PUBLIC HEALTH REPORTS

Public Health Reports
00(0) 1-9

DOI: 10.1177/0033354920973235
journals.sagepub.com/home/phr
SAGE

Diagnosis, Treatment, and Prevention Practices for Lyme Disease by Clinicians, United States, 2013-2015

Alyssa R. Beck, MPH[1,2]; Grace E. Marx, MD[1]; and Alison F. Hinckley, PhD[1]

Abstract

Objectives: Although tick-borne diseases account for a large number of health care visits in the United States, clinical practices for tick bite and Lyme disease treatment and prevention are not well understood. The objective of this study was to better understand factors associated with clinical practices related to tick bites and Lyme disease.

Methods: In 2013-2015, questions about tick-bite evaluation, Lyme disease diagnosis and treatment, appropriate use of Lyme disease testing, and tick-bite prevention were included in Porter Novelli's DocStyles survey, a nationally representative annual web-based survey of health care providers. We performed analyses of responses by provider license type and state-level incidence (high or low) of Lyme disease in 2019.

Results: A total of 4517 providers were surveyed across the 3 study years. Overall, 80.9% of providers reported that they had evaluated at least 1 patient for a tick bite, 47.6% had diagnosed at least 1 patient with Lyme disease, and 61.9% had treated at least 1 patient for Lyme disease in the previous year. Providers from states with a high incidence of Lyme disease saw more patients for tick bites and Lyme disease than providers from states with a low incidence of Lyme disease. Few providers correctly chose Lyme disease testing as clinically useful in the hypothetical case of a patient from a state with a high incidence of Lyme disease with an arthritic knee (36.0%) or with new-onset atrioventricular block (39.5%), and respondents across all provider types incorrectly chose testing when not clinically indicated. Most providers (69.7%) reported routinely recommending tick-bite prevention methods to patients.

Conclusions: Many providers evaluate patients for tick bites and treat patients for Lyme disease, but knowledge about appropriate testing is low. Providers may benefit from tailored education about appropriate Lyme disease diagnosis, testing, and effective tick-bite prevention.

Keywords

Lyme disease, tick-borne disease, tick bite, DocStyles

In the United States, Lyme disease is caused by infection with *Borrelia burgdorferi* or *Borrelia mayonii*, transmitted to humans through the bite of infected *Ixodes scapularis* or *I pacificus* ticks. Lyme disease was first described in 1977 and has been a nationally notifiable condition in the United States since 1991.[1,2] It is the most commonly reported vector-borne illness nationally, with 33 666 cases reported to the Centers for Disease Control and Prevention (CDC) in 2018.[3] Studies from 2014 and 2015 suggest that the annual number of people diagnosed with and treated for Lyme disease in the United States may be closer to 300 000.[4,5]

Most cases of Lyme disease occur in focal geographic regions, including the Northeast, mid-Atlantic, and upper Midwest. During 2008-2015, fourteen states in these regions accounted for 95.2% of all reported cases in the United States.[6] The geographic distribution of Lyme disease is related to various factors, including spatial distribution of the tick vectors, infection prevalence in ticks, abundance of reservoir hosts, and frequency of human exposure to ticks.[7,8]

[1] Division of Vector-Borne Diseases, Centers for Disease Control and Prevention, Fort Collins, CO, USA
[2] Oak Ridge Institute for Science and Education, Oak Ridge, TN, USA

Corresponding Author:
Alyssa R. Beck, MPH, Centers for Disease Control and Prevention, Division of Vector-Borne Diseases, Bacterial Diseases Branch, Epidemiology and Surveillance Team, 3156 Rampart Rd, Foothills Campus, Fort Collins, CO 80521, USA.
Email: alyssa.beck@cuanschutz.edu

Since 1995, CDC has recommended 2-step serologic laboratory testing to support clinician evaluation of patients with symptoms consistent with Lyme disease and with possible exposure to infected ticks.[9] However, serologic testing can be nuanced and is not always appropriate for patients with suspected exposure or disease. Clinicians must consider a patient's history, timing of symptoms, and pretest probability to order and interpret results of Lyme disease diagnostic testing accurately.[10] When a patient has an asymptomatic tick bite, serologic testing is not recommended because (1) the patient may not have been infected with the bacteria that causes Lyme disease and (2) antibodies to the Lyme disease bacteria generally are not detectable before an infected patient develops symptoms. Similarly, serologic testing for Lyme disease is not indicated for patients in Lyme disease–endemic areas who present with erythema migrans, the rash of early Lyme disease; in such cases, erythema migrans rash is a clinical diagnosis, and antibiotic treatment is recommended without diagnostic testing because test results can be negative in early Lyme disease when antibodies might not have yet fully developed.[11] However, serologic testing can provide supportive information for the diagnosis of disseminated Lyme disease, including Lyme arthritis and neurologic manifestations, when false-negative results are rare. Finally, test of cure is not recommended because of the long period in which antibodies can persist after the infection is successfully treated.[12] Perhaps not surprising, given these nuances, previous evaluations of health care providers (hereinafter, providers) indicate that confusion about Lyme disease testing is common.[13-16]

