Survey of veterinarians’ perceptions of borreliosis in North Carolina

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Objective—To evaluate the practices and perceptions of veterinarians in North Carolina regarding borreliosis in dogs in various geographic regions of the state.

Design—Cross-sectional survey.

Sample—Data from 208 completed surveys.

Procedures—Surveys were distributed to veterinary clinics throughout North Carolina. Descriptive statistics were used to summarize perceptions pertaining to borreliosis among dogs in North Carolina.

Results—A significantly higher proportion of responding veterinarians believed that borreliosis was endemic in the coastal (67.2%) and Piedmont (60.9%) areas of North Carolina, compared with more western regions (37.5%). The 3 variables found to be significantly different between the northern and southern regions of the state were the estimated number of borreliosis cases diagnosed by each responding veterinary clinic during the past year, the perception of borreliosis endemicity, and the perceptions related to the likelihood of a dog acquiring borreliosis in the state.

Conclusions and Clinical Relevance—Veterinarians’ perception of the risk of borreliosis in North Carolina was consistent with recent scientific reports pertaining to geographic expansion of borreliosis in the state. As knowledge of the epidemiological features of borreliosis in North Carolina continues to evolve, veterinarians should promote routine screening of dogs for Borrelia burgdorferi exposure as a simple, inexpensive form of surveillance that can be used to better educate their clients on the threat of transmission of borreliosis in this transitional geographic region. (J Am Vet Med Assoc 2014;244:592–596)

Borreliosis, a multisystem inflammatory disorder caused by gram-negative spirochetes belonging to the genus Borrelia, is the most common vector-borne disease in the northern hemisphere. Borrelia burgdorferi, the etiologic agent of borreliosis in the United States, is transmitted through the bite of infected hard ticks of the genus Ixodes, specifically Ixodes scapularis and Ixodes pacificus. Borreliosis-endemic regions of the United States have historically included the northeastern, upper midwestern, and western United States, where most human cases are reported annually. Because Borrelia infection is maintained through tick transmission to various wildlife vertebrate reservoirs, the density of Ixodid tick species, in combination with host species abundance and other environmental factors, may account for the variations in endemicity among geographic locations. The diagnosis of borreliosis presently relies on serologic evidence of exposure to B burgdorferi in areas that have been identified by the CDC as endemic areas for transmission of borreliosis and documentation of clinical disease. Historically, North Carolina has not been considered a borreliosis-endemic state because it had a lower proportion of infected ticks and animal hosts than can be found in endemic areas with a higher prevalence of the disease. Therefore, lack of travel history to a borreliosis-endemic state historically precluded veterinarians and physicians in North Carolina from making that diagnosis; often, humans or pets with borreliosis in North Carolina are assumed to have been exposed to B burgdorferi while traveling to borreliosis-endemic states.

A recent study that measured the prevalence of Borrelia spp in ticks collected from 7 coastal plains counties in North Carolina identified B burgdorferi or Borrelia bissetti DNA in 63.2% of the collected Ixodes affinis ticks and none of the collected I scapularis ticks. This high prevalence indicates that Borrelia spp may be widely distributed among I affinis ticks, which may or may not be able to effectively transmit B burgdorferi to dogs or humans. Despite the evolving understanding of the ecological and epidemiological features of Borrelia spp in North Carolina, researchers, physicians, and veterinarians have an incomplete picture of borreliosis risk in humans and pets throughout the state. Recently, it was found that a B burgdorferi seroprevalence in dogs > 5% may be a sensitive but nonspecific marker for predicting the risk of transmission of borreliosis to humans because seroprevalence rates in dogs are correlated with increasing rates of human infections at the state or county level. Therefore, dogs may

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| ABBREVIATION | STARI | Southern tick-associated rash illness |
be used as sentinels for the risk of *B. burgdorferi* transmission to humans in North Carolina. A previous North Carolina study failed to identify any dogs that were *B. burgdorferi* seropositive that did not have a travel history to a northeastern US borreliosis-endemic state. The epidemiological features of borreliosis in North Carolina are changing, and it is presently unclear how practicing veterinarians perceive the threat of *B. burgdorferi* to dogs in the state, how frequently veterinarians use diagnostic testing to screen for exposure to tick-borne diseases, and whether the routine use of acaricides or borreliosis vaccination is recommended as a component of routine health care.

