they help track environmental exposure in a given area. In this way, seropositive animals can function as sentinels in surveillance programs aimed at monitoring Lyme disease risk.

The correlation between canine seroprevalence and human Lyme disease incidence offers valuable insight into how dogs can serve as early warning signs for human risk. Researchers using national surveillance data discovered that the “mean incidence in humans increases with canine seroprevalence until the seroprevalence in dogs reaches approximately 30%” (Liu et al., 2023). The association plateaus after reaching 30%, meaning that human incidence rates stop rising in tandem with canine incidence rates, implying that regions with greater canine seroprevalence may have stabilized human cases by reaching their maximum environmental risk. So, it is crucial to watch Lyme disease in dogs so scientists can better map and predict the disease in humans. This collaboration is important to effectively use canine data through veterinarians and public health departments to improve Lyme disease prevention. Recognizing dogs as effective sentinel species strengthens prevention and preparedness against Lyme disease in humans and animals.

Given the high incidence rates of Lyme disease in the Northeast and upper Midwest, Herrin et al. (2018) conducted a study on the New York City metropolitan area. In the study, there were 234,633 dog test results, and the disease exposure ranged from around 1% to 27% in each county. The highest seroprevalence of dogs was found in heavily and densely populated forest areas. An R^2 value of 0.65, which shows that variations in dog exposure account for 65% of the variation in human Lyme disease rates, reflects the accuracy of canine data in predicting human risk. Apart from domestic dogs, research on wild canids offers valuable insights about how vector-borne diseases spread.

Dr. Susan Little, CDC director, emphasizes the collaboration between veterinarians and researchers to monitor Lyme disease in dogs, which helps scientists anticipate potential outbreaks in humans (Companion Animal Parasite Council [CAPC], 2011). In the study, the incidence of Lyme disease in humans is nearly zero when canine seroprevalence is low but increases dramatically by up to 100 times when more than 5% of dogs have been exposed. Veterinarians help provide data that guides prevention strategies by identifying and monitoring infection in dogs. Ultimately, warning pet owners about the dangers of the disease helps to protect whole communities.

The data on canine seroprevalence at the national level is provided by the Companion Animal Parasite Council (CAPC). In the maps, the nationwide seroprevalence of *B. burgdorferi* is 4% (1 in 20 dogs), with 292,509 of the 6.8 million dogs tested positive in 2025. Figures 2 and 3 help to provide a visual comparison of both human and dog data. Both display dense clusters in the Northeast and upper Midwest and spread into previously low-risk areas. These trends demonstrate how canine data can be utilized to inform public health strategies, highlighting the shared risk between humans and dogs. Public health departments and veterinary professionals use CAPC’s interactive maps to identify regional risk patterns and emerging zones of tick exposure before human case numbers rise. Although CAPC and CDC collect data separately, cross-sector collaboration enhances the effectiveness of surveillance efforts.

