Use of Geographic Characterization of Tick Surveillance Data to Assess County-level Tick-borne Disease Incidence

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BACKGROUND

Tennessee is home to many different species of tick and tick-borne pathogens (TBPs) that are responsible for hundreds of cases of human disease annually. Despite years of accumulated surveillance data, records remained difficult to query.

This practicum within the Vector-borne Diseases Department, Tennessee Department of Health (TDH) aimed to consolidate and standardize 19 years of historical tick surveillance records (2007-2025) in TennSurv, TDH's state-specific implementation of VectorSurv.

Consolidation of available TDH tick data into this vector surveillance platform allows for visualization and querying while also supporting statewide vector surveillance, strengthen epidemiologic investigations and developing new projects.

OBJECTIVES

Aims of this project:

1. Consolidating Tennessee tick and TBP data into TennSurv
2. Visualizing consolidated vector and pathogen data.
3. Comparison of county-level Lyme disease and ehrlichiosis incidence between counties with and without established tick populations.
4. Support retrospective analysis of tick and TBP trends and help to inform new studies in Tennessee.

Hypothesis:

Counties with established populations of *Ixodes scapularis* and *Amblyomma americanum* would have higher incidence rates of Lyme disease and ehrlichiosis, respectively, than counties without established populations.

METHODS

- Historical TDH tick surveillance data were compiled and standardized in Microsoft Excel, including information on geographical distribution, collection methods, life stages, and species.
- Collection sites were geocoded using TennSurv site codes to generate county-level spatial visualizations. Surveillance summaries were developed following CDC national tick surveillance guidance, classifying counties as:
  - **Established:** ≥ 6 records or > 1 life stage
  - **Reported:** <6 tick records or single life stage
  - **No Records:** no available surveillance records or no detected ticks
- Mann-Whitney U tests and negative binomial regression models were used in R to assess differences in Lyme disease and ehrlichiosis incidence between Established counties and Not Established counties. For analysis, reported and non-reported counties were combined into a not established category.
- Tableau county-level heatmaps and dashboards were developed to visualize the geographic distribution of tick abundance, species distribution, and tick-borne disease incidence across Tennessee counties.

RESULTS

24,000 + — Ticks Records consolidated

73 / 95 — TN Counties geocoded

23 → 45 — Established counties after consolidation for I. scapularis (+22)

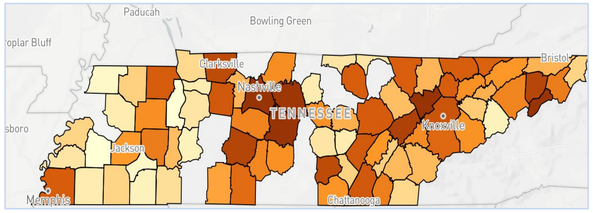


Figure 1. TennSurv map of cumulative tick records in Tennessee from 2007 –2025

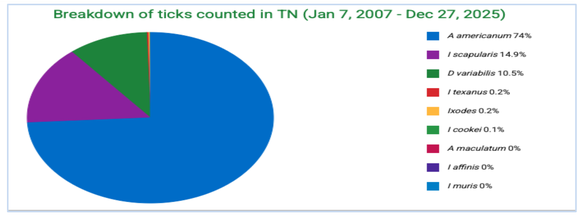


Figure 2. TennSurv Map: Distribution of identified tick species in Tennessee from 2007 – 2025 *Amblyomma americanum* was the predominant species (76.3%, n=17467), followed by *Ixodes scapularis (*11.9%, n=2724).

Table 1. Association Between Tick Establishment Status and County-Level Disease Incidence

Species - disease	IRR (95% CI)	P-value
I. scapularis / *Lyme disease*	0.664 (0.418 – 1.058)	0.075
A. americanum / Ehrlichiosis	0.922 (0.584 - 1.430)	0.718

Counties without established *I. scapularis* populations had an estimated **33.6% lower Lyme disease incidence** rate than counties with established populations (IRR = 0.664, 95% CI 0.418 – 1.058; p=0.075).
Established *A. americanum* status was not associated with ehrlichiosis incidence (IRR = 0.922, 95% CI: 0.584 - 1.430; p = 0.718).

Table 2. Spatial Clustering of Disease Incidence

Global Moran's I	
Lyme disease	**Ehrlichiosis**
I = 0.424 p < 0.001	**I = 0.543** p < 0.001

Global Moran's I demonstrated significant positive spatial autocorrelation for both **Lyme disease (I =0.424, p < 0.001)** and **Ehrlichiosis (I = 0.543, p < 0.001)**
These findings indicate that county-level disease incidence was spatially clustered across neighboring counties rather than randomly distributed.