Providers are encouraged to counsel their patients about Lyme disease prevention in endemic areas. Effective prevention techniques include performing tick checks after being outside, wearing US Environmental Protection Agency–recommended repellents, showering soon after being outdoors, examining gear and pets for ticks, treating clothing and gear with products containing 0.5% permethrin, and avoiding tick habitats.[17]

Currently, it is unclear how frequently providers in the United States see patients for tick bites, recommend Lyme disease testing and treatment, and offer counseling on tick-bite prevention. To address these uncertainties, a survey was designed and administered to a nationally representative sample of providers in the United States. The objective of this study was to better understand factors associated with clinical practices related to tick bites and Lyme disease.

Methods

Study Design and Population

DocStyles is a web-based survey of providers in the United States conducted by Porter Novelli, a public relations firm with a specialty practice in health and social marketing. CDC licensed results of the DocStyles 2013, 2014, and 2015 surveys after data collection from Porter Novelli. Analysis of these data was exempt from human subjects research review because individual identifiers were not included in the database.

Providers were identified from the SERMO Global Medical Panel, an opt-in panel of medical professionals in the United States.[18] Panelists were verified using a double opt-in sign-up process with telephone confirmation at place of work. SERMO identified a random sample of eligible providers from its main database and sent them an electronic invitation to participate in the study, including a link to the web-based survey. All respondents were screened to include only providers in the United States who actively saw patients; worked in an individual, group, or hospital practice; and had been in practice for at least 3 years.[19-21] Participants received an honorarium for completing the survey. A full description of the methodology is available elsewhere.[22]

We limited this analysis to family/general practitioners, internists, pediatricians, and nurse practitioners. We excluded obstetricians/gynecologists from analysis because these specialists would not be expected to frequently encounter tick-borne disease. Survey quotas were set to reach 1000 primary care physicians (family/general practitioners and internists), 250 pediatricians, and 250 nurse practitioners.

Variables Measured

The anonymized DocStyles surveys contained questions covering various medical topics. The 5 questions pertaining to tick bites and Lyme disease evaluated for this study were:

> Question 1 (2013): In the past year, how many patients did you treat for each of the following [tick bite; Lyme disease]? (Select one: none, 1-5 patients, 6-10 patients, 11-25 patients, 26-100 patients, >100 patients).
>
> Question 2 (2014): In the past year, how many patients did you evaluate for a recent tick bite? (Select one: none, 1-5 patients, 6-10 patients, 11-25 patients, 26-100 patients, >100 patients).
>
> Question 3 (2014): In the past year, how many patients did you diagnose with Lyme disease? (Select one: none, 1-5 patients, 6-10 patients, 11-25 patients, 26-100 patients, >100 patients).
>
> Question 4 (2015): (Scenario) You are seeing a patient who lives in Minnesota. In which of the following situations would Lyme disease testing be clinically useful? (Select all that apply: arthritic knee, tick bite—asymptomatic, erythema migrans rash, new-onset atrioventricular block, test of cure after Lyme disease treatment, none of these).
>
> Question 5 (2013): What steps do you routinely recommend to patients to prevent tick bites? (Select all that apply: I do not routinely discuss this, wear repellent, shower soon after

coming indoors, check for ticks daily, I recommend other actions not listed here).

Statistical Analysis

We combined analogous survey questions across study years for data analysis in 2019. We used SAS version 9.4 (SAS Institute, Inc) to calculate frequencies and Pearson χ^2 tests to compare categorical data. For each comparison, we selected the reference group as the provider type with the highest proportion of incorrect answers or the provider type with the lowest proportion of prevention recommendations. We defined 14 states as having a high incidence of Lyme disease based on having an average annual incidence of ≥10 confirmed cases of Lyme disease per 100 000 population during the 2008-2015 CDC reporting period.[6] All other states, including the District of Columbia, had a low incidence of Lyme disease (n = 36). Because Vermont does not participate in the DocStyles survey, information about providers from this state was not available. For questions 2-4, we estimated the annual frequency of visits to providers by patients with tick bites or Lyme disease using the midpoint value for each categorical response (eg, 3 for 1-5 patients or 101 for >100 patients) and the estimated total number of patients seen for the year (assuming an average of 45 working weeks in a year) reported by each respondent, including those who reported no patients. We used multivariable logistic regression with backward stepwise selection to identify factors related to clinical practice. Covariates considered for the regression analyses included practice setting (inpatient vs outpatient), Lyme disease endemicity based on state of residence, license type, years in practice (>10 years vs ≤10 years), and number of patients seen per week (>100 vs ≤100 patients). We set significance at an α level of .05.

Results

A total of 4517 people responded during 2013-2015. Across the 3 survey years, most respondents were male (n = 2778, 61.5%) and aged >40 (n = 3030, 67.1%), with a median age of 45 (range, 22-85) (Table 1). The median time in practice was 14 years (range, 3-50 years). Most respondents were non-Hispanic (n = 4318, 95.6%), white (n = 3023, 66.9%), and working in a group setting (n = 3060, 67.7%). One-third of respondents lived in states with a high incidence of Lyme disease (n = 1505, 33.3%).

