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Experiences with tick exposure, Lyme disease, and use of personal prevention methods for tick bites among members of the U.S. population, 2013–2015

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Abstract

Consistent and effective use of personal prevention methods for tickborne diseases, including Lyme disease (LD), is dependent on risk awareness. To improve our understanding of the general U.S. population's experiences with tick exposure and use of personal prevention methods, we used data from ConsumerStyles, a web-based, nationally representative questionnaire on health-related topics. Questions addressed tick bites and LD diagnosis in the last year, use of personal prevention methods to prevent tick bites, and willingness to receive a theoretical LD vaccine. Of 10,551 participants surveyed over three years, 12.3 % reported a tick bite for themselves or a household member in the last year, including 15.4 % of participants in high LD incidence (LDI) states, 16.3 % in states neighboring high LDI states, and 9.4 % in low LDI states. Participants in high LDI states and neighboring states were most likely to use personal prevention methods, though 46.6 % of participants in high LDI states and 53.9 % in neighboring states reported not using any method. Participants in low LDI states, adults ≥ 75 years of age, those with higher incomes, and those living in urban housing tended to be less likely to practice personal prevention methods. Likeliness to receive a theoretical LD vaccine was high in high LDI (64.5 %), neighboring (52.5 %), and low LDI (49.7 %) states. Targeted educational efforts are needed to ensure those in high LDI and neighboring states, particularly older adults, are aware of their risk of LD and recommended personal prevention methods.

Keywords

Tick-borne disease; Lyme disease; Risk; Prevention, humans

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CRediT authorship contribution statement

C.C. Nawrocki: Formal analysis, Writing - original draft, Writing - review & editing. **A.F. Hinckley:** Conceptualization, Methodology, Writing - review & editing, Supervision.

1. Introduction

Despite underreporting and variation in surveillance practices, Lyme disease (LD) is the most commonly reported vector-borne disease in the United States, with an estimated 329,000 cases diagnosed by clinicians annually (Nelson et al., 2015). The bacterial pathogens known to cause LD in the United States are *Borrelia burgdorferi* sensu stricto (ss) and *B. mayonii* (Pritt et al., 2016; Steere et al., 2016). These are transmitted to humans through the bite of *Ixodes scapularis* ticks, though *Ixodes pacificus* ticks also transmit *B. burgdorferi* ss in some parts of the Pacific Coast (Eisen et al., 2016a). Human LD cases are highly concentrated in the northeastern, mid-Atlantic, and upper midwestern portions of the country (Schwartz et al., 2017). However, surveillance data indicate that the distribution of cases has been expanding over the past two decades, as factors potentially related to weather and climate increase the geographical range of *I. scapularis* (Eisen, Eisen, and Beard paper (2016); Kugeler et al., 2015). As a result, states that share a border with high LD incidence (LDI) states are increasingly at risk of exposure to *I. scapularis* ticks that may carry *B. burgdorferi* ss and other human-infecting pathogens (Schwartz et al., 2017).

Avoiding tick exposure is the most effective way to prevent LD (Hayes and Piesman, 2003). Recommended prevention practices include measures that are meant to prevent tick exposure by an individual (personal prevention measures) and reduce ticks in the environment around households or on properties (environmental tick control measures). Personal prevention measures include using insect repellent, performing tick checks, showering soon after spending time outdoors, and wearing insecticide-treated or protective clothing (Eisen and Dolan, 2016; Hayes and Piesman, 2003; Connally et al., 2009). These methods have proven effective in preventing LD when practiced consistently (Vazquez et al., 2008; Connally et al., 2009). Environmental tick control methods can include landscaping to reduce tick habitat, deer fencing, host-targeted acaricide treatments, and acaricide applications on properties. Another potential method of LD prevention is a vaccine. While there is no LD vaccine currently on the market, one was available in the United States from 1998 until it was withdrawn in 2002 (Poland, 2011). Development and testing of new LD vaccines is in progress (Valneva, 2019).

Despite the demonstrated efficacy of many environmental tick control methods in reducing ticks on individual properties (Hinckley et al., 2016; Pound et al., 2009; Williams et al., 2018), these methods have not been shown to prevent LD and other tickborne diseases in humans (Hinckley et al., 2016). In addition, even if an environmental tick control measure is optimized and demonstrated to be effective on residential properties, it will likely be more complicated for a homeowner to implement properly and safely. Cost and inconsistent household participation can also be significant barriers to reducing tick populations at the community level (Hayes and Piesman, 2003). For example, though treating one's own property with an acaricide may reduce tick abundance on that property, if few other households in the community use an environmental tick control method, tick abundance in that community will likely remain high. Household members may still be exposed to ticks outside of their own properties. A survey in Connecticut, a high LDI state, found that 65 % of participants reported ever using environmental tick control methods to prevent LD, while 99 % reported using personal prevention methods at least sometimes (Gould et al., 2008).

