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STANDARD ARTICLE

Assessing knowledge, attitudes, and practices of Canadian veterinarians with regard to Lyme disease in dogs

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Abstract

Background: The blacklegged tick (BLT) is a vector for the bacterium *Borrelia burgdorferi* (Bb), which causes Lyme disease. Range expansion of the BLT in Canada is related to an increased risk of Lyme disease in many regions. Current literature, such as the 2018 American College of Veterinary Internal Medicine consensus statement, suggests that there may be differences in the approaches of veterinarians who encounter dogs exposed to Bb and dogs with Lyme disease.

Objectives: To determine current knowledge, attitudes, and practices of Canadian veterinarians regarding Lyme disease in dogs.

Animals: None.

Methods: An online survey was distributed to Canadian veterinarians through veterinary associations and industries. Survey responses were analyzed using descriptive statistics, spatial analysis, Fisher's exact tests, and univariable logistic regression.

Results: At the completion of the survey, 192 responses were received from veterinarians practicing in all 10 Canadian provinces. Answers to short scenario and treatment questions reflected a wide variety of clinical approaches taken by veterinarians. Regional differences were seen in reported tick distribution and clinical approaches.

Conclusions and Clinical Importance: Regional differences and generalized differences were found in approaches used by responding Canadian veterinarians with regard to managing Bb exposure and Lyme disease in dogs. We identified areas for future research and knowledge mobilization for veterinarians.

KEYWORDS
blacklegged tick, *Borrelia burgdorferi*, canine vector-borne disease, veterinary best practices

1 | INTRODUCTION

In Canada, the blacklegged tick (BLT), *Ixodes scapularis*, and the western BLT, *Ixodes pacificus*, are vectors for the bacterium *Borrelia burgdorferi* (Bb).[1,2] This bacterium is the causative agent of Lyme disease, which affects dogs, humans, and horses.[3,4] Over the past decade in Canada, BLT range expansion and an increase in Bb seropositivity in dogs have occurred.[5,6] Established BLT populations now exist in portions of Manitoba, Ontario, Quebec, Nova Scotia, and New Brunswick.[2,7] Western BLTs are found in southern and coastal British Columbia.[2,8] A high (>5%) seroprevalence for Bb in dogs has been noted in areas of southern Manitoba, eastern Ontario, southern Quebec, Nova Scotia, and New Brunswick.[5,6]

Abbreviations: ACVIM, American College of Veterinary Internal Medicine; Bb, *Borrelia burgdorferi*; BLT, blacklegged tick; CI, confidence interval; OR, odds ratio.

Common clinical signs of Lyme disease in dogs include shifting limb lameness, fever, and decreased food intake.[4] In rare cases, a potentially fatal protein-losing nephropathy, or Lyme nephritis, has been documented.[9,10] Several qualitative and quantitative serological tests detect antibodies to Bb, but they can only identify exposure to the bacterium, and results do not correlate directly with disease.[9] Because antibody titers can remain high for many months, it is difficult to determine when the dog was exposed to Bb.[11] Indeed, <10% of dogs seropositive for Bb antibodies develop clinical signs consistent with Lyme disease.[12] However, some studies have detected joint abnormalities at necropsy in dogs that were exposed to Bb, but lacked other overt clinical signs.[13,14] In dogs seropositive for Bb, urinalysis can serve as a preliminary screen for urinary protein loss and concern of Lyme nephritis, but urinalysis results are nonspecific.[9,15] Tick prevention products are the foundation of protection against transmission of tick-borne pathogens, including Bb.[9] Several Bb vaccines are available, but the efficacy of some vaccines currently is unclear.[9,16]

The 2018 American College of Veterinary Internal Medicine (ACVIM) consensus update on Lyme borreliosis in dogs and cats is a publication by veterinary experts in the field of Lyme borreliosis.[9] The goal of this updated statement was to summarize current knowledge as well as provide information on best practices.[9] The ACVIM statement identified consensus on some topics, but not others.[9] For example, panelists agreed that screening of healthy dogs that live in or near areas where Bb is endemic should be carried out.[9] However, consistent consensus recommendations do not exist for vaccination of dogs against Bb or antimicrobial treatment of dogs seropositive for the bacterium, but not exhibiting clinical signs.[9]

Our objective was to determine the methods and strategies used by Canadian veterinarians to identify and treat Lyme disease in dogs. With rapid changes in BLTs and Lyme disease in dogs in Canada, Canadian veterinarians have had to quickly adapt and develop their own best practices to manage Lyme disease in dogs. The breadth of approaches taken currently is unknown, and better understanding will help direct future research and knowledge mobilization efforts. We hypothesized geographical trends in survey responses would exist because geographic differences exist in tick populations and tick infection prevalence,[1,2,5,6] thus affecting the experience of veterinarians in dealing with Lyme disease in dogs.

