Knowledge, attitudes, and practices of British Columbia veterinary professionals regarding ticks, tick-borne diseases, and passive surveillance systems

by

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Abstract

Introduction: Tick populations are expanding in Canada, bringing an increased risk of tick-borne diseases (TBDs). Little is known about how British Columbia (BC) veterinary professionals handle ticks and their engagement with passive surveillance programs.
Methods: BC veterinary professionals were surveyed about ticks, TBDs, and passive surveillance systems. BC passive surveillance data was also collected and analyzed.
Results: Vet professionals lacked awareness of endemic tick species. Most vets felt they had an average ability to identify species, and most did their own ID. They were more likely to engage with passive surveillance systems when they are free. Lyme disease was the top TBD vet professionals wanted more information about.
Conclusion: We recommend tick ID guides be provided to veterinary clinics in BC. Knowledge translation of passive surveillance to vet professionals should be prioritized to capture tick populations as well as present and emerging TBDs in the changing climate in BC.

Keywords: ticks, tick-borne diseases (TBDs), Lyme disease, passive surveillance, knowledge translation, veterinary, British Columbia (BC), climate

Dedication

To my grandpa, who’s heart is so part of mine, I’m not sure how much of it really belongs to me anyways.

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Chapter 1. Introduction

1.1. Thesis outline

The objectives of this thesis are to assess the knowledge, attitudes, and practices (KAP) of veterinarians and veterinary technologists/technicians (vet techs) in British Columbia (BC) regarding ticks, tick-borne diseases (TBDs), and passive surveillance systems. The first chapter will provide a rationale for the research topic and background information on ticks, TBDs, and passive surveillance in BC. Chapter 2 is a rapid review of KAP research about ticks in veterinary settings. Chapter 3 includes the methodology for the survey questionnaire of BC veterinarians and vet techs and the methods/acquisition of the historical tick passive surveillance data available for BC. Chapter 4 provides the results of these data collection efforts. Lastly, Chapter 5 is a discussion of the survey results and passive surveillance data, which reflects on the findings, explores future directions, and discusses limitations.

1.2. Ticks and tick-borne diseases in BC

Ticks are ectoparasites that require bloodmeals on vertebrates to complete their lifecycle which means they can negatively affect humans and animals (Kocan, de la Fuente, & Coburn, 2015). Many tick species are medically relevant such as *Ixodes scapularis*, *Amblyomma americanum* and *Dermacentor variabilis*, because of their ability to transmit pathogens to humans and animals that can lead to Lyme disease, monocytic ehrlichiosis, Rocky Mountain spotted fever and more (Sonenshine & Roe, 2014). There are several ticks that vector the causative agent of Lyme disease, *Borrelia burgdorferi*, around the world but the most prominent one in central and Eastern North America is *I. scapularis* (Ogden, Lindsay, Morshed, Sockett, & Artsob, 2009). Whereas the tick that is mainly responsible for vectoring *B. burgdorferi* to humans in Western North America, and particularly in BC is *Ixodes pacificus* (Morshed et al., 2021). Lyme disease is also the most common tick-borne disease in BC and North America (British Columbia Centre for Disease Control [BCCDC], 2024). Lyme disease typically presents in early stages with a bullseye rash around the bite area called erythema migrans, headaches, fever, fatigue, joint pain and possible paralysis of the face (BCCDC, 2024). If caught early, Lyme disease can be treated with antibiotics, but if not, the patient may develop more

severe neurological and joint symptoms (BCCDC, 2024). Lyme disease is not only a risk for humans but also animals including dogs (Little, Heise, Blagburn, Callister, & Mead, 2010). Dogs and humans share some of the same symptoms such as fever and arthritis (Little et al., 2010). Along with *I. pacificus*, there are many other tick species in BC which has one of the most diverse species out of all the provinces. In fact, between 2002 and 2018 there were over 22 different species submitted to the Public Health Laboratory in BC (Morshed et al., 2021). Although the most submitted species was *I. pacificus*, the second most common was *Dermacentor andersoni* (Morshed et al., 2021). The tick *D. andersoni* is a vector of the bacterium *Rickettsia rickettsii* which causes Rocky Mountain spotted fever (RMSF) in humans (Dergousoff, Gajadhar, & Chilton, 2009) but it can also be passed to other animals including dogs (Dantas-Torres, Chomel, & Otranto, 2012). Unfortunately, RMSF if left untreated can lead to death in dogs and humans (Dantas-Torres et al., 2012) but usually patients are treated with antibiotics and recover successfully (BCCDC, 2012).

Although both *I. scapularis* and *I. pacificus* are capable of transmitting *B. burgdorferi*, the pathogen that causes Lyme disease, it is important to note the differences in their region, environment and host type all play a role in their ability to transmit it effectively (R. J. Eisen, L. Eisen, Ogden, & Beard, 2016). In the West, *I. pacificus* ticks have lizard hosts that are not efficient reservoirs of *B. burgderferi*, and the lizards may be capable of ridding ticks of *Borrelia* when they are fed on (Dizon et al., 2023; R. J. Eisen et al., 2016). Thus, it is expected that transmission of *B. burgdorferi* to animals and humans may be lower in BC by *I. pacificus* compared to *I. scapularis* in Eastern Canada. The incidence rates align with the differences in transmission of *I. pacificus* in BC where in humans it is 0.37 per 100,000 population, whereas in Ontario it is much higher, over 11 per 100,000, and 60 per 100,000 population in Nova Scotia (Government of Canada, 2023b). Another species of tick that is a competent vector of *B. burgforderi* is *Ixodes angustus* which is commonly found in BC (Lindquist et al., 2016). This tick is not known to prefer biting humans, but it is a vector of importance for the causative agent of Lyme disease for animals (Lindquist et al., 2016). Due to these differences in transmission and the risk of Lyme and other TBDs, ongoing active and passive surveillance efforts will be critical in assessing areas of emerging risk for these pathogens (Wilson et al., 2022).

1.3. Monitoring methods: passive vs active surveillance in BC

Monitoring methods are important to determine the population of ticks in an area and a commonly used one is called active surveillance. The standard active surveillance method used to estimate the size of established populations is called drag sampling (Ogden, Koffi, & Lindsay, 2014). Drag sampling is simply dragging a 1 m² white flannel sheet along vegetation in an area where ticks are suspected to be, then counting the number of ticks (Clow et al., 2018a; Diuk-Wasser et al., 2012; Guillot et al., 2020; Ogden et al., 2014). This is the standard recommendation to determine if an area is high risk for contracting Lyme disease (Ogden et al., 2014). Threshold levels at which to begin more intensive tick management strategies is not clear in the literature (Stafford et al., 2017). Although it has been stated that *Ixodes* spp. tick bites and *B. burgdorferi* presence would need to be near zero to eliminate Lyme disease risk completely (Stafford et al., 2017).

In 2019, the Canadian Lyme Disease Research Network (CLyDRN) set out to standardize national sentinel tick surveillance across Canada through a recently launched project called the Canadian Lyme Sentinel Network (CaLSeN) (Guillot et al., 2020). Active surveillance via drag sampling has been completed every year in each province since CaLSeN was launched in 2019 to provide more consistent data on Lyme disease risk in regions across Canada (Guillot et al., 2020). This is an alternative to each province doing their own different protocols for active tick surveillance which would make them noncomparable to each other (Guillot et al., 2020). BC participates in the CaLSeN program and ongoing active surveillance is conducted yearly through drag sampling at multiple field sites since 2019 (Guillot et al., 2020). A disadvantage of active tick surveillance is that it is often costly and requires a lot of resources (Guillot et al., 2020). An advantage of active surveillance is that it can provide more accurate data if the methods are consistent, but a combination of both active and passive is often the best strategy (Losos, 1996).

Passive surveillance is when members of the public, medical hospitals or veterinary clinics are encouraged to send in tick specimens to health jurisdictions that they collected off animals or humans (Clow et al., 2018b; Koffi et al., 2012). This type of program has been available in BC through the BC Centre for Disease Control (BCCDC) Public Health Laboratory (PHL) since 1993 which has identified ticks and tested them for

B. burgdorferi since its inception (Morshed et al., 2021). In some cases, a high number of passive surveillance tick submissions from an area is indicative of a larger population of ticks, and sometimes that is when active surveillance is recommended (Clow et al., 2018b). For early detection of Lyme disease risk in a study done in Quebec, passive surveillance was deemed an even better indicator than active (Ripoche et al., 2018). However, it is important to be aware that passive surveillance can have selection and self-selection bias, as well as underreporting in many areas (Losos, 1996). Currently the only way to get a tick submitted to the BCCDC PHL is if the tick was found attached to a human, in which case only the physician or health professional can submit the tick, or if the tick was found on an animal, only the veterinarian can submit it (BCCDC, 2024). However, the veterinarian will be charged $65 CAD for the identification of *Ixodes* spp. ticks associated with Lyme disease as they need to test for *B. burgdorferi* (BCCDC, 2024). All non-Lyme disease associated ticks submitted to the BCCDC PHL cost the veterinarian $30 CAD (BCCDC, 2024). This cost for testing can be a major deterrent for veterinarians and animal owners to submit ticks for identification since the owners would be charged the identification and testing fee. Additionally, having to go through either a physician or a veterinarian can make the process of identifying a tick or submitting it for testing more difficult, and people may be less likely to take this route. Another passive surveillance program that used to be available to the public, healthcare providers and veterinary clinics was through the Public Health Agency of Canada (PHAC) National Microbiology Laboratory (NML) for tick species identification and pathogen testing (Nelder et al., 2021). The Chief Research Scientist of Field Studies at the NML, Dr. Heather Coatsworth, confirmed the public passive surveillance program was free for all users, and it ran from 2006 to 2021 (personal communication, January 23, 2024).). After 2021, the program was restricted to active and passive surveillance tick projects with provinces, municipalities, and researchers across Canada but not the public (personal communication, January 23, 2024).

1.4. New passive surveillance program in BC: ©eTick

A new passive surveillance program called ©eTick, funded by the Public Health Agency of Canada (PHAC), launched in Canada for all provinces and territories apart from Nunavut (©eTick, 2024). The ©eTick program is an online public platform for image-based identification and population monitoring of ticks in Canada (©eTick, 2024).

In British Columbia, ©eTick was only launched in May of 2021, and since then it has received over 2000 tick submissions visible to the public at the time of writing this, many of which have been from veterinary clinics. The introduction of ©eTick can be a great solution to some of the current hurdles preventing people from getting ticks identified. There is potential to increase participation in passive surveillance in BC using ©eTick since it is a free resource to anyone, unlike the BCCDC PHL route which has the cost to veterinarians. Another hurdle ©eTick helps overcome is the accessibility by the public. People are no longer required to go through a healthcare provider or veterinarian to get a tick identified since anyone can submit a photo to ©eTick at no cost. In some cases, the tick may also be requested to be sent in for species identification as part of research projects or when the tick is too damaged. The introduction of ©eTick across Canada is also useful for resolving the issue of not having publicly available data in every province on tick populations. The data for each province is accessible to everybody, not just health care providers, and roughly the same data is collected as public health agencies like the NML or BCCDC PHL. The data collected on ©eTick that is publicly available includes the tick species, the date and location the tick was found, the type of host (human or animal), if it was found free in the environment and if the tick could have been acquired outside the province, (©eTick, 2024).

Recently ©eTick has added a category that is not publicly available to view where the user can choose what group they best identify with such as member of the public, healthcare professional, veterinarian/vet clinic or prefer not to answer/other (©eTick, 2024). Additional data not publicly available due to privacy reasons is the residence, travel history, age and sex of the person that submitted the tick, the type of animal host (dog, cat, etc.), and whether the tick was attached to the host (©eTick, 2024). The benefits of the publicly available data are that anyone can use it to find information about tick presence in areas they live or travel to. This is especially easy to do on ©eTick's interactive public map to inform themselves about the presence of ticks in those places. The non-publicly available data can be useful for researchers and other professionals monitoring characteristics of ©eTick participants and the hosts the ticks were found on.

Another benefit of ©eTick is the rapid response the public gets with species identification. The time it takes for an ©eTick technician to identify the species and life stage of the tick for their users is less than one business day. This is much faster than it

would take for the NML or the BCCDC PHL since the ticks usually need to be mailed to the lab for identification.

A downside of ©eTick is there is no pathogen testing. All the recipient gets is the name of the tick species and the diseases associated with it. For example, if someone submitted an *I. pacificus* tick in BC, the user would receive information about the associated risk of Lyme disease and measures to take to prevent Lyme disease (ie. visiting their healthcare provider if symptoms of Lyme disease develop). Not receiving pathogen results from the tick means there is no ability to confirm a possible diagnosis using just the image.

1.5. Tick population expansion risk due to climate change

Historically, a majority of research on the ecology of Lyme disease has been done for Eastern North America, and little has been done for BC particularly (Dizon, Lysyk, Couloigner, & Cork, 2023). There are only a few studies focusing on suitable habitats of the Western Blacklegged tick (*I. pacificus*), the vector of the causative agent of Lyme disease, *B. burgdorferi,* in BC (Dizon et al., 2023). Since models are predicting that with climate change, tick species will expand their range in Canada, potentially bringing an increased risk of Lyme disease and other TBDs with them (McPherson et al., 2017), more tick surveillance is needed in BC to assess this emerging risk. Even in the most optimistic case regarding climate change, it is expected that Lyme disease risk will increase in southern Canada with the spread of *I. scapularis* ticks (McPherson et al., 2017). The incidence of Lyme disease cases reported across Canada between 2009 and 2022 increased from 144 to 2525 cases (Government of Canada, 2023a). Since there is limited information looking directly at the effects of climate change on *I. pacificus* tick populations, more surveillance is needed on this species to track potential expansion in BC.

1.6. A one health approach to ticks and TBDs

In the tick world, a One Health approach is defined as: “an interdisciplinary approach for combating threats (e.g., tick-borne diseases) to the health of animals, humans, and the environment they share on Earth” (Dantas-Torres et al., 2012, p. 437). What the authors in this article mean by a One Health approach is the need for

physicians and veterinarians to collaborate and communicate about patient histories relating to ticks (Dantas-Torres et al., 2012). Additionally, communication at the regional or national level between health authorities in veterinary and human medicine is also stressed as part of the interdisciplinary approach in this article (Dantas-Torres et al., 2012). The main arguments the authors pose for incorporating a One Health or interdisciplinary approach to TBDs is to help control the zoonoses associated with ticks. Zoonosis is defined as a disease in which the pathogen can be transmitted from non-human animals to humans. Since ticks' blood feed on a variety of animal hosts, including but not limited to humans, dogs, deer, mice and many more, their life cycle makes tackling TBDs much more complex (Kocan, de la Fuente, & Coburn, 2015). Some TBDs that now affect humans were once only seen in domestic animals, such as babesiosis caused by some *Babesia* spp. (Dantas-Torres et al., 2012). This is one of many examples where there is a lot of crossovers between humans and animals regarding TBDs. The veterinarian authors who are at the Oswaldo Cruz Foundation in Brazil (Dept. of Immunology), the University of Bari in Italy (Dept. of Veterinary Public Health) and the University of California in the US (School of Veterinary Medicine) highlight a case in which a person and several of her dogs died of Rocky Mountain Spotted Fever because of being misdiagnosed with other conditions. Sadly, in the case of the woman the medical professional did not get a complete history by not asking if she was in contact with tick-infested animals. This was a very important example of how both veterinary and medical professionals both could have benefited with bilateral communication to give an accurate and lifesaving diagnosis to their patients.

Due to known knowledge and communication gaps about ticks and TBDs in Canada, CLyDRN, funded by the Canadian Institutes of Health Research (CIHR), was formed in 2018 as an initiative to connect patients, physicians, social scientists, veterinarians, and researchers together (Guillot et al., 2020). CLyDRN's goals are to improve upon the prevention, treatment, surveillance, and diagnosis of Lyme disease in Canada using a One Health approach (Guillot et al., 2020). Passive surveillance is a part of this collective effort for improving tick and TBD knowledge translation in the medical and veterinary communities as well as to the public. The ©eTick program is one of many resources that may contribute to this initiative.

1.7. Objectives and value/outcomes of thesis

The three objectives to this these are to:

1) Assess the knowledge, attitudes and practices of BC veterinarians and veterinary technologists/technicians (veterinary professionals) around ticks and TBDs.

2) Assess the awareness and use of passive surveillance systems including ©eTick by BC veterinary professionals.

3) Make recommendations to improve educational resources on ticks and TBDs for BC veterinary professionals.

The value of surveying BC veterinary professionals about ticks and TBDs is that an in depth assessment of their current knowledge about this issues has not yet been conducted. Gaining insight into their current understanding of ticks and TBDs and how they handle them in practice can allow for better resources to be supplied to them if significant knowledge gaps are found. This could lead to improved clinical outcomes. Additionally, assessing their knowledge and use of tick passive surveillance such as ©eTick can provide important information on how accessible these resources are and how often they are used. Veterinary professionals contribute valuable information to tick and TBD surveillance systems, and it is important to know their level of participation in them. Lastly, gathering survey data on the resources veterinary professionals commonly use for tick and TBD information, as well as preferred resource formats provides an opportunity for future knowledge translation should emerging TBD issues arise.

Veterinary technologists/technicians were included in the target population in addition to veterinarians because of the valuable role they play in clinics. The reason why the term veterinary technologist or technician was used is because depending on where the individual took their veterinary training program in Canada, they may be called either one of those names (Canadian Veterinary Medical Association [CVMA], 2024). The recognized name across Canada is a Registered veterinary technician/technologist (RVT) (CVMA, 2024). To get an RVT designation, two to three years of an accredited program must be completed in Canada (CVMA, 2024). Including both veterinarians and veterinary technician/technologists adds a more inclusive insight into how ticks and TBDs are handled in BC veterinary practices.

Chapter 2. Rapid review of KAP of veterinary professionals in Canada regarding ticks

A rapid evidence review was undertaken as the first step in this research. The goal of this review was to understand previous surveys of Canadian veterinarians KAP around ticks and TBDs and identify useful questions to include in a tick-specific survey instrument created for this research.

2.1. Knowledge gaps

Knowledge, attitudes, and practices (KAP) surveys are typically collected in the form of questionnaires, and they are useful to create a baseline knowledge of a specific group about a particular topic (World Health Organization [WHO], 2008). Knowledge in terms of KAP surveys is seen as the acquisition of information on a particular topic (Badran, 1995). Attitudes are ones predisposed beliefs and reactions, where values and ethics tend to intertwine (Badran, 1995). Practices are the true actions taken by the individual, or their behaviours (Badran, 1995). This triad framework is a helpful tool in uncovering knowledge gaps, barriers to understanding topics or accessing resources, and the typical behaviours exhibited by a group in relation to a topic (WHO, 2008).

2.2. Methods for rapid review search

2.2.1. Inclusion and exclusion criteria

The methods for this rapid review followed protocols provided by a Simon Fraser University (SFU) librarian and the resources on SFU's Library Research commons website including one by Dobbins (2017). For the criteria and search process, an SFU librarian was consulted to confirm the search terms and database were appropriate for the scope of this research. The criteria for choosing studies for the rapid review were:

1. The article needed to have ticks and/or mention of a tick-borne disease in the title and abstract.
2. Title and abstract include the word veterinary or veterinarian, searched using the truncated form veterin*.

3. The article needed to have at least knowledge and/or attitudes in the title and abstract. Although a majority of the KAP survey publications typically use the terms knowledge, attitudes, and practices, we wanted to leave room for the possibility of other words used instead of practices such as beliefs, or perceptions.

4. Research was done with veterinary professionals in Canada.

Articles were excluded if they surveyed only medical professionals such as doctors or nurses or other animal related professions such as farmers or pastoralists. Surveys of only pet owners or any citizens that are not veterinary professionals were excluded.

The search strategy for the rapid review was as follows:

1. The Medline (PubMed) databased was used for the search.

2. Search terms included “knowledge, attitudes” using the [tiab:~2] function[1].

3. MeSh Terms were added to the search builder for “knowledge, attitudes” using the “OR” function to not miss related terms.

4. The term “tick” was added with “AND” to the search builder which would pick up articles that had the singular and plural version “ticks”.

5. The truncated form “veterin*” was added to the search builder using the “AND” function to include not only veterinarians but veterinary professionals, technologists, technicians, assistants, or other professionals.

Additional searches were also conducted using google and google scholar to check for grey literature using the same search terms.