As such, it may be more worthwhile for educational campaigns to focus on the promotion of personal prevention methods in at-risk communities rather than environmental tick control methods.

A recent knowledge, attitudes, and behaviors (KAB) survey in Connecticut and Maryland found that the only factor associated with use of most recommended personal prevention methods was perceived prevalence of LD (Niesobecki et al., 2019). Thus, to effectively prevent LD in high LDI and neighboring states, individuals must be aware of their risk (Hayes et al., 1999). We analyzed 2013–2015 data from an annual, nationally representative, health-based survey to assess the general U.S. population's experiences with tick exposure, LD, tick bite prevention practices, and willingness to get a theoretical LD vaccine. The goal of this analysis was to assess how these factors differed by LDI category and to better define target populations for educational campaigns regarding LD risk and prevention.

2. Materials and methods

2.1. Study design and population

ConsumerStyles is an annual, cross-sectional survey conducted through a nationally representative online research panel called KnowledgePanel. Porter Novelli, a public relations firm specializing in health and social marketing, conducts the survey in three waves per year, and the Centers for Disease Control and Prevention (CDC) annually licenses results. Participants are randomly recruited by address from a pool of over 50,000 panelists 18 years of age and older and living in the United States, and asked questions about their knowledge and experiences with a variety of health-related topics. Individuals are recruited regardless of whether they have a landline phone or internet access, and are provided with a computer, if needed. The median time to complete the survey ranged from 26 min to 40 min over the three years. To ensure representativeness, data were weighted by KnowledgePanel using a correction factor based on nine different demographic factors (gender, age, household income, race/ethnicity, household size, education, census region, metro status, and internet access) to match the U.S. Current Population Survey (CPS) proportions.

2.2. Questions

Six different questions related to tick bites and LD were asked in the fall editions of ConsumerStyles from 2013 to 2015, and some questions were asked multiple years. We report results from four of these questions here. Responses were fielded beginning in either September or October each year. In 2015, the fall survey was administered in two waves; questions regarding ticks and LD were not asked in the second wave of the survey, and no results from this wave are reported here. Questions included in our analysis covered topics such as self-reported tick bites and LD diagnosis in the previous 12 months, tick bite prevention, and willingness to get a LD vaccine if one becomes available (Table 1).

2.3. Analysis

Participants were categorized as residing in a high LDI state, neighboring state, or low LDI state based on classifications from 2008 to 2015 LD surveillance data (Schwartz et al., 2017)

(Fig. 1). High LDI states included those with ≥ 10 confirmed cases of LD per 100,000 population during the reporting period, and neighboring states were those sharing a border with a high LDI state. Fourteen states were classified as high LDI, and eleven states and the District of Columbia were classified as neighboring. All other states were classified as low LDI.

Frequencies, proportions, and chi-square tests for comparisons of categorical measures were generated using SAS JMP v. 13.2.1 (Cary, NC), and logistic regression was carried out in R v. 3.5.1 (Vienna, Austria) using the survey (Lumley, 2004, 2019) and MASS (Venables and Ripley, 2002) packages. All reported frequencies are unweighted and proportions are weighted. Statistical analyses were conducted using weighted counts. The Bonferroni correction was used to adjust for multiple comparisons when comparing routine use of prevention behaviors between LDI categories. Participants who did not answer a question were excluded from analysis for that specific question. Multi-variable logistic regression with backwards stepwise selection by AIC was used to examine associations between participant characteristics and personal protective measures routinely taken. LDI category, sex, age group, education level, race/ethnicity, combined household income, urban versus non-urban residence type, and having a child were included as covariates in the regression analysis. We categorized attached and detached single-family homes and mobile homes as non-urban residences, and buildings with at least two other units as urban. Alpha was set at 0.05 for all tests of statistical significance. ConsumerStyles data are considered exempt from institutional review board requirements.

3. Results

Survey response rates were 79.2 % (3502/4420) in 2013, 76.6 % (3520/4594) in 2014, and 79.6 % (3529/4432) in 2015. Demographic characteristics of survey participants matched the CPS proportions for each year (see Appendix A). Across all three years, 51.8 % of participants were female, with a median age of 54 years (range 18–94). High LDI states represented 27.8 % of all participants, neighboring states represented 21.7 %, and low LDI states represented 50.5 %. Sex, race/ethnicity, education, combined household income, urban residence type, and having a child all differed by state LDI category (Table 2).

3.1. Tick bite

Four hundred sixty (12.2 %) participants in 2013, 432 (13.3 %) participants in 2014, and 417 (12.1 %) participants in 2015 reported that they or someone in their household had been bitten by a tick in the previous 12 months. The number of participants reporting a tick bite was not significantly different between years ($p = 0.66$). Across all three years, participants in neighboring states more commonly reported that they or someone in their household had experienced a tick bite in the previous 12 months (16.3 %) than high LDI (15.4 %) or low LDI states (9.4 %) ($p < 0.0001$).