2 | METHODS

2.1 | Online Survey

We utilized a survey for data collection (Appendix 1). It consisted primarily of multiple-choice questions, which covered demographic information, clinical experience and approaches regarding ticks and Lyme disease in dogs, and future educational needs. Four different clinical scenarios also were provided, and respondents were asked to outline their plans of action. The survey was made available in both French and English. Only Canadian veterinarians were permitted to complete the survey. This research was approved by the University of Guelph's Research Ethics Board (REB#19-02-029).

The survey was formatted using the Qualtrics software and was available from 6 June 2019 to 8 July 2019 (Version May 2019, Qualtrics, Provo, UT, 2019, https://www.qualtrics.com). It was sent to the national and all 10 provincial veterinary medical associations, as well as the Ontario Animal Health Network. The national association and 3 provincial associations (Saskatchewan, Manitoba, and Newfoundland and Labrador) confirmed that the survey was distributed to veterinarians in their contact list, and the Ontario Animal Health Network replied that it was distributed for review. The remaining associations did not reply, but may have distributed the survey to their network. Three industry groups (Merck Animal Health [Kirkland, QC], Zoetis [Kirkland, QC], and Boehringer Ingelheim [Burlington, ON]) distributed an information poster with the link to the survey to their veterinary clinic contacts via email and by in-person visits. Clinics enrolled in other studies currently being conducted by the investigators also were sent the survey.

Although our study was predominately for descriptive purposes and hypothesis generation, we intended to conduct comparisons among groups, and thus completed a sample size calculation.[17] To detect a difference of 40% between respondents in 1 province compared with the remaining provinces, with an alpha of 0.05 and power of 0.80, we would need 20 respondents per province for a total of 200 respondents.

2.2 | Descriptive statistics

Descriptive statistics in the form of counts and prevalence were calculated for each survey question to provide a summary of the responses.

2.3 | Spatial analysis

Spatial analysis was conducted to assess the frequency of tick sightings on dogs in the respondents' areas in each of the 4 seasons. The veterinarians were asked to rate the frequency of tick sightings on a scale from all of the time to rarely. Responses were geocoded using the centroid of the respondents' provided forward sortation addresses (FSAs). Mapping was done using the QGIS software (Version 3.4.15, QGIS Development Team, 2020, http://qgis.org), with vector layers accessed through University of Guelph's Scholars GeoPortal (Scholars Geoportal, 2020, http://geo1.scholarsportal.info). Some points were adjusted slightly if the FSA centroid was located in water or if responses directly overlapped. Only 186 respondents provided a forward sortation address, therefore only 186 of the total 192 collected responses were mapped. The responses then were assessed to identify geographic trends.

2.4 | Statistical analysis

Univariable logistic regression was performed using STATA (Version 14.2, STATACorp, College Station, TX, 2018, https://www.stata.com) to examine potential regional differences.[18] To perform the test, data were transformed into binary data by grouping the responses into categories with other responses that were the most similar. The dependent variable was the veterinarian's response to the clinical and resource-related questions. The independent variable was geographic region. If we reached our target sample size per province, then province was used as the geographic region. If sample size was low, responses were grouped into regions (west, British Columbia, Alberta, and Saskatchewan; central, Manitoba, Ontario, and Quebec; east, Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland and Labrador). Fisher's exact test and 95% confidence intervals (CI) were generated using the R software (Version 3.6.1, R Core Team, Vienna, Austria, 2019, https://www.R-project.org) to compare different clinical approaches (outcome) between respondents who lived in areas with established BLT populations (exposure positive) to those who did not (exposure negative).[18] A significance level (α) of .05 was used for all analyses.

3 | RESULTS

3.1 | Respondent population

In total, 194 surveys were received. However, 2 surveys were excluded because they were not completed by veterinarians, leaving 192 completed surveys. All 10 provinces were represented, with Ontario being the most represented province (93 of 192 responses; 48.4%; Table 1). Most respondents were small animal practitioners (172 of 192; 89.6%) and approximately half of respondents had been in practice for >15 years (97 of 192; 50.5%).