Patients Treated or Evaluated for a Tick Bite

The characteristics of providers who reported treating (2013) or evaluating (2014) a patient for a tick bite were similar. Overall,

Table 1. Demographic characteristics of health care provider respondents, by survey year, United States, DocStyles surveys, 2013-2015[a]

Characteristics	2013 (n = 1506)	2014 (n = 1510)	2015 (n = 1501)	Total (n = 4517)
Male sex	940 (62.4)	917 (60.7)	921 (61.4)	2778 (61.5)
Aged >40	1089 (72.3)	975 (64.6)	966 (64.4)	3030 (67.1)
Race				
White	1062 (70.5)	991 (65.6)	970 (64.6)	3023 (66.9)
Asian	302 (20.1)	354 (23.4)	367 (24.5)	1023 (22.6)
Other	103 (6.8)	124 (8.2)	122 (8.1)	349 (7.7)
Black or African American	39 (2.6)	41 (2.7)	42 (2.8)	122 (2.7)
Non-Hispanic ethnicity	1443 (95.8)	1437 (95.2)	1438 (95.8)	4318 (95.6)
High incidence of Lyme disease[b]	512 (34.0)	495 (32.8)	498 (33.2)	1505 (33.3)
Provider type				
Family/general practitioner	566 (37.6)	542 (35.9)	465 (31.0)	1573 (34.8)
Internist	440 (29.2)	466 (30.9)	535 (35.6)	1441 (31.9)
Pediatrician	250 (16.6)	252 (16.7)	250 (16.7)	752 (16.6)
Nurse practitioner	250 (16.6)	250 (16.6)	251 (16.7)	751 (16.6)
Practice setting				
Group	1027 (68.2)	1047 (69.3)	986 (65.7)	3060 (67.7)
Hospital	171 (11.4)	197 (13.0)	244 (16.3)	612 (13.5)
Individual	308 (20.5)	266 (17.6)	271 (18.1)	845 (18.7)
>10 Years of practice	1050 (69.7)	942 (62.4)	956 (63.7)	2948 (65.3)
≤100 Patients per week	890 (59.1)	921 (61.0)	950 (63.3)	2761 (61.1)

[a]Data source: Porter Novelli Public Services.[19-21]

[b]Fourteen states were defined as having a high incidence of Lyme disease based on having an average annual incidence of ≥10 confirmed cases of Lyme disease per 100 000 population during the 2008-2015 reporting period of the Centers for Disease Control and Prevention.[6] All other states were classified as having a low incidence.