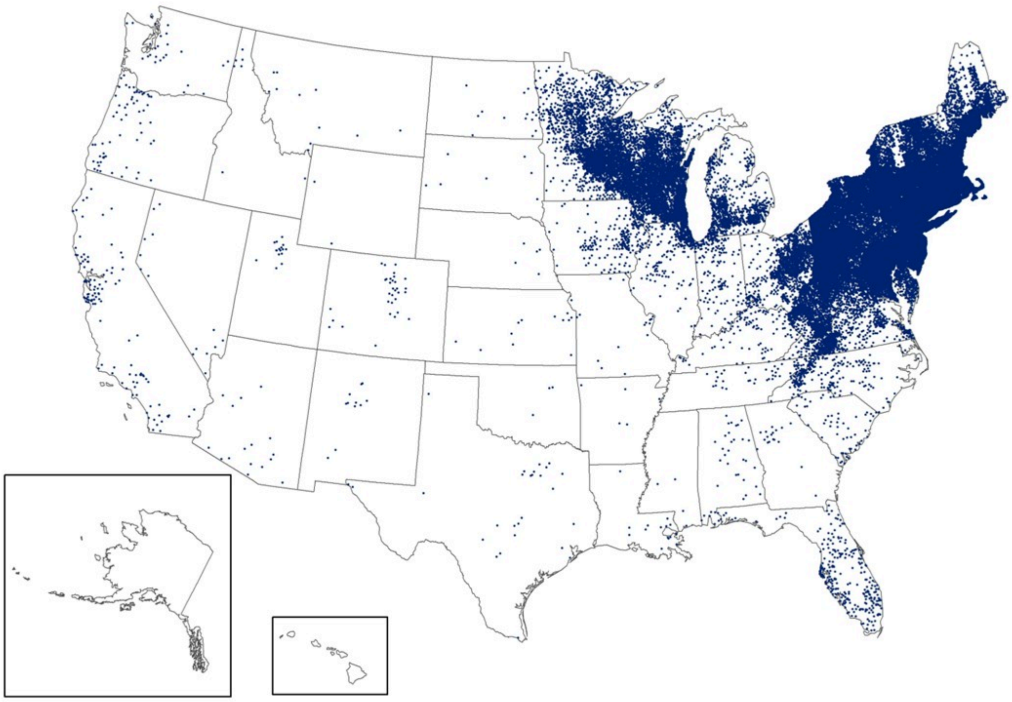

Figure 2. Distribution of Human Cases of Lyme Disease in 2023
In the human case maps, each dot represents one reported case based on the patient's place of residence.
Note. Adapted from *Lyme disease case maps.* Centers for Disease Control and Prevention. (2025, June 4). *Lyme disease case maps*.