3.2. Lyme disease diagnosis

Overall, 0.9 % of participants reported that they or someone in their household were diagnosed with LD in the previous 12 months. LD diagnoses did not differ between LDI

categories (p = 0.145) or between 2013 and 2014, despite the clarification of LD diagnosis "by a health care provider" in 2014 (p = 0.52) (Table 3).

3.3. Routine use of personal prevention practices

The most commonly reported personal prevention method differed by LDI category. In high LDI states, performing daily tick checks was most common (28.7 %), whereas using repellent was most common in neighboring and low LDI states (24.1 % and 16.6 %, respectively) (Table 4).

Using repellent was the most commonly selected prevention method across all LDI categories in 2013 and 2014 (20.6 %). Participants who lived in high LDI or neighboring states (OR = 1.74, 95 % CI: 1.45, 2.09; OR = 1.54, 95 % CI: 1.26, 1.88), were Black or African American (OR = 1.47, 95 % CI = 1.03, 2.11), and had a child (OR = 1.36, 95 % CI: 1.10, 1.68) were the most likely to routinely use repellent, while participants 75 years of age or older (OR = 0.55, 95 % CI: 0.34, 0.89) and those living in urban housing (OR = 0.69, 95 % CI: 0.54, 0.89) were the least likely (Table 5).

"Checking body for ticks daily" was the second most commonly selected prevention method (19.4 %). Participants who lived in high LDI and neighboring states (OR = 2.72, 95 % CI: 2.14, 3.44; OR = 1.83, 95 % CI: 1.40, 2.41), were White (OR = 2.11, 95 % CI: 1.51, 2.95), and had an income less than $25,000 (OR = 1.68, 95 % CI: 1.32, 2.13) were more likely to perform daily tick checks. Those who attended some college (OR = 0.80, 95 % CI: 0.66, 0.97) and lived in urban housing (OR = 0.50, 95 % CI: 0.38, 0.66) were the least likely to report routine use of this method.

Showering soon after coming indoors was the next most commonly selected prevention method across both years (15.5 %). Living in a high LDI or neighboring state (OR = 1.22, 95 % CI: 1.01, 1.49; OR = 1.26, 95 % CI: 1.02, 1.56) and being male (OR = 1.32, 95 % CI: 1.11, 1.56) were associated with this measure. Participants 75 years of age or older (OR = 0.43, 95 % CI: 0.28, 0.68), those with a race or ethnicity other than White, Black or African American, or Hispanic (OR = 0.54, 95 % CI: 0.32, 0.92), those with a combined household income of $75,000 or more (OR = 0.78, 95 % CI: 0.61, 0.99), and those who lived in urban housing (OR = 0.71, 95 % CI: 0.54, 0.92) were the least likely to report showering soon after coming indoors.

When included as an option in the 2014 survey, wearing insecticide-treated clothing was selected by 3.3 % of participants. Participants living in high LDI states were more likely to report wearing insecticide-treated clothing compared to participants from low LDI states (OR = 1.83, 95 % CI: 1.11, 3.02). Being male was also associated with routine use of this prevention practice (OR = 1.60, 95 % CI: 1.02, 2.52). Participants who had attended at least some college were the least likely to wear insecticide-treated clothing (OR = 0.57, 95 % CI: 0.34, 0.98).

Of the 10.2 % of participants who reported routinely taking other steps not listed to prevent tick bites, those who lived in high LDI states (OR = 1.87, 95 % CI: 1.43, 2.45) and had a bachelor's degree or higher (OR = 1.42, 95 % CI: 1.11, 1.82) were the most likely to use

other prevention methods; those 75 years of age and older were the least likely (0.47, 95 % CI: 0.29, 0.75).

Overall, more than half of all participants reported taking no routine steps to prevent tick bites (57.6 %), with those in neighboring and low LDI states being more likely than those in high LDI states to take no steps (OR = 1.44, 95 % CI: 1.21, 1.71; OR = 2.18, 95 % CI: 1.87, 2.53). Other characteristics associated with not practicing personal prevention included being over 75 years of age (OR = 1.68, 95 % CI: 1.19, 2.38), living in a residence classified as urban (OR = 1.54, 95 % CI: 1.26, 1.88), and having a combined income greater than $50,000 (OR = 1.37, 95 % CI: 1.14–1.64). Participants who were White were the least likely to report taking no steps (OR = 0.66, 95 % CI: 0.48, 0.90).

3.4. Willingness to vaccinate

The majority of participants across 2014 and 2015 reported being at least somewhat likely to receive a LD vaccine if one were to become available (54.5 %). Likeliness differed by LDI category; high LDI states had the highest proportion of participants at least somewhat likely to get the vaccine (64.5 %), followed by neighboring states (52.5 %) and low LDI states (49.7 %) ($p < 0.0001$).