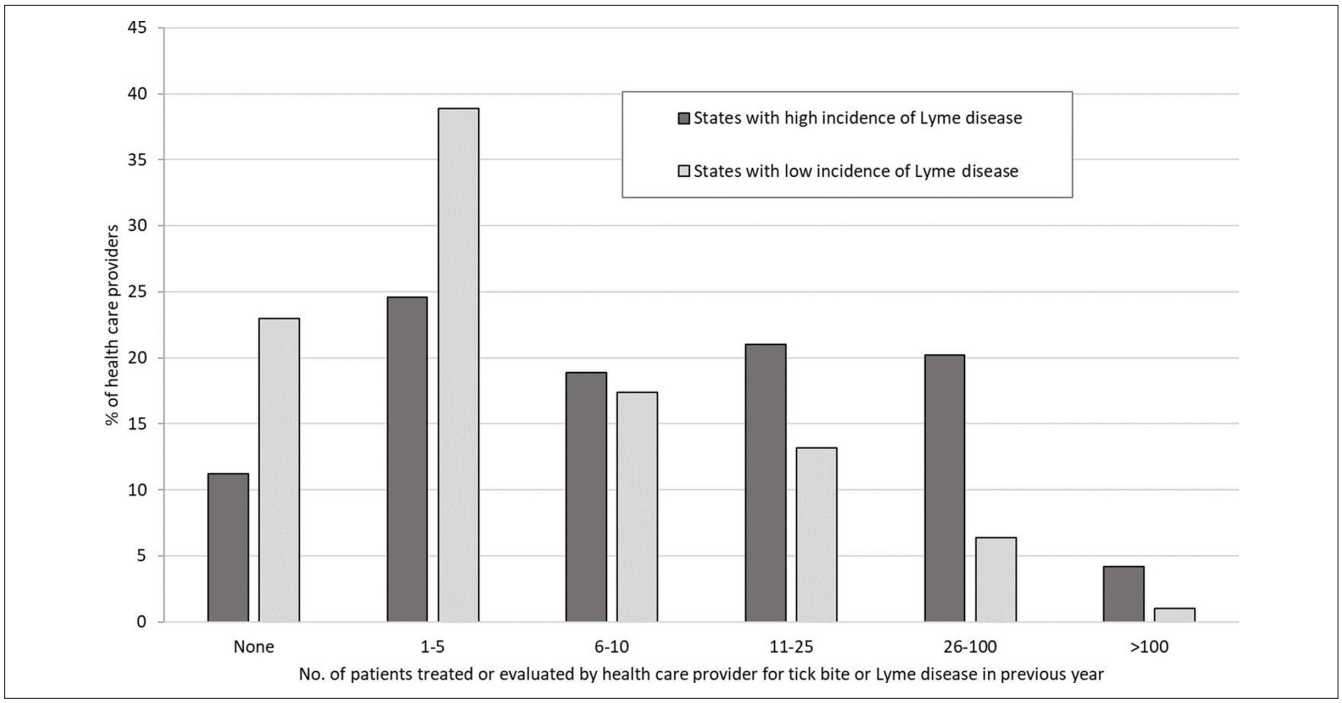

Figure. Estimated proportion of health care providers who treated or evaluated patients for a tick bite in the previous year (n = 3016), by number of patients treated or evaluated and by whether they practiced in a state with a high incidence of Lyme disease (n = 14) or a state with a low incidence (n = 36), United States. Data source: Porter Novelli Public Services, DocStyles surveys 2013-2014.[19,20] The 2013 DocStyles survey question used the word "treat" and the 2014 DocStyles survey question used the word "evaluate." High incidence was based on having an average annual incidence of ≥10 confirmed cases of Lyme disease per 100 000 population during the 2008-2015 Centers for Disease Control and Prevention reporting period.[6]

2440 of 3016 (80.9%) respondents in the 2013 and 2014 surveys had treated or evaluated at least 1 patient for a tick bite in the previous year. The percentage of providers who saw patients in the higher-range categories (26-100 and >100 patients) for tick bites was higher in states with a high incidence of Lyme disease than in states with a low incidence. Conversely, most (61.9%) providers in states with a low incidence reported seeing no patients (23.0%) or 1-5 patients (38.9%) for tick bites (Figure). Providers in states with a high incidence of Lyme disease reported seeing an average of 5 cases of tick bites per 1000 patients in the 2013 survey and 6 cases of tick bites per 1000 patients in the 2014 survey. Providers from states with a low incidence of Lyme disease saw 3 cases of tick bites per 1000 patients in the 2013 survey and 2 cases of tick bites per 1000 patients in the 2014 survey.

Providers who saw at least 1 patient for a tick bite in the previous year were more likely to live in a state with a high incidence of Lyme disease (odds ratio [OR] = 2.7; 95% CI, 2.1-3.4) and see >100 patients per week (OR = 1.9; 95% CI, 1.5-2.4) than providers who did not see patients for tick bites. Compared with nurse practitioners, family/general practitioners (OR = 3.0; 95% CI, 2.3-4.0), internists (OR = 1.5; 95% CI, 1.1-1.9), and pediatricians (OR = 2.1; 95% CI, 1.5-2.8) were significantly more likely to evaluate tick bites.

Lyme Disease Diagnosis and Treatment

Almost half (n = 719, 47.6%) of providers had diagnosed at least 1 patient with Lyme disease in the previous year, and 501 (33.2%) had diagnosed 1-5 patients with Lyme disease in the previous year. Providers from states with a high incidence of Lyme disease had diagnosed significantly more patients with Lyme disease than providers from states with a low incidence (2 vs 1 per 1000 patients; $P < .001$). Most providers (n = 932, 61.9%) had treated at least 1 patient for Lyme disease in the previous year. Providers from states with a high incidence of Lyme disease had treated significantly more patients for Lyme disease than providers from states with a low incidence (3 vs 1 per 1000 patients; $P < .001$). Eight providers (0.5%) reported treating >100 patients for Lyme disease in the previous year.

Based on regression analyses, providers who had diagnosed or treated at least 1 patient for Lyme disease in the previous year were more likely to see >100 patients per week (OR = 1.9; 95% CI, 1.6-2.3) than providers who had not diagnosed or treated patients for Lyme disease in the previous year. In addition, compared with nurse practitioners, family/general practitioners (OR = 2.0; 95% CI, 1.6-2.5) and internists (OR = 1.7; 95% CI, 1.3-2.1) were more likely to diagnose or treat patients with Lyme disease.

Table 2. Proportion of correct and incorrect answers by health care provider type in response to a survey question about appropriate clinical scenarios to use Lyme disease testing, United States, DocStyles survey, 2015[a]

