The Effects of Lifestyle on the Risk of Lyme Disease in the United States: Evaluation of Market Segmentation Systems in Prevention and Control Strategies

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Abstract: The aim of this study was to investigate lifestyles at risk of Lyme disease, and to geographically identify target populations/households at risk based on their lifestyle preferences. When coupled with geographically identified patient health information (e.g., incidence, diagnostics), lifestyle data provide a more solid base of information for directing public health objectives in minimizing the risk of Lyme disease and targeting populations with Lyme-disease-associated lifestyles. We used an ESRI Tapestry segmentation system that classifies U.S. neighborhoods into 67 unique segments based on their demographic and socioeconomic characteristics. These 67 segments are grouped within 14 larger “LifeModes” that have commonalities based on lifestyle and life stage. Our dataset contains variables denoting the dominant Tapestry segments within each U.S. county, along with annual Lyme disease incidence rates from 2000 through 2017, and the average incidence over these 18 years. K-means clustering was used to cluster counties based on yearly incidence rates for the years 2000–2017. We used analysis of variance (ANOVA) statistical testing to determine the association between Lyme disease incidence and LifeModes. We further determined that the LifeModes Affluent Estates, Upscale Avenues, GenXurban, and Cozy Country Living were associated with higher Lyme disease risk based on the results of analysis of means (ANOM) and Tukey’s post hoc test, indicating that one of these LifeModes is the LifeMode with the greatest Lyme disease incidence rate. We further conducted trait analysis of the high-risk LifeModes to see which traits were related to higher Lyme disease incidence. Due to the extreme regional nature of Lyme disease incidence, we carried out our national-level analysis at the regional level. Significant differences were detected in incidence rates and LifeModes in individual regions. We mapped Lyme disease incidence with associated LifeModes in the Northeast, Southeast, Midcontinent, Rocky Mountain, and Southwest regions to reflect the location-dependent nature of the relationship between lifestyle and Lyme disease.

Keywords: geographic information systems; lifestyle segment; LifeModes; market segmentation; market intelligence; tick-borne diseases; Lyme disease incidence; risk mapping

1. Introduction

The ability to profile a target audience in terms of its morbidity (i.e., sickness) characteristics and its health service needs is becoming increasingly critical for successful marketing initiatives [1]. A wide variety of healthcare entities—whether providers of care, producers of medical supplies and drugs, or organizations providing goods or services to the healthcare industry—are required to market themselves to their prospective customers.

To understand prospective customers, the basic questions start with who gets sick, what they get sick from, and where they get sick. Since morbid conditions are not randomly distributed within the population, but are concentrated within certain segments of it, this baseline information can be expanded by segmenting the population based on...
the clustering of lifestyle attributes—consumer behaviors, exercise patterns, recreational activities, dietary preferences, and so forth. Borrowing market intelligence tools such as market segmentation (i.e., geodemographic segmentation, lifestyle segments), we can identify a population, determine its lifestyle clusters, and estimate its propensity for various conditions. Market segmentation is a common marketing strategy that involves grouping potential customers into lifestyle segments by households, zip codes, and block groups [2]. This granular information could be used to plan health initiatives, develop treatment modalities, improve the delivery of care, and develop marketing programs for healthcare organizations, effective health insurance plans (private and public), and cost-effective approaches to the provision of care.

As the impact of mortality on the population is declining, the shift from acute conditions seemingly affecting populations at random to the growth of lifestyle-generated chronic conditions also serves to increase this interest in investigating the correlation between morbidity patterns and lifestyle segments [1]. Chronic diseases are much more selective in their impacts, resulting in lifestyle-related disparities in health status [5]. This effort involves the identification of and attention to the non-medical efforts that influence health status and the social contributors to ill health—factors clearly addressed through lifestyle-oriented morbidity analysis. To investigate this, we chose the most common infectious disease and chronic condition in North America: Lyme disease. The comprehensive, timely, and detailed data on Lyme disease morbidity levels provided by the CDC helped us to demonstrate the impact of lifestyle on Lyme disease. Moreover, North America is likely to dominate the global Lyme disease therapeutics market, due to the high rate of incidence of Lyme disease and high awareness about and adoption of new diagnostic methods [4]. This paper offers a unique human social behavioral approach to effectively analyze the impact of Lyme disease on American households by their lifestyle characteristics. We specifically tested four research questions: “Is there a difference in average Lyme disease incidence rates among different LifeModes?” “Which LifeModes have incidence rates that are higher/lower than average?” “Which pairs of LifeModes have significantly different incidence rates?”, and “Which LifeModes could potentially have the maximum incidence rate?” We focused on comparing each LifeMode’s mean to the national mean in order to ascertain spatial and temporal patterns of high-risk households and the effects of lifestyle on the risk of Lyme disease infection in the United States.

Our approach provides actionable information for key stakeholders with respect to the focus of interventions and the implementation of prevention and control policies to these specific households exhibiting spatial and temporal patterns of high risk of Lyme disease.

2. Human Social Behaviors Affecting the Risk of Contracting Lyme Disease

Lyme disease has become one of the most prevalent tick-borne diseases in the United States [5]. Lyme disease most commonly occurs in the upper Midwest and Northeastern United States but, over time, cases are starting to emerge in other areas, including California, contracted via *Ixodes pacificus* [6]. Much of this is due to various climate factors allowing for larger tick niches. Even though environmental and climatic factors are driving the increase in the Lyme disease vectors in these emerging areas, human social behaviors also affect the risk of contracting Lyme disease.

Recent studies of human social behavior researched the links between human activity, mobility patterns, and tick exposure in Lyme-disease-endemic areas of the United States and new emerging areas in Canada [7–10]. They used mechanisms of collecting data on human behavior (e.g., retrospective questionnaires) as well as smartphone applications to understand human behaviors affecting tick exposure. Moreover, they engaged the general public in active tick prevention and reporting in different regions of the United States and Canada. Bouchard et al. integrated social behavioral and Lyme disease risk maps in the Montérégie region of southern Quebec, Canada, where Lyme disease is a newly endemic disease [7]. Spatial variation in Lyme disease knowledge, risk perceptions, and
related behaviors in the population were measured using web survey data collected in 2012. These data were used as a proxy for the social-behavioral component of risk. Tick vector population densities were measured in the environment during field surveillance from 2007 to 2012 to provide an index of the ecological component of risk. Social-behavioral and ecological components of risk were combined with human population density to create integrated risk maps. Map predictions were validated by testing the association between high-risk areas and the current spatial distribution of human Lyme disease cases. This study demonstrated that social survey data are a valuable but underutilized source of information for understanding regional variation in Lyme disease exposure, and for integrating this information into risk maps.

Fernandez at al. designed the Tick App as a survey tool to collect data on human behavior and movements associated with tick exposure, while raising awareness among the general public by engaging app users in tick identification and reporting [8]. The Tick App consists of an enrollment survey to identify general risk factors, daily surveys to collect data on human activities and tick encounters as “Tick Diaries”, a survey to enter the details of tick encounters coupled with tick identification services as “Report a Tick”, and educational materials. They found that most users owned a pet, frequently engaged in outdoor activities (occupational, recreational, and/or peridomestic), and lived in the Midwest and Northeast regions. These factors increased significantly in counties with high Lyme disease incidence, or with a recent increase in the number of reported cases in low-incidence counties. Recurring users had a similar demographic profile to all users, but participated in outdoor activities more frequently. The number of active users peaked in June and July, with *Ixodes scapularis* nymphal activity peaking from late May through July. The number of “Tick Diaries” submitted per user was higher for older age groups and in the Midwest, while the number of tick reports increased with the frequency of outdoor activities. This assessment allowed the authors to identify what fraction of the population used the Tick App to tailor the design of potential future tick prevention interventions to the users’ characteristics.

