Human-biting Ticks Positive for Lyme Disease and Babesia in New England and the Mid-Atlantic Region in 2018

Introduction

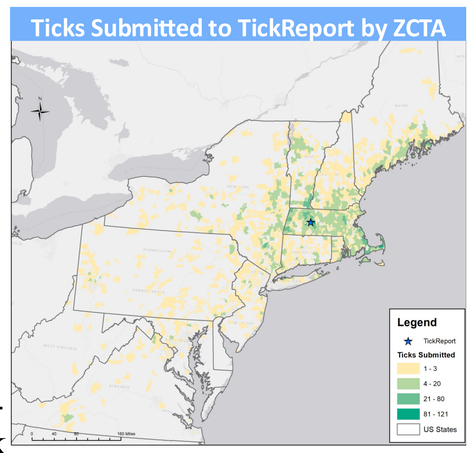

Ixodes Tick

In 2018, the Centers for Disease Control (CDC) reported 47,743 cases of tickborne disease in the United States. Underreporting of tickborne disease is common, and the number of people actually infected is estimated to be much higher. Lyme disease is the most prevalent, accounting for approximately 70% of cases and is transmitted by *Ixodes* ticks. However, it is not the only disease spread by *Ixodes* with an upsurge in the number of cases, as Babesiosis cases also have increased. Moreover, the ranges of these pathogens are has been expanding as well (Center for Disease Control, 2019).

There are a limited number of studies that have examined factors associated with human contact with ticks though one study has suggested environmental factors affect "questing" behavior and by extension, human contact with ticks (Arsnoe et al. 2015). The CDC reports county of residence and not the location of the tick exposure which can be misleading. TickReport is a diagnostic service at the University of Massachusetts at Amherst that tests ticks submitted by the public or public health agencies that have bitten humans for tick-borne pathogens. This project uses data from TickReport for all of 2018 to determine who is sending ticks to TickReport, as well as to examine spatial and temporal trends for human exposure to Lyme disease and Babesia. The study area is the New England and the Mid-Atlantic region, which encompasses the East coast high risk area for Lyme disease.

Methods

Ticks Submitted to TickReport by ZCTA



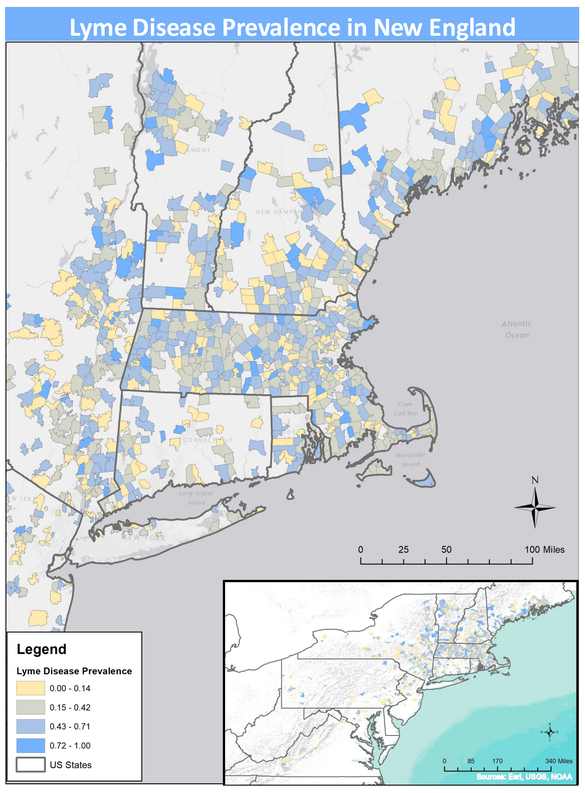
The location of exposure and the address of the person exposed was geocoded by zip code. The number of ticks and ticks pathogen positive was summed and spatially joined to the Zip Code Tabulation Areas (ZCTA). In order to examine who submits tick to TickReport, the ZCTAs with residence information was also joined with data from the American Community Survey (2018) on race, education, population density, and income. Distance from the TickReport lab was calculated as Euclidian distance in meters. The outcome of interest for the linear regression model was number of ticks submitted to TickReport. A linear regression models was run for race, education level, median household income, population density, and distance to TickReport, using ZCTAs that had submitted at least one tick. Ticks were primarily submitted from Massachusetts, costal Maine, and bordering states.

To examine spatial and temporal patterns for Lyme Disease and Babesia, the prevalence rate per ZCTA was calculated for both pathogens using the exposure location. Lyme disease is defined as a tick positive by PCR for *Borrelia burgdorferi sensu lato* and/or *Borrelia mayonii*, and Babesia is a tick positive for *Babesia microti*. Prevalence was mapped for all ZCTAs with at least two tick submitted in 2018. The mean centroid and two standard deviational ellipses for both disease pathogens was calculated. Cluster analysis was performed using global and local Moran's I for ZCTAs with at least two ticks submitted. Weighting was performed using inverse distance and row standardization.

