Understanding Commmunity-Level Vulnerabilities in Lyme Disease - Nova Scotia

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Background

Lyme disease ranks as one of the most prevalent vector-borne illnesses in North America, impacting tens of thousands of individuals annually. The primary carriers, deer ticks (Ixodes scapularis), thrive in temperate, wooded regions across the Northern Hemisphere. With the onset of global climate change, these ticks are expanding their geographical range northward, thereby elevating the risk of Lyme disease exposure for an increasing number of people.

Understanding the dynamics of Lyme disease transmission necessitates a comprehensive study of its primary vector, the deer tick (Ixodes scapularis). By closely examining the geographical spread and behavior of these ticks, we can gain invaluable insights into the patterns of disease transmission among human populations.

Nonetheless, the existing methods for tick surveillance are fraught with challenges: they are not only outdated but also costly and unsustainable across various regions within a reasonable temporal framework.

Hot Spots - Spread

Would a study showing the "hot-spots" be available and usefull?

Dr. Serge Olivier Kotchi, an expert from the Public Health Agency of Canada, specializes in examining the impact of climate change on the prevalence of vector-borne diseases in Canada, such as Lyme disease. He and his interdisciplinary team recently released a seminal study in the journal Remote Sensing, 2021, conclusively demonstrating that the risk associated with Lyme disease is escalating in northern regions of Canada due to shifting climate patterns.

To generate high-resolution Lyme risk maps covering extensive areas at a 1-kilometer scale, Dr. Kotchi and his research team employed a sophisticated approach. They integrated field surveillance data with land surface temperature and land cover metrics, sourced from NASA's Terra and Aqua satellites equipped with Moderate Resolution Imaging Spectroradiometer (MODIS) instruments.

The team's methodology not only advances the field but also presents a viable alternative to traditional "drag sampling" techniques previously employed in Canada for tick surveillance. In drag sampling, researchers would drag a one-square-meter cloth through wooded areas, subsequently counting the ticks that adhered to the fabric. Dr. Kotchi and his colleagues have demonstrated that their satellite-based approach offers a more scalable and comprehensive method for assessing the risk of Lyme disease.

Utilizing data from the years 2000 to 2015, they have validated the efficacy of Earth Observation (EO) data in identifying areas environmentally conducive to I. scapularis, and consequently, at high risk for Lyme disease. This innovative method can be integrated with ongoing surveillance initiatives to provide an annual assessment of the geographical expansion of Lyme disease risk.

This technology is available.

An Alternative Approach

Identifying high-risk hotspots enables targeted control and prevention measures at both municipal and health region levels. However, the question remains: Is there an alternative methodology capable of monitoring Lyme disease risk with both higher spatial resolution and over extended temporal spans?

Quantifying the spatiotemporal spread of tick-borne diseases like Lyme, which are sustained in enzootic transmission cycles, poses a significant challenge. While the distribution of infected vectors has served as a basis for mapping the entomological or acarological risk of Lyme disease, such vector-based datasets are rarely available in a longitudinal format. Notable exceptions include regions like New York State and the study we mentioned above. However, these datasets have limited utility for modeling the disease's geographic spread over time. Furthermore, when the primary focus is either the geographical distribution or the incidence rate of human cases, vector data only offer a partial correlation with the actual occurrence of the disease.

We propose leveraging data on serological diagnoses in Nova Scotia, coupled with residential characteristics, to identify a range of factors — demographic, economic, ethnic, and other regional attributes — that are linked with high-risk profiles of local residence. This approach aims to identify vulnerable populations, irrespective of whether individuals reside in or near identified hotspots.

Method

A recent study suggests that less than 10% of cases are under-reported, lending credibility to the existing surveillance mechanisms. We recommend adopting a two-layered approach for a more nuanced understanding of Lyme disease prevalence. Initially, we aim to identify the dominant regions that serve as key drivers for the spread of Lyme disease. Subsequently, we delve into the local factors that contribute to these regions being dominant in the first place.

The dissemination of Lyme disease is intrinsically linked to spatial dynamics. Understanding these spatial transmission patterns and the factors propelling them is crucial for forecasting localized disease incidence and crafting informed control strategies. Leveraging a unique dataset from Nova Scotia, Canada, we introduce an innovative methodology that uncovers a spatial network governing the spread of Lyme disease. Within this network, we identify and rank regions based on their dominance in disease transmission. Subsequently, we focus on isolating specific predictors within these dominant regions, characterized by unique community-level vulnerabilities such as demographic makeup and economic conditions. Our findings provide indispensable insights for the targeted deployment of public health interventions and the efficient allocation of resources.