2.3. Rapid review results

2.3.1. Database search results

The search methods above provided a result of 52 articles on the PubMed database. After applying the inclusion criteria by scanning article titles, 4 articles were

[1] This process searches the words “knowledge” and “attitudes” with at most two words between them.

identified. After applying the exclusion criteria of being focused on a Canadian population, one published article remained for this synthesis. The grey literature search found a non-peer reviewed document on baseline tick and TBD awareness of veterinarians in Canada conducted by the Canadian Veterinary Medical Association (CVMA, 2022). Although this study did not exclusively state it was a KAP survey, the questionnaire is structured similarly to other KAP surveys. This resulted in one published journal article and one published document being included in the final review. The article selection process can be seen in Figure 2.1.

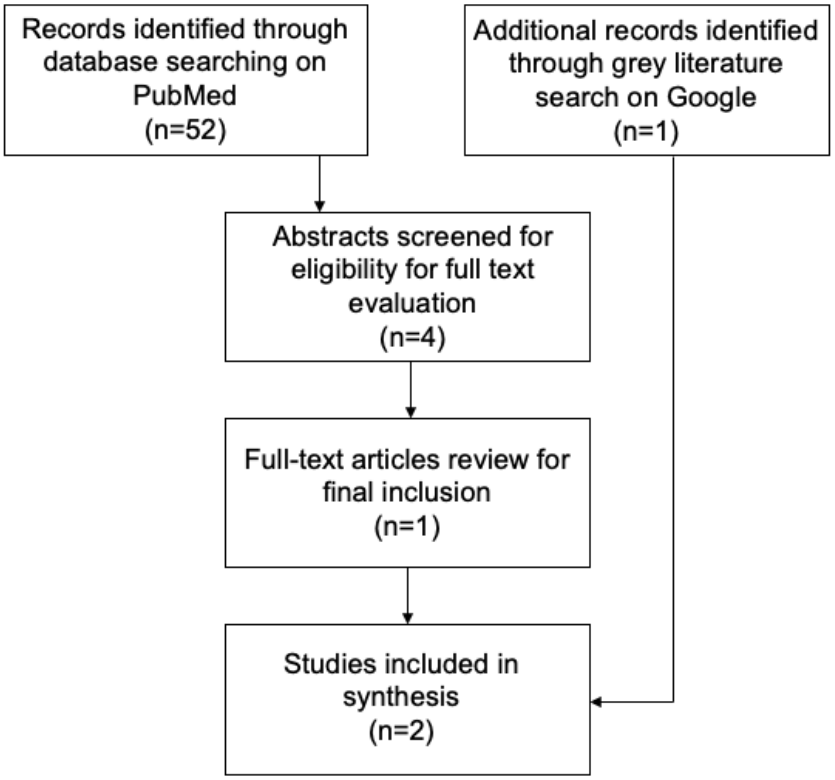

Figure 2.1. Articles identified for rapid review.

2.3.2. Rapid review respondent characteristics and encounters with ticks in practice

The article by Nichol et al. (2021) surveyed veterinarians across Canada during their data collection period of June to July 2019. Their survey was formatted in Qualtrics and distributed online to their national and provincial veterinary medical associations, including the Ontario Animal Health Network (Nichol et al., 2021). The authors did not

declare any incentivization for survey participants (Nichol et al., 2021). Three of the authors are based out of University of Guelph and one at Atlantic Veterinary College.

The CVMA (2022) did not specifically state their data collection period, but it can be assumed from the date on their survey in the supplemental material that it began in November 2021. There was no specified end date. The authors did not specify the exact software they used to format and distribute the survey, but it was done so by Kynetec along with the data analysis (CVMA, 2022). The survey was incentivized by each participant being put into a draw to win one of 10 $100 gift cards (CVMA, 2022). The authors are based out of the University of Guelph and the Canadian Veterinary Medical association.

In the national tick awareness study, British Columbia was referred to as “West”, while Alberta, Saskatchewan and Manitoba were called “Prairies”, and Quebec, New Brunswick, Nova Scotia, Newfoundland, and Prince Edward Island were grouped as “Eastern Canada” (CVMA, 2022). The province of Ontario was kept as its own category since it had the highest number of respondents (CVMA, 2022). Nichol et al. (2021) grouped the regional categories differently by putting BC, Alberta, and Saskatchewan as the Western provinces, then Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland and Labrador as the Eastern provinces. Manitoba, Ontario, and Quebec were grouped for central provinces (Nichol et al., 2021). The number of respondents may have had a typo in the CVMA (2022) report. The estimated percentage of veterinarian respondents (n=909) in their Figure 4D shows roughly ~18% for West (BC), ~28% for Prairies, ~28% Ontario, and ~27% for East (CVMA, 2022). These percentage value estimations were obtained from visually looking at the graph since the individual number of respondents for each province was not disclosed in Figure 4D (CVMA, 2022). When comparing these respondent percentages to the figure caption for their first question (Figure 5), the veterinarian respondents (n=909) have a list of totals for each group which are West (BC) (160/909 [18%]), Prairies (255/909 [28%]), Ontario (251/909 [28%]), and East is stated to be 486/909 which would come to 53%. This 53% does not match what was shown in Figure 4D with an estimated 27%. We believe this to be a typo, and the actual value of East veterinarian respondents should be 243/909 which would be 27%. Roughly 82% of their collective veterinarian respondents for all provinces were general practice vets and 82% practiced on companion animals only (CVMA, 2022).

Of the 192 respondents for the Nichol et al. (2021) study, 15 (7.8%) were from BC. Ontario had the highest response rate for this survey with 93 participants (Nichol et al., 2021). Small animal professionals comprised 89.6% (172/192) of the total respondents, with 50.5% (97/192) being in practice for greater than 15 years (Nichol et al., 2021).

Only the study by Nichol et al. (2021) reported veterinarians experience with tick encounters by season in their practice. In the Western provinces category, ticks were seen more frequently in spring (17/30 [56.7%]) and summer (13/30 [43.3%]) by respondents (Nichol et al., 2021). In the winter, 0% (0/30) of respondents indicated they see ticks and 13.3% (4/30) stated they see them in their practice in the fall (Nichol et al., 2021). In the Eastern provinces category, spring (22/40 [55%]) was reported to have the highest encounters with ticks, followed by summer (21/40 [52.5%]) and fall (21/40 [52.5%]), and not often in the winter (4/40 [10%]) (Nichol et al., 2021).

2.3.3. Knowledge of ticks in area

For recognition of tick species, BC (West) veterinarians had the highest response (35%) for knowing correctly that Western backlegged ticks (*I. pacificus*) have always been found in the area (CVMA, 2022). However, BC (West) veterinarians had an even higher response (44%) for saying Blacklegged or Deer ticks (*I. scapularis*) have always been around, which are not endemic to Western Canada (CVMA, 2022). Ontario and the Eastern Canada provinces had the highest percent recognition of Blacklegged or Deer ticks (*I. scapularis*) out of all tick species and province groups with 73% and 72% choosing always around as their option, respectively (CVMA, 2022). The survey of veterinarians in Canada by Nichol et al. (2021) only asked about knowledge of tick species in their area for blacklegged ticks. When asked whether blacklegged ticks are found in their practice area, 62.1% (118/190) chose “established’ which meant the area is considered high risk or endemic (Nichol et al., 2021). About 21.1% (40/190) chose “sporadically introduced on migratory birds or other mammals” (Nichol et al., 2021, p. 298). Nichol et al. (2021) found that in the West, which included BC, Alberta and Saskatchewan, the odds of a veterinarian respondent indicating blacklegged ticks were “established” in their area was lower than the Central region which included Manitoba, Ontario, and Quebec.

2.3.4. Clinical approaches to tick identification, tick testing and prevention

Approaches of veterinarians to tick identification and testing were discussed in the paper by Nichol et al. (2021), but not in the CVMA (2022) study. Regarding tick bites in their practice, 50.3% (96/191) of veterinarian respondents indicated they would identify the tick in their clinic (Nichol et al., 2021). Of those veterinarians that would identify a tick in their practice, 77.1% (74/96) of them assessed their skill-level as "average", which meant they could distinguish between American dog ticks and blacklegged ticks (Nichol et al., 2021). For the veterinarian respondents (39/191 [20.4%]), that indicated they wouldn't identify or examine the tick, 95.9% (37/39) provided a reason. The reasons provided by the veterinarian respondents were 43.2% (16/37) stated they don't have enough training in tick identification, 27.0% (10/37) said it is because of the cost, 24.3% (9/37) find it is too time consuming, and 21.6% (8/37) don't believe there is a clinical value to doing so (Nichol et al., 2021). For pathogen testing of blacklegged ticks, 43.9% (82/187) said they sometimes did, 36.9% (69/187) stated they never did and 19.3% (36/187) reported they always did so (Nichol et al., 2021).

In BC (West) 46% of veterinarians view educating their animal owners about tick-related risks, prevention, and control as an all-year commitment with Eastern Canada being the highest (60%) followed by Ontario (55%) (CVMA, 2022). The Spring was the most reported time of year for tick risk, prevention and control conversations in BC indicated by 50% of the veterinarian respondents (CVMA, 2022). Nichol et al. (2021) found that 90.1% (164/182) of their veterinarian respondents have discussions with their animal owners about ticks and TBDs during annual check-ups, and 51.1% (93/182) veterinarians suggest tick prevention for dogs during part of the year. Regarding questions about ticks, prevention and control, BC (West) veterinarians (48%) indicated they frequently receive questions from animal owners about LD transmission and its health effects, with Eastern Canada being the highest (61%), followed by Ontario (53%) then the Prairies (39%) (CVMA, 2022). In the scenarios section of the article by Nichol et al. (2021) there were four scenarios given to veterinarian respondents and the top five responses to each scenario was summarized in Table 4 in their paper. For scenario 1 where a dog comes to their clinic with an attached and engorged blacklegged tick, 40.1% (69/172) of veterinarians stated they would discuss LD with the animal owner and watch for symptoms. In the same scenario, 45.9% (79/172) of veterinarians would

discuss tick prevention with the animal owners (Nichol et al., 2021). In scenario 2 where a dog comes in for its yearly exam, with no reported LD symptoms, but tests seropositive for *B. burgdorferi*, they would have a discussion with the owner about LD and watch for clinical signs 46.8% (80/171) of the time (Nichol et al., 2021). For this same scenario 2, the veterinarians indicated they would discuss tick prevention with the animal owner 22.2% (38/171) of the time (Nichol et al., 2021). Scenarios 3 and 4 were more focused on specific tests done by veterinarians for diagnosis of possible LD.

2.3.5. Tick and TBD risk perception

Nichol et al. (2021) found that 64.7% (123/190) of their veterinarian respondents indicated that ≤ 5% of dogs were positive for *B. burgdorferi* in their area but 64.2% (122/190) believe that *B. burgdorferi* presence has increased in the past 5 years. Of all the regional veterinarian categories, 18% of the BC (West) veterinarians expressed the most concern for increased tick prevalence and global warming, followed by the Prairies and Ontario with 11% expressing concern, and only 5% of veterinarians in the East (n=909) (CVMA, 2022). Tick risk perception of veterinarians was characterized for dogs, cats, and pet owners/families (humans) (CVMA, 2022). Overall, most veterinarian respondents reported increasing tick risk concern for dogs and humans, whereas concern for cats has remained mostly the same (CVMA, 2022). Ontario veterinarians were the highest for reporting an increase in tick risk concern for dogs with 84% of respondents and 77% for humans (CVMA, 2022). The East was the second highest, with 80% of the veterinarian respondents reporting an increase in tick risk concern for dogs, and 74% for humans (CVMA, 2022). The Prairies were the next highest, reporting 63% increased tick risk concern for dogs and 53% for humans (CVMA, 2022). Lastly, the West (BC) was the lowest where 44% of respondents indicated an increase in tick risk concern for dogs, and 30% for humans (CVMA, 2022). Less than 3% of respondents, if any, indicated a decrease in concern regarding ticks to dogs, humans, or cats across all regions (CVMA, 2022).

2.3.6. Education needs and resources regarding ticks and TBDs

The veterinarian respondents across Canada collectively felt somewhat or very comfortable (78.7%; 137/174) regarding diagnosis and treatment of LD, whereas the Western province region (BC, Alberta, and Saskatchewan) was significantly more likely

to state they felt uncomfortable or unsure doing so (Nichol et al., 2021). Of all options provided in the survey, the three most chosen responses for more information that would be helpful for respondents were treatment best practices (149/173 [86.1%]), diagnostic best practices (135/173 [78.0%]), and current LD risk (107/173 [61.8%]) (Nichol et al., 2021). For information on LD in dogs specifically, 77% (134/174) of respondents found it on the Veterinarian Information Network, 55.2% (96/174) at conferences and 38.5% (67/174) at the American College of Veterinary Internal Medicine (ACVIM) (Nichol et al., 2021). There was no resource related information reported for ticks and TBDs in the CVMA (2022) study.

2.4. Synthesis of rapid review

This review summarizes the results of both known studies done on knowledge, attitudes, and awareness of veterinarians in Canada on ticks and TBDs.

In terms of the scale of research studies, the CVMA (2022) surveyed more respondents (909 veterinarians) than Nichol et al. (2021)'s (192 veterinarians). Both studies broke down veterinarians in Canada into different regional categories which differed from each other, this makes it difficult to compare across groups since the West was assigned as just BC by the CVMA (2022), but Nichol et al. (2021) assigned the Western provinces as BC, Alberta, and Saskatchewan. BC (West) made up an estimated 18% of the respondents for the CVMA (2022) study whereas 7.8% of respondents in the study by Nichol et al. (2021) were from BC. For both studies, most of the total respondents practiced on either companion or small animals. This means the results may not be applicable to other types of veterinarians in mixed, large, or specialized animal practices.

For tick species recognition, the two studies are not directly comparable because of the ways in which ticks were described. For the CVMA study, respondents misidentified Blacklegged or deer ticks as being in their area (CVMA, 2022). There is a possibility that they were confused by the lay terminology of the species, but veterinarians should be aware of the differences in these species. The CVMA survey listed only the common name of ticks, not the species name, which may lead to confusion in distinguishing between the two species. In the questions about blacklegged ticks asked by Nichol et al. (2021) *I. pacificus* and *I. scapularis* were just referred to as

“blacklegged ticks”. In Nichol’s study, the Western provinces’ veterinarian respondents were less likely to state that blacklegged ticks were established in their area compared to the Central region (Nichol et al., 2021). The CVMA study found that BC reported the highest rates for knowing Western blacklegged ticks (*I. pacificus*) have always been found in their area but these vets also said that Blacklegged or deer ticks (*I. scapularis*) have always been around, which is not correct (CVMA, 2022). Research with tick distribution shows that Western blacklegged ticks (*I. pacificus*) are endemic to BC (Lindquist et al., 2016) but deer ticks (*I. scapularis*) are endemic to Eastern and Central Canada, with growing reports of species movement westward to the prairies, but not BC (Lindquist et al., 2016). These results point to the need to be specific on questions about ticks, particularly those with similar names. It also suggests that there are limitations to what vets currently know about endemic species.

Both studies indicated a seasonality to vet’s conversations about tick prevention. The finding by the CVMA (2022) that half of BC veterinarian respondents have the most conversations about tick prevention in spring is similar to the finding by Nichol et al. (2021) where half of the veterinarian respondents in Canada indicated they recommend tick prevention for part of the year for dogs. This is in alignment with when ticks are typically seen in the highest abundance, specifically for the Western blacklegged tick (*I. pacificus*) with the most being seen in May. In BC, one problem with this timing of prevention conversations is that ticks can now found all year round due to BC’s temperate climate (Lindquist et al., 2016). It is possible that conversations in BC need to be more frequent that just during an annual check up.

Only 40% of the veterinarian respondents across Canada reported they would discuss Lyme disease risk with their animal owners if a dog came into their clinic with an engorged blacklegged tick attached (Nichol et al., 2021). The incidence of Lyme disease cases is not well documented in dogs across Canada (Bouchard et al., 2016), but it is well documented in humans and varies greatly by province. The incidence of Lyme disease cases in humans in BC is 0.37 per 100,000 population, whereas in Ontario it is 11.51 per 100,000, and 60.03 per 100,000 population in Nova Scotia (Government of Canada, 2023b). This variability in LD incidence across Canada likely contributes to why only 40% of the Canada wide veterinarian respondents would discuss LD risk with animal owners that brought a dog to their clinic with an engorged and attached blacklegged tick. Although risk of LD may vary greatly by province, the risk is rarely zero

in most Canadian provinces. LD risk should be discussed as a possibility, especially in the case of the scenario where an attached and engorged blacklegged tick is on an animal. Interestingly, Nichol et al. 2021 revealed that more than half of the respondents would not discuss tick prevention at a time where it would be most relevant (with an attached and engorged tick on a dog). This finding indicates a clear gap in communication between veterinarians and their animal owners regarding prevention. In another scenario where a dog with no previous LD symptoms tests seropositive for *B. burgdorferi*, nearly half of the veterinarian respondents said they would discuss LD with the animal owner, but only 22.2% would discuss tick prevention (Nichol et al., 2021). This adds to the possibility that there are missed opportunities for veterinarians in Canada to be educating their animal owners about tick prevention.

Over 64% of the veterinarian respondents in Canada believe that *B. burgdorferi* presence has increased in the past 5 years (Nichol et al., 2021). It is hard to say if *B. burgdorferi* has becomes more present overall in Canada since seroprevalence of *B. burgdorferi* in dogs varied by provinces from 2008 to 2015 (Evason et al., 2019). In Manitoba, Nova Scotia, New Brunswick, and Ontario, it was significantly higher from 2008 to 2015 whereas Alberta and BC had significantly lower seroprevalence of *B. burgdorferi* in dogs when compared to Ontario (Evason et al., 2019). This finding that the veterinarian respondents believe that *B. burgdorferi* presence has increased in the past 5 years could be a result of LD cases reported across Canada increasing by over 17 times between 2009 and 2022 (Government of Canada, 2023a).

A notable finding from Nichol et al. 2021 is that about half of the veterinarian respondents across Canada indicated they would personally identify a tick in their practice, and most of those respondents assess their skill level in identification as “average”. The one fifth of respondents that stated they would not identify the tick in practice indicated the most common reason was not having enough training, costs and time constraints. This cost barrier is present not only in BC where veterinarians are charged for pathogen testing by the BCCDC (2023), but in Ontario where the Public Health Laboratory only accepts ticks from humans (Public Health Ontario, 2023). This might drive veterinarians in Ontario to have to submit ticks to private laboratories which often charge for tick pathogen testing. An example of a private laboratory in Canada that comes up when searching “tick pathogen testing Ontario” is Geneticks (Geneticks, 2024). Geneticks charges $55 per tick to test for 3 pathogens that cause LD for the

longest wait time for results, this goes up to $100 if same day results are requested (Geneticks, 2024). This reveals a gap that could be filled with more targeted resources on tick identification for veterinarians in Canada. Free online resources such as ©eTick, could potentially increase participation of veterinarians in further examining ticks in practice, instead of simply disposing of them. Over one third of the respondents indicated they would never send blacklegged ticks in for pathogen testing, whereas over 40% stated they sometimes would (Nichol et al., 2021). There were no specific reasons provided as to why, but it could be possible that the financial and time barriers for further examining ticks could be a factor. Lack of awareness about tick pathogen testing resources available to veterinarians could be a possibility that was not explored here.

In both the Western and Eastern provinces, over half of the respondents stated they have the most tick encounters in spring (Nichol et al., 2021). Spring is the peak time to encounter Western blacklegged ticks (*I. pacificus*) but Blacklegged or deer ticks (*I. scapularis*) adults will begin to look for hosts in the fall as opposed to spring like other ticks that bite humans in Canada (Lindquist et al., 2016). Summer and fall were also reported as a frequent time for tick encounters by over half of the veterinarian respondents in the Eastern provinces (Nichol et al., 2021). This aligns with what is reported for Blacklegged or deer tick (*I. scapularis*) seasonality (Lindquist et al., 2016).

On average, veterinarian respondents in Canada reported feeling comfortable in the diagnosis and treatment of LD (Nichol et al., 2021). When looking at just the Western respondents (BC, Alberta, and Saskatchewan), they reported feeling more uncomfortable (Nichol et al., 2021). This finding may be a result of the fact that the incidence of LD is lower in Western provinces such as BC (Government of Canada, 2021), as well as the seroprevalence of *B. burgdorferi* not being as high in dogs in BC and Alberta when compared to Ontario (Evason et al., 2019). Therefore, it might be expected that veterinarians in Western Canada would not be as comfortable in diagnosing and treating LD since there is a lower incidence. Veterinarian respondents stated they would like to have more resources on treatment and diagnostic best practices, including up to date LD risk (Nichol et al., 2021). This highlights a need for better tick-related resources for veterinarians so they can make more informed decisions about ticks and TBDs in practice.