Ozdenerol et al., in their review, concluded that more research needed to be done on activity-based risk, perceptions of risk and known factors, and their influence on individuals’ choices to engage in protective behavior [9]. Donohoe et al. studied the impact of LD on the tourism industry, and found that the tourism industry needs to be considered in terms of employee health, travel choices, and the economic sustainability of tourism in LD-endemic areas [10]. A Czech study by Zeman and Benes [11] found that the liberalized housing in peri-urban locations and the real estate market after political and economic transformations influenced the amount of time people spent outdoors around their homes, which has increased due to lifestyle changes. This process has led to increased contact between the populations and the tick habitats. Linard et al. studied the spatial distribution of LD in Belgium [12]; their findings revealed that LD is associated with recreational and peridomestic outdoor activities in high-income peri-urban areas with isolated houses and forests.

The causal explanation of LD trends was also examined by studies examining the behavioral risk of exposure to tick-borne diseases, focusing on regions where LD is endemic, as well as individuals with occupational exposure [13–15]. McKenna et al. evaluated factors motivating high-risk individuals to implement Lyme disease prevention behaviors [13]. Patients presenting to the Lyme Disease Diagnostic Center in New York State completed a voluntary, anonymous questionnaire. Participants who reported having had Lyme disease in the past or having a family member or close friend with Lyme disease were more likely to use preventive behaviors. Increasing age was associated with increased use of preventive behaviors only for participants without a history of Lyme disease. These findings provided information that was important in developing community prevention programs for Lyme disease. They suggested that younger persons without a history of Lyme disease should be targeted for programs that would educate them about Lyme disease. Schwartz et al. conducted a statewide cross-sectional study of risk factors for seropositivity for antibodies
against *Borrelia burgdorferi* in outdoor workers in New Jersey; their analyses revealed that any use of insect repellent or antibiotics may have decreased the risk of Lyme disease in these workers; they concluded that Lyme disease is a hazard of outdoor work, and that increased recognition of this fact will be necessary in order to prevent Lyme disease in these workers [14].

Schwartz et al. conducted a second cross-sectional study of outdoor workers (*n* = 758) at high risk of Lyme disease. A questionnaire was administered, and antibodies against *Borrelia burgdorferi* and tick salivary gland proteins (anti-tick saliva antibody, a biological marker of tick exposure) were assayed via enzyme-linked immunosorbent assay. The statewide Lyme disease seroprevalence increased from 8.1% in 1988 to 18.7% in 1990. Anti-tick saliva antibody seropositivity varied by county, and was associated with measures of self-reported tick exposure. The data suggested that the prevalence of *B. burgdorferi* infection increased in New Jersey outdoor workers from 1988 to 1990 [15].

Bayles et al. measured the preventive behaviors of visitors to recreational parks in the St. Louis, MO area—an endemic area for tick-borne diseases other than LD [16]. They used geographic stratification techniques, creating 5 km radius buffers around the perimeter of each site, and overlaid the buffers on a map of census blocks with population estimates from the 2010 U.S. census. Based on human population densities, they classified parks as either suburban, exurban, or rural. Results presented significant differences in behaviors across parks. Those in exurban parks were more likely to perform frequent tick checks and use insect repellents, while those in suburban parks were more likely to avoid tick habitats. On the other hand, those in rural parks were less likely to avoid tick habitats.

In this paper, we determined the distribution of Lyme disease based on the geographic distribution of households whose lifestyle segments were identified as having a high propensity for Lyme disease. By identifying target populations at risk based on lifestyle preferences, we could target specific types of households and their locations for epidemiological analysis. In addition, we sought to determine whether the relationship between lifestyle and Lyme disease was location-dependent, meaning that lifestyle-related attributes might contribute to the likelihood of infection when the environmental conditions such as climate, tick and pathogen species range, and tick and pathogen habitat are met. This analysis also led to clues as to human behaviors and travel patterns that affect the risk of contracting Lyme disease, and provided evidence that human social behaviors—such as lifestyle preferences—must also be included in Lyme disease risk maps, even though environmental conditions (e.g., tick habitats, endemic areas) are not met. For zoonotic diseases, researchers have worked with GISs to create surveillance databases to improve the effectiveness of oral vaccine deployment programs by creating risk assessment maps to prioritize areas in which to distribute the oral vaccine to the wildlife [17]. It should be possible to determine whether a community should be targeted for an oral vaccine deployment program to eradicate Lyme disease based on high-risk lifestyle clusters.

Given that virtually every household in the U.S. has been assigned a lifestyle segment, linking segments to geographically identified patients (e.g., Lyme disease incidence) could subsequently predict the demand for health services. For example, at-risk populations in high-risk lifestyle clusters (e.g., segments) can be recruited in clinical trials for human vaccines. Establishing this link can also allow for more efficient, more targeted, and more cost-effective healthcare for Lyme disease. Ozdenerol et al. demonstrated this with respect to COVID-19 and lifestyle characteristics associated with COVID-19 infection and mortality rates at the U.S. county level, and sequentially mapped the impact of COVID-19 on different lifestyle segments. [1]. Moreover, we can also prioritize high-risk lifestyle segments whose lifestyle traits (e.g., travelers) are risky for Lyme disease in non-endemic areas for prevention strategies. Ozdenerol's methodology [1] aims to be a prototype for converting information on lifestyles into the incidence and prevalence of health conditions (e.g., Lyme disease morbidity) and into the demand for health services and prevention strategies.
3. Materials and Methods

3.1. Data

We combined data from multiple sources and merged them in geographic information systems (GISs) to create a visual representation through maps. We used the ESRI Tapestry segmentation system [2] to associate lifestyle clusters with Lyme disease. We explicitly describe both ESRI Tapestry segmentation and Lyme disease datasets under separate headings below.

3.1.1. ESRI Tapestry Segmentation System

We used the ESRI Tapestry segmentation system [2], which is available on an annual basis, as population and household counts by Tapestry segment are updated each year. The GIS that supports the ESRI Tapestry segmentation platform enables Experian’s ConsumerView database [18], the Survey of the American Consumer from GfK MRI [19], and the U.S. Census American Community Survey [20] datasets to be brought together as maps to create a complete picture of local communities and neighborhoods across the U.S.

The ESRI Tapestry segmentation system utilizes Experian’s consumer survey, which applies traditional customer profiling techniques such as relationships between purchased products and consumers’ beliefs and life patterns [21–23]. When composing lifestyle segments, geographic data represent where the focal groups are located and where they are buying and using products. Behavioral data focus on when the groups are more likely to buy, under what circumstances they would buy, and how they would choose to consume or use the product. Demographics represent the races, gender, age groups, and marital status of customers/consumers. Psychographic data concentrate on their uniqueness, personal preferences and lifestyle choices, what they do in their spare time, what products they chose to free up more spare time, and how they see themselves and their communities, as well as identifying careers, opinions, and income parameters [24–26].

ESRI Tapestry segmentation classifies U.S. neighborhoods into 67 unique market segments, based on socioeconomic and demographic factors, and then consolidates these 67 segments into 14 LifeModes with names such as “High Society”, “Senior Styles”, and “Factories and Farms” that have commonalities based on lifestyle and life stages [2]. ESRI Tapestry segmentation data were downloaded from ESRI [26]. Our dataset contains a variable denoting the dominant tapestry segment within each U.S. county. Appendix A shows a description of the traits of the LifeModes in a table.

3.1.2. Lyme Disease Incidence Rates

A dataset downloaded from the CDC Wonder database contains Lyme disease incidence rates from 2000–2017 on a county-by-county basis [27]. County-level population estimates were downloaded from the Census Bureau website in two different datasets: the “Intercensal Estimates of Resident Population for Counties and States: 1 April 2000 to 1 July 2010” and the “County Population Totals and Components of Change: 2010–2017” [28].