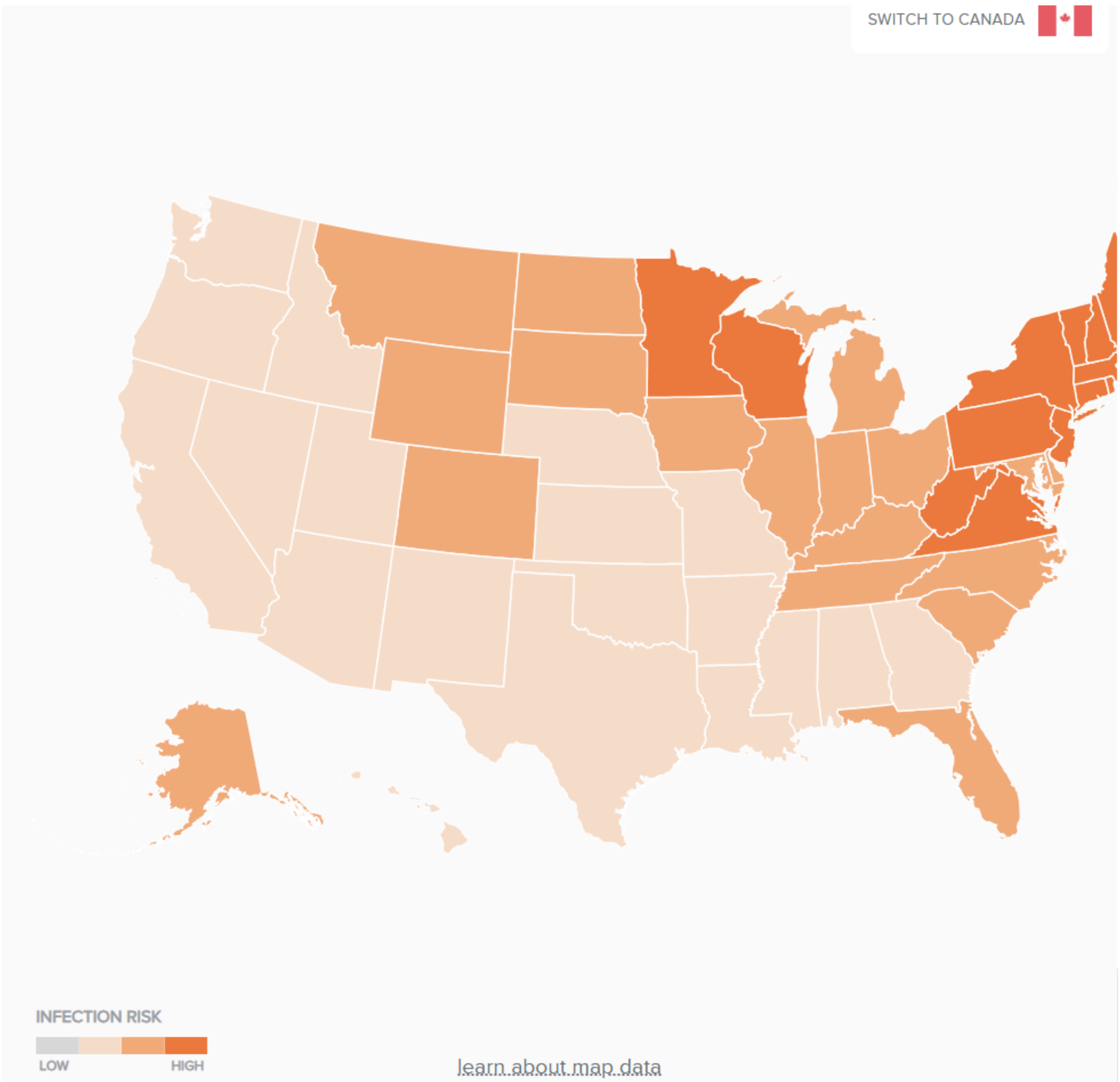

Figure 3. Risk of Canine Lyme Disease Infections in Cases of Lyme Disease 2023
Canine Lyme disease prevalence in the United States for the year 2023, based on data from the CAPC. The map displays the proportion of dogs testing positive for *B. burgdorferi* infection, utilizing a color gradient to represent the relative risk of infection. Lighter shades indicate lower infection risks, while darker shades indicate higher infection risks.
Note. Adapted from *Lyme disease prevalence data*. Companion Animal Parasite Council (CAPC). (2025).

Lessons from Wildlife Surveillance

Studying vector-borne diseases in wild canids provides better insight into managing disease in domestic dogs, enhancing surveillance and prevention strategies. Wild canids can act as reservoirs for these diseases, keeping them in nature, which can later be passed on to domestic dogs and vice versa. For example, coyotes and foxes have been found to carry Lyme disease and heartworm, which are dangerous to domestic dogs as well. Infection patterns are significantly influenced by environmental factors like habitat and climate. In California, a study was conducted examining the temporal and spatial relationships between the type of vegetation and climate. Coyotes were exposed to Anaplasma phagocytophilum and *B. burgdorferi*. The respective overall seroprevalences were 19% and 40%. Rainfall was positively correlated with an increase in seroprevalence (Aguirre, 2009), illustrating how environmental factors, such as rainfall, can influence infection rates in regions that are more susceptible to ecological shifts. Researchers also try to use non-invasive methods to monitor diseases in wild animals, like taking blood samples or just animal observation. These methods are useful for surveillance models for domestic dog populations. When a disease spreads between species, such as the canine distemper virus from domestic dogs to Ethiopian wolves, it highlights the importance of vaccination for both domestic and wild canids. So, by studying infection rates in wild canids, scientists can track how diseases spread, especially due to climate change and habitat destruction.

Correlation between canine and human Lyme disease

Advanced spatio-temporal models further support the use of dog data for human Lyme disease risk. A study of over 16 million canine test results (2012-2016) utilized Bayesian spatiotemporal modeling to estimate county-level seroprevalence and its relationship to human Lyme disease case rates. There was a strong correlation, especially in areas where dog infection rates ranged from 0% to 30%. This study demonstrates that dogs can serve as early warning signs for human Lyme disease, helping public health officials identify new risk areas and respond more quickly. These modeling studies align with real-world surveillance efforts, where collaborations between veterinary and public health departments improve disease surveillance and prevention (Liu et al., 2019).