2.5. Limitations

A limitation of this review is that there are only 2 articles to consider. It is possible that some articles could have been missed through the search strategy. Additionally, only one author screened the articles for this review, so human error and bias could have contributed to the inclusion and exclusion of articles. Another limitation for this review was one study was not peer reviewed. Therefore, there may be some mistakes or important information missing in this document.

The scope of Nichol's article is also very focused on Lyme disease in dogs and *B. burgforferi*. Although many questions in the survey did encompass ticks and tick prevention in a general sense, a lot of their questions specifically focused on Lyme disease diagnostics and testing for *B. burgforferi* (Nichol et al., 2021). Blacklegged ticks were also the focus for ticks in Nichol's publication, particularly in the scenario questions. As such, this line of inquiry may miss how veterinarians respond in scenarios where non blacklegged ticks were considered.

It is important to note that 192 veterinarians completed the survey by Nichol et al. (2021) and there were 909 veterinarian respondents to the survey by the CVMA (2022). When drawing conclusions about BC veterinarian respondents specifically, this reduces the respondents to an estimated 160 (CVMA, 2022) and 15 (Nichol et al., 2021) individuals. This difference in the number of respondents, specifically for BC veterinarians, and the characteristics of the respondents themselves can greatly influence the results of these studies. Therefore, the conclusions made from these studies should take small respondent numbers and their characteristics into consideration when speaking about Canada or BC veterinarians collectively.

2.6. Conclusions

This review provides a brief overview of the literature on Canada veterinarians' knowledge and awareness of ticks and TBDs and sheds some light on these factors in BC veterinary staff. Both studies found that there are regional differences in how veterinarians across Canada address ticks and TBDs. This was seen particularly with LD treatment and diagnosis where West (BC, AB, SK) vets felt more uncomfortable when comparing with Canada veterinarians overall. This indicates BC veterinarians may be

less prepared or experienced in diagnosing and recognizing clinical signs of LD in their animal patients. Since there was an expressed desire by the veterinarian respondents across Canada to have more resources on treatment best practices, diagnostic best practices, and the latest LD risk, it would be advantageous to know specifically what BC veterinarians' education needs are.

Another conclusion is that BC vets may not have a complete understanding of blacklegged tick presence in the province, specifically when it comes to the species types. However, only including common names of tick species when asking the veterinarians about them may have led to confusion and may not indicate their true responses if they had the full names. This possible misunderstanding by BC vets needs to be investigated further to determine if there is a true knowledge gap about Western blacklegged ticks (*I. pacificus*) and Blacklegged or deer ticks (*I. scapularis*).

Since collectively the veterinarians for Canada in Nichol et al. (2021)'s study expressed their tick identification skills as "average", it would have been great to see how this varied for each province. Investigating this same question but specifically only for BC vets would be a great addition to the baseline knowledge acquired in this study. Additionally, half the veterinarian respondents in Canada said they would identify a tick themselves in practice, but BC respondents were not looked at alone for this question. Determining if BC veterinarians also identify ticks themselves would contribute to a better understanding of how they handle ticks in practice.

Prevention appeared to be an annual conversation for veterinarians in Canada, either in Spring or another time of year. However, at times when vets had animal patients present with an engorged and attached tick, many may not have seized the opportunity to discuss prevention with their animal owners. This finding indicates a lack of prevention conversations when they might be most relevant, and points to the possibility that when asked about something generally in a survey, the response may be different than what is done in a true scenario. Scenario questions can help determine the true behaviours done by the respondents. Investigating what BC veterinarians say they discuss with animal owners about tick prevention and comparing this with scenario questions involving engorged or attached ticks to animals may uncover their true actions.

The top barriers for veterinarians in Canada not getting ticks identified were not having enough training, followed by cost. Since this question was only averaged for all the veterinarians in Canada, determining if BC vets are having this same problem would be necessary to determine their needs regarding tick identification. It was determined that many vets in Canada would never send ticks for pathogen testing, but the reasons or barriers for this were not uncovered. Surveying BC vets alone about why they may or may not identify ticks or submit them for pathogen testing would be valuable to make it more accessible for them.

Lastly, veterinarians in Canada were not surveyed specifically about their knowledge of tick passive surveillance systems. Learning if veterinarians are using these resources or not is important in determining if participation could be increased through education. Identifying barriers to the use of these resources is important to ensure they are accessible by veterinary professionals in Canada, and specifically in BC. Providing access to tick passive surveillance can contribute to veterinary professionals giving the proper treatment and potentially diagnoses of TBDs such as LD in a timely manner. Additionally, veterinary professionals' participation in passive surveillance can contribute important data for tracking tick populations and possible emerging or existing pathogens responsible for TBDs. BC has several passive surveillance systems for ticks, but it is unknown if there are accessibility issues for veterinary professionals.

Due to there only being 15 BC veterinarian respondents in the study by Nichol et al. (2021) and having them grouped with Alberta and Saskatchewan, generalizing the findings to BC veterinarians is not appropriate here. Additionally, although the CVMA study had more BC respondents (160), it was not peer reviewed. Also, there were many results sections covered in the Nichol et al. (2021) publication that were not covered in the CVMA (2022) one which limited the ability to compare between the two studies. Since the study by Nichol et al. (2021) didn't analyze BC as a separate category, the work in this thesis is valuable since it will build on the current tick and TBD knowledge of BC veterinary professionals exclusively. Using the Nichol et al. (2021) and the CVMA (2022) studies' questionnaires as templates, designing a personalized survey targeting BC veterinary professionals will add comparable data to the literature. The addition of veterinary technologist/technicians was done with forethought, to prepare for the possibility of low response rates from veterinarians in BC as seen in the study by Nichol et al. (2021), and because of the active role they play alongside veterinarians in practice.

Chapter 3. Thesis objectives, methodology of survey, and passive surveillance data acquisition for ©eTick, BCCDC PHL, BCCDC-Merck Project and NML

3.1. Methods for survey questionnaire

3.1.1. Ethical review

The survey questionnaire was approved by the Behaviour Research Ethics Board at the University of British Columbia (Study ID: H23-00364).

3.1.2. Survey development

The main goal of this survey was to learn what the typical approaches of BC veterinary professionals are to ticks in their practice, as well as some background information and their education needs regarding ticks. This survey development is mainly adapted from the only known closely related survey which was a KAP survey of veterinarians in Canada about Lyme disease in dogs (Nichol, et al., 2021). Most of the changes made from the Nichol et al. (2021) study's survey questions were done to investigate ticks and TBDs generally, and not just Lyme disease in dogs. The survey was created in SurveyMonkey (2023).

A question from the CVMA survey was also used as a basis to characterize knowledge about tick species (CVMA, 2022).

This survey also adapted demographic and clinic characteristics questions from Fiona Senyk's thesis survey about antineoplastic use in BC vet clinics (Senyk, 2021). These questions were in the background information section of the survey.

One major difference between the previous surveys and the current instrument used for this research is that the target audience has been broadened to include veterinary technologist/technicians (vet techs) and not just veterinarians.

3.1.3. Question development process

The questions for the survey were broken into four main sections including background information, clinical approaches, Lyme disease and other TBDs, and education needs. Each question was worded for ease of understanding. The survey had a mix of closed-response and open-response questions but focused mainly on closed-response questions to encourage participation since these kinds of questions tend to get higher responses (Robert, Grant, & Morgan, 2016). Open-response questions tend to require more writing for the survey participant so those were used sparingly. Closed-response question answers are useful for doing statistical analyses comparisons (Robert et al., 2016). The disadvantage of closed-response questions is that the questions were written from the perspective of the researcher which might limit the full accuracy of the survey participants' views (Robert et al., 2016). That is why multiple committee members contributed to providing feedback on this survey, and why a pilot survey was completed. A variation of the Likert scale was used for most of the questions that were asking about the frequency of certain behaviours or knowledge about ticks in their practice (Nemoto & Beglar, 2014).

3.1.4. Pilot survey

A pilot survey was completed to ensure that the questionnaire (Appendix) was comprehensible and instrument measures were adequate. The pilot survey was distributed to four BC veterinary technologist/technicians through convenience sampling and one of the veterinary technologist/technicians completed the pilot survey. Since this pilot participant filled out the survey with accurate clinic information and answered all the questions, their responses were added to the results. The finalized survey had very little changes from the pilot survey version. The other individual that piloted the survey was the BCCDC public health veterinarian, Dr. Erin Fraser of this committee, who did not fill out the survey, but instead gave feedback for each question. Minor changes were made.

3.1.5. Recruitment for survey and sample frame

The sample frame identified for this survey was the 2042 veterinarians in British Columbia (CVMA, 2023b), and the number of veterinary technologist/technicians was

unknown. The number of open and operating veterinary clinics were identified through Google Searches, which resulted in 450 clinics at the time of the survey launch.

An advertisement with the link and QR code for the survey was made targeting BC veterinarians and veterinary technologist/technicians (Appendix). Different agencies were approached to promote and distribute the survey including the British Columbia Society for the Prevention of Cruelty to Animals (BCSPCA) and the College of Veterinarians of BC. The College of Veterinarians of BC replied that they were interested but ultimately did not include our survey information in their newsletter. The BC SPCA did not respond to our request.

The Canadian Animal Health Surveillance System (CAHSS) was approached to distribute the survey through their vector-borne disease group and companion animal group. The CAHSS is a network formed in 2015 that focuses on animal health surveillance in many areas including vector-borne diseases (CAHSS, 2020). Collaborators that participate in the CAHSS are governments at the federal, provincial, and territorial levels, public health authorities, animal health laboratories, veterinary surveillance networks, council of chief veterinary officers, zoonotic disease networks and many others (CAHSS, 2020). The CAHSS agreed to share the survey link, description, and advertisement networks and through their LinkedIn page and X (formerly Twitter). It is unknown how many veterinary professionals saw the survey through the CAHSS media channels, but they have roughly 2000 followers on LinkedIn and over 980 followers on X as of 2024 (Canadian Animal Health Surveillance System, n.d; CahssCanada, n.d.). Although their audience includes veterinary professionals, their followers could be a variety of individuals.

After the initial launch of the survey via the CAHSS through their social media and tick working groups, responses were tracked and it was determined that the response to the survey was low. The survey was shortened by removing a few complex questions to prioritize a higher response rate.

The next phase of survey recruitment was follow-up telephone calls with a random, stratified selection of vet clinics throughout BC. The phone calls were intended to increase participation and remind veterinary professionals about our survey if they had already seen it but not taken it. The follow-up phone calls were also an opportunity

to hear veterinary professionals' experiences with ticks and TBDs if they opted to share. Using Google Maps, a list was compiled of all open and operating veterinary clinics in BC (total of 450) and the clinic's phone number.

Due to time and resource constraints, we did not phone all 450 vet clinics in BC and instead phoned roughly 15% of clinics from each health authority except in Northern Health authority where all open and operating clinics were phoned. The reason all the Northern Health authority clinics were contacted regarding this survey was that clinics were already being contacted regarding a free tick identification and pathogen testing program being offered by the BCCDC and Merck Animal Health at the same time.

In total, over 120 phone calls were attempted, 87 of which answered the phone. The phone script used can be found in the Appendix. Out of 87 clinics, 86 consented to receiving an email with the survey information and advertisement (Appendix). The one clinic that did not consent to receiving the survey was specialized in physical rehabilitation since clients would not visit them for tick-related problems.

3.2. Methods for obtaining passive tick surveillance data

Research was done to identify all passive tick surveillance programs operating in BC historically and up to the end of 2023. Surveillance reports were reviewed, and experts were contacted to better understand the passive surveillance landscape. Data holders were asked to provide as detailed information as possible within their usual data sharing agreement. Four tick passive surveillance programs were identified as relevant for this thesis including the NML's, the BCCDC Public Health Laboratory (PHL), ©eTick, and the BCCDC-Merck Animal Health program.

3.3. Data analysis

All data for the survey was analyzed and visualized in graphs using R Studio. The analyses were mostly descriptive, with some chi-square tests being performed in R Studio. Prior to analysis, the data was cleaned to remove three robot survey respondents, which did not answer questions accurately and instead provided either a single random number or letter for each response or did not complete the survey entirely. Since no name of their clinic, phone number or address was provided, it was

easy to identify the robot respondents from the real respondents. All other data cleaning was done in excel or R Studio prior to analysis. For the descriptive statistics, the count of respondents for each category was included, or calculated into a percentage of respondents out of the total. Objective one for this thesis, assessing the KAP of BC veterinarians and veterinary technologist/technicians, was analyzed using descriptive statistics in the form of counts and percentage of respondents, or averages. Objective 2, assessing the awareness of tick passive surveillance including ©eTick, is also accomplished through descriptive statistics, with the addition of the chi-square test done for the number of submissions to ©eTick in section 4.3.1. Lastly, the third objective of this thesis on making recommendations to improve educational resources on ticks and TBDs for BC veterinary professionals was also done so using descriptive statistics, in the form of the most common response by our respondents.

The tick surveillance data was accessed and analyses were done to extract BC specific data were possible. Where data access wasn't possible, annual reports were used to examine trends in submissions over time.

Chapter 4. Results

4.1. Survey results

4.1.1. Response rate

There were 27 BC veterinary professional respondents that completed our survey even after attempting multiple modalities of distribution. With only receiving 27 respondents, 24 of which being from unique veterinary clinics, this means our response rate was 24 out of 450 clinics or 5%. Before the survey was shortened and phone calls were undertaken, there was 15 respondents. Upon shortening the survey and completing the phone calls to vet clinics, there was an additional 12 respondents, resulting in 27.

4.1.2. Participant characteristics and tick-related visits in practice

Table 4.1 summarizes the characteristics of the 27 veterinary professional respondents and their veterinary practice. Most respondents were veterinarians (17/27 [63%]) and 37% (10/27) were veterinary technologists/technicians (Table 4.1). For veterinary professionals working at one practice only (23/27 [85%]), a majority are at a small animal practice (18/23 [78%]). Of the 4 respondents that stated they work at more than one type of practice, all work at a small animal practice in addition to at least one of either large animal, mixed animal, equine, or exotic practices. These 4 veterinary professional respondents estimated the percentage of time they spent at the small animal practice, when averaged came out to about 69% of the time. Nearly half of the respondents (13/27 [48%]) have worked in veterinary practice between 5 and 15 years (Table 4.1). None of the respondents have worked outside of Canada in the past 6 years (n=27), but seven of them have worked in another province outside of BC the past 6 months (Table 4.1). The average number of veterinarians working at the respondents' clinics was 2 (Table 4.1). Most of the respondents do not assess animals outside their clinic (20/27 [74%]) (Table 4.1). Of the 7 veterinary professional respondents that assess animals outside their clinic, 5 do so on a farm, and 2 are mobile vets (Table 4.1). The types of animals listed by the 7 veterinary professional respondents that work with animals outside of the clinic in mobile vet or farm settings were companion animals,

horses (equine), sheep (ovine), goats (caprine), pigs (swine), cattle (bovine), chickens (avian), and camelids.

Table 4.1. Participant characteristic and practice information of BC veterinarian and veterinary technologist/technicians (n=27) respondents of the survey.

Question	Responses
Job Title	n=27
Veterinarian	17 (63%)
Veterinary Technologist/Technician	10 (37%)
Type of Practice (Working at One Practice)	n=23
Small Animal	18 (78%)
Large Animal	2 (9%)
Mixed (Large + Small) Animal	2 (9%)
Shelter	1 (4%)
Number of Years Working in Veterinary Practice	n=27
<1 year	3 (11%)
>1-5 years	6 (22%)
>5-15 years	13 (48%)
>15 years	5 (19%)
Haven't Worked Outside of BC in Past 6 Years	n=20 (74%)
***Have Worked Outside of BC in Past 6 Years**	**n=7**
Alberta	3
Manitoba	1
Nunavut	1
Ontario	1
Prince Edward Island	1
Saskatchewan	1
Haven't Practiced Outside of Canada in Past 6 Months	n=27 (100%)
Average Number of Veterinarians at Practice	n=27 2
Assess Animals Outside Clinic	n=27
Yes	7 (26%)
No	20 (74%)
Setting Assess Animals in Outside Clinic	n=7
Mobile Vet	2 (29%)
Farm	5 (71%)

*Indicates question where participants could select multiple respondents.

Table 4.2 summarizes some tick-related visit information provided by respondents. Most of the respondents indicated that ticks are “rarely” or “never” the primary reason for their patient visits (22/27 [81%]) (Table 4.2). The average estimated number of tick related visits in the past year for the respondents was 14 ticks, with a median of 10 (Table 4.2). When averaged, our respondents submitted one tick in the past year to the BCCDC for pathogen testing (Table 4.2), although the most frequent response for this was zero ticks (13/21, [62%]). The one clinic that submitted 12 ticks in the past year for pathogen testing (Table 4.2) was a clinic in Vancouver Island Health authority. A majority of the veterinary professionals completed their veterinary education training within the last decade (16/26 [62%]).

Table 4.2. Tick-related practice information experienced by respondents (n=27).

Question	Responses
Tick bite or infestation as primary reason for visit	n=27
Always	0 (0%)
Usually	1 (4%)
Sometimes	4 (15%)
Rarely	18 (67%)
Never	4 (15%)
Tick bite or infestation as secondary reason for visit	n=27
Always	0 (0%)
Usually	2 (7%)
Sometimes	7 (26%)
Rarely	16 (60%)
Never	2 (7%)
Estimated number of tick-related visits in past year	n=26
Average	14
Median	10
Minimum	0
Maximum	100
Estimated number of ticks submitted to BCCDC in past year for pathogen testing	n=21
Average	1
Minimum	0
Maximum	12

The respondents were asked to estimate the number of tick related visits they get during all four seasons as shown in Figure 4.1. The highest numbers of tick related visits for the respondents were in summer and spring with two respondents indicating they receive more than 20 visits (Figure 4.1). In Spring and Summer, 17 and 11 respondents indicated they receive less than 10 tick related visits, respectively (Figure 4.1).

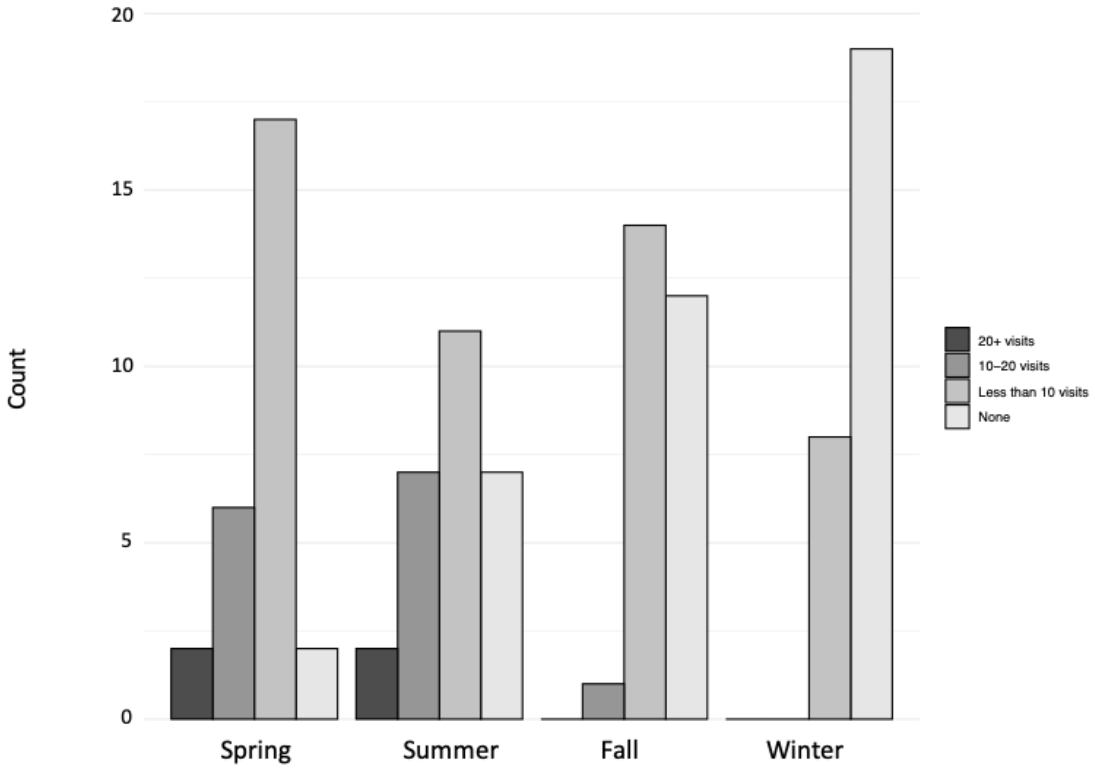

Figure 4.1. Estimated frequency of tick related visits to veterinary professionals' practice over the past year by season (n=27).