Clinical scenario[a]	No. of providers who answered survey question	No. (%)	*P* value[b]
Correct responses			
Arthritic knee			
Family/general practitioner	465	170 (36.6)	.09
Internist	535	189 (35.3)	.16
Pediatrician	250	105 (42.0)	.01
Nurse practitioner	251	76 (30.3)	Reference
Total	1501	540 (36.0)	—
New-onset atrioventricular block			
Family/general practitioner	465	162 (34.8)	<.001
Internist	535	275 (51.4)	<.001
Pediatrician	250	101 (40.4)	<.001
Nurse practitioner	251	55 (21.9)	Reference
Total	1501	593 (39.5)	—
Incorrect responses			
Asymptomatic tick bite			
Family/general practitioner	465	201 (43.2)	.20
Internist	535	229 (42.8)	.16
Pediatrician	250	60 (24.0)	<.001
Nurse practitioner	251	121 (48.2)	Reference
Total	1501	611 (40.7)	—
Erythema migrans rash			
Family/general practitioner	465	383 (82.4)	Reference
Internist	535	410 (76.6)	.03
Pediatrician	250	183 (73.2)	.004
Nurse practitioner	251	196 (78.1)	.17
Total	1501	1172 (78.1)	—
Test of cure after Lyme disease treatment			
Family/general practitioner	465	111 (23.9)	.40
Internist	535	100 (18.7)	.01
Pediatrician	250	32 (12.8)	<.001
Nurse practitioner	251	67 (26.7)	Reference
Total	1501	310 (20.7)	—
None of these			
Family/general practitioner	465	20 (4.3)	.10
Internist	535	36 (6.4)	Reference
Pediatrician	250	15 (6.0)	.70
Nurse practitioner	251	7 (2.8)	.02
Total	1501	78 (5.2)	—

[a]The survey question is as follows: "You are seeing a patient who lives in Minnesota. In which of the following situations would Lyme disease testing be clinically useful? (Select all that apply: arthritic knee, tick bite—asymptomatic, erythema migrans rash, new-onset atrioventricular block, test of cure after Lyme disease treatment, none of these)." Multiple answers were allowed. As such, totals may exceed 100%. Data source: Porter Novelli Public Services.[21]
[b]The Pearson χ^2 test was used to compare answers among provider types. $P < .05$ was considered significant.

Lyme Disease Testing Scenario

Five hundred forty (36.0%) providers correctly selected Lyme disease testing as clinically useful in a hypothetical scenario of a patient from Minnesota with an arthritic knee, and 593 (39.5%) providers correctly selected Lyme disease testing in the case of a patient with new-onset atrioventricular block (Table 2). Providers who correctly selected to test for Lyme disease in both scenarios were more likely to be from states with a high incidence of Lyme disease (OR = 1.6; 95% CI, 1.3-2.1) than from states with a low incidence and were more likely to identify as family/general practitioners (OR = 2.1; 95% CI, 1.3-3.1), internists (OR = 2.6; 95% CI, 1.7-3.9), or pediatricians (OR = 2.6; 95% CI, 1.7-4.1) than nurse practitioners.

More than 40% of family/general practitioners, internists, and nurse practitioners incorrectly selected Lyme disease testing as clinically useful for a case of a patient with asymptomatic tick bite; pediatricians were the least likely of all providers to answer this question incorrectly (24.0%) (Table 2) and were nearly twice as likely as family/general practitioners (OR = 2.4, 95% CI, 1.7-3.4), internists (OR = 2.4; 95% CI, 1.7-3.3), and nurse practitioners (OR = 2.9; 95% CI, 2.0-4.3) to answer correctly.

Most providers (n = 1172, 78.1%) incorrectly selected Lyme disease testing as clinically useful for a case of a patient with erythema migrans rash (range, 73.2%-82.4%) (Table 2). An average of 20% of providers would incorrectly order Lyme disease testing for a test of cure after Lyme disease treatment (range, 12.8%-26.7%). Pediatricians had more than twice the odds of correctly answering this question than family/general practitioners (OR = 2.1; 95% CI, 1.4-3.2) and nurse practitioners (OR = 2.5; 95% CI, 1.6-4.0). Providers who answered correctly about the test of cure were also more likely than providers who answered incorrectly to reside in a state with a high incidence of Lyme disease (OR = 1.4; 95% CI, 1.1-1.9).

Tick-Bite Prevention

Tick-bite prevention counseling was routinely offered to patients by most providers (n = 1050, 69.7%) (Table 3). The most commonly recommended prevention method was to wear repellent (57.5%), with family/general practitioners being the most likely (62.0%) and internists being the least likely (51.8%) to recommend wearing repellent ($P = .001$). Daily tick checks were recommended by 771 (51.2%) providers and were most frequently recommended by pediatricians (55.6%) and least frequently recommended by internists (43.0%) ($P = .001$). The recommendation to shower soon after coming indoors was relatively low across all provider types, ranging from 25.2% to 32.0% (mean, 30.0%).