Our dataset contains variables denoting the dominant Tapestry segment within each U.S. county and the annual Lyme disease incidence rate from 2000 through 2017, as well as the average incidence over these 18 years. K-means clustering was used to cluster counties based on yearly incidence rates for the years 2000–2017 [29]. The incidence rates per 100,000 people were then calculated using Equation (1):

\[
\text{new case counts per county} \quad \frac{\text{population per county}}{100,000}
\]

Figure 1 shows Lyme disease incidence rates at the county level in the United States for the period of 2000–2017. The mean incidence rate for all U.S. counties was 8.03 per 100,000 (n = 3141). The distribution of incidence rates was extremely right-skewed, with the majority of counties experiencing incidence rates below 1 per 100,000, but some counties experiencing much higher incidence rates. The maximum incidence rate of 641.17 cases
per 100,000 was found in Columbia County, New York. Two distinct areas with high Lyme disease risk were evident: one in the Northeastern United States—especially New York, Pennsylvania, and Connecticut—and one in the Midwestern states of Minnesota and Wisconsin. Most counties outside of these areas experienced much lower rates, below 10 per 100,000. All numbers represent cases per 100,000 people.

Figure 1. Lyme disease incidence rates in the United States for 2000–2017.

### 3.2. Methods

We first conducted a nationwide analysis in order to attain a greater depth of understanding of how these associations can be particularly useful for targeting at-risk populations in the context of the expansion of the geographic ranges of vectors (Figure 2). Vectors included *I. scapularis* and *I. pacificus*, because these two species are responsible for spreading the bacteria into the human population, *P. leucopus*, which is one of the main reservoirs of *B. burgdorferi*, and *O. virginianus*, because this species along with other medium–large-sized mammals aids in tick survival [30]. We mapped the locations of high-risk LifeModes nationwide.

Figure 2. Species range and Lyme disease incidence rates in the U.S. *Ixodes pacificus*: western blacklegged tick; *Ixodes scapularis*: blacklegged tick; *Peromyscus leucopus*: white-footed deer mouse; *Odocoileus virginianus*: white-tailed deer.

Due to the extreme regional nature of Lyme disease incidence, we carried out our national-level analysis at the regional level. We divided the U.S. into seven regions that were adapted from the USGS regional map (https://www.usgs.gov/media/images/usgs-regional-map) (accessed on 4 August 2017). Figure 3 shows these regions by state boundaries.
Statistical Analysis

We used analysis of variance (ANOVA) [31] to determine whether there was any association between Lyme disease incidence and LifeModes. Our research question was “Is there a difference in average incidence rate among different LifeModes?” We further used analysis of means (ANOM) [32] and post hoc tests to determine which particular LifeModes had higher risk. Our research question was “Which LifeModes have incidence rates which are higher/lower than average?”.

Since there are many similarities and overlaps between lifestyle segments within the same LifeModes, and testing at the segment level would also drastically reduce sample sizes, curtailing the power of the statistical tests, we chose to use the broader Tapestry LifeModes, rather than lifestyle segments, for the statistical analysis. We ran Tukey’s HSD post hoc test with the following research questions: Which pairs of LifeModes have significantly different incidence rates? Which LifeModes could potentially have the maximum incidence rate?

The same statistical analyses from the national analysis (i.e., ANOVA, ANOM, and Tukey’s post hoc test) were carried out separately for each of these seven regions. We ran the ANOM test for the five regions where a significant difference was detected. Tukey’s HSD post hoc test could not be performed at the regional level, because some of the LifeModes had fewer than two counties within some of the regions. We mapped Lyme disease incidence with associated high-risk LifeModes in the Northeast, Southeast, Midcontinent, Rocky Mountain, and Southwest regions.

Our national analysis included all of the counties in the United States. First, exploratory data analysis was performed to determine whether the Lyme disease incidence rates were normally distributed. Figure 4 shows the quantile plot for the untransformed rates, clearly indicating the severe right-skewness in the data; we used a log-transform to remedy this. Figure 5 shows the quantile plot for the log-transformed rates. As the Figure 5 plot is much closer to the normal distribution than the non-transformed data, we used the log-transformed data.
we can conclude that this LifeMode had a below average risk of Lyme disease. Figure 6
Similarly, for each LifeMode with a confidence interval entirely below the overall mean,
we can conclude that this LifeMode had an above average risk of Lyme disease. For each LifeMode with a confidence interval entirely above the overall mean (8.03 per
incidence rates that are significantly above/below the overall mean incidence rate. The
Table 1 contains 95% confidence intervals for the mean incidence of each LifeMode.

Figure 4. The quantile plot for the untransformed rates.
Figure 5. The quantile plot for the log-transformed rates.

One-way ANOVA was performed with LifeModes as the factor variable and log-
transformed incidence rates as the response variable to determine whether there were
differences in average incidence rates between different LifeModes; Table 1 displays these
results. The one-way ANOVA compares the means between the LifeModes and deter-
mines whether any of those means are statistically significantly different from one another.
Specifically, it tests the null hypothesis:

$$\mu_1 = \mu_2 = \mu_3 = \cdots = \mu_k$$

where
$$\mu$$ is the group mean and
$$k$$ is the number of groups. If the one-way ANOVA returns

| Source | SS | MS | DF | F-Value | p-Value |
|--------|----|----|----|---------|---------|
| Total  | 2,652,356 | 803.7 | 13 | 0.000 | 0.000 |
| Error  | 2,508,283 | 185.3 | 144,073 | 0.000 | 0.000 |
| Adj SS | 3134 | 2.3 | 233.4 | 0.000 | 0.000 |
| Adj MS | 233.4 | 0.000 | 0.000 |

The quantile plot for the log-transformed rates.
"All means are equal":

\[ H_0 : \mu_1 = \mu_2 = \mu_3 = \cdots = \mu_k \]

where \( \mu \) is the group mean and \( k \) is the number of groups. If the one-way ANOVA returns a statistically significant result, we accept the alternative hypothesis (\( H_A \)) "Not all means are equal", which is that there are at least two group means that are statistically significantly different from one another.

Analysis of means (ANOM) was also performed to determine which LifeModes have incidence rates that are significantly above/below the overall mean incidence rate. The above table contains 95% confidence intervals for the mean incidence of each LifeMode. For each LifeMode with a confidence interval entirely above the overall mean (8.03 per 100,000), we can conclude that this LifeMode had an above average risk of Lyme disease. Similarly, for each LifeMode with a confidence interval entirely below the overall mean, we can conclude that this LifeMode had a below average risk of Lyme disease. Figure 6 displays a graphical representation of the analysis of means for Lyme disease incidence vs. LifeModes.

Table 1. Analysis of variance.

| Source      | DF | Adj SS  | Adj MS  | F-Value | p-Value |
|-------------|----|---------|---------|---------|---------|
| LifeMode    | 13 | 144,073 | 11,082.5| 13.79   | 0.000   |
| Error       | 3121 | 2,508,283 | 803.7   |         |         |
| Total       | 3134 | 2,652,356 |         |         |         |

Pooled standard deviation = 28.3492.

The one-way ANOVA cannot tell us which specific LifeModes were statistically significantly different from one another—it could only tell us that at least two groups were. Tukey’s HSD post hoc test determined which pairs of LifeModes were significantly different. We could also determine which LifeMode(s) had the highest incidence rate(s).
4. Results
4.1. National Analysis Results

The results of the one-way ANOVA analysis for Lyme disease incidence (ANOVA, $F$-value = 30.659, $p < 0.001$; Table 2) show a significant association between Lyme disease incidence and LifeModes at the national level for an 18-year period from 2000 to 2017.

Table 2. Results of the one-way ANOVA for Lyme disease clusters and incidence.

| ANOVA F-Value | $p$-Value | Significant? |
|---------------|-----------|--------------|
| Lyme disease incidence | 30.659 | <0.001 | Yes |

*** $p < 0.001$.

We then used analysis of means (ANOM) to investigate which LifeModes had higher risk. As Table 3 states, LifeModes 1 (Affluent Estates), 2 (Upscale Avenues), 5 (GenXurban), and 6 (Cozy Country Living) exhibited a significantly higher mean incidence rate than the overall mean. LifeModes 4 (Family Landscape), 7 (Ethnic Enclaves), 10 (Rustic Outposts), and 12 (Hometown) had a significantly lower mean incidence rate than the overall mean. Appendix B shows an in-depth description of the lifestyle traits of the high- and low-risk LifeModes and lifestyle segments influencing Lyme disease morbidity.