TABLE 1 Demographic information collected from respondents concerning their role in veterinary practice, length of time in practice, and the province in which their clinic is located

Parameter	Number of respondents	Percentage of respondents
Practitioner type	192	
Small animal practitioner	172	89.6
Mixed animal practitioner	17	8.9
Other (researcher/professor/clinic owner)	3	1.6
Length of time in veterinary practice	192	
<1 year	7	3.6
>1-5 years	37	19.3
>5-15 years	51	26.6
>15 years	97	50.5
Province	192	
Alberta	11	5.7
British Columbia	15	7.8
Manitoba	21	10.9
New Brunswick	4	2.1
Newfoundland and Labrador	8	4.2
Nova Scotia	21	10.9
Ontario	93	48.4
Prince Edward Island	8	4.2
Quebec	4	2.1
Saskatchewan	6	3.1
Not specified	1	0.5

3.2 | Clinical experience

The frequency with which veterinarians see ticks on dogs varied by season and geographic area (Figure 1). In the western provinces, ticks were most frequently reported to be seen all of the time or regularly in the spring (17 of 30; 56.7%) and summer (13 of 30; 43.3%) compared to the fall (4 of 30; 13.3%) and winter (0 of 30; 0%). In the central provinces, ticks were seen all of the time or regularly in the spring (73 of 116; 62.9%), summer (49 of 116; 42.2%), and fall (53 of 116; 45.7%). Winter (3 of 116; 2.6%) was not a commonly reported season for tick sightings in this region. In the eastern provinces, ticks were seen frequently in the spring (22 of 40; 55.0%), summer (21 of 40; 52.5%), and fall (21 of 40; 52.5%), but not in the winter (4 of 40; 10.0%). Across Canada, a higher number of respondents reported rarely seeing ticks on dogs in the winter (120 of 186; 64.5%) or did not answer the question (23 of 186; 12.4%).

The majority of respondents reported that ≤5% of dogs in their practice area were seropositive for Bb (123 of 190; 64.7%), yet most believed the seroprevalence of Bb had increased over the past 5 years (122 of 190; 64.2%), and that BLTs are established in their area (118 of 190; 62.1%; Table 2). The odds of a respondent reporting that BLTs were established in their practice area was lower in the western region (odds ratio [OR], 0.0714; 95% CI, 0.0249, 0.205; $P < .001$) compared to the central region (referent). No difference was noted between the eastern region and the central region (Table 3A).

Respondents from the western region were less likely to report a Bb seroprevalence of ≥1% compared to the central region (OR, 0.0357; 95% CI, 0.00459, 0.277; $P = .001$; Table 3B). Additionally, the odds value of a respondent reporting that Bb seroprevalence had increased in their practice area was lower in the western region compared to the central region (OR, 0.118; 95% CI 0.0389, 0.358; $P < .001$; Table 3C). No significant differences were detected between the eastern and the central regions.

The majority of respondents (151 of 180; 83.9%) reported diagnosing ≤5 cases of clinical Lyme disease in dogs in the past year. Nearly half of respondents (88 of 190; 46.3%) reported that the number of cases they diagnosed had increased over the past 5 years. The majority of survey respondents reported rarely or never seeing dogs with clinical signs consistent with the classical presentation of Lyme disease (161 of 191; 84.3%). When asked to list other clinical signs that they have seen and believed were associated with Lyme disease, the most common responses related to renal function. Nephritis (including Lyme nephritis and glomerulonephritis) was mentioned (15 of 74; 20.3%), as were