4. Discussion

Results from the 2013–2015 fall ConsumerStyles surveys indicate tick exposure, use of personal prevention methods, and likeliness to receive a LD vaccine are more common in high LDI and neighboring states than low LDI states. Still, nearly half of all participants from high LDI states and more than half of participants from neighboring states reported not taking personal prevention steps for tick bites, suggesting that much of the population in at-risk areas may not be aware of their risk for LD and other tickborne diseases. While trends in demographic factors associated with using personal prevention practices aligned with previous studies, adults 75 years of age and older stood out as a group consistently less likely than other age groups to practice personal prevention methods.

In 2013 and 2014, more participants in neighboring states reported that they or a household member were bitten by a tick in the last year than those in high LDI states. Several neighboring states fall within geographic hotspots of *Amblyomma americanum*, a species of tick that does not transmit LD but is known to exhibit greater mobility and more aggressive host-seeking behavior than *I. scapularis*, leading to more frequent human-tick encounters (Schulze et al., 2006, 2005; Stromdahl and Hickling, 2012). Therefore, it is possible that those in neighboring states who reported that they or a household member were bitten by a tick in the past year either recognized tick bites more often or were bitten more often than those in high LDI states, due to the greater abundance of *A. americanum* in their state. Additionally, participants were not asked which state the tick bite occurred in, and some bites may have been acquired outside of the individual's state of residence.

A small percentage (1.7 %) of participants in high LDI states reported that they or someone in their household were diagnosed with LD in the previous year, which did not differ significantly from participants in neighboring and low LDI states. This proportion is low

in comparison to a KAB survey regarding LD prevention conducted in endemic areas of Connecticut, in which nearly 5% of participants reported a LD diagnosis in the past year (Gould et al., 2008). It should be noted, that despite a large overall sample size in our study, numbers of participants reporting LD diagnosis in the past year were very small when broken down by LDI category. Thus, it is difficult to draw conclusions from these data.

Results regarding routine use of personal prevention methods were fairly consistent with results from a similar question asked in a 2011 ConsumerStyles survey (Hook, et al., 2015). Overall proportions of participants reporting routine repellent use were similar in our analysis (20.6 %) and in Hook et al. (21.1 %), but tick checks were more frequently reported in 2011, and the proportion of participants taking no steps to prevent tick bites was slightly higher in our study (Hook et al., 2015). It is possible that routine use of tick checks was higher in 2011 than in 2013 and 2014 due to slight differences in wording. In 2011, the question specifically asked about routine steps taken to prevent tick bites “when the weather is warm in your area,” while in 2013 and 2014 this specification was not made (Hook et al., 2015). Additionally, the option provided in 2013 and 2014 was “I check my body for ticks daily”, and in 2011 it was “I check my body for ticks when I come in.” As such, it is possible that participants may practice tick checks when they come in from outside during tick season, but this does not necessarily equate to checking for ticks daily. Repellent use may not have differed between 2011 and 2013–2014 because it is also used to prevent bites from other arthropods, such as mosquitos.

Niesobecki et al. reported much higher proportions for routine use of personal protective measures in Connecticut and Maryland than we report for participants from high LDI states (Niesobecki et al., 2019), though a recent KAB study in Delaware reported results similar to ours for the same measures (Gupta et al., 2018). The population surveyed in Niesobecki et al. was recruited specifically to participate in a survey regarding tickborne disease and may have been more knowledgeable or interested in tickborne disease prevention than the convenience sample surveyed in the Delaware KAB and the representative sample surveyed here (Niesobecki et al., 2019).

Themes in demographic characteristics of participants reporting routine use of personal prevention methods in our study mostly aligned with themes in the literature. As expected, high LDI and neighboring states were generally more likely to practice personal prevention methods than those in low LDI states, likely due to more exposure to LD. Similar findings are reported in Hook et al., in which geographic regions that corresponded with high LDI and neighboring states had lower proportions of participants who did not take personal prevention steps (Hook et al., 2015). Living in urban housing was negatively associated with nearly every prevention practice; this is likely because participants living in urban settings may have less surrounding tick habitat, and subsequently, less risk of tick exposure than those in more rural areas. Daily tick checks were more commonly selected by participants of lower income and who attended some college. Niesobecki et al. reported similar results and proposed that individuals with lower income and education levels may be more likely to have occupations that require time outdoors, and less likely to practice personal prevention methods that are more costly (e.g., using repellent, wearing insecticide-treated clothing) (Niesobecki et al., 2019).

Adults 75 years of age and older were often the least likely to routinely use personal prevention methods. Schwartz et al. presented surveillance data that showed an increase in LD in older adults, with a peak among those 50–55 years of age (Schwartz et al., 2017). It is possible that LD is less easily recognized in older adults due to the sometimes non-specific symptoms of early LD and an increased potential for similar conditions, such as arthritis, that can be due to other causes. Studies have also shown that older adults may be more likely to have comorbidities at the time of LD onset and take longer to recover following treatment (Borsic et al., 2018; Weitzner et al., 2017). The increased potential for unrecognized LD in older adults, longer recovery period, and under-utilization of personal prevention methods makes this an important population to target in future educational campaigns.