4.1.3. Knowledge of ticks

Figure 4.2 shows a list of tick species of concern that respondents were asked if they have always been found in the area or not. The * denotes species that have always been found in BC. For knowledge of local ticks of concern being found in the respondents' local area, the most common response for all species was "don't know" (Figure 4.2). In Figure 4.2, 36% (9/25) of veterinary professionals indicated that Western blacklegged ticks (*I. pacificus*) and Blacklegged or deer ticks (*I. scapularis)* 28% (7/25) have always been found in the area. For *Ixodes angustus*, all respondents chose "I don't know" or "never found" (Figure 4.2).

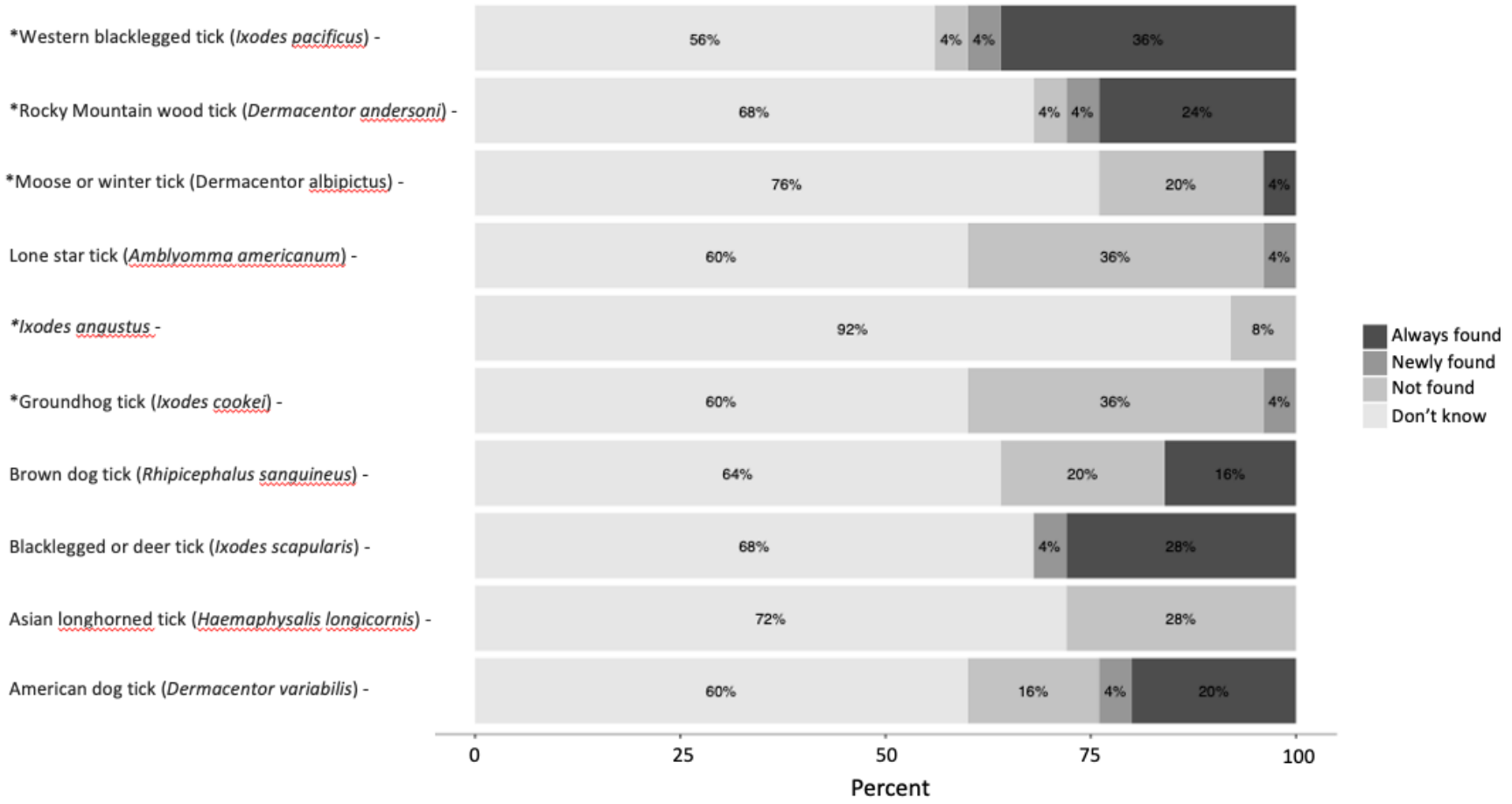

Figure 4.2. Average of veterinary professionals' knowledge of tick species found in their local area (n=25). *Indicates which species have always been found in BC.

When looking at veterinary professionals' knowledge of tick species by the respondent's health authority it was different for several of the regions. In the Vancouver Island Health (VIH) authority, 60% (6/10) of respondents said Western blacklegged ticks (*I. pacificus*) had always been found, and 40% (4/10) said Blacklegged or deer ticks (*I. scapularis*) had always been found. None of the respondents in VIH said they were not found. For Rocky Mountain wood ticks (*D. andersoni*), 20% (2/10) respondents said they had always been found. For Vancouver Coastal Health (VCH) authority, 25% (1/4) respondents said that Western blacklegged ticks (*I. pacificus*) and Blacklegged or deer ticks (*I. scapularis*) had always been found. None of the VCH respondents said the two blacklegged tick species had not been found. VCH respondents did not think Rocky Mountain wood ticks (*D. andersoni*) had been found (0/4, [0%]). The nearly identical response about VCH knowledge of Western blacklegged ticks (*I. pacificus*), Blacklegged or deer ticks (*I. scapularis*), and Rocky Mountain wood ticks (*D. andersoni*) was seen for Fraser Health. Only 17% (1/6) of the Interior Health authority respondents thought that Western blacklegged ticks (*I. pacificus*) and Blacklegged or deer ticks (*I. scapularis*) were always found in the area. None of the Interior Health respondents thought Blacklegged or deer ticks (*I. scapularis*) were not found in the area, and 17% (1/6) of respondents thought that Western blacklegged ticks (*I. pacificus*) were not found. For Rocky Mountain wood ticks, 67% (4/6) of the Interior Health respondents stated they had always been found in their area. The one Northern Health authority respondent answered "I don't know" for all tick species. Overall, the majority of respondents answers for all health authorities were "I don't know" for all tick species listed.

Respondents were asked to estimate the change in frequency of ticks brought into their clinic in the past 5 years (Figure 4.3). The respondents estimated that the frequency of ticks have increased (12/25 [48%]), stayed the same (10/25 [40%]), or decreased (2/25 [8%]) (Figure 4.3).

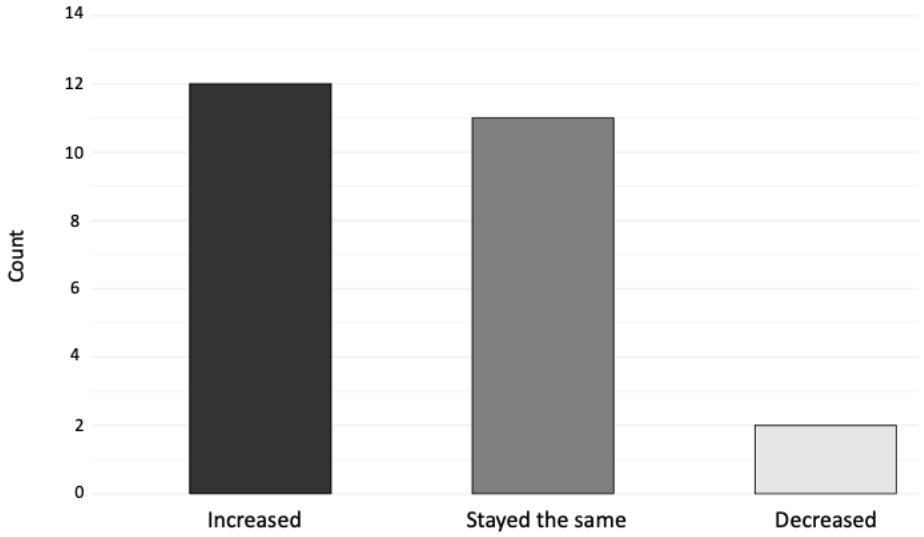

Figure 4.3. Estimated change in frequency of ticks that have been brought into veterinary professionals' clinics in the past 5 years (n=25).

4.1.4. Clinical approaches to ticks in practice

Participants were asked in the survey to self-assess their skill level in tick identification as either beginner which was defined as "I know when something is a tick", average meaning "I can differentiate tick species, for example, I can tell Rocky Mountain wood ticks from blacklegged ticks", expert meaning "I can look at ticks under the microscope, apply identification keys, and differentiate Ixodes species", or not having much experience. Most respondents assessed their skill level in tick identification as average (65% [13/20]) or beginner (30% [6/20]). No respondents selected expert as their self-assessed skill level.

When asked what the most challenging aspect of ticks in practice are, nearly 78% (14/18) selected submitting them for testing and 33% (6/18) chose in-house tick identification.

Figure 4.4 shows the average estimated percentage of time the respondents spent doing the provided options for post engorged and post not engorged tick removal

from an animal or tick brought into their clinic. The time spent doing the tasks provided in the questionnaire were mostly the same regardless of if the tick was engorged or not engorged (Figure 4.4). Around 41% of the time for either engorged or not engorged ticks, the respondents would dispose of them without further identification (Figure 4.4). The next most frequent response for the participants were to identify the engorged and not engorged ticks in house 34% of the time (Figure 4.4). About 20% of the time, they would ask a colleague for help (Figure 4.4). Less commonly, 17% of the time they would send the ticks to a lab for further identification (Figure 4.4).

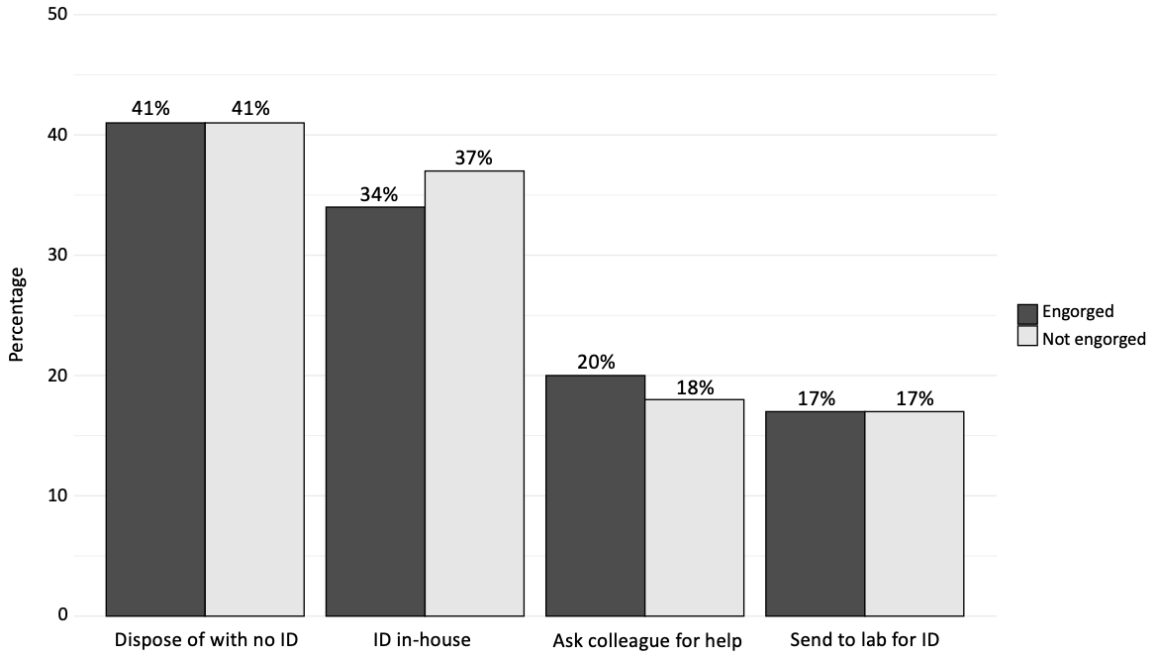

Figure 4.4. Estimated percentage of time veterinary professional respondents spend doing the following post engorged tick removal (n=21) and post not engorged tick removal (n=20) from an animal or tick sample brought into their clinic. Percentages on the graph indicate the percentage of time spent doing the provided options, not proportion of respondents.

The reasons why veterinary professional respondents may not follow-up with identifying a tick were summarized in Figure 4.5. Nearly 44% (10/23) of the respondents don't follow-up with tick identification because it is too expensive for the owner (Figure 4.5). Close to 22% (5/23) of the respondents don't follow-up with identification because they already know the species (Figure 4.5).

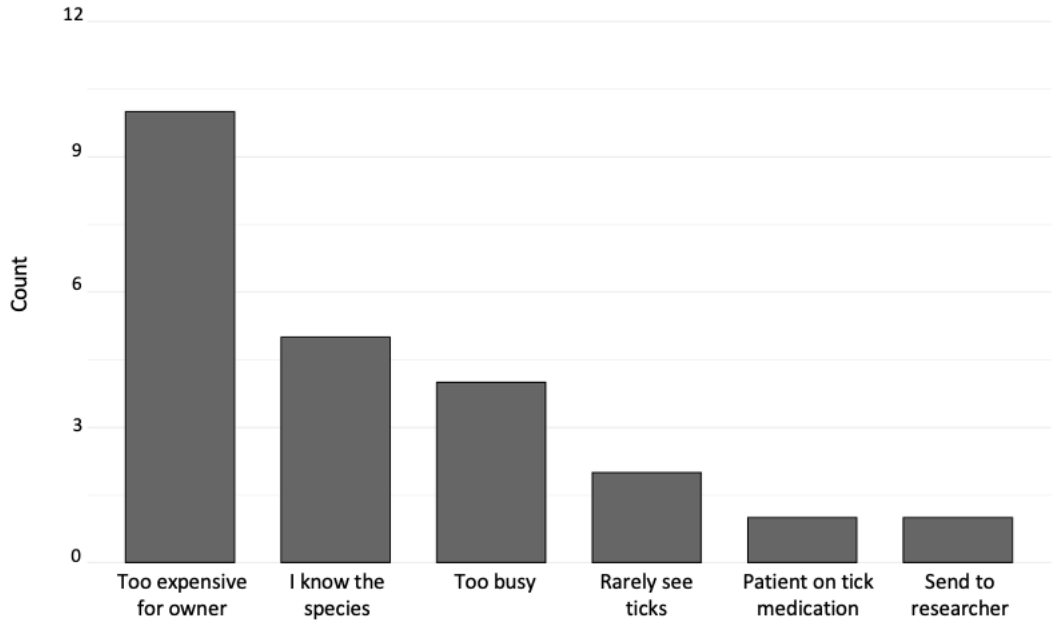

Figure 4.5. Reasons vet professionals don't follow-up with tick identification (n=23).

Figure 4.6 summarizes the frequency of conversations the respondents have with pet owners regarding topics related to ticks. The discussion topic "prevention for pets" was among the highest, with a total of 90% (20/22) respondents selecting "all the time" or "most of the time" for the frequency of these conversations (Figure 4.6). When looking at veterinary technologist/technician respondents only, 100% (8/8) selected "all the time" or "most of the time" for discussing prevention for pets compared to 86% (12/14) for the veterinarian respondents.

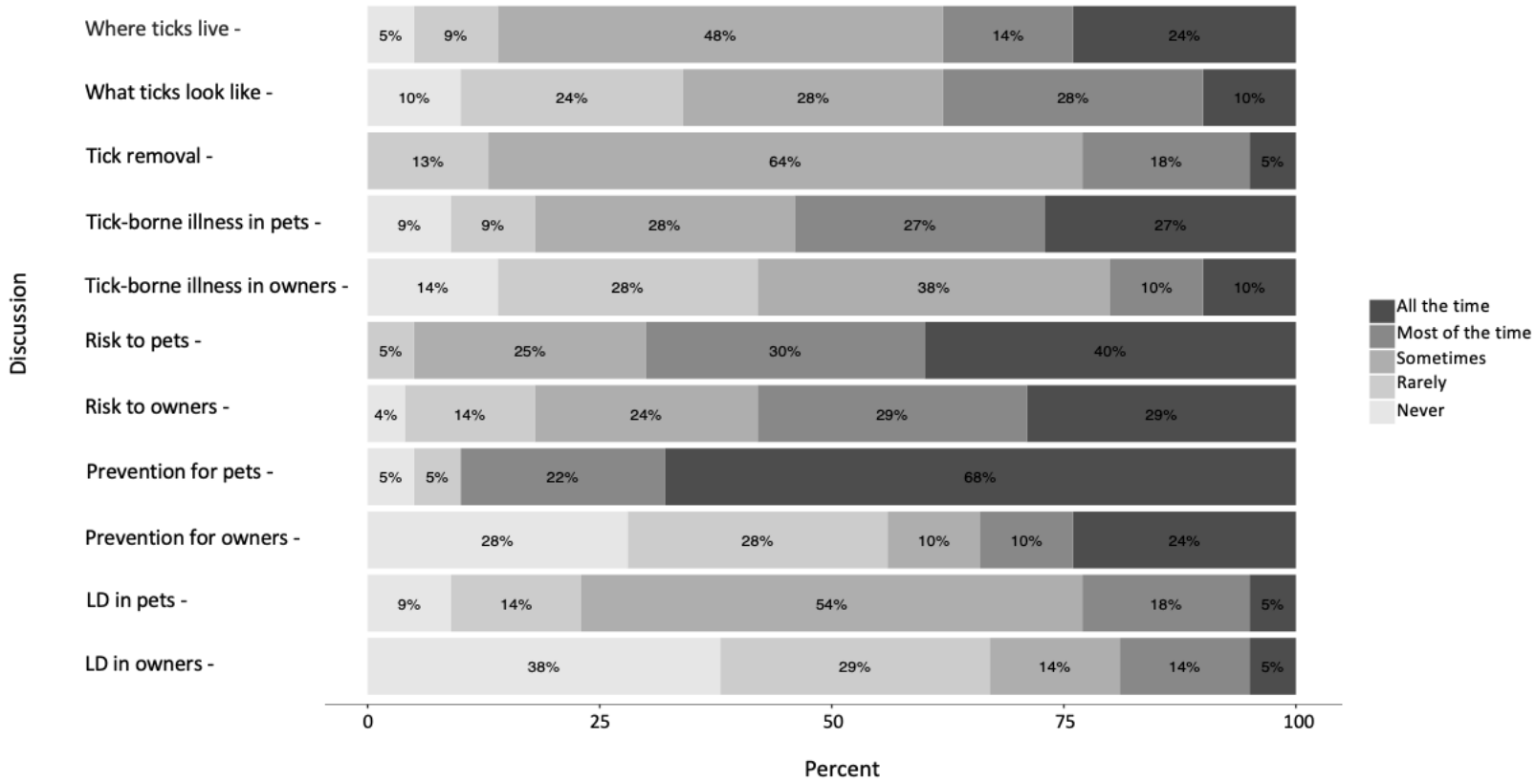

Figure 4.6. How often vet professionals have discussions about topics regarding tick risk, prevention, and control with animal owners (n=22). One respondent in this question added in the "other" category that was not included in the graph that they also discuss ticks with their animal owners regarding travel related plans.

4.1.5. Knowledge, concern, and experiences with TBDs in practice

The respondents' level of concern regarding Lyme disease (LD) in their animal patients is shown in Figure 4.7. Over 52% of the respondents (11/21) are not concerned about LD in their animal patients (Figure 4.7).