When animals exhibit symptoms such as fever, lameness, and lethargy, they are typically treated with a four-week course of antibiotics, most often doxycycline, which is effective against tick-borne bacteria. However, false negatives can occur, especially in the case of acute infection, immunodeficiency, or very young animals. Although antibody titers are commonly used to assess exposure to *B. burgdorferi*, they do not necessarily indicate whether an animal has Lyme disease. Some animals remain seropositive for years after treatment, even if their symptoms aren't apparent, so it is crucial to take exposure history and clinical assessment into account when interpreting test results. Prevention is an essential part of treating Lyme borreliosis, and people should try to avoid tick-infested areas and remove ticks as soon as possible, within 24 to 48 hours of attachment. (MSD Veterinary Manual, 2025)

Surveillance Methods and Limitations

Human Lyme disease surveillance in the US relies on multiple approaches to collect data and confirm efficacy. The Department of Public Health used four surveillance techniques: passive physician surveillance, active physician surveillance, enhanced laboratory surveillance, and mandatory laboratory surveillance (Ertel et al., 2012). Connecticut, a state with high rates of Lyme disease, implemented these methods to track the disease better. For passive physician surveillance, underreporting is a common occurrence, and it depends on doctors voluntarily reporting Lyme cases. Active physician surveillance improved on this aspect and formed a network of healthcare professionals who agreed to submit monthly updates, resulting in higher-quality data but requiring more effort. Laboratory-based surveillance focused on test results and not clinical judgment. Enhanced laboratory surveillance involves labs sending extra reporting forms with positive test results to physicians for confirmation. As part of required laboratory surveillance, a law has mandated that laboratories report positive and inconclusive test results to the public health departments. Each method produced different data. For example, physician-based reports were more likely to identify early-stage Lyme disease, characterized by erythema migrans, a circular red rash that often appears at the site of a tick bite. In contrast, laboratory-based surveillance identifies more late-stage cases, such as Lyme arthritis, because patients with these conditions are more likely to undergo testing. Still, laboratory surveillance had a lower positive predictive value, meaning that many of the reported cases turned out not to be actual Lyme disease. The study found that over 25% of all reports were lost to follow-up because of missing information and a lack of physician response. Since dogs are regularly screened for tick-borne disease, they can help close these gaps.

An essential resource for canine surveillance is the CAPC's mapping tools and laboratory test results. IDEXX compiles results from thousands of veterinary clinics across the United States, providing data for public health monitoring. The CAPC transforms this data into interactive prevalence maps, providing accessible, real-time insights into regional disease trends. For the IDEXX chart, the dogs are assessed for symptoms like fever, anorexia, lethargy, lameness, polyarthritis, and lymphadenopathy. Following a positive test, a urinalysis and the Lyme Quant C6 Antibody Test are administered to check for proteinuria and an active infection. A C6 antibody level above 30 U/mL supports a Lyme disease diagnosis and indicates the need for treatment and retesting in six months. A dog should only be monitored for proteinuria and new symptoms if the test comes out to be positive, but shows no clinical signs. Even if a test is negative and no symptoms are present, tick prevention and annual retesting are highly recommended. To achieve treatment success throughout the year, the algorithm emphasizes the importance of monitoring antibody presence (IDEXX Laboratories, 2025). Sentinel surveillance's strength lies in its ability to identify changes in the spread of disease before any human cases are reported. The differences in reporting, testing frequency, and geographic range can impact the quality of the data. However, since CAPC maps are voluntary reports from medical professionals, they may not be as accurate. Prevalence estimates may also vary, as testing biases and veterinarians tend to test more frequently in symptomatic or high-risk domestic dogs. Still, canine surveillance is an invaluable but underutilized tool for tracking Lyme disease in a One Health context, providing a model for collaboration between veterinary and public health departments.