Likeliness to get a LD vaccine if one were to become available was generally high among participants. Notably, half of all participants in low LDI states reported being at least somewhat likely to get a hypothetical LD vaccine—a surprising finding given LD risk is generally low in these states. While it is possible that some of these participants may spend time in higher risk areas, including other states, during the months when LD transmission commonly occurs, we hypothesize that this result may reflect members of the U.S. population who are generally in favor of vaccination as a primary disease prevention method. One study found that 94 % of parents surveyed by ConsumerStyles in 2010 had either already vaccinated or planned to vaccinate their children with all recommended childhood vaccines, indicating vaccine confidence in the United States is generally high (Kennedy et al., 2011). Thus, reasons for indicating willingness to get a LD vaccine may be related to confidence in vaccines in general rather than perceived risk of LD. Future research should further explore willingness to get a LD vaccine among various populations and factors that influence willingness.

4.1. Limitations

Results reported here are subject to limitations. First, all data from the ConsumerStyles surveys were self-reported and therefore subject to recall bias. Second, we report weighted proportions. Though weighted proportions increase the representativeness of responses to the general U.S. population, the un-weighted proportion of participants from neighboring states who reported regularly wearing insecticide-treated clothing was notably higher than the weighted proportion (3.1 % vs. 1.9 %, respectively) due to a small number of responses. These results are also subject to limitations regarding the phrasing of questions. For example, the question regarding LD diagnosis in the past year was changed in 2014 to specify diagnosis “by a provider.” As a result, responses in 2013 may have included diagnoses that were self-diagnoses or given by someone other than a provider. However, no significant difference in responses was found between the two years, indicating that this specification did not affect the results. Similarly, we did not explicitly define the term “household member” in the questions regarding tick bite and LD diagnoses by any household member in the past year. As such, some participants may consider their pets members of their household and may have answered “yes” to these questions based on their pets’ experiences. Misclassification may have occurred when assigning participants to an urban or non-urban residence based on housing type, causing us to over- or under-estimate the use of prevention methods in these strata. We also were not able to distinguish suburban

households from urban or non-urban households. Thus, we were not able to characterize tick bite prevention behaviors for this specific demographic group. It is also possible that participants who used environmental or yard-based methods to control ticks on their properties would not have considered this a routine step taken to prevent tick bites, due to the wording of the question. As a result, these individuals may be included among those who selected they do not take any steps to prevent tick bites. Alternatively, these participants may have selected that they routinely take steps other than those listed to prevent tick bites. However, we did not collect further information from individuals who selected this option.

These findings are also limited by classifications made for stratifying survey participants. For current surveillance purposes in the United States, states are classified as either high LDI (>10 cases/100,000 population) or low LDI (< 10,000 cases/100,000 population). The states Schwartz et al. classified as neighboring fall into the low LDI category, and therefore our results for low LDI states may not be generalizable to all states that are considered low LDI for surveillance purposes (Schwartz et al., 2017). However, our results pertaining to neighboring states represent information usually not captured in surveillance data: tick exposure and personal prevention method use in states that are approaching, but not yet considered high LDI. Our results indicate that neighboring states are perhaps more similar to high LDI states than low LDI states in terms of tick exposure and use of personal prevention methods. Lastly, not all who reside within a particular region have the same risk of LD due to a number of environmental and individual factors that we were not able to capture here. Future studies assessing personal prevention behaviors for LD should include a measure of participants' perceived risk of contracting LD and an assessment of individual and household behaviors that may contribute to overall risk.

5. Conclusions

Although tick exposure and use of personal protective measures are highest in high LDI and neighboring states, nearly half of all participants in these regions report not taking steps to prevent tick bite. More educational efforts are needed to ensure populations in these regions are aware of local incidence of LD. In particular, educational campaigns targeted to high risk groups who are less likely to routinely practice personal prevention, such as older adults, are needed to increase awareness of LD risk and knowledge of prevention methods. Lastly, a LD vaccine would likely be well-received by the U.S. population as a primary prevention method.

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Appendix A

Participant demographics for the fall waves of the 2013, 2014, and 2015 ConsumerStyles surveys.