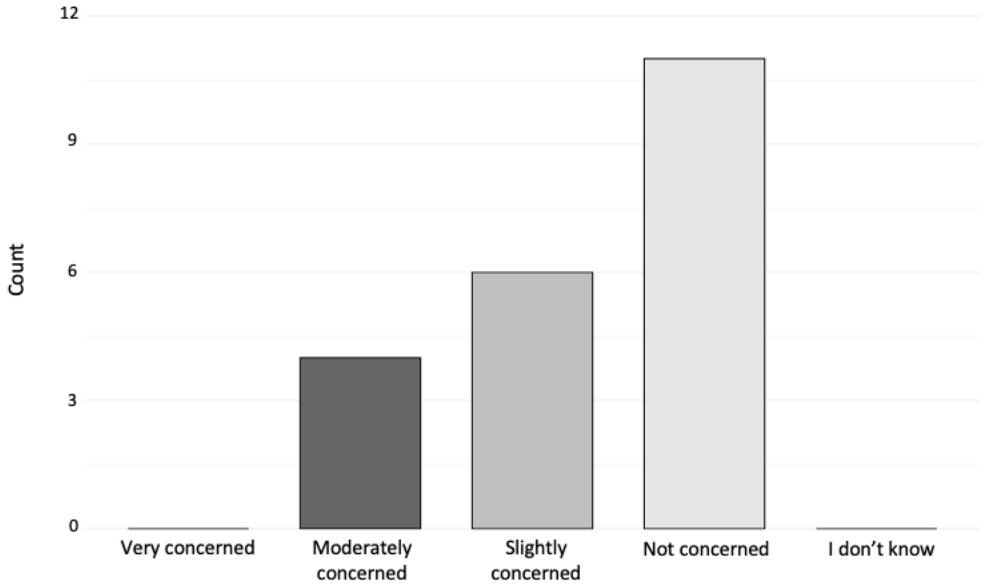

Figure 4.7. Respondents level of concern regarding LD in animal patients (n=21).

Respondents were asked how often they recommend the LD vaccine for their animal patients (Figure 4.8) and 40% of respondents (6/15) never would. Only 26% (4/15) of respondents sometimes would recommend the vaccine, and 7% (1/15) said they would “all the time” or “most of the time” (Figure 4.8).

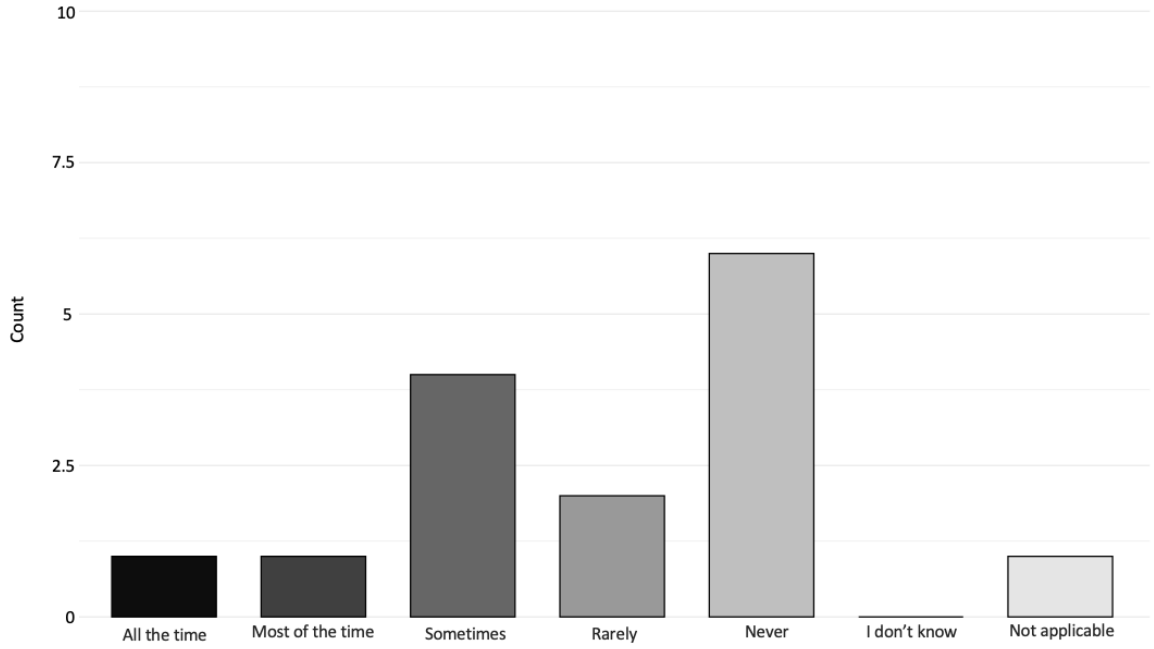

Figure 4.8. Frequency that respondents recommend the LD vaccine for their animal patients (n=15).

Respondents were asked about the tick-borne illnesses they have diagnosed in the past 12 months as shown in Figure 4.9. Of all the tick-borne illnesses listed in Figure 4.9, the most diagnosed one in the past 12 months was ehrlichiosis (33% [7/21]). Out of the other tick-borne illnesses apart from ehrlichiosis, between 66% and 95% were not diagnosed by the veterinary professional participants in the past 12 months or prior to 12 months ago (Figure 4.9). In the comments section at the end of the survey, a respondent put that most of the ehrlichiosis, anaplasmosis, and babesiosis cases have been from rescue dogs from other countries. It is important to note for Figure 4.9 that although 14 of the respondents were veterinarians, there were 7 veterinary technologist/technician respondents included in the results. Only veterinarians can make formal diagnoses, however, the veterinary technologist/technicians may have been involved in these cases. There was also an option to say “I don’t know” for this question.

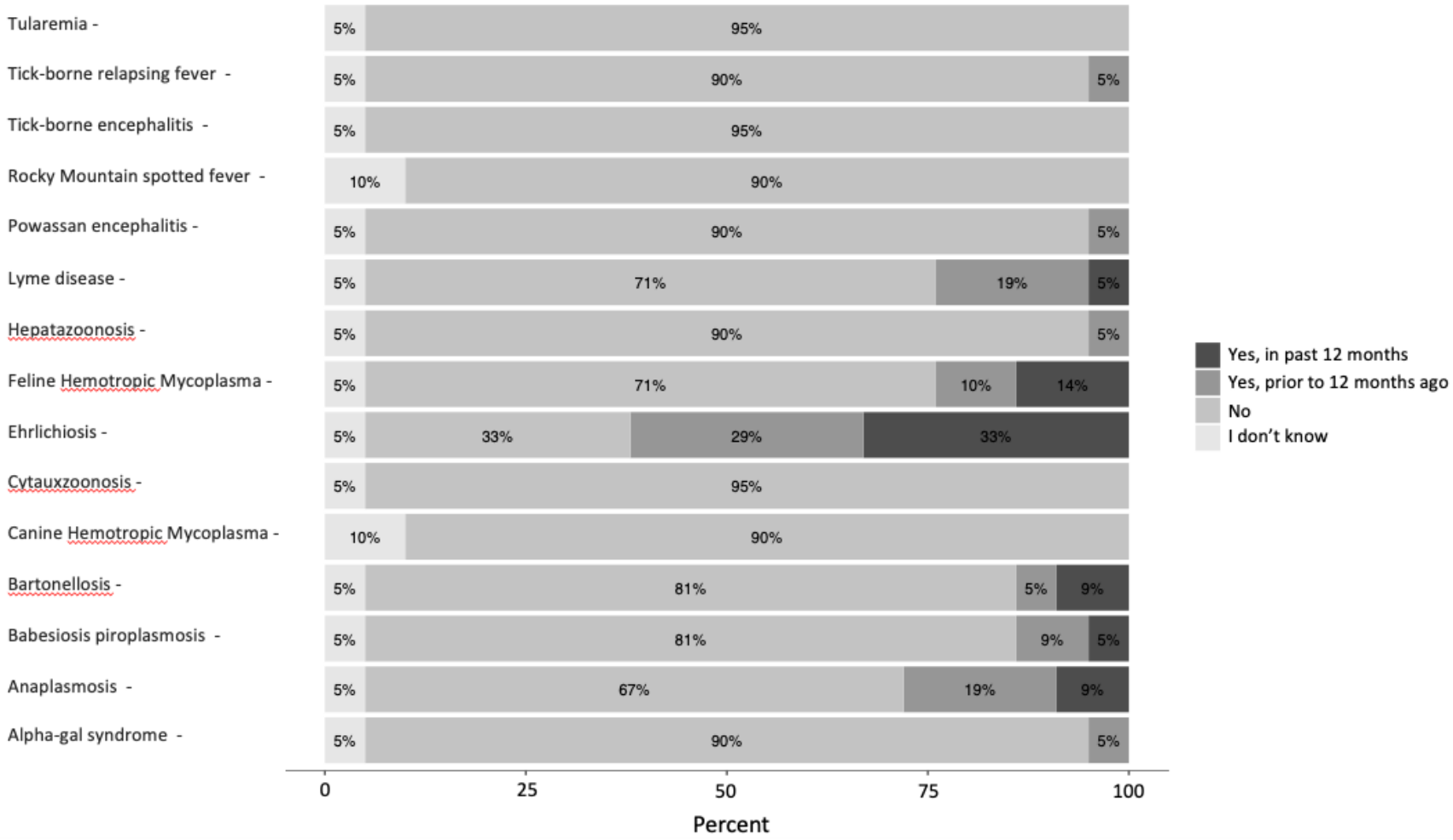

Figure 4.9. Tick-borne illness diagnosed in the past 12 months by respondents (n=21). One respondent added in the "Other" category that was not included in the graph they did diagnose tick paralysis prior to 12 months ago.

A follow-up question to the one in Figure 4.9 asked about the type of tests used to make their diagnosis, of those respondents (n=10), 7 vet professionals stated they used the IDEXX SNAP 4Dx test which tests for the antibodies indicative of Lyme disease, ehrlichiosis, anaplasmosis and dog heartworm (IDEXX, n.d.). It is important to note this question was open-ended and did not capture all the steps that are likely taken for testing.

Figure 4.10 represents the TBDs veterinary professional respondents would like to learn more about. The most chosen TBD was Lyme disease, followed by ehrlichiosis, and Rocky Mountain spotted fever as the third (Figure 4.10).

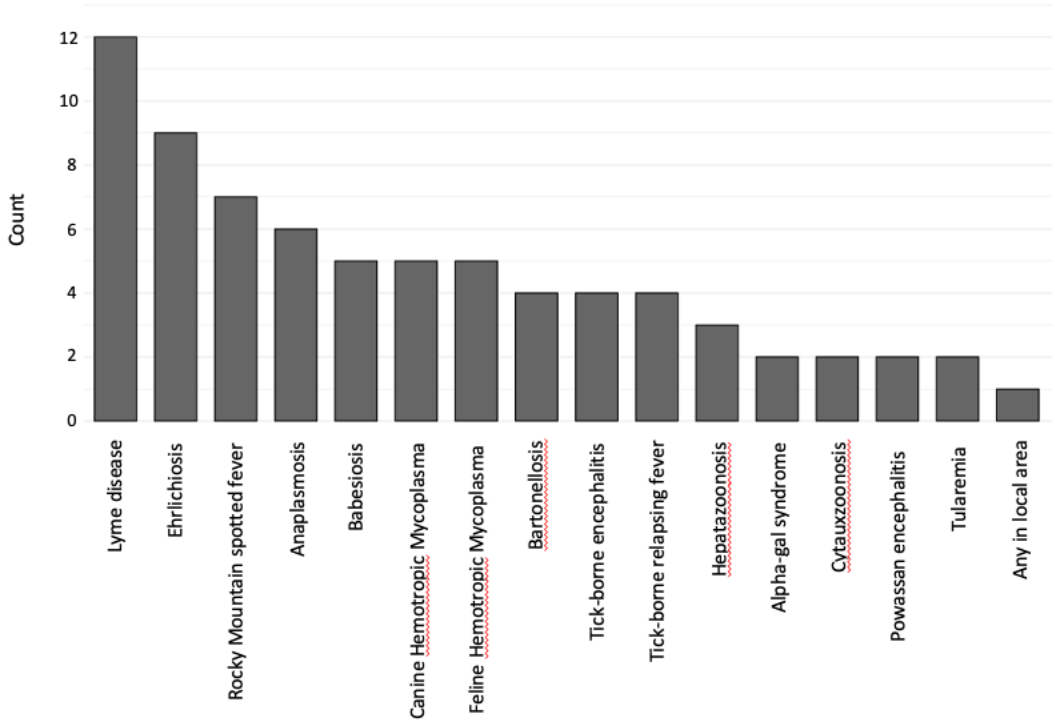

Figure 4.10. Tick-borne diseases veterinary professional respondents would like to learn more about. They could select more than one answer (n=16).

4.1.6. Education needs

Figure 4.11 shows the importance of each resource that the respondents may use to get their tick and TBD information from. Veterinary Information Network® (VIN) was indicated as “extremely important” by 47% (8/17) survey participants (Figure 4.11). Public health organizations were selected as “somewhat important” by 53% (9/17) respondents (Figure 4.11).

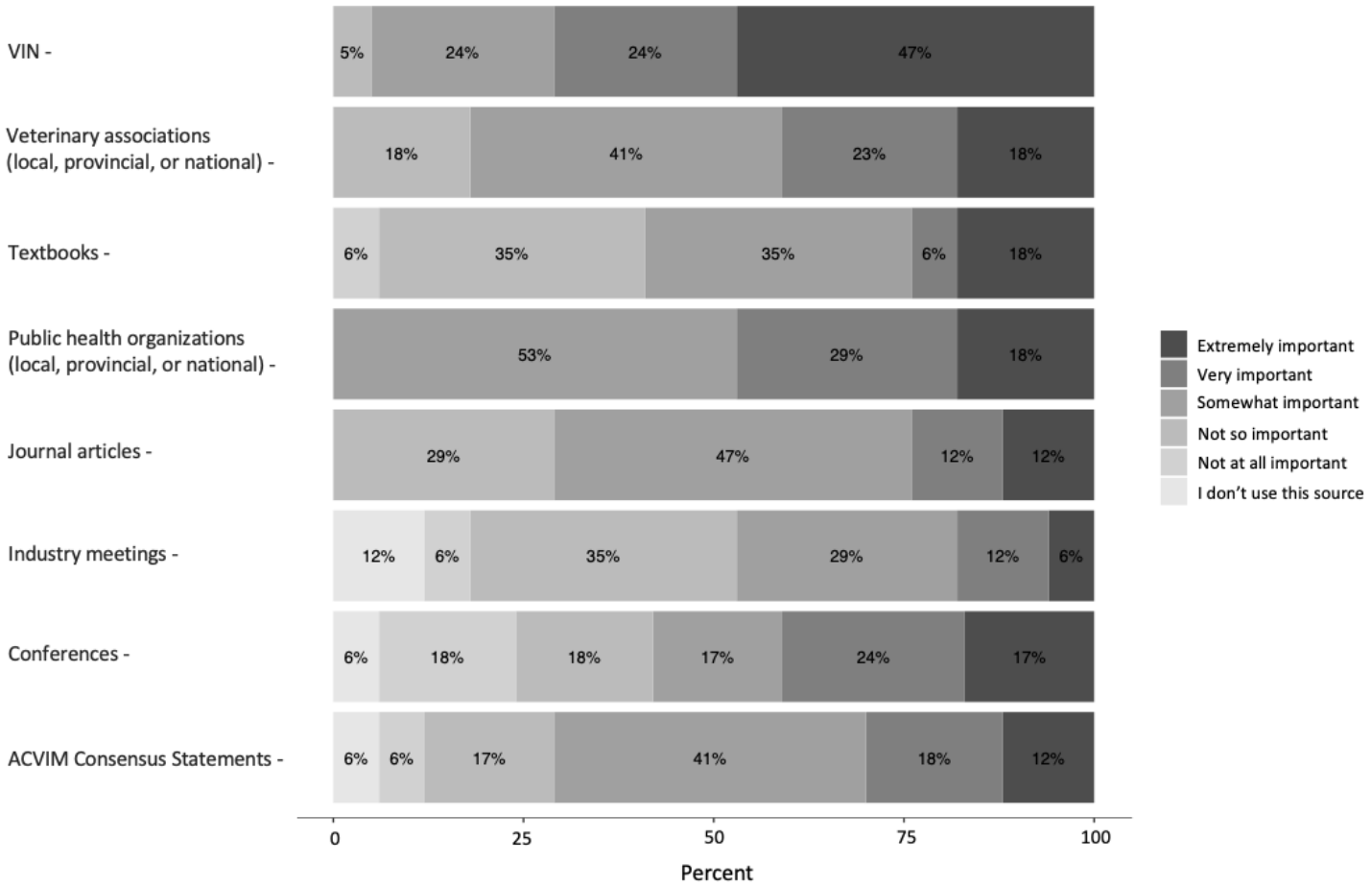

Figure 4.11. Most important resources for veterinary professional respondents to get tick and TBD information (n=17). Two respondents put in the "other" category that were not included in the above graph that their local lab and online CE (continuing education) were other important sources for them. VIN stands for Veterinary Information Network®, and ACVIM stands for The American College of Veterinary Internal Medicine.

To assess education needs of the respondents, they were asked to choose from the options shown in Figure 4.12 on what tick and TBD information they would like to know more about. Current disease risk (79% [15/19]), followed by diagnostic best practices (53% [10/19]), and tick distribution (53% [10/19]) were among the topics they would like to learn more about the most (Figure 4.12).

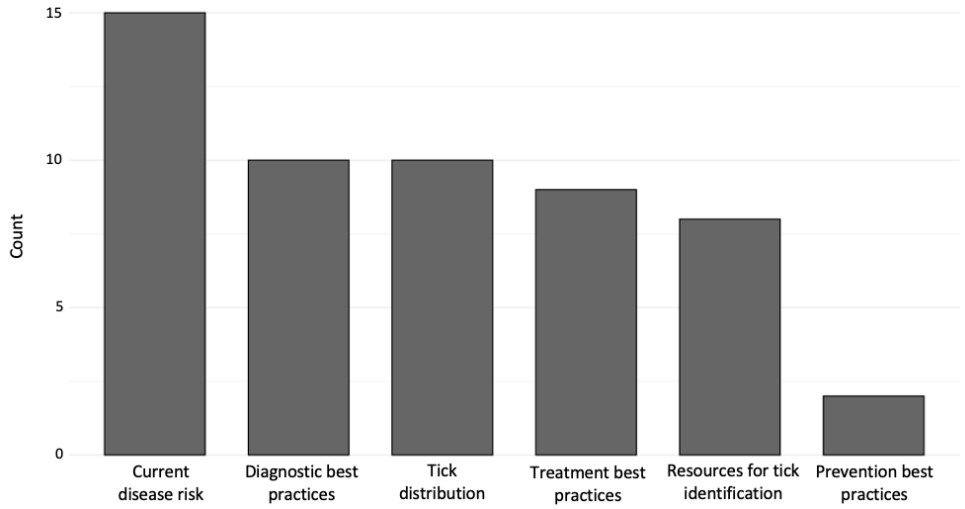

Figure 4.12. Tick and TBD related topics veterinary professional respondents need more information about. They could select more than one (n=19).

To determine the best mode of delivery of tick and TBD information to the veterinary professional respondents, they were asked to choose their preferred resource format from the options shown in Figure 4.13. Exactly 50% (9/18) of the respondents prefer email, followed by 17% (3/18) preferring infographics (Figure 4.13).

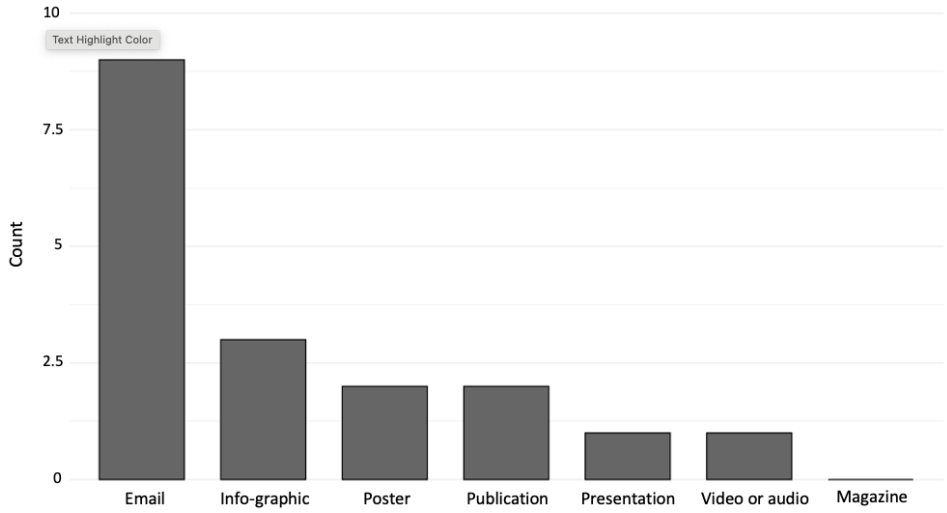

Figure 4.13. Preferred resource format of veterinary professionals to receive tick and TBD information on (n=18).