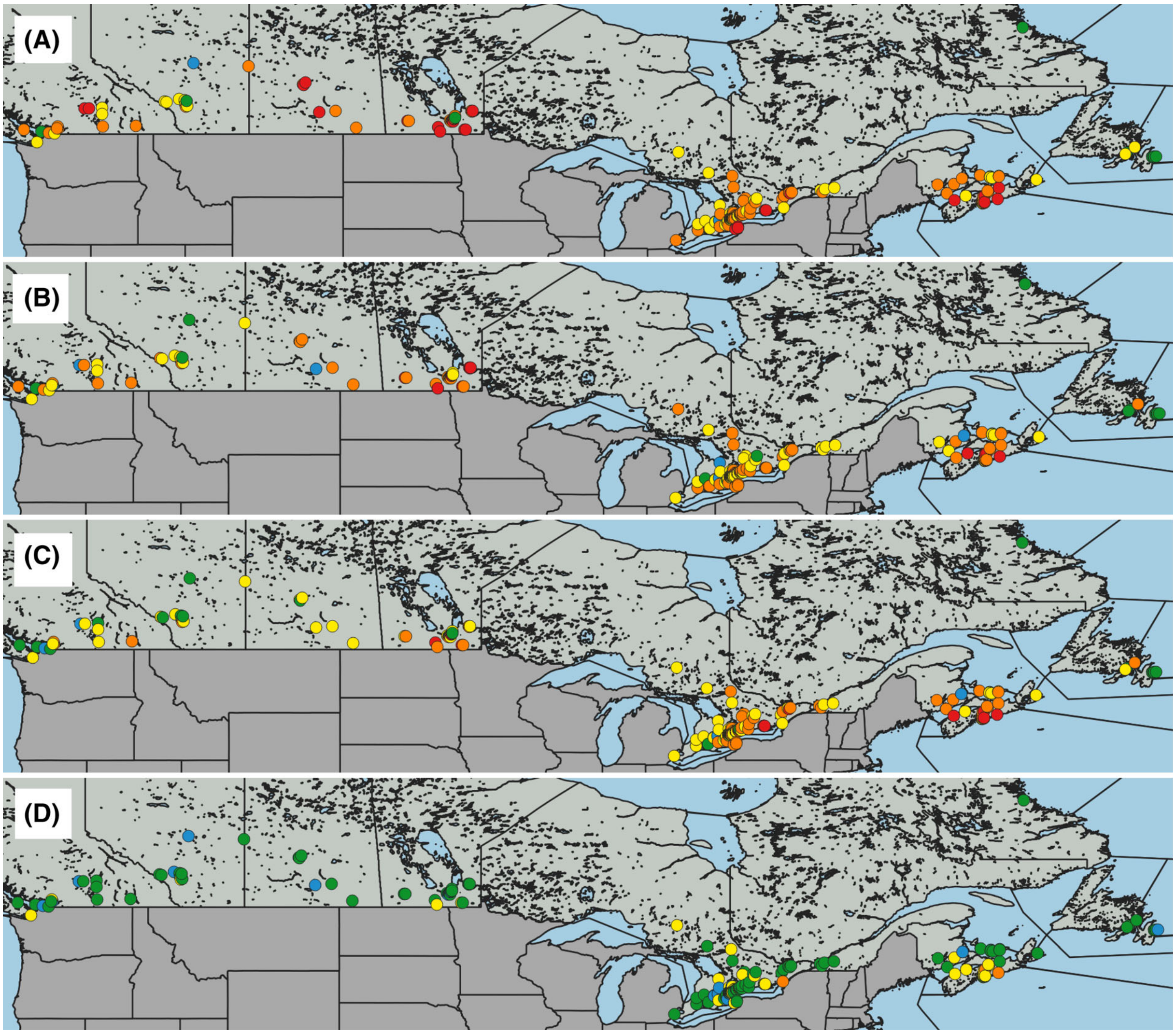

FIGURE 1 Canadian veterinarians' (n = 186) experience with tick encounters in Spring (A), Summer (B), Fall (C), and Winter (D). The frequency of ticks seen in practice ranged from all the time/daily basis (red dot), regularly/weekly basis (orange dot), occasionally/monthly basis (yellow dot), and rarely (green dot). Some respondents did not provide data for every season (blue dot). These maps were generated using the QGIS software (Version 3.4.15, QGIS Development Team, 2020, http://qgis.org). Vector layers were accessed through University of Guelph's Scholars GeoPortal (Scholars Geoportal, 2020, http://geo1.scholarsportal.info)

other types of nephropathy, general renal disease and renal failure, and renal changes and damage (25 of 74; 33.8%). Urinary signs, such as proteinuria, also were mentioned (10 of 74; 13.5%).

3.3 | Clinical approaches

When asked about responses to tick bites, approximately half of respondents (96 of 191; 50.3%) reported that they would identify the tick in-clinic with the majority of these respondents (74 of 96; 77.1%) rating their tick identification skill level as average (average being described as ability to differentiate American dog ticks from BLTs). One-fifth (39 of 191; 20.4%) of respondents stated they would not proceed with further examination of a tick. The majority of those respondents (37 of 39; 94.9%) elaborated on their reasoning for this decision. The most common responses included that they felt they did not have sufficient training for tick identification (16 of 37; 43.2%), doing so incurred financial costs (10 of 37; 27.0%), it was challenging to find time for tick identification (9 of 37; 24.3%), and they did not believe there was clinical value in tick identification (8 of 37; 21.6%). Differences in reported BLT pathogen testing frequency also were reported among survey respondents, with variable numbers reporting always (36 of 187; 19.3%), sometimes (82 of 187; 43.9%), and never (69 of 187; 36.9%) having the ticks tested. Veterinarians who said they sometimes or always tested the ticks were asked what they would do if the tick that was removed from the dog was positive for Bb. The most common responses were to prescribe 4 weeks of antibiotics (32 of 109; 29.4%) or to not prescribe antibiotics at all (23 of 109; 21.1%). A subset of respondents (20 of 109; 18.3%) stated that they would monitor the dog for clinical signs.