Tick-bite prevention methods overall were recommended more often by providers from states with a high incidence of Lyme disease than by providers from states with a low incidence of Lyme disease (OR = 2.6; 95% CI, 2.0-3.4), except for showering soon after coming indoors, which was not significantly different between high- and low-incidence states (31.8% vs 29.0%; $P = .30$). In addition, providers who offered recommendations were more likely than providers

Table 3. Proportion of health care providers who gave selected tick-bite prevention recommendations to patients, by provider type, United States, DocStyles survey, 2013[a]

Tick-bite prevention recommendations routinely discussed with patients[a]	No. of providers who answered survey question	No. (%) who provided recommendation	*P* value[b]
Wear repellent			
Family/general practitioner	566	351 (62.0)	.001
Internist	440	228 (51.8)	Reference
Pediatrician	250	149 (59.6)	.048
Nurse practitioner	250	138 (55.2)	.39
Total	1506	866 (57.5)	—
Check for ticks daily			
Family/general practitioner	566	308 (54.4)	<.001
Internist	440	189 (43.0)	Reference
Pediatrician	250	139 (55.6)	.001
Nurse practitioner	250	135 (54.0)	.01
Total	1506	771 (51.2)	—
Shower soon after coming indoors			
Family/general practitioner	566	181 (32.0)	.05
Internist	440	127 (28.9)	.30
Pediatrician	250	63 (25.2)	Reference
Nurse practitioner	250	80 (32.0)	.09
Total	1506	451 (30.0)	—
Other actions not listed on survey			
Family/general practitioner	566	77 (13.6)	.06
Internist	440	43 (9.8)	Reference
Pediatrician	250	27 (10.8)	.67
Nurse practitioner	250	40 (16.0)	.02
Total	1506	187 (12.4)	—
Does not routinely discuss prevention of tick bites			
Family/general practitioner	566	154 (27.2)	.01
Internist	440	154 (35.0)	Reference
Pediatrician	250	72 (28.8)	.10
Nurse practitioner	250	76 (30.4)	.22
Total	1506	456 (30.3)	—

[a]The survey question is as follows: "What steps do you routinely recommend to patients to prevent tick bites? (Select all that apply: I do not routinely discuss this, wear repellent, shower soon after coming indoors, check for ticks daily, I recommend other actions not listed here)." Multiple answers were allowed. As such, percentages may total to more than 100%. Data source: Porter Novelli Public Services.[19]
[b]The Pearson χ^2 test was used to compare answers among provider types. $P < .05$ was considered significant.

who did not routinely discuss tick-bite prevention recommendations to have been in practice for >10 years (OR = 1.4; 95% CI, 1.1-1.8) and see >100 patients per week (OR = 1.5; 95% CI, 1.2-1.9).

Discussion

Most providers saw patients for tick bites in states with a high incidence of Lyme disease and states with a low incidence and by all provider types. However, self-reported frequency of Lyme disease diagnosis, treatment, and tick-bite prevention counseling varied. Providers from high-incidence states were more likely than providers from low-incidence states to see patients for tick bites, diagnose Lyme disease, and treat Lyme disease. Generally, more patients were treated for Lyme disease than were diagnosed with Lyme disease, likely because of the differences between these clinical terms. Providers may interpret "treat" in various ways, such as how many patients came into the office for Lyme disease, how many patients were billed for Lyme disease, or how many patients brought up concerns about Lyme disease. The term "treat" may also include patients who did not have a confirmed diagnosis. The interpretation of "diagnosis," conversely, is likely limited to a single encounter through laboratory testing or clinical judgment.

Results from the 2015 scenario question about the patient from Minnesota highlight important concerns about appropriate use of serologic testing for Lyme disease. Few providers correctly chose testing as clinically useful in the case of a patient with an arthritic knee or with new-onset atrioventricular block. Because Minnesota has a high incidence of Lyme disease, clinical suspicion of Lyme disease would be appropriate in both scenarios and should be considered. Because these manifestations of Lyme disease occur in disseminated disease, serologic testing would have high sensitivity and specificity and would be clinically indicated.[12]

Conversely, hypothetical use of Lyme disease testing when not clinically indicated was also apparent. Approximately 40% of providers selected testing as clinically useful in the case of a patient with an asymptomatic tick bite. This result echoes findings of a 2012 DocStyles question that asked about clinical practices in the case of a teenaged patient with an attached, partially engorged tick. In that survey, nearly 20% of providers indicated that they would order a test for Lyme disease.[23] Findings from the 2015 survey results were nearly double this earlier finding and may demonstrate an upward trend of unnecessary Lyme disease testing for asymptomatic tick bites. Inappropriate Lyme disease testing can create a substantial economic burden and undesired consequences for patient care.[24] False-positive results can lead to an incorrect diagnosis of Lyme disease, inappropriate or harmful treatments, and a delay or omission of the correct diagnosis and appropriate treatment.