The participants were asked if they were aware of ©eTick and if they have already used it or not (Figure 4.14). Only 11% (2/18) respondents had heard of ©eTick and submitted to it already, while 44% (8/18) had heard of it and not submitted, and 44% (8/18) hadn't heard of it at all (Figure 4.14).

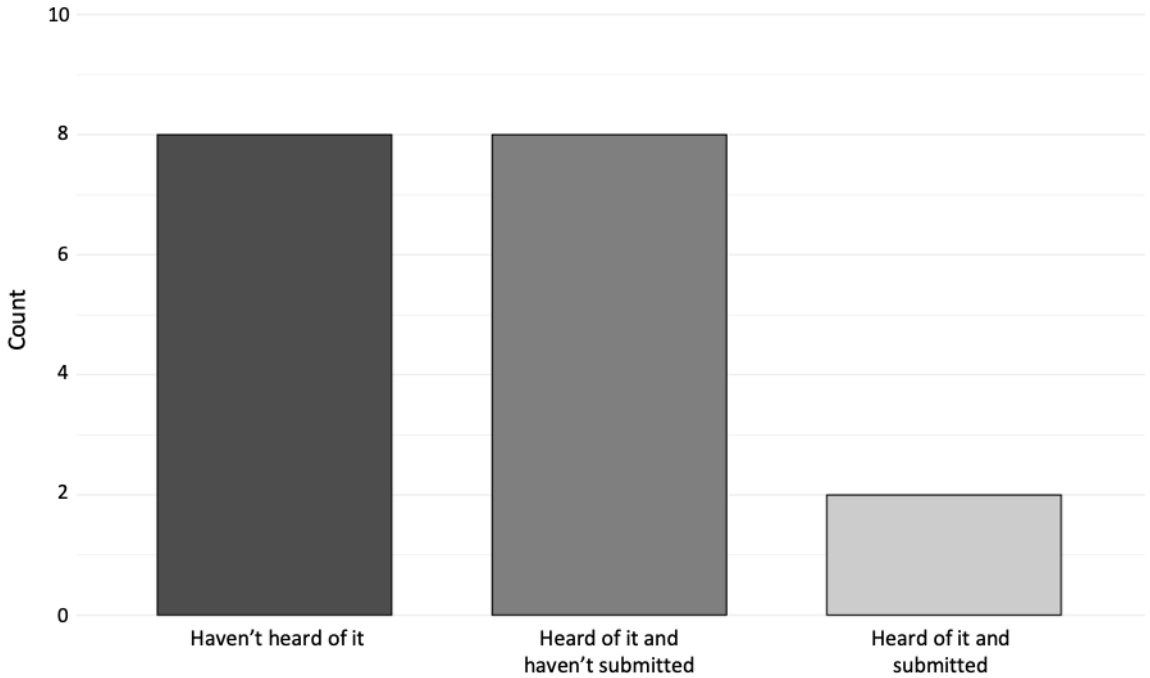

Figure 4.14. Veterinary professional respondents' awareness of ©eTick and if they have submitted to it (n=18).

After being informed of ©eTick at the end of the survey, 68% (13/19) respondents indicated they would be willing to submit to ©eTick in the future. Additionally, 78% (14/18) of the respondents said they would use results from ©eTick to inform their veterinary practice about ticks.

Lastly, we asked the respondents if they were aware of the free pathogen testing program being offer by BCCDC-Merck which was underway at the time, and 78% (14/18) of our respondents did not know about it.

4.2. Veterinary clinic participant characteristics by health authority region and qualitative data from phone calls.

4.2.1. Veterinary clinic participant characteristics by health authority

Geographic data was collected on the clinics where participants had agreed to the survey. These variables included the health authority, population density and population size of the city/town their clinic resides in. Using Statistics Canada's definitions of population size, three of our respondents' clinics were from a large urban area, six were from medium population centres, seventeen from small population centres, and one was less than small, which would be considered rural (Stats Canada, 2023). After the follow-up phone calls, the number of surveys completed increased the total respondents from 15 to 27.

While conducting this research, it became clear that there are many cities that do not have veterinary clinics at the time that the survey was conducted and that some clinics might have recently closed. See Table 4.3.

Table 4.3. Summary of total veterinary clinics in each BC health authority, total cities in each authority, cities with vet clinics and the number of closed clinics identified online.

Health region	Total clinics	Total cities	Cities with clinics	Cities without clinics	Number of closed clinics
Northern	30	28	12 (43%)	16 (57%)	4
Interior	78	69	38 (55%)	31 (45%)	1
Vancouver Island	102	48	29 (60%)	19 (40%)	1
Vancouver Coastal	83	12	11 (92%)	1 (8%)	1
Fraser Health	157	20	16 (80%)	4 (20%)	0

It important to note that many of the cities that are without veterinary clinics are often close to nearby cities that do have clinics. This would be very accessible in more urban and densely populated areas such as in the Fraser Health and Vancouver Coastal Health regions. An exception to this would be Northern Health authority, where the distance between cities may be far greater than that of the more urbanized areas in BC.

4.2.2. Qualitative information gathered during follow-up phone calls

During the follow-up phone calls to veterinary clinics, records were kept of the date, time, and outcome of the phone call such as if they answered the phone, consented to receive the survey or not, and some notes of the conversation if any extra information was shared. During a few conversations with staff, information was shared about their experience with ticks in practice in the present and/ or the past. In this summary of the phone calls, only the health authority/region will be shared in the paraphrased quotes to not disclose the clinics and maintain anonymity. Three separate clinics in the Northern Health authority region said they rarely get ticks off companion animals. One staff member said they tend to only get them off ungulates and would not get ticks from dogs unless “it was resting near infested ungulates” [quote]. A staff member from a different clinic stated they used to work in Kelowna where they saw ticks frequently but haven’t seen one on a companion animal since they started working at their current clinic in Northern Health authority.

A veterinarian in Vancouver Island Health authority shared that many veterinary clinics are being bought out by Veterinary Centers of America (VCA). This concentration of ownership is interesting and will reflected upon later in the discussion section.

This veterinarian also shared that in the world of ticks, they felt it is often “reactive medicine instead of preventative” [quote]. The veterinarian shared in their experience that animal owners tend to react after their pet or animal has already been bitten and getting them on board with prevention can be difficult.

This same veterinarian participant stated they found the BCCDC tick submission process difficult to navigate. This prevented them from submitting a tick even though they had wanted to.

4.3. Results of passive tick surveillance programs operating in BC

Four sources of tick passive surveillance data were operating in BC prior to or at the time that this survey was taking place: the Public Health Agency of Canada's National Microbiology Laboratory (NML), the BCCDC Public Health Laboratory (PHL), ©eTick, and the BCCDC-Merck project (Table 4.4). Table 4.4 outlines how data from each program was obtained and the parameters of the data available for this project. Raw data about BC vet clinic submissions to the NML was provided by the Chief Research Scientist of Field Studies (personal communication, January 23, 2024). The BCCDC PHL was not able to provide a raw dataset, but a non-peer reviewed report was identified on their website about their past tick and TBD surveillance in BC (BCCDC, 2023) and this data is shown in Figure 4.17. The BCCDC-Merck Animal Health data for number of ticks requested and received for pathogen testing were provided by Stefan Iwasawa, a vector biologist at the BCCDC who is leading the program (personal communication, March 14, 2024). The ©eTick data was provided voluntarily by the project coordinator/research associate and creator/director of ©eTick (©eTick, 2024). There was no personally identifying information included in any of these sources.

Table 4.4. BC tick passive surveillance data sources

Passive surveillance program	Raw data accessible (Yes/No)	Target populations	Data collection years	Program active
NML	Yes	Veterinary clinics	2010 – 2021	No
BCCDC PHL	No	Veterinarians	2002 - 2021	Yes
BCCDC-Merck Project	Yes	Veterinary clinics	2023	Yes
©eTick	Yes	-Veterinary clinics -Health professionals -Public	2023	Yes

4.3.1. ©eTick passive surveillance tick data

Table 4.5 contains the number of valid tick submissions to ©eTick in the first 3 years since its launch in BC in May 2021. Prior to May 16th 2023, ©eTick did not track its users by categories such as veterinarian, doctor, or member of the public, so Table 4.5 includes an amalgamation of all users. In 2021, they received 198 valid tick submissions (Table 4.5). In 2022 and 2023 the total submissions increased to 978 and 994

respectively (Table 4.5). In 2021 and 2022, the number of submissions from human hosts were highest but in 2023, the number of tick submissions from animals (466/994, [47%]) surpassed humans (392/994, [39%]) (Table 4.5).

Table 4.5. Summary of valid ©eTick submissions data by host type (animal or human) or free in the environment in British Columbia.

Host	2021	2022	2023
On an animal	58 (29%)	313 (32%)	466 (47%)
On a human	116 (59%)	513 (52%)	392 (39%)
Free in the environment	24 (12%)	152 (16%)	136 (14%)
Total	**n=198**	**n=978**	**n=994**

As of May 16th 2023 users could identify as a veterinarian/vet clinic, health professional, member of the public, or other/prefer not to answer. The submission data to ©eTick by those groups is summarized in Table 4.6 for the dates of May 16th 2023 to December 31st 2023. For this summary, data on whether the users had already used ©eTick before and what type of host the tick was found on was also included (Table 4.6). Around 44% of ©eTick users associated with a veterinary clinic were returning users, meaning they submitted more than once on different days (Table 4.6). About 96% of the ticks submitted by vet clinics were found on animals as opposed to on a human or free in the environment (Table 4.6).

Table 4.6. Summary of ©eTick submission data from BC residents May 16th 2023 to December 31st 2023 for valid and invalid submissions by group (n=737).

Category of ©eTick users		Responses
Veterinarian/vet clinic	Total number of submissions	n=122
	On a human	2 (2%)
	On an animal	117 (96%)
	Free in the environment	2 (2%)
	Number of users that made the submissions	n=61
	Number of returning users	27 (44%)
	Number of single time users	34 (56%)
Health professional	Total number of submissions	n=21
	On a human	17 (80%)
	On an animal	2 (10%)
	Free in the environment	2 (10%)
	Number of users that made the submissions	n=19
	Number of returning users	1 (5%)
	Number of single time users	18 (95%)
Member of the public	Total number of submissions	n=496
	On a human	182 (37%)
	On an animal	143 (29%)
	Free in the environment	171 34%)
	Number of users that made the submissions	n=350
	Number of returning users	21 (6%)
	Number of single time users	329 (94%)
Other/prefer not to answer	Total number of submissions	n=98
	On a human	40 (41%)
	On an animal	45 (46%)
	Free the environment	13 (13%)
	Number of users that made the submissions	n=78
	Number of returning users	3 (4%)
	Number of single time users	75 (96%)

*Indicates where colleague Stefan Iwasawa [BCCDC] and I are included in this data as ©eTick users from CLyDRN (CaLSeN) tick sampling. Stefan made 93 and I made 10 tick submissions found free in the environment, making us multiple submission and returning users for members of the public.

The total number of ©eTick submissions by self-identified group/category for the dates of May 16th 2023 to December 31st 2023 were also visualized in a graph and a chi-square test was performed on these values (Figure 4.15). There were significantly more submissions from the public (n=496) compared to every other category (P<0.001 for each category compared to the public) (Figure 4.15). More veterinary clinics (n=122) submitted to ©eTick than health professionals (n=21) (P<0.001) (Figure 4.15).

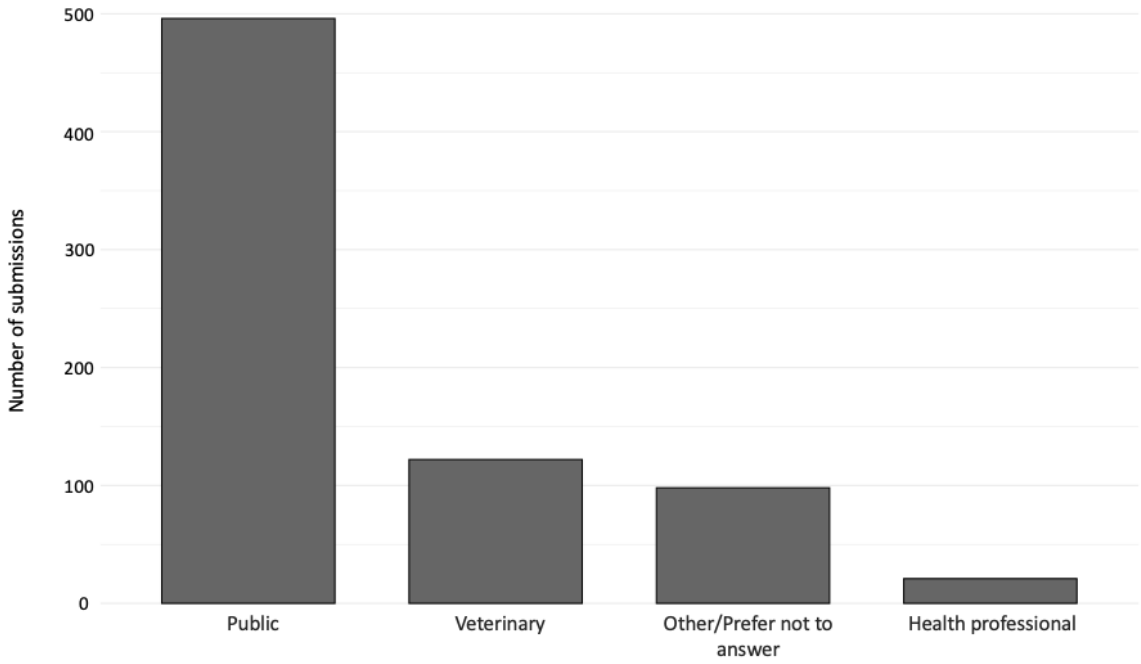

Figure 4.15. Number of ©eTick submissions by category from May 16th 2023 to December 31st 2023. This includes valid (publicly available) and invalid (not publicly available) submissions (n=737). The total for the categories is 496 submissions from members of the public, 122 from veterinary professionals, 98 preferred not to answer, and 21 from health professionals.

4.3.2. National Microbiology Laboratory (NML) veterinary clinic passive surveillance tick data

Figure 4.16 is showing all the BC veterinary clinic submissions to the NML between the years of 2010 to 2021. All the NML submissions were from ticks found on dogs, with the exception being one from a cat in 2012 and two from humans in 2015 and 2017 (Figure 4.16). The highest year for tick submissions to the NML during this period was 2013 with 19 ticks (Figure 4.16). The lowest years for vet clinic submissions were 2018 and 2020 where only one tick was received (Figure 4.16).

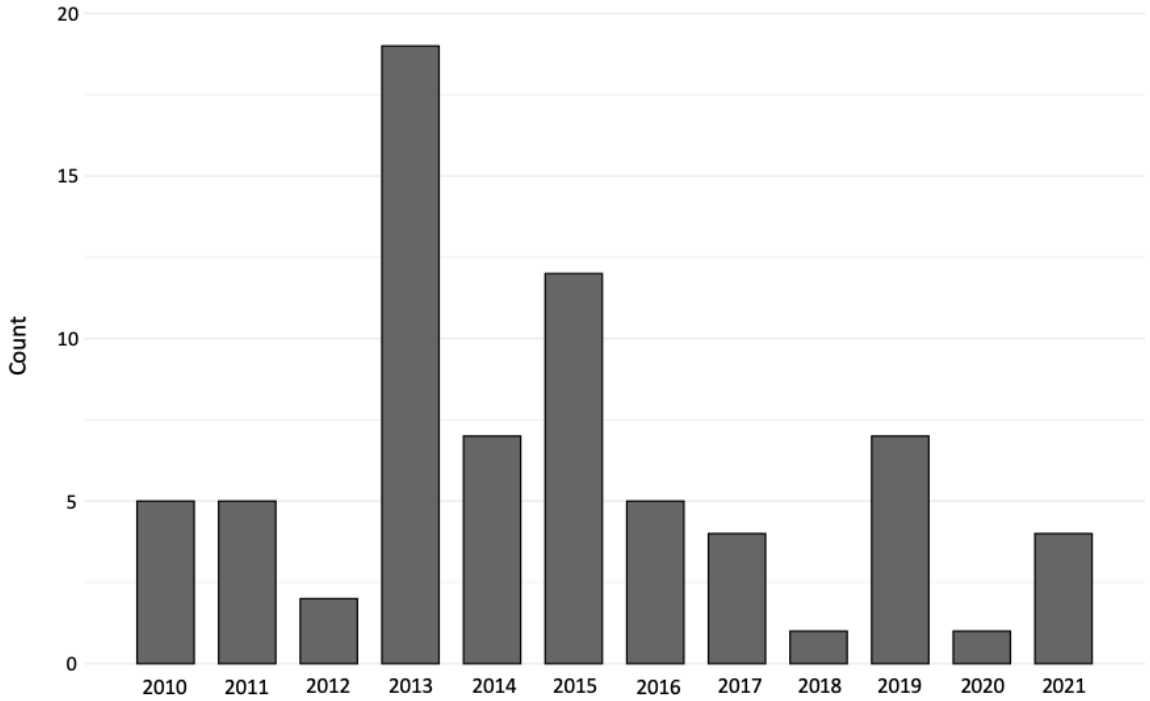

Figure 4.16. BC veterinary clinic passive surveillance tick submissions to the National Microbiology Laboratory (NML) from 2010 to 2021.

4.3.3. BCCDC veterinarian passive surveillance tick data

The BCCDC published a report on ticks and TBD surveillance in BC in 2023, and one of their Figures was included in this thesis (Figure 4.17). Figure 4.17 shows total yearly tick submissions from animals and humans for the years 2002 to 2021. Between 2002 and 2013, tick submissions from both animals and humans were similar for most years with a range of around 200 to 500 per year (Figure 4.17). In 2014 when fees were instated for veterinarians, there was a considerable drop in animal tick submissions from veterinarians, with that first year having an estimation of just over 100 submissions (Figure 4.17). From 2015 onward, there were an estimated 50-100 submissions per year and some years below 50 (Figure 4.17). Human tick submissions went up in 2014 to nearly 700 and have increased to over 1000 in 2016 and every year since (Figure 4.17).

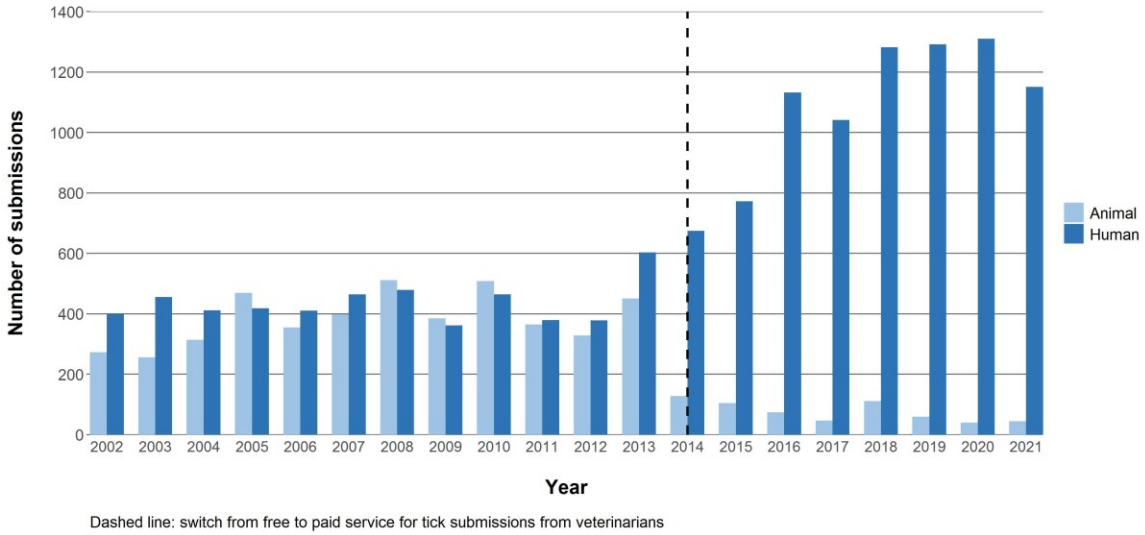

Figure 4.17. Number of ticks from humans and animals submitted to the BCCDC Public Health Laboratory, 2002 to 2021.