Enhanced understanding of the geographic differences in perceptions of the epidemiological features of borreliosis may be used to promote ongoing surveillance of *B. burgdorferi* and can facilitate continued education of veterinarians and other public health officials regarding the threat of borreliosis among pets and humans in North Carolina. Therefore, the purpose of the study reported here was to evaluate the practices and perceptions of veterinarians in North Carolina regarding borreliosis in dogs across different geographic regions of the state.

**Materials and Methods**

**Data collection**—In 2001, a company that develops veterinary diagnostic products implemented a voluntary, passive system for the reporting of test results for selected canine blood-borne pathogens obtained with the company's diagnostic testing kits. Participating veterinary clinics received a rebate toward the cost of the commercial in-house ELISA® after submission of a log of test results. In January 2012, a survey was distributed from the North Carolina State University College of Veterinary Medicine Intracellular Pathogens Research Laboratory to all veterinary clinics that submitted commercial in-house ELISA® results to the company from 2007 through 2011. Surveys were sent to the senior veterinarian in each clinic to measure factors associated with borreliosis in dogs in North Carolina. Each clinic was given 5 months to respond to the survey; clinics that did not respond to the survey were excluded from analysis. The study protocol was reviewed and approved by the North Carolina State University Institutional Review Board.

**Statistical analysis**—Descriptive statistics were used to summarize survey results. The 3 natural landforms of North Carolina were used to categorize 3 eastern-western regions of the state: the coastal plains, Piedmont, and mountain regions. Additionally, the state was categorized into northern and southern regions on the basis of the approximate geographic center of the state (79°27.3′W, 35°36.2′N) according to the US Geological Survey. Univariate analyses, including the χ² test, Fisher exact test, and Fisher-Freeman-Halton test, were used with statistical software to assess potential associations between the survey responses and clinic locations in North Carolina (3 eastern-western regions, northern region, and southern region). For all tests, *P* ≤ 0.05 was considered significant.

**Results**

**Descriptive statistics**—Surveys were sent to 512 North Carolina veterinary clinics, and 208 responses were received within 5 months. Among participating clinics, 27 (12.9%) were in the mountain region, 119 (56.9%) were in the Piedmont region, and 63 (30.1%) were in the coastal plains region; 146 (69.8%) were located in the northern part of the state, and 63 (30.1%) were located in the southern part of the state. Approximately 70 (33.5%) clinic respondents reported having clients who resided in urban locations, whereas 162 (77.5%) and 164 (78.5%) reported having clients who resided in rural and suburban locations, respectively. The median number of years spent practicing veterinary medicine by the responding veterinarians was 21.9 (interquartile range, 13.0 to 30.0 years). Responses were obtained for clinics in 64 counties throughout the state, whereas 36 counties had no responses from any clinic. The number of counties with veterinary clinics that did not respond to the survey did not vary by the northern-southern region (*P* = 0.45), but did vary among the 3 eastern-western regions (*P* = 0.03). Of the counties in the mountain region, approximately half (53.8%) did not have a veterinary clinic that responded to the survey, compared with 36.6% in the coastal plains region and 21.2% in the Piedmont region.