Table 3. The results of the ANOM tests.

| Code | LifeMode | Risk Level | Lyme Disease Cases per 100,000 | % Suitable (Climate and Habitat) |
|------|----------|------------|-------------------------------|-------------------------------|
| N/A  | Nationwide Average | N/A | 8.03 | 1.9 |
| 1    | Affluent Estates    | High | 30.14 | 5.4 |
| 2    | Upscale Avenues     | High | 36.10 | 4.2 |
| 3    | Uptown Individuals  | Low  | 3.87  | 2.8 |
| 4    | Family Landscapes   | Low  | 3.95  | 0.9 |
| 5    | GenXurban           | High | 13.78 | 6.0 |
| 6    | Cozy Country Living | High | 12.15 | 2.5 |
| 7    | Ethnic Enclaves     | Low  | 0.44  | 0.2 |
| 8    | Middle Ground       | Low  | 3.94  | 1.2 |
| 9    | Senior Styles       | Low  | 5.23  | 0.1 |
| 10   | Rustic Outposts     | Low  | 2.14  | 0.8 |
| 11   | Midtown Singles     | Low  | 5.28  | 0.5 |
| 12   | Hometown            | Low  | 2.54  | 0.5 |
| 13   | Next Wave           | Low  | 12.92 | 1.6 |
| 14   | Scholars and Patriots | Low | 2.11  | 3.1 |

The results of Tukey’s HSD test indicated that either LifeMode 1 (Affluent Estates) or LifeMode 2 (Upscale Avenues) had the highest Lyme disease incidence rate.

Our systematic review of the households that fall within these high- and low-risk LifeModes revealed commonalities of lifestyle preferences and life stages that could affect the risk of contracting Lyme disease. Appendix C shows a county-based summary of LifeModes associated with high incidence and low incidence, along with their predominant lifestyle traits. Single-family home ownership, living in old suburbs and/or urban settings with older homes, being active in sports and outdoor recreation, and engaging in outdoor activities such as gardening and maintaining lawns are common lifestyle preferences among both high- and low-risk households. This explains the risk of tick bites in Lyme-disease-endemic areas. What makes the high-risk households different to the low-risk households is that they are generally older and wealthier individuals, being predominantly white, from high-income neighborhoods, college-educated professionals, enthusiastic travelers, and active in outdoor recreational sports such as walking, jogging, hiking, etc. Low-risk households have a wide range of ages, with less income, and varying net worth depending
on how well they budget. These individuals are ethnically diverse (e.g., Hispanic families),
from low-income neighborhoods, educated to high-school level or less, and engage in
outdoor activities such as hunting, fishing, lawn maintenance, and vegetable gardening;
however, they also partake in many indoor activities. Low-risk households are not as
enthusiastic travelers as high-risk households, but they take trips to theme parks, water
parks, or the zoo.

4.2. Climate and Habitat Variables of High-Risk LifeModes

Figure 7 shows the high-risk life modes and suitable climate and habitat variables
overlaid with species ranges for western blacklegged ticks, blacklegged ticks, white-tailed
deer, and white-footed deer mice. High-risk LifeModes are heavily concentrated in the
Mid-Atlantic area (i.e., New York, Connecticut, and Pennsylvania), and one in the upper
Midwest (i.e., Minnesota and Wisconsin). High-risk-LifeMode areas are associated with
the presence of white-footed deer mice (which transmit bacteria to ticks) and white-tailed
deer (which are associated with tick life cycles). These are Lyme-disease-endemic areas
with environmental conditions conducive to tick habitats and an abundance of hosts for
the ticks. We examined climatic and habitat variables that influenced the distribution of
LD in high-risk-LifeMode areas such as heavily forested areas, overwintering areas, and
areas with high amounts of annual precipitation (e.g., snow residence). We combined
these three layers into one suitability layer. Food is essential to survival, because ticks
feed on other species to survive. Areas that have food available for their hosts (e.g., Per-
omyscus leucopus, Odocoileus Virginianus, and medium-sized mammals) are important to
note, including forested areas—especially oak forests, because they provide much of this
food [30]. We also extracted overwintering areas whose average minimum temperatures
remain higher than $-10$ degrees Celsius during the winter months (December–February),
and with a snow residence time of more than 50 days [33]. These are important climate and
habitat factors that affect ticks’ development, survival, and host-seeking behavior, as well
as strongly influencing tick abundance. The proportion of ticks infected with the Lyme
disease spirochete, Borrelia burgdorferi, depends on the abundance of hosts for the ticks and
the capacity of tick hosts to serve as $B. burgdorferi$ reservoirs.

Figure 7. At-risk LifeModes and climate and habitat suitability with species range. $Ixodes pacificus$: western blacklegged tick; $Ixodes scapularis$: blacklegged tick; $Peromyscus leucopus$: white-footed deer
mouse; $Odocoileus virginianus$: white-tailed deer.

Counties that consist predominantly of households engaged in at-risk LifeModes are
shown in gray. These maps reveal that a significant portion of the United States consists of
at-risk LifeModes. The Lyme-disease-endemic areas (orange dots) are within areas that
have the heaviest concentrations of at-risk LifeModes.

The high-risk LifeModes of Affluent Estates, Upscale Avenues, GenXurban, and Cozy
Country Living had high percentages of suitable area coverage conducive to tick survival.
We also found that there were high-risk traveler households that did not live in endemic
areas, but contracted the disease elsewhere (Figure 7). Cases are reported according to
county of residence, not by county of exposure. For example, major concentrations of
high-risk Urban Chic households are found in urban areas on the Northern and Southern California coasts, as well as along the east coast; they travel extensively, visit national parks, stay active; and for fitness they engage in downhill skiing, backpacking, hiking, biking, yoga, aerobics, tennis, and weightlifting.

We further conducted trait analysis of the high-risk LifeModes to see which traits were related to higher Lyme disease incidence. Figure 8 shows demographic and behavioral traits for high-risk LifeModes determined from our analyses. It can be seen that counties of high-risk LifeModes are within the ticks’ range for each trait category. Most counties at high risk of Lyme disease have household sizes below the national average, with a median net worth generally higher than average. The diversity in these areas is generally lower, with the predominant race being White or Asian and Pacific Islanders. These individuals are also generally older, live in suburban or rural settings, and spend most of their budget on healthcare. Within the ranges of either of the ticks, individuals are not well traveled. However, when looking at individuals at high risk of Lyme disease outside of tick ranges, one finds an increase in travelers. These individuals also enjoy both indoor and outdoor recreation, but there were far fewer individuals who were interested in outdoor recreation outside of tick ranges than within tick ranges.

Figure 8. Demographic and behavioral traits for counties with high-risk LifeModes. Blue indicates the number of counties located within *Ixodes scapularis* (blacklegged tick), *Ixodes pacificus* (western blacklegged tick), or any overlap of the two ranges. Red indicates the number of counties located outside of their ranges.