TABLE 2 Respondent-reported canine seroprevalence for *Borrelia burgdorferi* and tick distribution in their practice area

	Number of respondents	Percentage of respondents
Annual prevalence of dogs in their practice that are seropositive for exposure to *Borrelia burgdorferi* is approximately	190	
<1%	69	36.3
1-5%	54	28.4
>5-20%	15	7.9
>20%	2	1.1
I do not know	50	26.3
Over the past 5 years, the prevalence has	190	
Increased	122	64.2
Decreased	4	2.1
Stayed the same	28	14.7
I do not know	36	18.9
Within their practice area, blacklegged ticks are	190	
Established—the area is classified as a "risk area" or "endemic"	118	62.1
Sporadically introduced on migratory birds or other mammals (ie, adventitious)	40	21.1
Nonexistent	6	3.2
Do not know	26	13.7

With regard to screening testing, 41.0% (77 of 188) of respondents reported that >50% of dogs in their practice are tested for Bb, and 25.0% (47 of 188) reported that only dogs with clinical signs consistent with Lyme disease are tested. Of the respondents who reported they were practicing in established BLT areas, 47.5% (56 of 118) reported testing >50% of dogs, and 19.5% (23 of 118) reported testing only dogs with clinical signs consistent with Lyme disease. Of the 187 respondents who answered both the question about tick establishment in their area and the question about screening testing, the odds of testing >50% of dogs was significantly higher if the respondent lived in an area with an established BLT population compared with respondents who did not (OR, 2.06; 95% CI, 1.06, 4.09; *P* = .031).

If a dog was positive on a qualitative serological testing (eg, SNAP 4Dx Plus [IDEXX Laboratories, Markham, ON], AccuPlex4 [Antech Diagnostics, Mississauga, ON]), the most common next-step responses were to conduct a urinalysis to assess for proteinuria (104 of 177; 58.8%), or to run a quantitative serological assay (eg, Lyme Quant C6 [IDEXX Laboratories, Markham, ON]) (70 of 177; 39.5%). A small percentage of respondents said they would conduct no further testing (18 of 177; 10.2%). If a dog was positive on an antibody screening test, the most popular management options were to

TABLE 3 Univariable logistic regression examining geographic patterns in survey responses

Region	A. OR (CI)	*P*-value	B. OR (CI)	*P*-value	C. OR (CI)	*P*-value	D. OR (CI)	*P*-value	E. OR (CI)	*P*-value
West (British Columbia, Alberta and Saskatchewan)	**0.0714 (0.0249, 0.205)**	**<.001**	**0.0357 (0.00459, 0.277)**	**.001**	**0.118 (0.0389, 0.358)**	**<.001**	**3.77 (1.45, 9.79)**	**.006**	**0.0378 (0.0130, 0.110)**	**<.001**
East (Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland and Labrador)	0.526 (0.221, 1.25)	.15	0.746 (0.290, 1.92)	.54	0.626 (0.231, 1.70)	.36	1.95 (0.738, 5.13)	.18	0.842 (0.339, 2.09)	.71
Central (Manitoba, Ontario and Quebec)	Referent		Referent		Referent		Referent		Referent	

Note: The independent variable was region, and the dependent variables are listed. Significant results are presented in bold. A represents status of blacklegged tick populations in veterinarian's practice areas. The dichotomous-dependent variable was an established blacklegged population compared with blacklegged ticks that are sporadically introduced or nonexistent in that area. B represents examining current canine seroprevalence for *Borrelia burgdorferi*. The dichotomous-dependent variable was an annual seroprevalence of 1% or greater compared with an annual seroprevalence of <1%. C represents examining change in canine seroprevalence for *B burgdorferi* over the past 5 years. The dichotomous-dependent variable was an increase in canine seroprevalence compared with seroprevalence that has decreased or stayed the same. D represents Bb vaccination usage. The dichotomous-dependent variable was never recommending *B burgdorferi* vaccination compared with occasionally or always recommending *B burgdorferi* vaccination. E represents comfort level with diagnosing and treating canine Lyme disease. The dichotomous-dependent variable was uncomfortable or unsure when treating canine Lyme disease compared with very comfortable or somewhat comfortable treating canine Lyme disease.