Source: British Columbia Centre for Disease Control. (2023). *Ticks and Tick-Borne Disease Surveillance in British Columbia: June 2023*. (http://www.bccdc.ca/Documents/Ticks_and_Tick-Borne_Disease_Surveillance%20_BC.pdf, page 13, Figure 6)

4.3.4. BCCDC-Merck Animal Health free pathogen testing for vets project data

An active surveillance program was identified and operating through a BCCDC-Merck Animal Health collaboration. Merck Animal Health is a company that operates globally and conducts research for veterinary medicine and other veterinary services to treat diseases for farm and companion animals (Merck Animal Health, 2024). For this program, the cost was covered for species ID and pathogen testing of *Borrelia* spp., the pathogen that causes LD, as well as *Anaplasma* spp., *Ehrlichia* spp., *Babesia microti,* and *Rickettsia rickettsi*. The only cost for the veterinary professional or clinic would be that of a postage stamp to send the tick in the mail, around $1.00 CAD or less. Since ©eTick did not start tracking veterinarian/vet clinic users by category until May 16th 2023, prior to this date veterinary users were identified by their email or username they submitted to ©eTick under. If the email or username included some form of or acronym indicating “vet” or “animal hospital” or “AH”, then they were sent a request for free pathogen testing if their tick was an *Ixodes* spp. found on a companion animal. All ticks were requested to be sent to the BCCDC PHL. From February 6th to December 31st 2023, there were 168 requests sent asking veterinary clinics in BC that submitted to ©eTick if they would participate in the BCCDC-Merck program. 100 ticks were received

for testing (65% participation rate). All 100 ticks were negative for *B. bugdorferi* and the results for the other pathogens were not disclosed.

Chapter 5. Discussion, limitations, conclusion, and future directions

5.1. Discussion

After repeated attempts to distribute the survey through different modalities including follow-up phone calls and direct email distribution, it was still very difficult to get a response from BC veterinary professionals. The studies by Senyk (2021) and Nichol et al. (2021) both distributed their surveys online and also received low response rates from BC veterinary professionals. We attempted to accommodate for this and increase participation by the personal phone calls and emails. This still resulted in a low response rate to our survey. If there weren't time constraints, we would have phoned all 450 vet clinics, but were only able to attempt phone calls to over 120. Even with these attempts at multiple modalities, we were unable to determine adequately why the response rate was so low. I speculate that veterinarians and veterinary technologist/technicians may be too busy or overwhelmed in their roles to complete even an online survey questionnaire. It is also possible that the survey was too complex, and that something simpler may have increased the response rate.

Additional reasons for the low response rate could include lack of interest and lack of incentives. Since most respondents indicated that ticks are rarely or never the primary reason for their visits by animal owners, there may not be as much interest for tick-related surveys. This is supported anecdotally for part of the Northern Health authority region where three veterinarians said they rarely or never get ticks on animals in their practice. However, veterinary clinics did participate in the tick submissions via the BCCDC-MERCK collaboration and many use the ©eTick platform, so there are vet professionals who are engaged in this area. Incentives are often a useful way to entice people to take part in surveys. Unfortunately, I did not have a budget for this project.

Given this low response rate, the results of the survey and the conclusions drawn are very limited. These conclusions are only applicable to the small participant group that took the survey, and not generalizable to all BC veterinary professionals. Comparisons will be made between our survey results, and the past findings in the Nichol et al. (2021) publication and the CVMA (2022) report to contribute to the small portion of literature on this topic. The characteristics of the rapid review articles and this

thesis survey are shown in Table 5.1. A summary of all three studies key findings is described in Table 5.2.

Table 5.1. Characteristics of the KAP studies in Chapter 2. Rapid Review by Nichol et al. (2021) and the CVMA (2022), in comparison to the survey done for this thesis.

Authors, Year and Journal (if applicable)	Study Location	Participants	Data Collection Period
CVMA (2022) -Not peer reviewed	Canada	- 909 veterinarians (all of Canada) - 168 BC (West)	November 2021 – unknown date
Nichol et al. (2021) -Journal of Veterinary Internal Medicine	Canada	- 192 veterinarians (all of Canada) - 15 BC -32 West (BC, AB and SK)	June – July 2019
Cooper et al. (2024) -Unpublished Master's thesis	BC	-27 veterinary professionals (17 vets & 10 vet techs)	April – August 2023

Table 5.2. Key findings of the KAP studies in Chapter 2. Rapid Review by Nichol et al. (2021) and the CVMA (2022), in comparison to the survey done for this thesis.

CVMA (2022)	Nichol et al. (2021)	Cooper et al. (2024)
1. ID skills not assessed.	1. Tick ID ability: "Average"	1. Tick ID ability: "Average"
2. Barriers to tick ID not assessed.	2. Barriers to tick ID: not enough training and cost.	2. Barriers to tick ID: cost.
3. Possible misunderstanding by BC vets that *I. scapularis* are in BC.	3. West (BC, AB, SK) vets more likely to say blacklegged ticks not in area.	3. Misunderstanding that *I. scapularis* are in BC. Regional differences in tick species knowledge

5.1.1. Participant characteristics

Most of the respondents for this survey were veterinarians working in small animal practices. This was the same for the previous literature by Nichol et al. (2021) and the CVMA (2022) where most of the veterinarians worked on small or companion animals. Only four of the respondents to the survey were working at more than one type of practice and all the respondents had only been working in Canada. A few participants had worked in other provinces. These shared characteristics only apply to our small

respondent group, therefore the findings in this thesis are not generalizable to all veterinary professionals in BC.

5.1.2. Knowledge of ticks

Possible gaps were identified in BC veterinary professionals' knowledge of tick species and their endemicity. None of our respondents accurately identified *Ixodes angustus*, one of the vectors of the Lyme disease pathogen, as a species in their area. Although several were able to accurately identify that Western blacklegged ticks (*I. pacificus*) have always been found in BC, many inaccurately chose the Blacklegged or deer ticks (*I. scapularis*) as well (Table 5.2). This response was seen in Fraser Health authority and VCH where a quarter of respondents chose both species as always found in the area. This was comparable to VIH, where slightly more respondents chose the Western blacklegged tick (*I. pacificus*) accurately, but several also chose the Blacklegged or deer tick (*I. scapularis*). There is a possibility this might align with findings in the CVMA (2022) study, where BC veterinarians also incorrectly chose the Blacklegged or deer (*I. scapularis*) tick as being found in their area (Table 5.2). Unfortunately, we are not able to conclusively say if this was a misunderstanding by the respondents in the CVMA (2022) study since only common names were used, not species names. However, it is important for veterinarians to be aware of each of the blacklegged tick species in Canada, even just by common names for accurate risk assessment of LD. In the Nichol et al. (2021) publication, West (BC, AB, SK) vets were more likely to think Blacklegged ticks are not in their area, when in fact they are (Table 5.1). This could have consequences for animal patients in BC since there is still a risk, albeit lower, of *I. pacificus* ticks transmitting the pathogen that causes LD.

Interior Health had the highest recognition for Rocky Mountain wood ticks (*D. andersoni*) always being found in their area, and only 1 respondent chose both types of Blacklegged tick species for always found (Table 5.2). This is what we would expect since Rocky Mountain wood ticks are the most submitted type of tick to the BCCDC by Interior Health authority (BCCDC, 2023). Interestingly, the one Northern Health authority respondent said they didn't know for all tick species.

Since most of the respondents to our survey didn't know if most of the tick species had been found in their local area, this points to a lack of knowledge or

awareness about tick species in general. Overall, this finding suggests that more education about tick species is warranted for BC vet workers.

5.1.3. Clinical approaches

The clinical approach section of this questionnaire revealed several barriers to tick identification and testing for the veterinary professional respondents. The number one problem our respondents had in dealing with ticks in practice was submitting them for testing. More evidence to support this was provided by a veterinarian over the phone who had trouble navigating the BCCDC tick submission process and gave up. Most respondents indicated they would dispose of a tick brought into their clinic without further identification regardless of if the tick was engorged or not engorged. Reasons provided for why the respondents wouldn't follow-up with tick identification were that it was too expensive for their pet owners. This finding aligns with what Nichol et al. (2021) found where cost was also a barrier and not having enough training in identifying ticks for the veterinarian respondents across Canada. In the Nichol et al. (2021) publication, most veterinary professionals self-assessed their skill level as "average" which means they can tell Blacklegged ticks from dog ticks or wood ticks (Table 5.2). This skill level is advantageous in practice when weighing the risk of an animal patient contracting Lyme disease (LD), since Blacklegged ticks could transmit *B. burgdorferi*, while the other species don't (Centers for Disease Control and Prevention, 2023).

One aspect that was not explored in the survey for this study is that veterinary professionals may be moving away from testing ticks to instead testing the animal directly for tick borne diseases. The IDEXX SNAP 4Dx Plus test for antibodies to *B. burgdorferi* (IDEXX, n.d.) cost is not published on their website, but it is possible it could be more affordable than the $65.00 CAD test for tick ID and pathogen testing by the BCCDC lab. This different approach could be a contributor to the low numbers of ticks from animals submitted to the BCCDC passive surveillance program. A future direction that could be explored is to directly contact IDEXX regarding sales trends in BC.

When given a choice of discussion topics related to ticks and TBDs that veterinary professionals might have with their pet owners, prevention for pets was among the highest. This aligns somewhat with what Nichol et al. (2021) found where most of the veterinarians across Canada discuss prevention at yearly check-ups.

However, discussing tick prevention didn't seem to carry-over into scenarios where a dog comes into the clinic with an attached and engorged tick, or when a dog tests positive for *B. burgdorferi* (Nichol et al., 2021). In those scenarios, just under half of the vets would discuss prevention (Nichol et al., 2021). This points to a possible missed opportunity to discuss tick and TBD prevention with animal owners when it would be most relevant.

5.1.4. Knowledge of and experience with TBDs

Most of our respondents in BC were not concerned about Lyme disease (LD), whereas most of the veterinarian respondents across Canada for Nichol et al. (2021) indicated they believe *B. burgdorferi* presence has increased in the past 5 years. This could be due to the regional differences in LD risk where the incidence of human LD is much lower than in Eastern Canada. This could also be why most of the veterinary professional respondents never recommend the LD vaccine for their patients, with only a handful of them recommending it sometimes.

While LD happened to be the top disease the respondents wanted to learn more about, the most commonly diagnosed disease in patients was ehrlichiosis. It was stated that this could be a disease seen more commonly in rescue dogs from other countries. Given the continued popularity of rescue dogs from other countries, tick awareness programs should include a broad range of information about both endemic and foreign ticks.

5.1.5. Education needs and resources

There were very similar findings in regard to education needs of veterinary professionals between studies. Both ours and Nichol et al. (2021)'s respondents wanted more information on diagnostic best practices and current disease risk, as well as LD. Tick distribution was also high on the list chosen by our respondents for educational needs. Email is the preferred choice for knowledge translation of tick and TBD info to our respondents, followed by infographics. Having email as the preferred resource format as opposed to posters, publications or presentations could be an indicator of the busyness of veterinary professionals in BC. Email is also a direct form of communication and might be the most effective route for knowledge dissemination. Our respondents and the

Nichol et al. (2021) respondents both get their tick-related information from the Veterinary Information Network® (VIN). VIN is an organization that connects veterinarians and veterinary students globally with the most up-to-date resources on veterinary information, including diseases, drug information, learning tools and more (Veterinary Information Network®, 2024). A membership is required to join the VIN and registering as an individual costs $65/month or $810 annually (VIN, 2024). Since VIN was the most important resource for our veterinary professional respondents, as well as Nichol et al. (2021)'s, they may be filling knowledge gaps for tick education that are not being covered by public health authorities. Even with a monthly or annual cost for membership, the benefits appear to outweigh the cost factor for veterinary professionals. The VIN could be a potential partner for knowledge translation of the tick and TBD information needs to veterinary professionals in Canada or BC. However, we are unable to see the tick and TBD resources that VIN is providing to their veterinary community and if they are evidence-based. With the pros of this resource being widely used by veterinary professionals in Canada or BC, the con is that there could be pitfalls in their message boards about ticks and TBDs if they don't provide regional specific information. The quality control of their tick and TBD resources is unknown and they may not all be generalizable to the context of tick species in BC. Regardless, considering them as a future partner for knowledge translation of evidence-based tick and TBD resources would still be valuable to reach BC and Canada veterinary professionals.

5.1.6. Veterinary clinic characteristics by health authority and qualitative results

The sampling frame construction and survey data suggest that there may be a shortage of veterinarians and vet clinics in the Northern Health authority. After multiple attempted phone calls to all Northern Health authority clinics, many did not answer the phone. We could not rely on reported number of veterinarians on websites since verifying this number during phone calls revealed the number of vets stated online often did not match the number of currently practicing vets in their clinics. Also, there were several clinics without websites, so learning the number of veterinarians per clinic was not possible with our constraints. The CVMA has noted that there are labour shortages impacting veterinary clinics across Canada and that clinic owners are having issues hiring and keeping veterinary employees (CVMA, 2023a). This issue could possibly be impacting the Northern Health authority region disproportionately more than other areas.

This may have contributed to the lack of response by Northern Health authority veterinary professionals to our survey. These Northern Health authority veterinary professionals may also not be in a position to prioritize tick and TBD related issues with the increased pressure due to lack of clinics and/or staff. This Health authority should be prioritized more for free tick and TBD related resources to help ease this possible burden on their clinics. Although some Northern Health veterinary professionals reported they don't often get ticks off companion animals, including them in surveillance efforts will be important for tracking tick populations and emerging diseases in the BC landscape with climate change. Therefore, they should be included in knowledge translation efforts about ©eTick.

Follow-up phone call conversations to veterinary clinics in BC produced some anecdotal information about clinics and experiences with ticks in practice. A veterinarian stated over the phone that they are witnessing a concentration of veterinary clinic ownership by Veterinary Centers of America (VCA) who is buying out several clinics. This claim was corroborated by looking at the veterinary clinic list for Vancouver Island Health authority where several clinics now have VCA in their name. This concentration of ownership may facilitate knowledge translation about ticks and TBDs as allied clinics could share information and practice strategies. Similar to the possible cons of the VIN, an industry group being a main source of information, VCA's quality control of evidence-based tick and TBD resources is unknown, but they could still be considered as a channel for knowledge translation.

After the veterinarian shared the challenges they had navigating the BCCDC tick submission process, the BCCDC was contacted to bring it to their attention. They said they would work on fixing the website to make it easier to navigate for their veterinarian users in the future.

5.1.7. Passive surveillance data for ©eTick, BCCDC, NML and BCCDC-Merck Animal Health project

The four tick passive surveillance identified for this project were the NML, the BCCDC PHL, ©eTick, and the BCCDC-Merck project. Submissions to the BCCDC by veterinarians had averaged 200 ticks per year from 2002 until 2013 when the service was free (BCCDC, 2023). In 2014, when the BCCDC started charging for tick

identification and pathogen testing, submissions dropped to below 200 yearly, with submissions being at an all-time low for veterinarians in the years 2020 and 2021 with below 100 ticks per year (BCCDC, 2023). However, it is likely this service was impacted by the COVID-19 pandemic during 2020 and 2021. Historically, submissions from veterinary clinics to the NML has been not as high as the BCCDC, with the NML's highest year for submissions being 19 ticks in 2013. Total submissions per year to ©eTick in BC are mirroring submissions to the BCCDC in recent years with the total ticks being around 1000 per year (BCCDC, 2023; ©eTick, 2024). However, most submissions to the BCCDC are from medical doctors and the majority of ©eTick submissions are from the public, followed by veterinarians/vet clinics. This indicates ©eTick is filling a gap in passive surveillance accessibility for BC residents and veterinary professionals. Comparing our survey results to the surveillance data gathered, most of our respondents had not submitted a tick to the BCCDC in the past year for pathogen testing. Additionally, the respondents would only submit a tick after removal for further identification 17% of the time, whereas the majority (41%) would dispose of it without any further ID. This aligns with the seemingly low tick submission rates by veterinarians seen in the BCCDC data.

Something notable about the BCCDC tick submission data was the sudden increase in tick submissions from humans after the fee was introduced for veterinarians in 2014. This increase was considerably high, jumping from roughly 600 ticks off humans in 2013, to over 1000 in 2016 and onward (BCCDC, 2023). There is no evidence to support this, but since animal submissions have remained low and human submissions have increased noticeably, there is a possibility people may tell their doctor the tick was off themselves instead of their pet to avoid the fee. This is only speculation, and it is unknown if veterinary professionals would encourage their pet owners to do this, but it is a possible theory. If this were to be true, it drives home the importance of having tick ID and testing be free for accuracy of public health records for tick host data. More evidence to support the fact that veterinary professionals will access passive surveillance when it is free is the high submission rate that was seen for the BCCDC-Merck project.

Interestingly, tick submissions by veterinarians to the BCCDC has been much lower than doctors in recent years, but the opposite was true for ©eTick, where submissions by veterinary professionals were shown to be statistically significantly

higher than submissions by health professionals. Having ©eTick as a free resource has seemingly increased tick passive surveillance participation by veterinary professionals who may not be accessing the BCCDC tick submission route due to cost barriers. Also, it was revealed that over half of the veterinary professionals submitting to ©eTick were repeat users in 2023, indicating that once they know about this free resource, many are likely to continue to use it. This is a major finding in terms of knowledge translation for ©eTick since learning about this free resource will likely increase participation going forward. Tick submissions were also substantially higher in 2023 and 2022 compared to 2021 in the year of the launch, largely thanks to the knowledge translation and promotion that was done on news outlets in BC (BCCDC, 2022; CTV, 2022). Even more interesting was the finding that members of the public were submitting significantly more than both veterinary and health professionals in 2023. This high number of submissions by the public is an indication that both vets and the public are interested in tick identification. Indeed, with the public's high participation in passive tick surveillance, they may end up being the ones to educate their own veterinary clinics about ©eTick.

5.2. Limitations

There were several limitations to this research that need to be considered, particularly with respect to generalizability. The survey had a very low response rate (5%). Other researchers have also noted that surveys with practicing veterinarians are hard to undertake. Senyk (2021) has improved this factor by using an incentive.

Since the survey was distributed online and through social media, there is a possible bias that we could only reach veterinary professionals who have an online presence or those who are social media fluent. Although follow-up phone calls increased the total respondents from 15 to 27, the survey still needed to be completed virtually which may have been a barrier for possible respondents. The CAHSS who distributed our survey online also has a broad audience, including veterinarians but also non-veterinarian members. This may have limited our advertisement of the survey.

Time was also a limitation. We would have phoned all 450 veterinary clinics to increase advertisement of our survey if we had had another six months to undertake this work.

The respondents were mostly veterinarians (63%) and 37% were technologist technologist/technicians that worked in small animal practices exclusively (78%). Therefore, this sample is not a representative population of all BC veterinarians and vet techs.

As with all surveys there is also inherent response bias, where participants may answer differently than what they typically do in their day-to-day approaches to ticks. Although the survey was anonymous, participants may be likely to answer questions in a way that reflects more of how they view themselves, than their true behaviours and knowledge. Also, there are many limitations in the process of creating the survey since it was developed from the point of view of the researcher by using other past surveys as a guide to creating questions. This survey development process may contribute to missing important information in questions that would be relevant to the field of veterinary medicine.

5.3. Conclusion

The population of veterinary professionals in BC were a difficult group to reach for a knowledge, attitudes, and practices (KAP) survey about ticks, TBDs, and passive surveillance systems. The response rate in this study was too low to generalize these findings to all BC vets and vet techs, but knowledge gaps were identified in our small respondent group regarding tick species. Most of the respondents were unable to answer questions about the tick species provided in the survey even though they self-reported their own ID skills as “average”. Particularly, *Ixodes angustus* which is one of the ticks that can transmit the pathogen for LD in BC was not recognized as an endemic species by any of the veterinary professionals. Furthermore, only some of the respondents recognized the Western blacklegged tick (*I. pacificus*), the more well-known vector of the causative agent of LD for BC. We recommend providing general tick ID guides including the TBD risks for BC species to vet clinics as an educational resource. Attitudes concerning LD in animal patients were low in BC veterinary professionals, which may relate directly to the low incidence rate seen in the province. Providing veterinary professionals with education about ticks and TBDs, particularly LD, is important, especially as the climate changes.

Adoption of the ©eTick program in BC holds promise as a tool to help veterinary professionals identify ticks and TBD risk. The program is gaining in popularity with the general public, veterinary workers and clinicians, and the number of repeat users is growing. Since half our respondents didn't know about ©eTick, more knowledge translation about the program directly to vet professionals is warranted. In the changing climate of BC, it is important to capitalize on as much tick surveillance data as possible from different contexts, and BC veterinary professionals play an important role in this data capture.