The Canine Lyme Multiplex Assay (2025), developed by Cornell University's Animal Health Diagnostic Center, detects antibodies against three specific proteins: OspA, OspC, and OspF. It provides better insights than previous tests, such as the IDEXX 4Dx Plus Test. Dogs that are already vaccinated (show antibodies for OspA) and dogs that are infected (show antibodies for OspC and OspF). When the immune system recognizes certain bacteria, it produces proteins called antibodies that help the body to identify and fight infections. When a dog is infected or vaccinated, its immune system produces antibodies that the test can detect. The test then measures the amount of antibodies to help doctors determine if antibiotic treatment is working. Being able to separate vaccination from infection is crucial for using dogs as early warning signs, so we do not mistakenly think there is more Lyme disease in an area than actually exists. This test can also detect infection rate as fast as three weeks after the dog is infected, improving the accuracy of using dogs to monitor Lyme disease and protect humans and animals, aligning with the One Health approach. Although not a direct source of human infection, animals can harbor infected ticks that are not attached and could attach to a human. To effectively control Lyme disease, public health departments and veterinarians must collaborate to integrate canine serologic data into broader surveillance efforts.

Broader Context: Vaccine Development

According to Day (2007), understanding a puppy's immune system development is crucial when creating effective vaccines. Newborns are at first protected by maternal antibodies (MDA), but as they grow and their MDA levels drop, they begin to develop their own immune response. The CDC (2024) states that each component of the vaccine has a specific function, such as enhancing immune system protection, maintaining the efficacy of the vaccine, or avoiding contamination. Effective Lyme disease vaccination for domestic dogs supports the One Health framework by reducing the risk to humans through a decrease in the number of infected ticks. When using dogs as sentinels, vaccination status must be considered, since it can affect serologic results. For instance, proteins like OspC are bound by antibodies the body produces in response to specific vaccines. False positives can result from this, demonstrating that a dog was exposed to the Lyme bacterium when they were not. A positive test is more likely to show real environmental exposure; unvaccinated dogs offer more precise data. Therefore, it is important to consider factors like age, breed, and vaccination history because dogs with weaker immune systems or puppies are more prone to producing false negative results.

While dogs have benefited from effective Lyme disease vaccines, human vaccine development has faced a more complicated path. Humans have been without access to a Lyme disease vaccine for over two decades. Over the years, scientists have been working to develop a human vaccine for Lyme disease, as cases continue to rise across the United States. According to Steere et al. (1998), one of the earliest vaccines was LYMErix, which worked by helping the body produce antibodies that would enter the tick while it was biting and kill the Lyme bacterium. Although only 75% effective, LYMErix was withdrawn from the market in 2002 due to low demand, limited recommendation, and concerns about its potential side effects, including arthritis. Lyme disease was not as fast-growing as it is now, so new vaccine strategies are being developed that could bring a human Lyme vaccine back to the market, with Pfizer and Valneva working on a vaccine that explicitly blocks the protein (OspA) needed for the bacteria to transfer from the tick to the human body. The vaccine is currently under phase 3 of clinical trials and may be ready in 2025 (Pfizer & Valneva, 2022). Phase three means there are thousands of individuals testing efficacy and safety in the target populations and evaluating interactions with other vaccines (Han, 2015). Another innovative approach being explored is at Yale University (Hathaway, 2022); researchers are using mRNA technology to create a vaccine that trains the immune system to respond to tick saliva–an ideal target since Lyme disease is transmitted through tick saliva. This irritates the tick site, warning the person and making it harder for the tick to feed long enough to transmit the disease. By causing ticks to fall off early, this technique successfully stopped the disease from spreading in guinea pigs. Dogs have long received vaccinations against this disease, and these new methods can help protect humans (Sajid et al., 2021).

Discussion

The key findings support the use of dogs as sentinel species in disease surveillance by showing a clear link between canine Lyme disease seroprevalence and human Lyme disease incidence. A threshold effect was considered, where human incidence increases with canine seroprevalence and then plateaus after a certain point. Geographic overlap of human and canine cases is demonstrated through surveillance maps and diagnostic data. These trends are valuable for having a more comprehensive One Health strategy for Lyme disease surveillance.