Similarly, 78% of providers incorrectly indicated Lyme disease testing to be clinically useful for patients with erythema migrans rash. Our findings are similar to results from a 2009 DocStyles question, which described an "otherwise healthy patient who presents with a large, circular, 'bull's-eye' rash around a site where he had removed an engorged tick seven days earlier," when approximately 75% of respondents answered that they would order a blood test for Lyme disease.[25] Motivations for testing in this scenario can include difficulty in rash identification or desire for diagnostic confirmation.[25]

In July 2019, the US Food and Drug Administration cleared several Lyme disease serologic assays that use an enzyme immunoassay as the second test in a 2-step testing algorithm as an alternative to the traditional Western blot for laboratory diagnosis of Lyme disease.[26] Compared with the traditional algorithm, the modified testing algorithm is more sensitive for detection of an immune response in early disease, while avoiding some of the drawbacks of the Western blot (eg, subjective interpretation of results). With time, newer Lyme disease testing algorithms may improve and simplify appropriate use and interpretation of Lyme disease testing by providers.[27]

Encouragingly, most providers reported routinely recommending steps to patients to prevent tick bites, with 50% of providers routinely recommending 2 or more steps. Although almost 60% of providers reported recommending repellent to prevent tick bites, self-reported repellent use among the public is low.[28-30] Further investigation into various perceived barriers to wearing repellent could provide insight into the outward disagreement between provider recommendations and patient behaviors. This apparent discrepancy could also be the result of reporting bias, which may overestimate the true frequency of tick-bite prevention recommendations by providers. The recommendation to shower soon after coming indoors, although shown to be effective for reducing the risk of Lyme disease,[31] was relatively underused as a prevention option, even in states with a high incidence of Lyme disease. The recommendation to shower soon after spending time outdoors in tick habitat could be encouraged as a method that could be easily adapted into daily patient behaviors and may appeal to those who are not inclined to use repellent.

Limitations

This analysis had several potential limitations. First, questions might have been interpreted differently by providers than intended. For the scenario question, the "arthritic knee" was assumed to be understood as new onset but could have been interpreted as longstanding by respondents. "Testing" for Lyme disease could also have been interpreted as a diagnostic modality other than serology. These potential discrepancies might have contributed to misclassification of respondents as having answered correctly or incorrectly. Second, we were not able to determine the clinical scenarios for which respondents would recommend Lyme disease testing if they selected "none of these" for their response, restricting our ability to evaluate responder knowledge. Third, classification of providers being from a state with either low or high incidence of Lyme disease does not acknowledge the nuance of the importance of states with emerging Lyme disease, where incidence is increasing and where local transmission is possible, or states where other tick species or incidence of other tick-borne diseases is common. Patients may also have reported previous travel to states with a high incidence of Lyme disease, which was not measured. Lastly, as in most self-reported surveys, selection and response bias might have limited the representativeness of these results.

Conclusions

Efforts to promote education among providers on tick-bite prevention and appropriate Lyme disease management are warranted given our survey results. The importance of tick-bite prevention should be emphasized, particularly because of the confusion about tick bite and Lyme disease clinical management and testing. Clinician education on these topics should be promoted through medical school curricula, public health agency communications, and health profession societies to improve patient care.

Authors' Note

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of CDC.

Acknowledgments

The authors thank Anna Perea and Sarah Hook from the Centers for Disease Control and Prevention (CDC) for their previous work that contributed to the development of this article.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Project support was provided in part by an appointment to the CDC Fellowship Program, administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the US Department of Energy and CDC.