One-way ANOVA and Tukey’s HSD post hoc test for Lyme disease incidence by demographic and social traits were conducted in order to determine which traits were related to higher Lyme disease incidence. Results from the ANOVA tests can be seen in Table 4. Lifestyle traits whose mean incidence rates significantly differed across groups included area setting, household size, median age, median income, median net worth, predominant career field, predominant spending category, gardening, travelling, interest in indoor recreational activities, and interest in outdoor recreational activities.
Table 4. Results of the one-way ANOVA tests for Lyme disease incidence by lifestyle trait.

| Lifestyle Trait          | F-Value | p-Value *** | Significant? |
|--------------------------|---------|-------------|--------------|
| Setting                  | 3.366   | 0.005       | Yes          |
| Married couples          | 1.853   | 0.158       | No           |
| Children                 | 1.104   | 0.332       | No           |
| Household size           | 3.888   | 0.049       | Yes          |
| Median age               | 6.687   | 0.010       | Yes          |
| Median income            | 18.19   | <0.001      | Yes          |
| Median net worth         | 64.67   | <0.001      | Yes          |
| Diversity index          | 2.725   | 0.099       | No           |
| Predominant race         | 1.301   | 0.247       | No           |
| Predominant career field | 12.65   | <0.001      | Yes          |
| Predominant spending category | 3.966 | <0.001      | Yes          |
| DIY home improvement     | 3.308   | 0.069       | No           |
| Gardeners                | 5.029   | 0.007       | Yes          |
| Travelers                | 19.44   | <0.001      | Yes          |
| Indoor recreation        | 5.18    | 0.023       | Yes          |
| Outdoor recreation       | 2.116   | 0.146       | No           |

*** p < 0.001.

Table 5 shows significant pairwise comparisons between lifestyle traits in order to determine which traits differ the most. Individuals who live in suburban areas are at higher risk of Lyme disease than those in semi-rural or urban areas. Suburban areas tend to have bigger backyards, which could lead to more outdoor activities, such as lawn maintenance, gardening, etc. Individuals may not prepare for tick encounters when conducting shorter trips in their backyards, which could lead to increased tick exposure. Households in high-risk counties often also have more people living in them, increasing the amount of people with similar behaviors in these bigger yards. Furthermore, individuals at higher risk are older, with higher income and net worth. When looking more closely at the predominant career fields, there are many instances where people who work in management, along with a combination of other career fields, have higher mean incidence rates for Lyme disease. People who spend a majority of their expenses on healthcare have lower incidence rates than those who spend a majority of their expenses on education. Areas that have individuals who garden along with individuals who do not garden tend to have higher mean Lyme disease incidence rates than those who mostly do not garden or those who mostly do garden. If it is not a social norm to garden, people may not understand what kind of precautions are needed in order to reduce exposure to tick bites while gardening. Furthermore, people who travel are at higher risk of Lyme disease than those who do not. This makes sense, because some people may not have ticks in their region and, thus, fail to take proper precautions; when travelling, they are unaware of the tick prevention measures necessary in their destination. Finally, people who are interested in indoor recreation have higher mean incidence rates than those who are not. People who are interested in outdoor recreation are well educated in the proper prevention techniques needed when they are outside, while people who mainly enjoy indoor recreation may not know or practice these techniques.

4.3. Regional Analysis Results

We found that there was a difference in the average Lyme disease incidence among the different LifeModes in the Northeast, Southeast, Midcontinent, Rocky Mountain, and Southwest regions, as shown in Table 6. The United States has two major Lyme disease hotspots: one in the Mid-Atlantic area (i.e., New York, Connecticut, and Pennsylvania), and one in the upper Midwest (i.e., Minnesota and Wisconsin). The risk of Lyme disease is very low throughout the rest of the United States.
Table 5. Pairwise comparisons for Lyme disease incidence by lifestyle trait.

| Demographic Trait | Significant Comparison                                      | Mean Difference | p-Value       |
|-------------------|-------------------------------------------------------------|-----------------|---------------|
| Setting           | Suburban vs. Semi-rural                                     | 32.8            | 0.039         |
|                   | Urban vs. Suburban                                          | -33.0           | 0.026         |
| Household size    | Above national median vs. Below national median             | 9.4             | 0.049         |
| Median age        | Above national median vs. Below national median             | 18.7            | 0.010         |
| Median income     | Above national median vs. Below national median             | 22.7            | <0.001        |
| Median net worth  | Above national median vs. Below national median             | 35.2            | <0.001        |
| Predominant career field | Office and administrative support and food preparation and serving vs. Office and administrative support only | 57.4            | 0.006         |
|                   | Management, office and administrative support, and sales vs. Construction and extraction, and office and administrative support | 73.7            | <0.001        |
|                   | Production and office and administrative support vs. Management and office and administrative support | -58.0           | 0.011         |
|                   | Management, office and administrative support, and sales vs. Management and office and administrative support | 59.6            | 0.001         |
|                   | Office and administrative support vs. Management, office and administrative support, and sales | -51.1           | <0.001        |
|                   | Production and office and administrative support vs. Management, office and administrative support, and sales | -74.3           | <0.001        |
| Top spending category | Health care vs. Education                                  | -24.9           | 0.002         |
| Gardeners         | No vs. Mixed                                                | -80.4           | 0.009         |
| Travelers         | Yes vs. Mixed                                               | -74.3           | 0.017         |
| Interested in indoor recreation | Yes vs. No                                                | 43.5            | <0.001        |

Table 6. Results of the one-way ANOVA test for Lyme disease incidence by region.

| Region            | F-Value | p-Value  | Significant? |
|-------------------|---------|----------|--------------|
| Northeast         | 13      | <0.001   | Yes          |
| Southeast         | 12.42   | <0.001   | Yes          |
| Midcontinent      | 2.695   | 0.002    | Yes          |
| Rocky Mountains   | 7.305   | <0.001   | Yes          |
| Southwest         | 3.175   | 0.001    | Yes          |
| Northwest and Pacific | 1.197   | 0.307    | No           |
| Alaska            | 0.986   | 0.488    | No           |

We also found that the ANOM test results reflected the location-dependent nature of the relationship between lifestyle and Lyme disease (Table 7). For example, LifeMode 1 (Affluent Estates) experiences above average Lyme disease incidence in the Northeast but below average incidence in the Rocky Mountains region. LifeMode 2 (Upscale Avenues) experiences above average incidence in the Northeast and Rocky Mountains. LifeMode 4 (Family Landscape) experiences below average incidence in the Southeast. LifeMode 6 (Cozy Country Living) experiences above average incidence in the Northeast, Southeast, Midcontinent, and Southwest. LifeMode 7 (Ethnic Enclaves) experiences below average incidence in the Southeast and Southwest. LifeMode 10 (Rustic Outposts) experiences below average incidence in the Northeast. LifeMode 11 (Midtown Singles) experiences below average incidence in the Rocky Mountains. LifeMode 12 (Hometown) experiences below average incidence in the Southeast and Midcontinent regions. Figure 9 shows high-risk LifeModes in each region.
Figure 9. High-risk LifeModes with regional boundaries.

Table 7. Results of the ANOM test by region.

| Region       | Mean Lyme Disease Incidence | High-Risk LifeModes                          | Low-Risk LifeModes                  |
|--------------|-----------------------------|---------------------------------------------|-------------------------------------|
| Northeast    | 29.052                      | 1 Affluent Estates, 2 Upscale Avenues, 6 Cozy Country Living | 10 Rustic Outposts                  |
| Southeast    | 0.6918                      | 6 Cozy Country Living                       | 4 Family Landscape, 7 Ethnic Enclaves, 12 Hometown |
| Midcontinent | 8.9868                      | 6 Cozy Country Living                       | 12 Hometown                         |
| Rocky Mountains | 0.1235                   | 2 Upscale Avenues, 1 Affluent Estates, 11 Midtown Singles | 1 Affluent Estates, 7 Ethnic Enclaves |
| Southwest    | 0.7373                      | 6 Cozy Country Living                       | 7 Ethnic Enclaves                   |

It is interesting to note that while LifeModes 1 (Affluent Estates), 2 (Upscale Avenues), 5 (GenXurban), and 6 (Cozy Country Living) were all found to be associated with higher Lyme disease incidence nationwide, LifeMode 5 (GenXurban) was not significantly higher in any of the individual regions, LifeModes 1 (Affluent Estates) was significantly higher only in the Northeast, and LifeMode 2 (Upscale Avenues) was significantly higher only in the Northeast and Rocky Mountains. It is likely that the high incidence rates in the Northeast skewed the nationwide statistics. It is important to note that LifeMode 6 (Cozy Country Living) is consistently associated with higher incidence rates across most of the nation. It is recommended that local policy decisions outside of the Northeast should be based on our regional results for the location in question rather than on our national results.