An important finding across multiple studies is the consistent relationship between human and Lyme disease cases. Many researchers recognize that dogs offer a practical and scalable approach to regional surveillance due to their frequent outdoor activity, broad geographic distribution, and yearly clinical visits, which enable frequent sampling that can help public health departments identify emerging hotspots and monitor endemic areas over time. Many strengths of current research include the large-scale data sets (CAPC), capturing trends that passive human surveillance systems may miss. However, several potential biases must be acknowledged, including a major weakness in dog ownership patterns, use of tick prevention, and regional veterinary testing practices. Not all dogs are tested equally, and many veterinarians might only test if the dog shows symptoms, making true exposure rates inaccurate. There is a notable lack of demographic and environmental context in many canine surveillance datasets. For example, seropositivity rates are most of the time reported without considering a dog's travel history, lifestyle, or the density of *Ixodes* ticks in an area. These gaps reduce the precision of spatial risk models and make direct comparisons across regions more difficult. The COVID-19 pandemic also disrupted surveillance efforts, causing underreporting, which is already a problem with Lyme disease surveillance.

The range of *Ixodes* ticks is growing as a result of changing land patterns, increased humidity, and warmer winters. If veterinary and human health systems do not adapt together, this ecological shift might exceed existing surveillance models and result in blind spots. Therefore, domestic dogs have great potential as Lyme disease sentinel species, but only when their data is analyzed with inputs from human and environmental surveillance.

Several limitations affect the reliability and generalizability of canine Lyme disease surveillance data, stemming from inconsistencies in testing, reporting, and diagnostic practices. The frequency with which veterinary clinics test and report cases can affect the data's consistency and quality since some regions can be underrepresented due to geographic variation in clinical participation. Testing bias is often reflected in surveillance data, as dogs that show symptoms of Lyme disease or live in high-risk areas are more likely to be tested by veterinarians than the general dog population. Mapping tools often rely on voluntary reporting, which can result in data gaps and regional differences. Without standardized reporting procedures, comparing trends becomes challenging. Finally, diagnostic tests can produce false positives or negatives; a positive antibody test does not always signify an active infection. These factors limit the generalizations of results, since regional inconsistencies in data reporting, testing methods, and veterinary access lead to inconsistent data quality. Not all canine test results reflect the same population groups. Some may include travel-associated exposures, repeated tests, or vaccinated individuals. The lack of standardized data across states or between veterinary practices limits the precision of cross-comparisons. Additionally, the root causes for the plateau between humans and dogs are still unknown. This study does not explore the specific factors behind the reduced correlation beyond the threshold.

These findings highlight the important role of domestic dogs as sentinels to strengthen public health readiness through integrated disease surveillance. The strong correlation between human and dog disease cases supports incorporating veterinary data into monitoring systems. Tracking seroprevalence in domestic dogs allows public health departments to identify emerging risk areas and respond more proactively. Collaboration between veterinarians and public health departments is essential since veterinarians often observe rising tick activity before it is shown through human cases. Public health departments can then implement broader strategies, like community education campaigns and habitat management. This One Health approach can improve the accuracy of risk assessments, strengthen prevention efforts, and enhance communication with both pet owners and the general public. So, incorporating animal-based surveillance results in earlier detection and more effective use of resources, especially in areas where the Lyme disease outbreak is on the rise.

Future research should focus on determining when and how an increase in canine Lyme disease is linked to an increase in human cases in order to improve dog-based Lyme disease monitoring. Scientists should also investigate how factors like local tick population, dog vaccination rates, and health programs affect Lyme disease risk in different regions. It would be helpful to create a more consistent and clear system for reporting Lyme test results in dogs. We should continue researching how environmental factors, such as weather patterns, climate change, and land use, can more effectively predict and prevent future outbreaks. A more robust One Health framework that connects veterinary, human, and ecological surveillance will be essential for responding to the evolving landscape of Lyme disease risk.

Conclusion

Several studies in this review strengthen the effective use of domestic dogs as sentinel species for Lyme disease risk. The accuracy of veterinary data is improved by the use of tools like the Lyme Multiplex Assay and CAPC's interactive maps. Despite the limitations of underreporting, incorporating canine surveillance into public health systems can fill in these gaps. This research asked whether domestic dogs can serve as effective sentinel species for human Lyme disease risk within a One Health framework. The findings show that canine data can reveal regional patterns of tick-borne disease and enhance early detection efforts that align with human health surveillance. Combining dog-based data with human health indicators can help communities identify emerging hot spots and lessen the impact of this growing vector-borne disease.

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