ORCID iD

Alyssa R. Beck, MPH https://orcid.org/0000-0002-4942-2285

References

1. Steere AC, Malawista SE, Snydman DR, et al. Lyme arthritis: an epidemic of oligoarticular arthritis in children and adults in three Connecticut communities. *Arthritis Rheum*. 1977;20(1):7-17. doi:10.1002/art.1780200102
2. Centers for Disease Control and Prevention. Lyme disease (*Borrelia burgdorferi*). Accessed September 18, 2019. https://wwwn.cdc.gov/nndss/conditions/lyme-disease
3. Centers for Disease Control and Prevention. Reported cases of Lyme disease by state or locality, 2009-2018. Accessed January 8, 2020. https://www.cdc.gov/lyme/stats/tables.html
4. Hinckley AF, Connally NP, Meek JI, et al. Lyme disease testing by large commercial laboratories in the United States. *Clin Infect Dis*. 2014;59(5):676-681. doi:10.1093/cid/ciu397
5. Nelson CA, Saha S, Kugeler KJ, et al. Incidence of clinician-diagnosed Lyme disease, United States, 2005-2010. *Emerg Infect Dis*. 2015;21(9):1625-1631. doi:10.3201/eid2109.150417
6. Schwartz AM, Hinckley AF, Mead PS, Hook SA, Kugeler KJ. Surveillance for Lyme disease—United States, 2008-2015. *MMWR Surveill Summ*. 2017;66(SS-22):1-12. doi:10.15585/mmwr.ss6622a1
7. Gage KL, Burkot TR, Eisen RJ, Hayes EB. Climate and vectorborne diseases. *Am J Prev Med*. 2008;35(5):436-450. doi:10.1016/j.amepre.2008.08.030
8. Mead P, Hook S, Niesobecki S, et al. Risk factors for tick exposure in suburban settings in the northeastern United States. *Ticks Tick Borne Dis*. 2018;9(2):319-324. doi:10.1016/j.ttbdis.2017.11.006
9. Centers for Disease Control and Prevention. Recommendations for test performance and interpretation from the Second National Conference on Serologic Diagnosis of Lyme Disease. *MMWR Morb Mortal Wkly Rep*. 1995;44(31):590-591.
10. Moore A, Nelson C, Molins C, Mead P, Schriefer M. Current guidelines, common clinical pitfalls, and future directions for laboratory diagnosis of Lyme disease, United States. *Emerg Infect Dis*. 2016;22(7):1169-1177. doi:10.3201/eid2207.151694
11. Wormser GP, Dattwyler RJ, Shapiro ED, et al. The clinical assessment, treatment, and prevention of Lyme disease, human granulocytic anaplasmosis, and babesiosis: clinical practice guidelines by the Infectious Diseases Society of America. *Clin Infect Dis*. 2006;43(9):1089-1134. doi:10.1086/508667
12. Halperin JJ, Baker P, Wormser GP. Common misconceptions about Lyme disease. *Am J Med*. 2013;126(3):264.e1. doi:10.1016/j.amjmed.2012.10.008
13. Conant JL, Powers J, Sharp G, Mead PS, Nelson CA. Lyme disease testing in a high-incidence state: clinician knowledge and patterns. *Am J Clin Pathol*. 2018;149(3):234-240. doi:10.1093/ajcp/aqx153
14. Fix AD, Strickland GT, Grant J. Tick bites and Lyme disease in an endemic setting: problematic use of serologic testing and prophylactic antibiotic therapy. *JAMA*. 1998;279(3):206-210. doi:10.1001/jama.279.3.206
15. Henry B, Crabtree A, Roth D, Blackman D, Morshed M. Lyme disease: knowledge, beliefs, and practices of physicians in a low-endemic area. *Can Fam Physician*. 2012;58(5):e289-e295.
16. Magri JM, Johnson MT, Herring TA, Greenblatt JF. Lyme disease knowledge, beliefs, and practices of New Hampshire primary care physicians. *J Am Board Fam Pract*. 2002;15(4):277-284.
17. Centers for Disease Control and Prevention. Ticks. Accessed September 18, 2019. https://www.cdc.gov/ticks/avoid/on_people.html
18. SERMO. Overview. Accessed September 23, 2019. http://www.sermo.com/overview
19. Porter Novelli Public Services. *DocStyles 2013-15 Methodology*. Deanne Weber; 2013.
20. Porter Novelli Public Services. *DocStyles 2013-15 Methodology*. Deanne Weber; 2014.
21. Porter Novelli Public Services. *DocStyles 2013-15 Methodology*. Deanne Weber; 2015.
22. Porter Novelli. PNSTYLES. Accessed January 14, 2020. http://styles.porternovelli.com
23. Perea AE, Hinckley AF, Mead PS. Tick bite prophylaxis: results from a 2012 survey of healthcare providers. *Zoonoses Public Health*. 2015;62(5):388-392. doi:10.1111/zph.12159
24. Reid MC, Schoen RT, Evans J, Rosenberg JC, Horwitz RI. The consequences of overdiagnosis and overtreatment of Lyme disease: an observational study. *Ann Intern Med*. 1998;128(5):354-362. doi:10.7326/0003-4819-128-5-199803010-00003
25. Brett ME, Hinckley AF, Zielinski-Gutierrez EC, Mead PS. U.S. healthcare providers' experience with Lyme and other tick-borne diseases. *Ticks Tick Borne Dis*. 2014;5(4):404-408. doi:10.1016/j.ttbdis.2014.01.008
26. Mead P, Petersen J, Hinckley A. Updated CDC recommendation for serologic diagnosis of Lyme disease. *MMWR Morb Mortal Wkly Rep*. 2019;68(32):703. doi:10.15585/mmwr.mm6832a4

27. Branda JA, Linskey K, Kim YA, Steere AC, Ferraro MJ. Two-tiered antibody testing for Lyme disease with use of 2 enzyme immunoassays, a whole-cell sonicate enzyme immunoassay followed by a VlsE C6 peptide enzyme immunoassay. *Clin Infect Dis*. 2011;53(6):541-547. doi:10.1093/cid/cir464
28. Butler AD, Sedghi T, Petrini JR, Ahmadi R. Tick-borne disease preventive practices and perceptions in an endemic area. *Ticks Tick Borne Dis*. 2016;7(2):331-337. doi:10.1016/j.ttbdis.2015.12.003
29. Hook SA, Nelson CA, Mead PS. U.S. public's experience with ticks and tick-borne diseases: results from national healthstyles surveys. *Ticks Tick Borne Dis*. 2015;6(4):483-488. doi:10.1016/j.ttbdis.2015.03.017
30. Niesobecki S, Hansen A, Rutz H, et al. Knowledge, attitudes, and behaviors regarding tick-borne disease prevention in endemic areas. *Ticks Tick Borne Dis*. 2019;10(6):101264. doi:10.1016/j.ttbdis.2019.07.008
31. Connally NP, Durante AJ, Yousey-Hindes KM, Meek JI, Nelson RS, Heimer R. Peridomestic Lyme disease prevention: results of a population-based case-control study. *Am J Prev Med*. 2009;37(3):201-206. doi:10.1016/j.amepre.2009.04.026