5. Discussion

If we are to limit the impact of emerging Lyme disease on human health in the U.S., the appropriate prevention measures should be implemented and targeted towards the at-risk populations in the high-risk locations [9]. Prevention measures include personal protection, environmental management for tick control, and community-based interventions such as rodent-targeted vaccines (RTVs), as many small rodents are carriers of B. Burgdorferi [9], e.g., P. leucopus [5], Sciurus griseus [34], Zapus hudsonius, and Ictidomys tridecemlineatus [35], among others. The common approach for defining human populations at risk of Lyme disease has been identifying endemic locations and predicting the occurrence of vectors using risk maps. In many cases, potential geographic distributions of vectors have been predicted using statistical associations between climate or landscape variables (or their remote-sensed proxies), which are likely to be associated with vector survival and/or reproduction and, thus, the observed occurrence of vectors [36,37]. The human populations at risk are, at least, defined in part by the geographic occurrence of the arthropod vectors,
whose existence is tightly linked to climatic variables on a continental scale [38,39], as well as to suitable habitats on a more local geographic scale [36].

Even though environmental and climatic factors are driving the increase in the Lyme disease vectors in the emerging geographic areas, human social behaviors—such as lifestyle preferences—also affect the risk of contracting Lyme disease. Our findings contributed a human behavioral aspect to these investigations, and led to geographically identified at-risk target populations based on lifestyle preferences [1]. Our resultant risk maps show at-risk LifeMode households in localized endemic areas, and are potentially very useful to guide public health policy and target surveillance and intervention activities [1]. We can predict which households will be at risk of Lyme disease in new emerging endemic areas based on our findings on lifestyle preferences.

With a greater depth of understanding of these at-risk households based on lifestyle, we can further explore the localized households in the risk maps that were the result of predicting expansion of the geographic ranges of vectors. For example, household-level findings provide prevention opportunities for localized interventions such as the deployment of rodent-targeted vaccines (RTVs). RTVs have been successful in preventing *B. burgdorferi* infection in rodent reservoirs and host-seeking ticks by disrupting transmission cycles [40–42]. At-risk households are potential grounds to deploy RTVs that can block or significantly reduce the chance/ability of arthropod vectors to become infected with and transmit disease-causing pathogens to uninfected reservoirs or humans [40–44].

Protection and prevention products such as tick-repellent products could be more efficiently marketed to these at-risk populations/households based on their lifestyle preferences. For example, Affluent Estates and Upscale Avenues households are early adapters of new products and technology; they enjoy the outdoors, and are health conscious; they have high rates of homeownership that would make them likely to invest in chemical control products. This lifestyle segmentation not only provides information on how to market to these at-risk households, but can also be used to conduct more efficient health intervention, prevention, and treatment. For example, public health messages and clinical information could be issued to the public and medical practitioners in these at-risk households for better assistance in clinical diagnoses. Lifestyle segmentation can provide clues for physicians as to how to more properly diagnose patients, in much the same way as these data enable more efficient marketing to consumers.

Clinical trials of new vaccines for Lyme disease can recruit patients from high-risk households based on their lifestyle preferences, and can determine their overall motivation to engage in clinical research. High-risk LifeModes and their locations are clearly the areas in the U.S. where the public might benefit from a Lyme disease vaccine. Clinical trials and digital advertising campaigns can use these at-risk households as georeferencing targets and tailor their recruitment campaigns and marketing efforts based on these households’ lifestyle preferences. These areas are also targeted areas to increase awareness of a vaccine among the public and clinicians in order to prevent Lyme disease in the United States.

We also found that there is a location-dependent relationship between lifestyle and infection; that is, there were counties that had LifeModes and segmentations that were associated with high Lyme disease incidence, but no actual incidence was recorded in those counties. Therefore, at-risk-LifeMode households might not constitute a risk in non-endemic areas when climate and habitat conditions are not suitable for vectors. Some counties that have high Lyme disease incidence in non-endemic areas include at-risk lifestyle populations/households such as Urban Chic, because these are enthusiastic travelers who might have visited endemic areas and contracted the disease during their leisurely outdoor activities, such as hunting and hiking. Many hunting activities occur in forested areas for wild game associated with *B. burgdorferi* transmission, which creates a relevant risk of exposure for hunters [45]. Educational tools, clinical trials campaigns, and public health messages—such as vaccine awareness—could be issued to these at-risk lifestyle populations/households in those non-endemic areas in order to make prevention—such
as personal protection—part of their planning before visiting endemic areas for camping, hiking, hunting, and other outdoor activities.

6. Conclusions

We conclude that there needs to be more research done on translating science into real-world solutions. Given that virtually every household in the U.S. has been assigned a lifestyle segment, linking segments to geographically identified patients (e.g., incidence, morbidity) in healthcare delivery systems could support the ability to estimate morbidity levels for various conditions and, subsequently, predict the demand for health services. Establishing this link can also allow for more efficient, more targeted, and cost-effective health care [1]. Our methodology for Lyme disease in this paper, and for COVID-19 in a previous methodological paper [1], aims to be a prototype for converting information on lifestyles into the incidence and prevalence of health conditions, along with the demand for health services.

Author Contributions: E.O. was the principal researcher and author. E.O. acquired data and project funding; was responsible for the conceptual design, spatial and statistical analysis, and administration of the project; participated in and supervised data analysis and interpretation; and drafted the manuscript. E.O., J.D.S., and R.M.B.-B. conducted the statistical analysis and interpreted the results. E.O., R.M.B.-B., and J.D.S. designed the figures. J.D.S. created climate suitability maps. R.M.B.-B. conducted post hoc analyses of social traits and pairwise comparisons between lifestyle traits. R.M.B.-B. and J.D.S. helped to draft the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Raw data “Lyme disease rates” were derived from the CDC Wonder database available in the public domain at https://www.cdc.gov/lyme/stats/survfaq.html, accessed on 23 November 2021. The authors confirm that the data supporting the findings of this study are available within the article. The GIS data and maps of High and Low Risk LifeModes are not publicly available due to commercialization of research findings.

Conflicts of Interest: The authors declare that they have no competing interest.

Appendix A

Table A1. Dominant traits for each LifeMode adapted from ESRI Tapestry 2020 Summary Table (http://downloads.esri.com/esri_content_doc/dbl/us/2020TapestryLifeModeGroupSummaryTables.pdf, accessed on 5 January 2020).

| LifeMode Name | Code | Counties | Households | Population | Household Type | Average Household Size | Diversity Index | Median Age | Median Income | Median Net Worth |
|---------------|------|----------|------------|-------------|-----------------|------------------------|----------------|------------|---------------|------------------|
| Affluent Estates | 1    | 71       | 12,589,391 | 36,589,686  | Married couples | 2.88                   | 46.2           | 43.1       | USD 129,800   | USD 715,900       |
| Upscale Avenues | 2    | 41       | 7,030,246  | 19,167,649  | Married couples | 2.69                   | 67.7           | 40.9       | USD 105,000   | USD 268,400       |
| Uptown Individuals | 3   | 13       | 4,848,096  | 9,282,562   | Singles         | 1.85                   | 66.2           | 35.3       | USD 89,700    | USD 44,500        |
| Family Landscape | 4    | 159      | 9,571,331  | 27,460,541  | Married couples | 2.85                   | 55.9           | 37.2       | USD 81,100    | USD 184,000       |
| GenXurban      | 5    | 163      | 14,252,029 | 34,994,853  | Married couples | 2.41                   | 43.3           | 43.9       | USD 66,800    | USD 157,800       |
### Table A1. Cont.