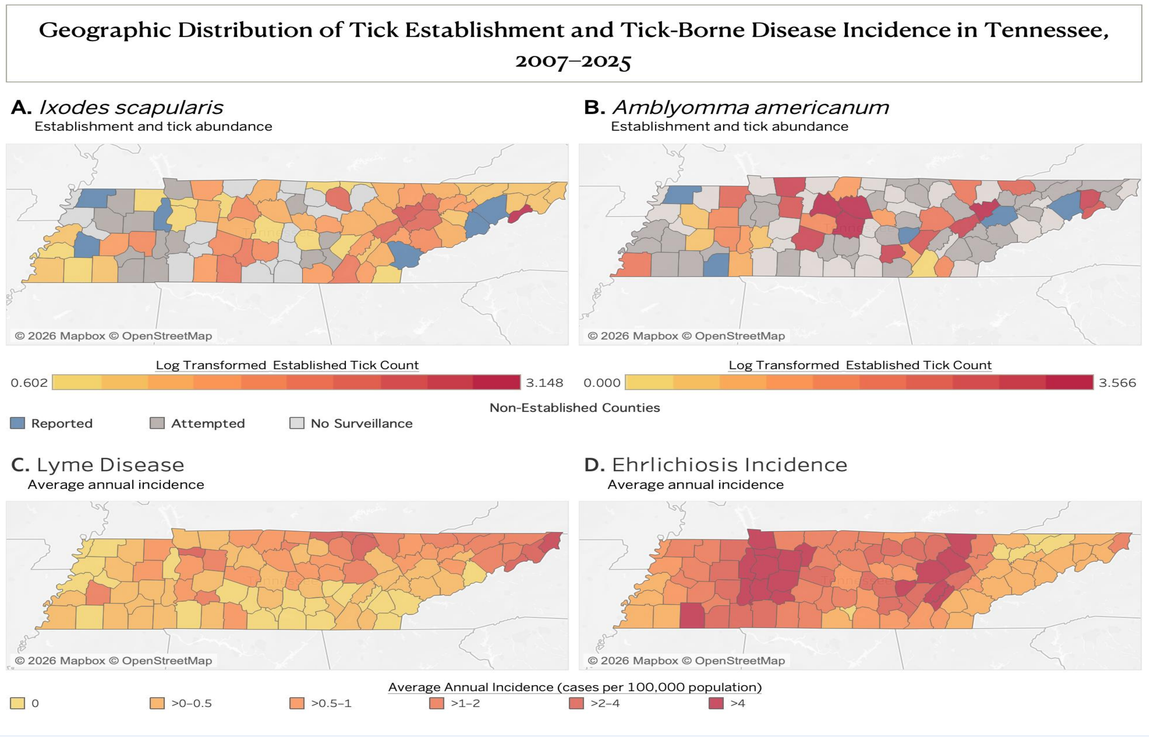


Figure 3. Geographic distribution of tick establishment and tick-borne disease incidence in Tennessee, 2007–2025.

Panels A–B illustrate *Ixodes scapularis* and *Amblyomma americanum* establishment and log-transformed tick counts (2007–2025).

Panels C–D display average annual Lyme disease and ehrlichiosis incidence per 100,000 population (2007–2025). Higher Lyme disease incidence was observed in northern and northeastern Tennessee, while higher ehrlichiosis incidence was concentrated in Middle and Western Tennessee. Higher recorded *A. americanum* tick counts were also observed in parts of Middle Tennessee, suggesting some geographic overlap with ehrlichiosis incidence. Gray counties indicate no surveillance or attempted surveillance without tick detections.

RESULTS

Table 3. Mann- Whitney U Tests

Mann-Whitney U	Effect Size (r)	p-value
Lyme disease	0.10	0.394
Ehrlichiosis	0.13	0.233

Mann-Whitney U tests also found no statistically significant differences for Lyme disease (r=0.10, p=0.394). or ehrlichiosis (r=0.13, p=0.233).

CONCLUSIONS

Consolidation of surveillance records through improved geographic characterization of tick populations in Tennessee, strengthening VBD's capacity to conduct targeted epidemiologic investigations and assess county-level patterns of tick presence and disease burden. .

The comparison of tick surveillance with county-level disease incidence showed that counties with established *I. scapularis* populations showed a trend toward higher incidence, although the association was not statistically significant. *A. americanum establishment* status alone also did not explain variation in ehrlichiosis incidence.

The spatial clustering of both diseases further highlights the value of integrating tick and disease surveillance to characterize geographic patterns of disease burden.

NEXT STEPS

Further evaluation and analysis on host-seeking densities, pathogen prevalence, surveillance effort, and environmental factors to improve the characterization of geographic variation in tick-borne disease burden
Continued integration of tick and disease surveillance data, including additional factors such as hunting activity, rural-urban population density, and socioeconomic factors, may improve identification of counties with elevated tick-borne disease burden

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