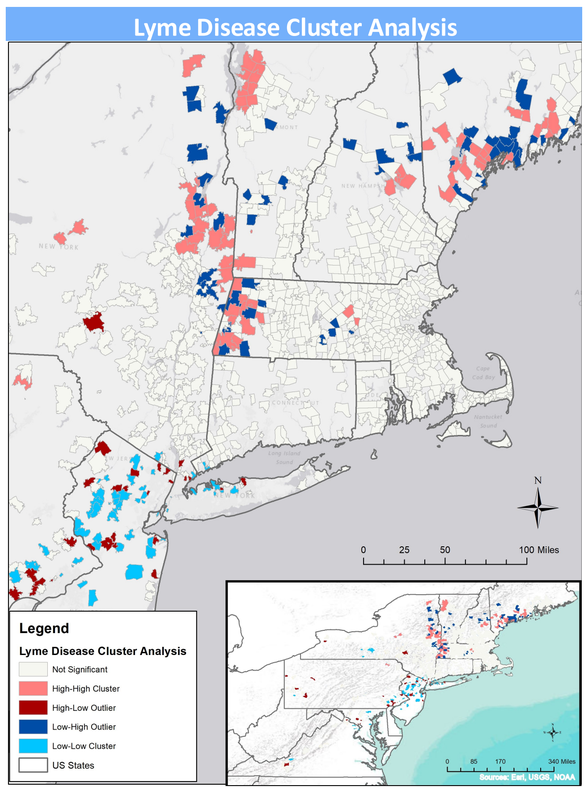
Spatial Trends for Lyme Disease and Babesia

In 2018, both Lyme disease and Babesia were spatially correlated ($p<0.001$). Babesia ($I=0.069$) was more spatially clustered than Lyme disease ($I=0.035$). Lyme disease had greater prevalence throughout New England compared to Babesia. Overall, 34% of *Ixodes* ticks submitted to TickReport (2306/6710) were positive for the pathogen for Lyme disease and 6.6% were positive for Babesia (440/6710). Hotspots for Lyme disease were in Western Massachusetts into New York and Costal Maine. Costal Maine into Eastern Massachusetts were hotspots for Babesia along with Cape Cod and the Connecticut/ New York border. The mean center for Babesia was further east towards Cape Cod and the standard deviations enclosed a smaller area than for Lyme disease. For both Lyme disease and Babesia, there are outlier ZCTAs with high prevalence as far south as New Jersey.