| Demographics | LifeMode Name | Code | Counties | Households | Population | Household Type | Average Household Size | Diversity Index | Median Age | Median Income | Median Net Worth |
|--------------|---------------|------|----------|------------|-------------|---------------------|-----------------------|----------------|------------|---------------|------------------|
| Cozy Country Living | 6 | 1261 | 15,175,430 | 38,619,224 | Married couples | 2.51 | 28.1 | 45.5 | USD 62,700 | USD 163,200 |
| Ethnic Enclaves | 7 | 106 | 9,019,686 | 30,363,455 | Married couples | 3.34 | 82.8 | 32.1 | USD 59,500 | USD 79,800 |
| Middle Ground | 8 | 80 | 13,638,949 | 33,367,170 | Mixed | 2.40 | 70.4 | 36.5 | USD 54,500 | USD 36,800 |
| Senior Styles | 9 | 69 | 7,315,711 | 14,828,033 | Mixed | 1.94 | 49.1 | 58.3 | USD 50,800 | USD 111,600 |
| Rustic Outposts | 10 | 965 | 10,431,913 | 27,770,247 | Married couples | 2.59 | 50.5 | 41.0 | USD 46,300 | USD 75,400 |
| Midtown Singles | 11 | 21 | 7,755,759 | 18,806,661 | Singles | 2.37 | 79.2 | 31.3 | USD 39,100 | USD 12,900 |
| Hometown | 12 | 141 | 7,628,789 | 19,341,859 | Married couples | 3.34 | 82.8 | 32.1 | USD 59,500 | USD 79,800 |
| Next Wave | 13 | 5 | 4,795,987 | 16,045,217 | Mixed | 3.30 | 89.6 | 30.0 | USD 39,900 | USD 13,300 |
| Scholars and Patriots | 14 | 45 | 2,028,867 | 6,609,014 | Mixed | 2.27 | 60.0 | 22.9 | USD 33,300 | USD 10,900 |

### Table A2.

Table A2. In-depth description of the lifestyle traits of the high- and low-risk LifeModes and lifestyle segments influencing Lyme disease morbidity, adapted from ESRI Tapestry 2020 Summary Table (http://downloads.esri.com/esri_content_doc/dbl/us/2020TapestryLifeModeGroupSummaryTables.pdf, accessed on 5 January 2020).

| Education | LifeMode Name | Code | No High-School Diploma | High-School Diploma/GED | Some College | Associate Degree | Bachelor's Degree | Graduate Degree |
|-----------|---------------|------|------------------------|-------------------------|--------------|------------------|-------------------|----------------|
| Affluent Estates | 1 | 3.2% | 13.4% | 15.6% | 7.5% | 33.5% | 26.9% |
| Upscale Avenues | 2 | 6.3% | 18.4% | 17.0% | 8.0% | 29.0% | 21.3% |
| Uptown Individuals | 3 | 4.9% | 9.4% | 11.4% | 4.6% | 37.8% | 31.9% |
| Family Landscape | 4 | 7.2% | 25.1% | 22.8% | 10.6% | 22.4% | 11.7% |
| GenXurban | 5 | 7.0% | 27.2% | 21.4% | 10.0% | 21.3% | 13.1% |
| Cozy Country Living | 6 | 8.7% | 33.7% | 21.8% | 10.5% | 16.4% | 8.9% |
| Ethnic Enclaves | 7 | 21.8% | 27.9% | 20.9% | 8.3% | 14.6% | 6.4% |
| Middle Ground | 8 | 11.5% | 26.1% | 20.9% | 8.7% | 20.6% | 12.1% |
| Senior Styles | 9 | 9.4% | 26.2% | 20.6% | 7.9% | 20.8% | 15.2% |
| Rustic Outposts | 10 | 16.9% | 38.6% | 20.9% | 8.6% | 9.9% | 5.1% |
| Midtown Singles | 11 | 14.6% | 28.6% | 22.6% | 8.5% | 16.9% | 8.7% |
| Hometown | 12 | 15.9% | 36.7% | 23.0% | 8.5% | 10.6% | 5.3% |
| Next Wave | 13 | 32.6% | 28.9% | 16.7% | 5.8% | 11.3% | 4.7% |
| Scholars and Patriots | 14 | 6.2% | 16.9% | 21.2% | 8.2% | 26.4% | 21.1% |

### Appendix B

Table A2. In-depth description of the lifestyle traits of the high- and low-risk LifeModes and lifestyle segments influencing Lyme disease morbidity, adapted from ESRI Tapestry 2020 Summary Table (http://downloads.esri.com/esri_content_doc/dbl/us/2020TapestryLifeModeGroupSummaryTables.pdf, accessed on 5 January 2020).
| LifeMode Name | Segment Name | Households | Population | Household Type | Average Household Size | Diversity Index | Median Age | Median Income | Median Net Worth |
|---------------|--------------|------------|------------|----------------|------------------------|----------------|------------|--------------|-----------------|
| **High-Risk** |              |            |            |                |                        |                |            |              |                 |
| **Upscale Avenues** |              |            |            |                |                        |                |            |              |                 |
| 2A—Urban Chic | 1,639,592    | 3,999,202  | Married couples | 2.39  | 49.9  | 43.6 | USD 120,600 | USD 352,900 |
| 2B—Pleasantville | 2,709,951    | 7,865,434  | Married couples | 2.87  | 62.5  | 43  | USD 103,500 | USD 375,800 |
| 2C—Pacific Heights | 872,917      | 2,780,970  | Married couples | 3.16  | 74.4  | 43.1 | USD 104,200 | USD 302,400 |
| 2D—Entrepeneuring Professionals | 1,807,786    | 4,513,063  | Married couples | 2.48  | 74.1  | 35.7 | USD 97,300  | USD 110,100 |
| **GenXurban** |              |            |            |                |                        |                |            |              |                 |
| 5A—Comfortable Empty Nesters | 3,087,193    | 7,809,376  | Married couples | 2.50  | 35.0  | 48.6 | USD 80,300  | USD 295,500 |
| 5B—in Style | 2,828,681    | 6,739,676  | Married couples with no kids | 2.34  | 41.9  | 42.4 | USD 79,800  | USD 162,100 |
| 5C—Parks and Rec | 2,475,722    | 6,245,809  | Married couples | 2.50  | 53.0  | 41.4 | USD 66,600  | USD 124,000 |
| 5D—Rustbelt Traditions | 2,748,758    | 6,817,742  | Married couples | 2.46  | 49.0  | 39.5 | USD 55,800  | USD 97,500  |
| 5E—Midlife Constraints | 3,111,675    | 7,822,250  | Married couples with no kids | 2.29  | 37.9  | 47.3 | USD 57,300  | USD 135,400 |
| **Cozy Country Living** |              |            |            |                |                        |                |            |              |                 |
| 6A—Green Acres | 4,086,329    | 11,064,683 | Married couples | 2.69  | 27.9  | 44.5 | USD 83,900  | USD 272,500 |
| 6B—Salt of the Earth | 3,611,849    | 9,375,498  | Married couples | 2.57  | 21.1  | 44.6 | USD 61,600  | USD 164,100 |
| 6C—The Great Outdoors | 1,905,000    | 4,905,828  | Married couples | 2.43  | 37.0  | 47.9 | USD 62,100  | USD 155,600 |
| 6D—Prairie Living | 1,339,996    | 3,407,393  | Married couples | 2.50  | 25.8  | 44.6 | USD 60,300  | USD 155,600 |
| 6E—Rural Resort Dwellers | 1,280,816    | 2,873,228  | Married couples with no kids | 2.21  | 24.6  | 54.9 | USD 55,600  | USD 163,900 |
| 6F—Heartland Communities | 2,871,438    | 6,992,594  | Married couples | 2.39  | 33.3  | 42.5 | USD 46,700  | USD 71,500  |
| **Low-Risk** |              |            |            |                |                        |                |            |              |                 |
| **Family Landscape** |              |            |            |                |                        |                |            |              |                 |
| 4A—Soccer Moms | 3,719,727    | 11,053,960 | Married couples | 2.96  | 52.9  | 37.1 | USD 100,500 | USD 284,700 |
| 4B—Home Improvement | 2,145,166    | 6,166,197  | Married couples | 2.86  | 67.5  | 38.2 | USD 79,200  | USD 181,300 |
| 4C—Middleburg | 3,706,438    | 10,240,384 | Married couples | 2.74  | 50.6  | 36.6 | USD 66,900  | USD 119,000 |
| **Ethnic Enclaves** |              |            |            |                |                        |                |            |              |                 |
| 7A—Up and Coming Families | 3,211,195    | 10,051,661 | Married couples | 3.11  | 75.1  | 31.8 | USD 80,000  | USD 131,500 |
| 7B—Urban Villages | 1,311,794    | 5,002,060  | Married couples | 3.78  | 86.2  | 34.4 | USD 71,600  | USD 124,400 |
| 7C—American Dreamer | 1,857,195    | 5,962,189  | Married couples | 3.19  | 84.7  | 32.9 | USD 55,200  | USD 64,200  |
| 7D—Barrios Urbanos | 1,309,286    | 4,789,156  | Married couples | 3.62  | 80.8  | 29.2 | USD 43,200  | USD 51,300  |
| 7E—Valley Groovers | 304,463      | 1,232,632  | Married couples | 3.96  | 84.7  | 27.7 | USD 38,200  | USD 16,300  |
| 7F—Southwestern Families | 1,025,763    | 3,325,737  | Married couples | 3.19  | 64.7  | 34.8 | USD 34,200  | USD 19,500  |
| **Rustic Outposts** |              |            |            |                |                        |                |            |              |                 |
| 10A—Southern Satellites | 3,988,291    | 10,719,631 | Married couples | 2.66  | 42.0  | 40.7 | USD 52,900  | USD 99,100  |
| 10B—Rooted Rural | 2,488,566    | 6,283,674  | Married couples | 2.47  | 30.3  | 45.7 | USD 46,700  | USD 96,000  |
| 10C—Driers and Miners | 821,345      | 2,142,316  | Married couples | 2.53  | 44.0  | 41.8 | USD 44,500  | USD 68,600  |
| 10D—Down the Road | 1,457,986    | 4,080,295  | Married couples | 2.73  | 73.0  | 35.4 | USD 41,900  | USD 40,600  |
| 10E—Rural Bypasses | 1,675,825    | 4,344,331  | Married couples | 2.54  | 61.1  | 40.8 | USD 35,900  | USD 34,400  |
| **Hometown** |              |            |            |                |                        |                |            |              |                 |
| 12A—Family Foundations | 1,292,794    | 3,536,499  | Singles | 2.70  | 43.7  | 40  | USD 45,800  | USD 58,200  |
| 12B—Traditional Living | 2,405,368    | 6,102,717  | Married couples | 2.50  | 57.6  | 36  | USD 42,600  | USD 33,800  |
| 12C—Small Town Simplicity | 2,314,916    | 5,451,181  | Singles | 2.25  | 52.6  | 41.1 | USD 35,200  | USD 18,900  |
| 12D—Modest Income Homes | 1,615,521    | 4,251,462  | Singles | 2.55  | 34.3  | 37.5 | USD 26,700  | USD 13,500  |
### Appendix C