	ConsumerStyles 2013 (N = 3502)		ConsumerStyles 2014 (N = 3520)		ConsumerStyles 2015 (N = 3529)	
Characteristic	**Unweighted no.**	**Weighted %**	**Unweighted no.**	**Weighted %**	**Unweighted no.**	**Weighted %**
Sex						
Male	1762	47.7	1829	48.4	1815	48.6
Female	1740	52.3	1691	51.6	1714	51.4
Age in years						
18–29	452	18.8	444	20.9	508	21.7
30–44	714	27.2	678	25.8	673	24.7
45–59	1079	27.6	1060	26.6	1028	26.3
≥ 60	1257	26.4	1338	26.7	1320	27.3
Race/ethnicity						
White	2694	67.1	2682	66.4	2666	66.3
Black or African American	312	11.3	346	11.5	331	11.2
Hispanic	304	14.0	324	14.7	376	14.9
Other	192	7.6	168	7.5	156	7.7
Education						
Less than HS	229	10.6	242	12.2	202	11.8
HS	1018	30.7	1151	29.7	1092	29.7
Some college	1127	29.2	1044	29.0	1111	29.0
≥ Bachelor	1128	29.5	1083	29.1	1124	29.6
Income						
< $25,000	569	18.4	659	18.5	654	17.7
$25–$49,999	922	23.4	875	22.0	875	21.9
$50–$74,999	702	20.8	685	19.4	714	20.8
≥ $75,000	1309	37.5	1301	40.1	1286	39.6
Employment status						
Employed	1890	55.0	1877	55.5	1901	57.8
Not employed	1612	45.0	1643	44.5	1628	42.2

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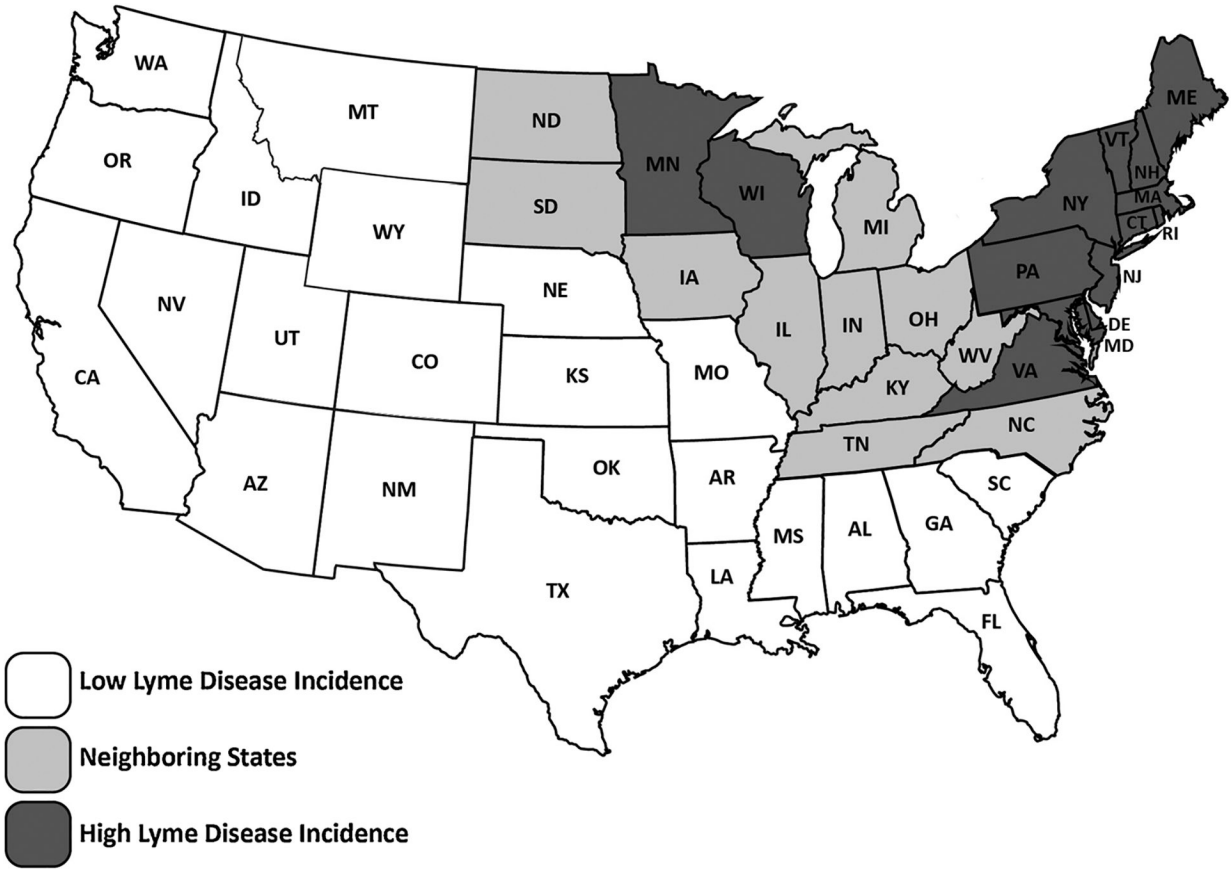

Fig. 1.
United States by Lyme disease incidence category 2013–2015.

Table 1

ConsumerStyles tick-related questions and year(s) questions were asked.