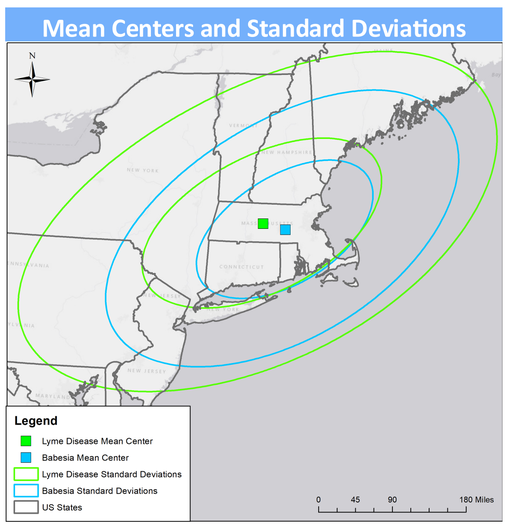
Lyme Disease Prevalence in New England



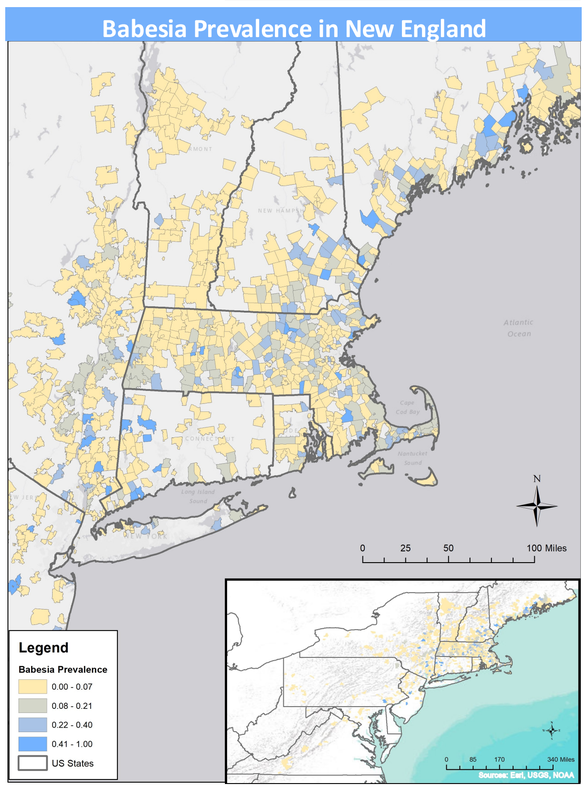
Lyme Disease Cluster Analysis



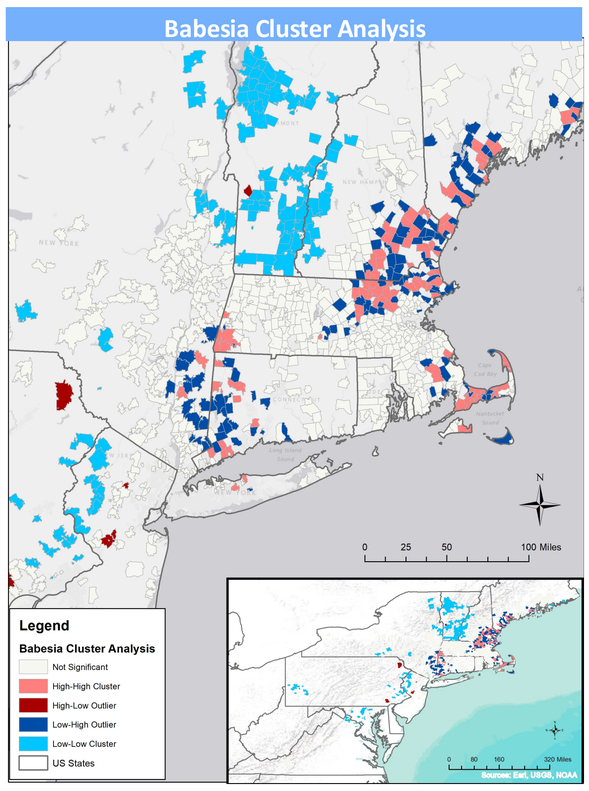
Mean Centers and Standard Deviations



Babesia Prevalence in New England



Babesia Cluster Analysis



Submission and Pathogen Positive Trends

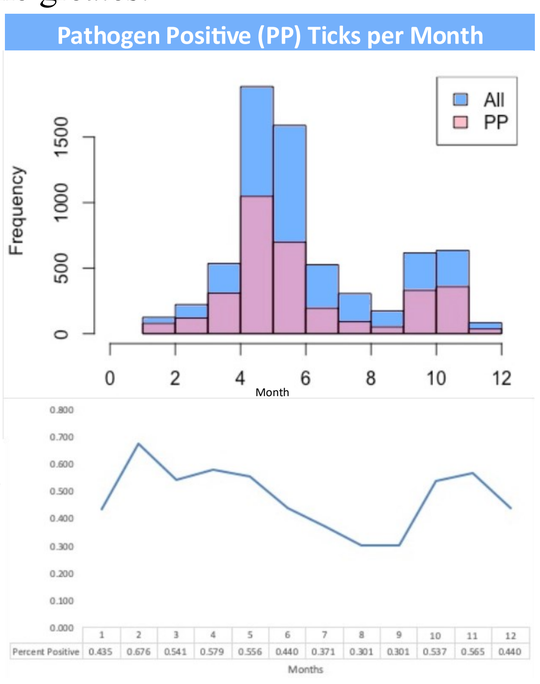
When comparing ZCTAs that have submitted at least one tick, higher number of ticks were associated with lower population density, lower income but higher education, a greater percentage of the population reporting race as white and closer distance to TickReport in Amherst, MA. The greatest effect was seen for percent of population with at least a college degree.

The most ticks were submitted in May and June, followed by October and November. However, more ticks were pathogen positive in late Spring followed by a reduction through the Summer before an increase in the Fall.

Table 1. Linear Regression Model of Sociodemographic and Spatial Variables Associated with Submitting Ticks

Variables	Estimate	Error	P-value
Population Density (1,000 people per square mile)	-0.034	0.012	0.004
Distance from TickReport (per 10 km)	-0.068	0.0075	<0.001
Percent of Population reporting Race as White	2.07	0.95	0.03
Percent of Population with at least a College Degree	14.1	1.39	<0.001
Median Family Income (per $1,000)	-0.037	0.006	<0.001

Pathogen Positive (PP) Ticks per Month



Limitations

Limiting the analysis to ZCTAs with more than one tick submitted resulted in more accurate analysis, but limited the geographic area to mostly New England. As ticks submissions are associated with education, there are likely to be less educated or other areas with unknown prevalence excluded from the analysis.

Conclusions

Both Lyme disease and Babesia were spatially autocorrelated. Lyme disease was prevalent across New England, and Babesia was more clustered, primarily in costal Maine and Massachusetts. In 2018, ticks were still submitted at a high level through November with pathogen positive ticks highest in Spring and Fall. Finally, ticks were more likely to be submitted from highly educated areas leading to a potential for underestimates in less educated areas.

Data: TickReport (University of Massachusetts at Amhurst), 2018 American Community Survey (US Census Bureau)

Projection: NAD 1983 2011 State Plane Massachusetts Mainland FIPS 2001 (meters), using Lambert Conformal Conic

Lexi Sack | UEP 235 Advanced Geospatial Modeling | December 2019

Created with ArcMap 10.7.1 and RStudio 1.1.463

Tufts UNIVERSITY