The estimated number of cases of canine borreliosis diagnosed during the past year varied greatly by clinic, with 103 (49.5%) clinic respondents reporting approximately 1 to 5 cases, 47 (22.6%) reporting approximately 6 to 26 cases, 11 (5.3%) reporting approximately 26 to 50 cases, and 4 (1.9%) reporting approximately >50 cases. However, 43 clinic respondents (20.7%) reported no diagnoses of borreliosis during the past year. Estimated numbers of cases did not vary by the eastern-western region of the state (*P* = 0.06) but did vary by the northern-southern region (*P* = 0.01). Of the clinics in the northern region, 35.8% (n = 52) of responding veterinarians, respectively, believed that borreliosis is endemic in North Carolina, compared with 15.8% (10) in the southern region. However, 19.3% (n = 28) and 23.8% (15) of clinic respondents in the northern region and the southern region, respectively, reported that no cases were diagnosed during the past year.

For a majority (n = 120 [57.4%]) of clinics, the senior veterinarian respondent believed that borreliosis is endemic in North Carolina. Perceptions of endemcity varied greatly by the eastern-western and northern-southern geographic regions (*P* = 0.04 and *P* = 0.005, respectively). Of the clinics in the coastal and Piedmont regions of the state, 67.2% (n = 41) and 60.9% (66) of responding veterinarians, respectively, believed that borreliosis is endemic in North Carolina, compared with only 37.5% (9) in the mountain region. Additionally, of the clinics in the northern region of the state, 77.5% (n = 93) of responding veterinarians believed that borreliosis is endemic in North Carolina, compared with only 22.5% (27) in the southern region. For more than three-quarters (n = 185 [88.5%]) of veterinary clinics located throughout the state, the respondent veterinarian believed that at least 1 dog had acquired borreliosis in North Carolina during the past year. This perception did not vary by the eastern-western region (*P* = 0.40), but did vary by northern-southern region (*P* < 0.001), with 97.1% (n = 136) of clinic respondents in the northern region reporting that at least 1 dog had acquired borreliosis in North Carolina, compared with 77.7% (n = 49)
of clinic respondents in the southern region. Similarly, approximately two-thirds (n = 136 [65.3%]) of the clinic respondents reported that a proportion of dogs with borreliosis in North Carolina were exposed to *B. burgdorferi* in the state. Interestingly, 46 (22.0%) clinic respondents reported that they had not identified a dog that acquired *B. burgdorferi* outside of the state (on the basis of results of a commercial in-house ELISA). This perception did not vary by the eastern-western or northern-southern region (P = 0.10 and P = 0.37, respectively).

History of tick attachment in the clinic's dog patient population varied, with 88 (42.3%) clinic respondents reporting a history of tick attachment in 0% to 25% of the population, 47 (22.5%) reporting a history of tick attachment in 25% to 50% of the population, and 71 (34.1%) reporting a history of tick attachment in > 50% of the population. Two-thirds of all clinic respondents (n = 138 [60.8%]) reported that > 50% of their clients used tick- and flea-preventative products. Of the 188 (90.3%) clinic respondents who recommended vaccination against borreliosis, 34 (16.3%) routinely recommended vaccination for all dogs in the practice, 117 (55.9%) recommend vaccination for dogs with unusual risk factors (eg, travel to a highly endemic region to go deer hunting), and 37 (17.7%) recommended vaccination at the client's request.

**Discussion**

Results of the survey indicated that veterinarians' perceptions related to transmission of borreliosis in North Carolina varied widely across geographic regions of the state. A higher proportion of responding veterinarians believed that borreliosis is endemic in the coastal plains (67.2%) and Piedmont (60.9%) areas of North Carolina, compared with the mountain region (37.5%). These results correspond to current distribution maps of established populations of *I. scapularis* in North Carolina, which categorize the western regions of the state as unable to support *I. scapularis* populations.6 Additionally, the recent expansion of populations of *I. affinis* infected with *B. burgdorferi* in the coastal plains area may have contributed to a belief of heightened risk in that region. Although it is suggested that *I. affinis* rarely bite humans and therefore are seldom implicated in transmission to humans, reports12,13,14 indicate that *I. affinis* may play a more important role than *I. scapularis* in the maintenance of the enzootic cycle of *B. burgdorferi*; therefore, overlapping populations of these arthropod vectors may have important implications for the amplification, transmission, and spread of *B. burgdorferi*, particularly in southern states where such overlap is more common.12