1. What steps do you routinely take to prevent tick bites? *Select all that apply*: I wear repellent; I shower soon after coming indoors; I check my body for ticks daily; I take other steps not listed here; I don't take any steps to prevent tick bites (2013, 2014)
2. In the past 12 months, has anyone in your household been bitten by a tick? *Select one*: Yes, I was bitten; Yes, someone else in my household; No; Don't know (2013, 2014, 2015)
3. In the past 12 months, has anyone in your household been diagnosed with Lyme disease?[a] *Select one*: Yes, I was; Yes, someone else in my household; No; Don't know (2013, 2014)
4. If a vaccine that prevented Lyme disease were available, would you get vaccinated? *Select one*: Very likely; Somewhat likely; Somewhat unlikely; Very unlikely (2014, 2015)

[a] In 2014, participants were asked, "In the past 12 months, has anyone in your household been diagnosed with Lyme disease *by a health care provider*?".

Ticks Tick Borne Dis. Author manuscript; available in PMC 2024 February 13.

Table 2

Participant demographics by state Lyme disease incidence category (2013–2015).

	High LDI (N = 2989)		Neighboring (N = 2462)		Low LDI (N = 5100)		
Characteristic	**Unweighted No.**	**Weighted %**	**Unweighted No.**	**Weighted %**	**Unweighted No.**	**Weighted %**	**P-value**
Sex							
Male	1496	46.1	1279	49.7	2631	48.8	0.02
Female	1493	53.9	1183	50.3	2469	51.2	
Age in years							
18–24	218	12.5	181	11.7	355	12.2	
25–34	350	16.1	295	17.5	677	18.4	
35–44	393	16.0	322	16.3	678	17.0	
45–54	567	19.3	432	18.0	923	18.1	0.05
55–64	711	17.0	616	18.5	1105	15.5	
65–74	529	13.1	450	12.9	941	13.1	
≥ 75	221	6.0	166	5.1	421	5.7	
Race/ethnicity							
White	2491	76.7	2037	76.9	3514	56.6	
Black or African American	223	8.7	256	12.2	510	12.4	<0.0001
Hispanic	152	7.7	91	6.2	761	21.8	
Other	74	5.9	37	3.4	196	7.8	
Education							
Less than HS[C]	142	8.4	169	13.0	362	12.6	
HS	967	31.0	832	32.7	1462	28.3	<0.0001
Some college	866	27.4	724	27.8	1692	30.5	
≥ Bachelor degree	1014	33.2	737	26.5	1584	28.6	
Combined household income							
< $25,000	440	13.3	470	20.8	972	19.8	
$25–$49,999	685	19.6	675	23.4	1312	23.5	<0.0001
$50–$74,999	582	20.5	480	19.8	1039	20.5	
≥ $75,000	1282	46.6	837	36.0	1777	36.2	
Residence type							

	High LDI (N = 2989)		Neighboring (N = 2462)		Low LDI (N = 5100)		
Characteristic	**Unweighted No.**	**Weighted %**	**Unweighted No.**	**Weighted %**	**Unweighted No.**	**Weighted %**	**P-value**
Urban	590	18.6	309	30.0	791	16.3	< 0.0001
Non-urban	2396	81.3	2145	87.9	4283	83.1	
Has child							
Yes	594	25.5	516	29.1	1131	30.6	<0.0001
No	2391	74.4	1938	70.4	3961	69.2	

[c] High school.

Table 3

Number of participants who reported Lyme disease diagnosis for themselves and/or member of household in last 12 months by state Lyme disease incidence category.

State LDI category	2013 n (%)	2014[a] n (%)	Both years n (%)
Overall	28 (0.77)	32 (1.1)	60 (0.9)
High LDI	18 (2.0)	15 (1.4)	33 (1.7)
Neighboring	5 (0.5)	7 (1.6)	12 (1.0)
Low LDI	5 (0.2)	10 (0.8)	15 (0.5)

[a] In 2014, participants were asked, "In the past 12 months, has anyone in your household been diagnosed with Lyme disease *by a health care provider*?".

Table 4

Type of personal protective measure routinely taken by Lyme disease disease incidence category (2013, 2014).

Prevention Measure	Total (N = 7022) n (%)[a]	High LDI (N = 1995) n (%)	Neighboring (N = 1632) n (%)	Low LDI (N = 3395) n (%)
Using repellent	1405 (20.6)	479 (25.2)	366 (24.1)	560 (16.6)
Daily tick checks	1368 (19.4)	570 (28.7)	371 (23.3)	427 (12.7)
Showering soon after coming indoors	1075 (15.5)	320 (16.2)	280 (17.8)	475 (14.3)
Insecticide-treated clothing[b]	114 (3.3)	46 (4.3)	24 (1.9)	44 (1.2)
Other steps	759 (10.2)	283 (14.1)	144 (8.1)	332 (9.1)
No steps	4004 (57.6)	929 (46.6)	880 (53.9)	2195 (65.3)

[a] Multiple answers were allowed. Totals may exceed 100 %.

[b] Insecticide-treated clothing was listed as an option in 2014 only.

Ticks Tick Borne Dis. Author manuscript; available in PMC 2024 February 13.