**Table A3.** County-based summary of LifeModes associated with high incidence and low incidence, along with their predominant lifestyle traits.

#### Tapestry Segmentation for High Incidence of Lyme Disease

| LifeMode Name | Segment Name | Number of Counties with High Incidence | Population | Setting | Predominant Race | Interest in Gardening | Interest in Travelling | Interest in Indoor Recreation | Interest in Outdoor Recreation |
|---------------|--------------|---------------------------------------|-------------|---------|----------------|------------------------|------------------------|------------------------------|------------------------------|
| Affluent Estates | 1A—Top Tier | 3 | 2,402,683 | Suburban | White | No | Yes | Yes | No |
| | 1B—Professional Pride | 1 | 524,989 | Suburban | White | No | Yes | No | No |
| | 1C—Boomburbs | 2 | 562,351 | Suburban | White | No | No | Yes | No |
| | 1D—Savvy Suburbanites | 18 | 4,486,279 | Suburban | White | No | Yes | Yes | No |
| | 1E—Ex Urbanites | 2 | 191,412 | Suburban | White | No | Yes | Yes | No |
| Upscale Avenues | 2A—Urban Chic | 1 | 11,399 | Suburban | White | About half and half | No | No | Yes |
| | 2B—Plaisantville | 14 | 10,233,995 | Suburban | White | Yes | Yes | Yes | Yes |
| GenXurban | 2C—Pacific Heights | 1 | 476,143 | Urban | Asian and Pacific Islander | No | No | Yes | Yes |
| | 2D—Enterprising Professionals | 5 | 2,754,881 | Suburban | White | Yes | Yes | Yes | Yes |
| Cozy Country Living | 5A—Comfortable Empty Nesters | 4 | 1,534,893 | Suburban | White | No | Yes | Yes | Yes |
| | 5B—In Style | 13 | 3,644,911 | Metropolitan | White | No | No | Yes | No |
| | 5C—Parkers and Rec | 21 | 7,663,153 | Suburban | White | No | No | Yes | No |
| | 5D—Rustbelt Traditions | 3 | 385,848 | Suburban | White | No | No | Yes | No |
| | 5E—Midlife Constants | 7 | 711,763 | Urban | White | No | No | Yes | No |
| | 6A—Green Acres | 44 | 4,974,044 | Rural | White | No | No | Yes | No |
| | 6B—Salt of the Earth | 53 | 3,644,095 | Rural | White | Yes | No | Yes | Yes |
| | 6C—The Great Outdoors | 34 | 1,706,308 | Rural | White | Yes | Yes | Yes | Yes |
| | 6D—Prairie Living | 22 | 437,400 | Rural | White | No | Yes | Yes | No |
| | 6E—Rural Resort Dwellers | 36 | 833,376 | Rural | White | Yes | No | Yes | No |

#### Tapestry Segmentation for Low Incidence of Lyme Disease

| LifeMode Name | Segment Name | Number of Counties with High Incidence | Population | Setting | Predominant Race | Interest in Gardening | Interest in Travelling | Interest in Indoor Recreation | Interest in Outdoor Recreation |
|---------------|--------------|---------------------------------------|-------------|---------|----------------|------------------------|------------------------|------------------------------|------------------------------|
| Family Landscape | 4A—Soccer Moms | 24 | 6,819,435 | Suburban | White | No | No | Yes | No |
| | 4B—Home Improvement | 4 | 1,325,371 | Suburban | White | No | No | Yes | Yes |
| | 4C—Middletown | 96 | 11,650,487 | Semi-rural | White | No | About half and half | Yes | No |
| Ethnic Exclaves | 7A—Up and Coming Families | 36 | 24,899,099 | Suburban | White | No | No | No | No |
| | 7B—Urban Villages | 3 | 5,418,585 | Urban | Hispanic | No | No | Yes | No |
| | 7C—American Dreamers | 5 | 5,566,295 | Urban | White, Hispanic | No | No | Yes | No |
| | 7D—Barrios Urbanos | 10 | 4,217,326 | Urban | Hispanic | No | No | Yes | No |
| | 7E—Valley Growers | 8 | 3,387,636 | Urban | Hispanic | No | No | Yes | No |
| | 7F—Southwestern Families | 20 | 8,235,115 | Urban, Suburban | Hispanic | Yes | No | Yes | Yes |
| Rustic Outposts | 10A—Southern Satellites | 210 | 14,222,472 | Rural | White | No | No | Yes | Yes |
| | 10B—Rooted Rural | 178 | 4,485,653 | Rural | White | Yes | No | Yes | No |
| | 10C—Diners and Miners | 62 | 1,504,617 | Rural | White | Yes | No | No | Yes |
| | 10D—Down the Road | 14 | 1,171,061 | Semi-rural | White | No | No | Yes | No |
| | 10E—Rural Bypasses | 103 | 2,885,518 | Rural | White, Black | No | No | Yes | No |
| Hometown | 12A—Family Foundations | 4 | 2,173,757 | Metropolitan | Black | Yes | No | Yes | No |
| | 12B—Traditional Living | 42 | 7,677,951 | Urban | White | No | No | Yes | Yes |
| | 12C—Small Town Simplicity | 32 | 1,106,914 | Semi-rural | White | No | No | Yes | No |
| | 12D—Modest Income Homes | 14 | 4,135,857 | Urban | Black | No | No | Yes | No |
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