TABLE 4 Respondents were encouraged to outline their action plan for the 4 scenarios presented

	Number of respondents	Percentage of respondents
Scenario 1: A dog presents to the clinic with an attached and engorged blacklegged tick.	172	
Remove the tick	149	86.6
Test the tick	74	43.0
Discuss canine Lyme disease with owner and monitor for clinical signs	69	40.1
Discuss tick prevention with owner	79	45.9
Schedule future qualitative *Borrelia burgdorferi* serological test (>3 weeks later)	103	59.9
Scenario 2: A dog presents to the clinic for its annual exam and tests seropositive for exposure to *B burgdorferi*. The owner has not seen any clinical signs of Lyme disease.	171	
Discuss canine Lyme disease with owner and monitor for clinical signs	80	46.8
Discuss tick prevention with owner	38	22.2
Perform a urinalysis	93	54.4
Administer a quantitative *B burgdorferi* serological test	52	30.4
Administer antibiotics	39	22.8
Scenario 3: A dog presents to the clinic with a 2-week history of shifting lameness.	173	
Conduct a physical exam	68	39.3
Administer a qualitative *B burgdorferi* screening test	143	82.7
Administer a CBC and Biochemistry panel	59	34.1
Perform radiographs	64	37.0
Administer antibiotics	57	32.9
Scenario 4: A dog presents to the clinic with polyuria, polydipsia, lethargy, and vomiting. Biochemistry reveals elevated urea and creatinine. Testing is positive for *B burgdorferi*.	168	
Hospitalize and administer IV fluids	70	41.6
Perform a urinalysis	72	42.9
Administer a quantitative test	33	19.6
Treat for renal disease/failure	45	26.8
Administer antibiotics	104	61.9

Note: Since respondents were able to write out multiple steps for each question, the sum of the percentages mentioned do not add up to 100% for each question. Only the top 5 responses to each scenario question are shown. The responses are arranged in the order that was most commonly reported by respondents. Some steps may be performed in a different order, or done concurrently, in practice.

discuss tick prevention products (143 of 177; 80.8%) and Bb vaccination (92 of 177; 52.0%) with the dog owner and monitor for clinical signs (126 of 177; 71.2%). One-third of respondents reported they would treat with antibiotics in the absence of clinical signs of Lyme disease (59 of 177; 33.3%).

The majority of respondents (164 of 182; 90.1%) reported that they discuss ticks and tick-borne disease with their clients routinely as part of the annual examination. Approximately half of veterinarians recommend tick prevention for all dogs for part of the year (93 of 182; 51.1%). Respondents' definitions of part of the year varied, but a general trend across Canada of not recommending tick prevention in January (recommended by 0 of 85 respondents; 0%) and February (2 of 85; 2.4%) was observed. There was variability in Bb vaccination recommendation, with 56.9% (103 of 181) of respondents reporting that they recommend Bb vaccination as a non-core vaccination based on the lifestyle of the dog and 17.1% (31 of 181) of respondents reported that they never recommend these vaccines. The odds of a respondent never recommending Bb vaccination were higher in the west (OR, 3.77; 95% CI, 1.45, 9.79; P = .006) when compared to the central region (Table 3D).

3.4 | Scenarios

Respondents were presented with 4 scenarios outlining situations that they may encounter in practice and were asked to provide a brief description of their approaches. For each question, at least 5 common steps were outlined by ≥19% of respondents (Table 4). A wide variety of responses to the scenario questions was seen. In 3 of the 4 scenarios, administering antibiotics, most commonly doxycycline, was mentioned as 1 of the top 5 responses. Also, having a discussion with the owner about clinical signs and tick prevention appeared in multiple scenario responses, as did performing a qualitative serological test. Owner consent frequently was mentioned as a factor in determining management plans, and therefore the steps described did not imply this approach would always be followed in practice by the veterinarian.

3.5 | Resources

When asked about comfort level in diagnosing and treating Lyme disease, the majority of respondents felt somewhat comfortable or very comfortable (137 of 174; 78.7%). Respondents from the west were more likely to report that they were uncomfortable or unsure when diagnosing and treating Lyme disease when each province was compared to the rest of Canada (OR, 0.0380; 95% CI, 0.0130, 0.110; $P < .001$; Table 3E).