Current spatial predictions of risk indicate the expansion of borreliosis into an area in the northern coastal plains of North Carolina and define the coastal plains as transitional areas for borreliosis expansion, which are areas that cannot be defined as high or low risk on the basis of the probability of infected nymphs within the area.15 Furthermore, Wake County, a central county in the Piedmont region, was declared endemic for human borreliosis for the first time in 2010, according to CDC case standards.18 The media attention surrounding the human cases of borreliosis in the coastal plains and Piedmont regions may have contributed to the high proportion of clinic respondents in those regions who believed that borreliosis is endemic, or is becoming endemic, in North Carolina.19

Three variables were also found to vary significantly between the northern and southern regions of the state, including the estimated number of canine borreliosis cases diagnosed in the past year at each participating clinic, the perception of borreliosis endemicity, and the perception related to the possibility of a dog acquiring borreliosis in the state. Historically, Virginia, which shares its southern border with North Carolina, has been considered to be a state of intermediate to low risk for borreliosis. However, according to the CDC, the incidence of borreliosis in Virginia has increased in recent years from 3.6 cases/100,000 persons in 2005 to 11.4 cases/100,000 persons in 2010.20 Additionally, in 2011, Virginia had declared roughly two-thirds of its counties endemic for borreliosis, including 5 along the Virginia-North Carolina border.19,21 Recent studies12,13 confirm the expansion of *I. affinis* beyond the North Carolina border and into southeastern Virginia. Because *I. affinis* plays a more important role than *I. scapularis* in the maintenance of the enzootic cycle of *B. burgdorferi*, the expanding distribution of this tick vector may contribute to further amplification and spread of *B. burgdorferi* throughout Virginia. The expanding range of borreliosis within Virginia may subsequently influence the perceptions of veterinarians in the northern regions toward a heightened perception of risk of borreliosis.

Despite increasing reports of borreliosis in North Carolina, the presence of borreliosis throughout the southeastern United States has been a highly controversial issue for more than a decade.22,23 A borreliosis-like syndrome in humans known as STARI is prevalent throughout the southeastern United States and is known to be transmitted by the lone star tick (*Amblyomma americanum*). The clinical signs and symptoms of STARI are similar to those of borreliosis, including an erythema migrans–like rash, fever, and muscle and joint stiffness.22–24 The recognition of STARI, in conjunction with northward movement of *A. americanum*, has led to difficulties in differentiating the 2 diseases, making accurate reporting difficult, and has further complicated accurate diagnosis and treatment of borreliosis versus STARI. Studies have failed to identify any specific microorganism as the cause of STARI. Although the pathogen *Borrelia lonestari* was initially associated with this illness, more recent evidence fails to support this association.26

Use of the C6 peptide in the commercial in-house ELISA has resulted in a highly sensitive and specific commercial enzyme immunoassay used for in-house detection of antibodies against *B. burgdorferi* in blood, serum, or plasma. The titer of antibodies against the C6 peptide correlates with the number of infecting *Borrelia* organisms in dogs.27 Additionally, the C6 peptide is not found in sera of dogs that have received commercially available *B. burgdorferi* vaccines.28 In addition to detection of antibodies against *B. burgdorferi*, the commercial in-house ELISA detects *Dirofilaria immitis* antigen, anti-Ehrlichia canis antibodies, and antibodies against...
Anaplasma phagocytophilum. Therefore, veterinarians can use an in-house test kit to test for exposure to 4 vector-borne infections in dogs. In the context of the use of dogs as sentinel for human borreliosis, serologic cross-reactivity occurs among Borrelia spp as well as Leptospira spp with a conventional indirect fluorescent antibody test; however, the commercial in-house ELISA kit provides 96% sensitivity and 100% specificity for detection of anti-B burgdorferi C6 peptide antibody. Therefore, the results of the present study would be minimally influenced by cross-reactive antibodies, prior vaccination against B burgdorferi, or exposure to A americanum that could potentially transmit STARI. It is unlikely that veterinary clinicians would misinterpret commercial in-house ELISA B burgdorferi results and subsequently overestimate the potential risk of borreliosis in their canine patient population.