Table 5

Selected characteristics of users of the most common personal protection measures (2013, 2014).

Characteristic	Using repellent (N = 1405)		Daily tick checks (N = 1368)		Showering soon after coming indoors (N = 1075)	
	n (%)	aOR	n (%)	aOR	n (%)	aOR
StateLDIcategory						
High	479 (34.1)	1.74 (1.45–2.09)	570 (41.7)	2.72 (2.14–3.44)	320 (29.8)	1.22 (1.01–1.49)
Neighboring	366 (26.0)	1.54 (1.26–1.88)	371 (27.1)	1.83 (1.40–2.41)	280 (26.0)	1.26 (1.02–1.56)
Low	560 (39.9)	reference	427 (31.2)	reference	475 (44.2)	reference
Sex						
Male	660 (47.0)	N.S.[a]	737 (53.9)	1.19 (0.97–1.45)	586 (54.5)	1.32 (1.11–1.56)
Female	745 (53.0)	N.S.	631 (46.1)	reference	489 (45.5)	reference
Age in years						
18–24	96 (6.8)	reference	90 (6.6)	reference	84 (7.8)	reference
25–34	192 (13.7)	1.08 (0.78–1.50)	169 (12.4)	1.35 (0.95–1.92)	167 (15.5)	1.10 (0.78–1.56)
35–44	213 (15.2)	0.95 (0.67–1.34)	180 (13.2)	1.02 (0.71–1.47)	126 (11.7)	0.71 (0.50–1.02)
45–54	273 (19.4)	0.95 (0.69–1.31)	286 (20.9)	1.23 (0.89–1.71)	202 (18.8)	0.80 (0.58–1.12)
55–64	313 (22.3)	1.05 (0.77–1.44)	315 (23.0)	1.01 (0.73–1.39)	235 (21.9)	0.84 (0.60–1.18)
65–74	253 (18.0)	1.00 (0.73–1.37)	241 (17.6)	0.81 (0.58–1.13)	206 (19.2)	0.86 (0.61–1.22)
≥ 75	65 (4.6)	0.55 (0.34–0.89)	87 (6.4)	0.86 (0.57–1.31)	55 (5.1)	0.43 (0.28–0.68)
Race/ethnicity						
White	1094 (77.9)	1.07 (0.81–1.43)	1176 (86.0)	2.11 (1.51–2.95)	839 (78.0)	0.96 (0.72–1.29)
Black or African American	136 (9.7)	1.47 (1.03–2.11)	73 (5.3)	1.25 (0.80–1.95)	101 (9.4)	1.23 (0.84–1.80)
Hispanic	112 (8.0)	reference	67 (4.9)	reference	94 (8.7)	reference
Other	63 (4.5)	0.77 (0.48–1.24)	52 (3.8)	1.24 (0.72–2.13)	41 (3.8)	0.54 (0.32–0.92)
Education						
HS[b] or less	527 (37.5)	N.S.	562 (41.1)	reference	390 (36.3)	N.S.
Some college	423 (30.1)	N.S.	391 (28.6)	0.80 (0.66–0.97)	334 (31.1)	N.S.
≥ Bachelor degree	455 (32.4)	N.S.	415 (30.3)	0.86 (0.71–1.05)	351 (32.7)	N.S.
Combined household income						
< $25,000	230 (16.4)	reference	240 (17.5)	reference	195 (18.1)	reference
$25–$49,999	331 (23.6)	0.80 (0.62–1.03)	334 (24.4)	0.64 (0.50–0.83)	257 (23.9)	0.83 (0.63–1.08)

Characteristic	Using repellent (N = 1405)		Daily tick checks (N = 1368)		Showering soon after coming indoors (N = 1075)	
	n (%)	aOR	n (%)	aOR	n (%)	aOR
$50–$74,999	292 (20.8)	0.95 (0.73–1.23)	278 (20.3)	0.71 (0.55–0.91)	235 (21.9)	1.05 (0.80–1.38)
≥ $75,000	552 (39.3)	0.92 (0.73–1.17)	516 (37.7)	0.62 (0.48–0.79)	388 (36.1)	0.78 (0.61–0.99)
Residence type [c]						
Urban	175 (12.5)	0.69 (0.54–0.89)	124 (9.1)	0.50 (0.38–0.66)	123 (11.4)	0.71 (0.54–0.92)
Non-urban	1229 (87.5)	reference	1239 (90.6)	reference	949 (88.3)	reference
Has child						
Yes	366 (26.0)	1.36 (1.10–1.68)	331 (24.2)	1.14 (0.92–1.41)	245 (22.8)	N.S.
No	1037 (73.8)	reference	1035 (75.7)	reference	829 (77.1)	reference

[a] N.S. denotes that this characteristic was not significant after performing backwards stepwise logistic regression and was therefore not included in the final model.

[b] Residence types classified as “other” were excluded from regression analyses due to a small number of participants falling into this category (n = 3).

[c] High school.