Respondents identified a variety of areas for which more information would be helpful, with the top 3 areas being treatment best practices (149 of 173; 86.1%), diagnostic best practices (135 of 173; 78.0%), and current Lyme disease risk (107 of 173; 61.8%). Respondents reported finding most of their information on Lyme disease in dogs from the Veterinarian Information Network (134 of 174; 77.0%), conferences (96 of 174; 55.2%), and ACVIM consensus statements (67 of 174; 38.5%).

4 | DISCUSSION

The distribution of ticks and tick-borne diseases in Canada has changed rapidly over the past decade and continues to evolve.[19] This changing landscape has presented many challenges to Canadian veterinarians—from creating evidence-based recommendations for tick prevention to determining appropriate testing and treatment protocols. Our study provides a snapshot of the current practices of respondent veterinarians in Canada and emphasizes key areas for knowledge mobilization and future research.

The frequency with which respondent veterinarians reported encountering ticks is consistent with current research.[8] Respondents from western Canada noted that spring and summer were the peak seasons for detecting ticks on dogs, which aligns with adult *Dermacentor* spp. activity (*D. andersoni* and *D. variabilis*).[8] These species are established in many western provinces.[8] Adult western BLT populations, which currently are restricted to British Columbia, also are predominately active in the spring.[8] In central and eastern Canada, respondents indicated that spring, summer, and fall are common times for ticks. Spring and early summer activity coincides with *D. variabilis* phenology, which is a common species in many areas of central and eastern Canada.[8] Additionally, BLT populations are known to be established in many areas of central and eastern Canada, and adults are highly active in spring, early summer and fall.[7,8]

Data on seroprevalence of Bb in dogs in 2008 and 2015 showed that seroprevalence remained <5% in most Canadian provinces, but did increase over time.[6] Seroprevalence in Nova Scotia and New Brunswick were the highest (>5% in 2015) with significant increases over time identified in Nova Scotia, Ontario, Quebec, and Manitoba. British Columbia experienced minimal changes.[6] The experiences of our respondents reflect these findings.

When a tick is detected, >60% of respondents indicated either always or sometimes submitting the tick for pathogen testing. Recommendations of pathogen testing of ticks have shifted over recent years in human medicine, with it no longer being encouraged as part of the clinical approach.[20,21] A positive tick test result has limited predictive value for the occurrence of disease.[20,21] Additionally, a false sense of security may result if the tick was negative, but other tick bites were not detected.[20,21] The same rationale applies to dogs and no evidence is available that treatment is indicated based on testing results. Communicating the utility of tick testing is important, especially given that a subset of respondents reported using the results to guide antibiotic treatment.

Based on the respondents, the percentage of dogs screened annually using a qualitative test was surprisingly low. Canada still has many areas that are considered low risk, which may be an explanation for this finding.[2] However, when the status of BLT populations is considered, these numbers remain low even in established areas. The ACVIM Consensus statement recommends routine screening testing because veterinarians can gain a better understanding of risk in an area and conduct enhanced monitoring for clinical signs, including renal changes.[9,22] The use of quantitative testing, on the other hand, was surprisingly high. Limited data support any predictive value of titers with clinical disease. Qualitative titers may have specific value if a dog has clinical signs, because decreasing titers may signal response of the dog to antibiotic treatment.[9]

Nonetheless, the approach after a positive Bb test result in a dog without clinical signs is not entirely clear. As the body of evidence on Lyme nephritis has continued to grow, screening of seropositive dogs for proteinuria has become strongly recommended.[9,10] Of the respondents who do routinely test, a little over half of them perform urinalysis on all seropositive dogs, which represents an opportunity to further promote this best practice among Canadian veterinarians. The majority of ACVIM panelists (4 of 6) did not recommend antimicrobial treatment for seropositive dogs without clinical signs or proteinuria.[9] Our survey results reflect that antimicrobial treatment remains an area of debate in this clinical situation. For dogs without clinical signs, most of our respondents monitor for clinical signs or perform a urinalysis, with only a subset prescribing antibiotic treatment. Additional long-term randomized control trials are needed to provide more evidence for the rationale for or against the use of antibiotics in this context. Such information is especially important given the critical need for antibiotic stewardship.