Although 512 invitations to participate in the survey were sent out, only 208 were returned. Current contact information for some veterinary clinics was not available. Additionally, the number of missing responses varied significantly among the 3 eastern-western regions. Because of the limited sample size and high nonresponse rate, results of the survey may have been subject to selection bias. Veterinarians who responded to the survey may have had different impressions regarding the presence of borreliosis in North Carolina, compared with veterinarians who did not respond. Survey instructions indicated that the most senior veterinarian in each clinic should be the respondent, but this was not confirmed. Different veterinarians in each clinic may also have had different impressions pertaining to borreliosis in North Carolina. Subsequently, results of the survey may not have reflected all veterinarians’ perceptions of borreliosis in North Carolina.

In addition, this survey did not obtain specific test results or demographic information such as travel history for individual dogs in each clinic; therefore, no assumption could be made about the specific demographics or travel history for individual dogs. All canine health-related information obtained from the surveys was based on information obtained from the owner and the veterinarian’s perception of the dog’s health status. Therefore, it is possible that responses may have been subject to recall bias. Additionally, C6 peptide-positive dogs may have been exposed to B burgdorferi outside of North Carolina. We attempted to assess the proportion of the clinic’s clients that acquired borreliosis within North Carolina instead of traveling to a borreliosis endemic area. Although it is unlikely that the responding veterinarian was aware of every client’s detailed travel history, the influence of travel history likely had only a marginal effect on the results.

Results of previous studies suggest that dogs may serve as an appropriate sentinel for the risk of borreliosis in the eastern United States, and it has been reported that dogs are approximately 6 times as likely to be infected with B burgdorferi as humans because of more frequent environmental exposure to ticks. Because approximately 95% of infected dogs remain without clinical signs following infection with B burgdorferi, routine screening of healthy dogs for anti-B burgdorferi antibodies is an essential component of sentinel surveillance of borreliosis. Because erythema chroni-
cum migrans has not been reported in dogs, there is no accepted case definition for borreliosis in dogs. A majority of veterinarians (76.1%) surveyed responded that they test healthy dogs for routine surveillance of B burgdorferi exposure or perform testing in conjunction with routine heartworm testing (15.7%) when clinical signs of borreliosis are not present. Continued education of veterinarians regarding the potential threat of borreliosis in North Carolina could potentially result in increased use of the ELISA for routine surveillance and also increase the number of veterinarians participating in the company’s voluntary, passive reporting system for the surveillance of blood-borne pathogens. Because veterinarians have an easy-access and cost-effective method for routine surveillance of B burgdorferi exposure in dogs through screening for the C6 peptide, sequentially obtained canine surveillance data should provide a more complete picture of borreliosis risk for dogs and humans in North Carolina. The present study revealed that veterinarians’ perceptions of risk of borreliosis in North Carolina was consistent with current scientific reports pertaining to borreliosis expansion and transmission in the state. Understanding veterinarians’ perceptions of the epidemiological features of borreliosis will give insight into why they may or may not choose to use the ELISA or continue to participate in the passive reporting system. Identification of these factors can be used to create more targeted educational efforts to promote the routine testing of dogs for surveillance efforts across the state. As the epidemiological features of borreliosis in North Carolina continue to be determined, veterinarians should promote routine testing of dogs for borreliosis as a simple, inexpensive form of surveillance to better educate their clients on the threat of borreliosis. Although this study focused on North Carolina veterinarians and their perceptions, the results should have relevance for veterinarians and public health officials in other regions of B burgdorferi expansion. As with many vector-borne infections, a one-health approach to surveillance and disease prevention should benefit animal and human health.

References


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