Consistent use of tick prevention and Bb vaccination were not identified among respondents, and this finding is not surprising given the Canadian context. The latitudinal and longitudinal span of Canada is vast and includes 7 climatic regions.[23] Given the impact of climate on tick distribution and activity, it is challenging, even at the provincial level, to provide uniform tick prevention recommendations.[9,24] The most recent guidelines of the Canadian Parasitology Expert Panel emphasize the importance of considering a pet's lifestyle in conjunction with known tick population distribution in determining the approach to tick prevention.[24] Additionally, a multimodal approach to tick prevention is considered optimal by many, which includes avoiding tick habitats and conducting regular tick checks.[24] Vaccinating against Bb also is mentioned, but experts are divided on the use of, and appropriate protocol for, vaccination.[9] Current regional data on tick distribution and pathogen infection prevalence would assist Canadian veterinarians with establishment of evidence-based tick and tick-borne disease prevention protocols in the clinic.

Overall, many of the respondents had considerable comfort in dealing with ticks and Lyme disease in dogs. Comfort level appeared to align with experience, because veterinarians in regions with established BLT populations and higher seroprevalence in dogs (central and east) were more comfortable than were veterinarians in lower risk areas (west).[2,6] Our results emphasize key areas on which to focus for continuing education. These include diagnostic best practices, treatment best practices, and prevention best practices. All efforts should be tailored to the geographic area of focus, given the different contexts in Canada, and efforts should continually evolve in light of the growing body of evidence on tick species invasion in Canada and tick-borne diseases in dogs, including, but certainly not limited to, Lyme disease.

5 | LIMITATIONS

Because our survey was online and distributed by email and social media, we may have created a selection bias for veterinarians who actively engage with online content. Our sample size was 192, which represents 1.5% of the estimated 12 886 veterinarians in Canada in 2019.[25] When comparing the respondent population with the provincial distribution of veterinarians in Canada, Quebec, Alberta, and British Columbia were underrepresented by >5%, and Ontario, Nova Scotia, and Manitoba were overrepresented by >5%. Response bias also may be present. Ontario, Nova Scotia, and Manitoba are some of the highest risk areas for Lyme disease in Canada, and thus veterinarians in these provinces may have higher motivation to participate and may be more experienced in dealing with Lyme disease in dogs when compared to veterinarians in other provinces.[26] For statistical analyses, survey response categories were combined to create binary responses. Doing so limited the possible comparisons that could be explored with the data. Additionally, provinces were combined into regions, which means that patterns specific to 1 province may not be apparent, especially for provinces with a smaller population or response level. Incomplete responses were also a factor, particularly when veterinarians were asked about tick sightings in the winter. We only had a "rarely" option and did not include a "never" option, and thus it is possible that respondents did not provide an answer because they did not find a suitable option. Finally, responses to scenario questions may have been based on assumptions that were not explicitly described, and thus the data may not reflect all steps in a respondent's course of action.

6 | CONCLUSION

By use of our survey, we were able to determine the methods and strategies that currently are used by Canadian veterinarians to identify and treat Lyme disease in dogs. Our results will help generate a more comprehensive understanding of the methods currently followed in practice by Canadian veterinarians. This information will aid in the synthesis of knowledge on the topic and lead to future educational outreach for veterinarians about Lyme disease in dogs. From our survey, we were able to determine where many veterinarians get their information, and as a result, we can ensure that educational tools are made available through these sources.

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CONFLICT OF INTEREST DECLARATION

J. Scott Weese, Michelle Evason, and Katie M. Clow have received speaker fees from Merck Animal Health, Vetoquinol (J. Scott Weese), Zoetis (Michelle Evason, Katie M. Clow), Boehringer Ingelheim (Katie M. Clow), and IDEXX (Michelle Evason). Katie M. Clow has developed veterinary educational material on tick identification that was sponsored by Zoetis, Boehringer Ingelheim, and Merck Animal Health, attended symposia sponsored by Merck Animal Health and Boehringer Ingelheim, and has research funded by Merck Animal Health, Zoetis, and Boehringer Ingelheim. Michelle Evason has developed educational materials on infectious disease (including Lyme-borreliosis) sponsored by Merck Animal Health, and has received research support from Zoetis and IDEXX. The authors declare that this research was not influenced by these relationships.

OFF-LABEL ANTIMICROBIAL DECLARATION

Authors declare no off-label use of antimicrobials.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) OR OTHER APPROVAL DECLARATION

Authors declare no IACUC or other approval was needed.

HUMAN ETHICS APPROVAL DECLARATION

Approved by the University of Guelph's Research Ethics Board (REB#19-02-029).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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