The issue of cost figured significantly in this thesis research. Our survey showed that vets were concerned about passing costs on to their clients. The BCCDC's passive surveillance system's submissions from vets dropped in 2014 when they started charging fees. There was also a corollary increase in human tick submission through medical doctors at this time. It is possible that some of these submissions by medical doctors were from ticks the owners took off their pets, although this remains speculative. While BCCDC PHL tick submissions have dropped, the free BCCDC-Merck program was able to recruit veterinary clinics to submit ticks, showing that there is still a real interest in learning about pathogens, but only if there are no fees attached.

The rise in popularity of ©eTick is a positive sign that passive surveillance is welcomed by the veterinary community. This system will help paint a clearer picture of the presence and distribution of tick species across Canada. However, ©eTick only tells half of the story. Pathogen testing of submitted ticks is still needed to determine what diseases could result from a tick bite. This research shows that more funding for pathogen testing of ticks from animals is warranted and it could be achieved by partnering with private laboratories, or government labs. However, getting surveillance data from private labs may be difficult. The BCCDC PHL has the tools for pathogen testing but lacks the funding to support a free program for veterinarians. The success of the BCCDC-Merck temporary funding shows that ©eTick could set the stage for more testing by encouraging vets to send ticks in for pathogen identification of certain TBDs. With tick populations increasing in the changing climate, capturing data on new or current pathogens that cause TBDs in BC needs to be prioritized.

In BC, veterinary professionals may be too busy to follow-up with ticks in practice. Many vet professionals stated that ticks are rarely or never the primary reason for their visits. More education about the importance of ticks may shift this dynamic.

The public seems to be the most engaged in passive surveillance programs, and they do so not only for ticks found on humans but also animals. Therefore, pet owners should be prioritized as a group for knowledge translation about ©eTick since they could act as intermediaries to deliver tick information to their veterinary clinics. Their participation also broadens the potential for passive surveillance and ©eTick could dramatically increase what is known about current and emerging tick populations in BC.

The issue of concentration of clinic ownership is complex. On one hand, vet clinics may be closing, limiting access to vets for people, particularly those in small towns in the North. However, the standardization that comes with one company managing many vet clinics could be an opportunity to routinize tick educational resources. The VCA could help facilitate knowledge translation about ©eTick to clinics under their ownership. They could also encourage or incentivize vets to submit ticks to labs for analyses.

The VIN emerged as a primary source of education for BC veterinary professionals. Although this is a commercial entity, and we cannot validate the quality of their tick and TBD resources, it could play an important role in providing species and pathogen information to veterinary professionals. This group should be included going forward in efforts to promote evidence-based information on tick species and emerging pathogens.

One Health in the tick field could be strengthened by supporting the veterinary community with the tick and TBD resources they need and encouraging their participation in passive surveillance programs. The sooner ticks and TBDs are identified, the better we are able to respond to the risk. Veterinary professionals are in a unique position to make a real impact in this area.

Future research should incentivize KAP surveys to BC veterinary professionals to increase their engagement and add more to the existing literature. Using an online survey modality alone seems unlikely to garner enough information to shape future directions.

In this small respondent group, BC veterinary professionals were found to have several knowledge gaps and encountered barriers to tick ID and pathogen testing. These issues can be addressed through targeted knowledge translation with more partners including those from industry and more government funding for surveillance programs.

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Appendix. Survey

Questions (via SurveyMonkey)

Consent Form for Participants:

Are you a veterinarian or veterinary technologist/technician in British Columbia (BC)? We want to know more about your experiences with ticks in your clinic!

As the climate changes, tick distribution, tick abundance and the transmission of tick-borne pathogens can change. This could lead to changes in the prevalence of Lyme disease and other tick-borne diseases (TBDs) in BC.

As animal care providers, your knowledge of ticks and TBDs is valuable and we want to learn more about what you know, and what you need for educational resources on ticks.

About the Survey

The Principle Investigator Dr. Anne-Marie Nicol (Faculty of Health Science) and Stephanie Cooper an MSc Candidate are conducting a survey to improve our understanding of BC veterinarian's and veterinary tech's baseline knowledge of ticks and tick-borne diseases, as well as their future educational needs in the context of climate change. The co-investigators of this study are Dr. Erin Fraser, a public health veterinarian at the BCCDC and clinical assistant professor at the School of Population & Public Health at UBC, as well as Dr. Robert Hogg (Distinguished Professor in the Faculty of Health Science at SFU).

Confidentiality

This confidential survey will only take approximately 20-30 minutes and we encourage all veterinarians and veterinary techs in your practice to complete it, the more the merrier!

Your responses to this survey will be kept confidential and results will be aggregated for analyses. Findings will be summarized in a report and shared with veterinarians and veterinary technicians in the upcoming months. The survey will not ask you for any personal identifiers such as your name or address, but it does ask for the address of

the veterinary clinic you work at and your occupation which could be used to infer your identity.

Questions?

If you have any questions, please do not hesitate to contact Stephanie Cooper or Dr. Anne-Marie Nicol: .

Thank you very much for your consideration.

Your participation is voluntary and if the questionnaire is completed, it will be assumed that consent has been given. By consenting, participants have not waived any rights to legal recourse in the event of research-related harm. If you have any concerns about your rights as a research participant and/or your experiences while participating in this study, please contact the Director, SFU Office of Research Ethics.

Click the "OK" button below if you wish to consent to this survey. You can withdraw your consent at any time by closing the survey and not submitting your final responses at the end.

Section 1: Background Information

* 1. Name of main Veterinary Practice you work at:

* 2. Address of Veterinary Practice:

Address

Address 2

City/Town

Province

Postal Code

Country

* 3. What is your job title?

- Veterinarian
- Veterinary Technologist/Technician
- Other (please specify)

4. What year did you complete your veterinary training program that pertains to your current job title (i.e. veterinary technologist program or doctor of veterinary medicine)?

5. What type(s) of practice do you work in? Select all that apply.

- Small Animal (including Canine/Feline) Practice Large Animal
- Practice
- Mixed (large and small) Animal Practice Equine Practice
- Specialized Practice (please specify)
- Other (please specify)

6. If you selected more than one type of practice in the previous question, please specify your estimated percentage of time spent working in each practice is (if you selected one practice type, put 100%):

Small Animal (including Canine/Feline) Practice:	
Large Animal Practice:	
Mixed (large and small) Animal Practice:	
Specialized Practice (please specify):	
Equine Practice:	
Other (please specify):	

7. I have been working in veterinary practice for:

- ◯ <1 year
- ◯ >1 - 5 years
- ◯ >5 – 15 years
- ◯ >15 years Rather
- ◯ not say

8. In the past 6 years, have you worked in a veterinary practice in another province or territory outside of BC? Select all that apply:

- ☐ No, I have not
- ☐ Alberta Manitoba
- ☐ New Brunswick Newfoundland and
- ☐ Labrador Northwest Territories
- ☐ Nova Scotia
- ☐ Nunavut
- ☐ Ontario
- ☐ Prince Edward Island
- ☐ Quebec Saskatchewan
- ☐ Yukon

9. Have you worked in a veterinary practice outside of Canada in the past 6 months?

- ◯ No
- ◯ Yes (please specify):

10. How many veterinarians work at your clinic?

- ◯ 1-3
- ◯ 4-6
- ◯ 7-9
- ◯ >9
- ◯ I don't know

11a. Do you assess animals in settings outside of the veterinary clinic office, such as on a farm or ranch?

- ◯ Yes
- ◯ No

11b. If you answered "yes" to the previous question (Q11a), what is the setting you work with animals in outside of the veterinary clinic? Please specify:

11c. If you answered "yes" to Q11a, what type of animals do you work with outside of the veterinary clinic? Please specify:

For the next two questions, please select the response that best fits for you.

12. How frequently do your animal patients present with a tick bite or infestations as the PRIMARY reason for the visits:

Always	Usually	Sometimes	Rarely	Never	I don't know
◯	◯	◯	◯	◯	◯

13. How frequently do your animal patients present with a tick bite or infestations as the SECONDARY reason for the visits or you noticed a tick that the owner has not mentioned:

Always	Usually	Sometimes	Rarely	Never	I don't know
◯	◯	◯	◯	◯	◯

14. Can you quantify the number of animal patient visits that were related to ticks in the past year? A ballpark estimate is fine:

15. Thinking about your tick related visits over the past year, can you estimate how frequently the visits occur per season?

	None	Less than 10 visits	10-20 visits	20+ visits
Spring	○	○	○	○
Summer	○	○	○	○
Fall	○	○	○	○
Winter	○	○	○	○

16. Have any of the following 'ticks of concern' been found in your local area?

	Have always been in the area	Have been newly found in the area (in the last 2-3 years)	Have not been found in the area	Don't know
Western blacklegged tick (*Ixodes pacificus*)	○	○	○	○
Blacklegged or Deer tick (*Ixodes scapularis*)	○	○	○	○
Rocky Mountain wood tick (*Dermacentor andersoni*)	○	○	○	○
American dog tick (*Dermacentor variabilis)*	○	○	○	○
Brown dog tick (*Rhipicephalus sanguineus*)	○	○	○	○
Lone star tick (*Amblyomma americanum*)	○	○	○	○
Groundhog tick (*Ixodes cookei*)	○	○	○	○
Asian longhorned tick (*Haemaphysalis longicornis*)	○	○	○	○
Moose or Winter tick (*Dermacentor albipictus*)	○	○	○	○
Ixodes angustus	○	○	○	○

17. **Over the past 5 years, the number of ticks or animals with ticks that have been brought into our clinic has:**

- ◯ Increased
- ◯ Decreased
- ◯ Stayed the same

Section 2: Clinical Approaches

1a. When you remove tick(s) from an animal and it is *engorged*, please specify your estimated percentage of time for how often you do the following:

Identify the tick species in-house:	
Send the tick to a laboratory for species identification:	
Ask a colleague to help:	
Dispose of it without further examination of the tick:	
Other (please explain):	

1b. When you remove tick(s) from an animal which is *not engorged* or a patient brings a tick sample to the clinic, please specify your estimated percentage of time for how often you do the following:

Identify the tick species in-house:	
Send the tick to a laboratory for species identification:	
Ask a colleague to help:	
Dispose of it without further examination of the tick:	
Other (please explain):	

2. What are some of the reasons why you may not follow up with identifying a tick. Select all that apply.

- ◯ I don't need to follow up, I know what the species is.
- ◯ It's too expensive for the owner to have the tick identified by the lab in BC.
- ◯ I am too busy or don't have enough time.
- ◯ I don't feel like I have enough training.
- ◯ Other (please describe):

2. What are some of the reasons why you may not follow up with identifying a tick. Select all that apply.

- ◯ I don't need to follow up, I know what the species is.
- ◯ It's too expensive for the owner to have the tick identified by the lab in BC.
- ◯ I am too busy or don't have enough time.
- ◯ I don't feel like I have enough training.
- ◯ Other (please describe):

3. Thinking about tick borne diseases, please estimate the number of ticks you submitted last year to the BC CDC for pathogen testing. If none, please put zero.

4. If you or your client send or have sent ticks to another lab in Canada or the US, please describe here:

5. How often do your discussions with animal owners regarding tick risk, prevention, and control include the following? Please select all that apply.

	All the time	Most of the time	Sometimes	Rarely	Never	I don't know
Risks to pets	○	○	○	○	○	○
Risks to pet owner / family / human health	○	○	○	○	○	○
Prevention measures for pets	○	○	○	○	○	○
Prevention measures for pet owners	○	○	○	○	○	○
Where ticks like to live	○	○	○	○	○	○
What ticks look like	○	○	○	○	○	○
How to remove ticks	○	○	○	○	○	○
Tick-borne illness in pets	○	○	○	○	○	○
Tick-borne illness in pet owners	○	○	○	○	○	○
Lyme disease symptoms in pets	○	○	○	○	○	○
Lyme disease symptoms in pet owners	○	○	○	○	○	○
Other (specify name below)	○	○	○	○	○	○

Other (please specify)

Section 3: This next section is about Lyme disease & other tick-borne diseases (TBDs)

1. How concerned are you about Lyme Disease in your animal patients that visit your clinic?

- ◯ Very concerned
- ◯ Moderately concerned
- ◯ Slightly concerned
- ◯ Not concerned
- ◯ I don't know

2. How often do you recommend the Lyme disease vaccine for your animal patients?

All the time	Most of the time	Sometimes	Rarely	Never	I don't know	Not applicable
◯	◯	◯	◯	◯	◯	◯

3a. Have you diagnosed any of the following tick-borne illnesses in the past 12 months in your animal patients? Select all that apply:

	Yes, in the past 12 months	Yes, prior to 12 months ago	No	I don't know
Lyme disease	○	○	○	○
Ehrlichiosis	○	○	○	○
Anaplasmosis	○	○	○	○
Rocky Mountain spotted fever	○	○	○	○
Babesiosis (piroplasmosis)	○	○	○	○
Bartonellosis	○	○	○	○
Hepatazoonosis	○	○	○	○
Tick-borne encephalitis	○	○	○	○
Canine Hemotropic Mycoplasma	○	○	○	○
Feline Hemotropic Mycoplasma	○	○	○	○
Cytauxzoonosis	○	○	○	○
Powassan encephalitis	○	○	○	○
Tularemia	○	○	○	○
Tick-borne relapsing fever	○	○	○	○
Alpha-gal syndrome	○	○	○	○
Other (specify name below)	○	○	○	○

Other (please specify)

3b. If you diagnosed any of the following tick-borne illnesses in the past 12 months, which test(s) did you use to make your diagnosis? Please describe:

Lyme disease	
Ehrlichiosis	
Anaplasmosis	
Rocky Mountain spotted fever	
Babesiosis (piroplasmosis)	
Bartonellosis	
Hepatazoonosis	
Tick-borne encephalitis	
Canine Hemotropic Mycoplasma	
Feline Hemotropic Mycoplasma	
Cytauxzoonosis	
Powassan encephalitis	
Tularemia	
Tick-borne relapsing fever	
Alpha-gal syndrome	
Other (specify):	

4. Which of the following tick-borne diseases would you like to learn more about? Select all that apply:

- [ ] Lyme disease
- [ ] Ehrlichiosis
- [ ] Anaplasmosis
- [ ] Rocky Mountain spotted fever
- [ ] Babesiosis
- [ ] Bartonellosis
- [ ] Hepatazoonosis
- [ ] Tick-borne encephalitis
- [ ] Canine Hemotropic Mycoplasma
- [ ] Feline Hemotropic Mycoplasma
- [ ] Cytauxzoonosis
- [ ] Powassan encephalitis
- [ ] Tularemia
- [ ] Tick-borne relapsing fever
- [ ] Alpha-gal syndrome
- [ ] Other (please specify):

Section 4: Education needs of veterinarians & vet techs in BC on ticks.

1. Please comment on your general comfortability in identifying tick species. Check the box that best describes you. I would assess my skill level in identifying tick species as:

- ◯ Beginner - "I know when something is a tick."
- ◯ Average - "I can differentiate tick species, for example, I can tell Rocky Mountain wood ticks from blacklegged ticks."
- ◯ Expert - "I can look at ticks under the microscope, apply tick identification keys, and differentiate Ixodes species."
- ◯ I don't have much tick experience or education

2. How important are each of these sources for where you usually get your information on ticks and tick-borne diseases?

	Extremely important	Very important	Somewhat important	Not so important	Not at all important	I don't use this source
Conferences	○	○	○	○	○	○
Industry meetings	○	○	○	○	○	○
VIN	○	○	○	○	○	○
Textbooks	○	○	○	○	○	○
Journal articles	○	○	○	○	○	○
ACVIM Consensus Statements	○	○	○	○	○	○
Public health organizations (local, provincial or national)	○	○	○	○	○	○
Veterinary associations (local, provincial or national)	○	○	○	○	○	○
Other (please specify below)	○	○	○	○	○	○

Other (please specify)

3. The most challenging aspect of dealing with ticks in practice is (select all that apply):

- [ ] In-house tick identification
- [ ] Submitting ticks for identification or pathogen testing
- [ ] Tick removal
- [ ] Other (please specify):

4. I would find it helpful to have more information on (select all that apply):

- [ ] Tick distribution
- [ ] Current disease risk
- [ ] Diagnostic best practices
- [ ] Treatment best practices
- [ ] Prevention best practices
- [ ] Resources for tick identification
- [ ] Other (please describe)

5. What is your preferred format of resources to get the latest information about ticks and tick-borne diseases?

- ( ) Publication
- ( ) Email
- ( ) Presentation
- ( ) Poster
- ( ) Info-graphic
- ( ) Magazine
- ( ) Other (please specify):

6. What trade journals (i.e. news, magazines, etc.) do you usually use to get your information about veterinary medicine? Answers do not have to be tick-related here:

7a. Have you heard about a new program for tick identification called eTick?

- ◯ Yes
- ◯ No
- ◯ Other (please specify):

7b. If you selected “yes” to the previous question (Q7a), where did you hear about eTick?

- ◯ Colleague
- ◯ News or radio (media outlet)
- ◯ Conference
- ◯ Email
- ◯ Patient
- ◯ Industry representative
- ◯ Veterinary association
- ◯ Other (please specify):

7c. If you selected "yes" to Q7a, have you submitted a photograph of a tick to eTick before?

- ◯ Yes
- ◯ No

7d. If you selected "yes" to Q7a, have other staff members in your practice submitted a photograph of a tick to eTick before?

- ◯ Yes
- ◯ No
- ◯ I don't know

Recently launched in BC, eTick (etick.ca) is a zero-cost public platform for image-based identification and population monitoring of ticks. Simply put, any member of the public or healthcare provider can send photographs of a tick directly from their phone or electronic device to the app (etick.ca) to get the species identified.

8. Now knowing about eTick as an online image-based identification platform for identifying ticks, in the future would you:

- ◯ Submit to eTick
- ◯ Not submit to eTick
- ◯ Maybe submit to eTick

9. Is there anything else you would like to know about eTick?

10. Would you use results you got from eTick to inform your practice about ticks?

- ◯ Yes
- ◯ No
- ◯ Maybe

11. Are you aware of the BCCDC and Merck Animal Health Companion Animal Tick project? (Over the next three years a limited and targeted amount of Ixodes ticks collected off companion animals will be requested by eTick for free identification and pathogen testing)

- ◯ Yes
- ◯ No
- ◯ I don't know

These are some other comments/ideas I would like to share:

Email for Survey

Are you a veterinarian or veterinary technologist/technician in British Columbia (BC)? We want to know more about your experiences with ticks in your clinic!

I'm reaching out to invite you to participate in the BC Veterinarian and Vet Tech Survey on Ticks and Tick-Borne Diseases (TBDs).

As animal care providers, your knowledge of ticks and TBDs is valuable and we want to learn more about what you know, and what you need for educational resources on ticks.

About this survey
The Principle Investigator Dr. Anne-Marie Nicol (Faculty of Health Science) and Stephanie Cooper an MSc Candidate are conducting a survey to improve our understanding of BC veterinarian's and veterinary tech's baseline knowledge of ticks and tick-borne diseases, as well as their future educational needs in the context of climate change.

This confidential survey will only take approximately 20-30 minutes and we encourage all veterinarians and veterinary techs in your practice to complete it, the more the merrier!

Confidentiality
Your responses to this survey will be kept confidential and results will be aggregated for analyses. Findings will be summarized in a report and shared with veterinarians and veterinary technicians in the upcoming months.

Questions?
If you have any questions about the survey, please contact Stephanie Cooper or Dr. Anne-Marie Nicol.

Thank you very much for your consideration.

Phone Script

Hi there, my name is Stephanie Cooper and I am a graduate student at Simon Fraser University and during this tick season I am doing research on BC veterinarians and vet techs experiences with ticks and their educational resource needs regarding ticks. I was wondering if I could talk to you for a moment to tell you about the survey my research team and I created, or if you would prefer, I can just send you the information to your vet clinic email which you could pass on to your veterinarians and vet techs if anyone is interested?

(Optional script if they want to hear the pitch): Thank you so much this will be really quick, I created an electronic survey in collaboration with the BCCDC public health veterinarian and my committee where we ask questions about vets and vet techs experience with ticks, such as their comfortability in identifying them, how many ticks they receive per year, and where they tend to get their resources on ticks. Our survey has already been completed by many vets and vet techs across the province but we are trying to reach more participants and wondered if anyone in your clinic might be willing to complete it? The criteria for participants is simple, all veterinarians and veterinary technologists or technicians in BC are welcome. The survey is confidential and will only take approximately 20-30 minutes at the most. If you would like to share the survey with the veterinarians and vet tech's in your clinic I can send the survey link and more details directly to your clinic email if you would like. Let me know if you have any questions and thank you so much for your time I really appreciate it.

Survey Ads


ARE YOU A VETERINARIAN OR VET TECH IN BC?
SFU SIMON FRASER UNIVERSITY
SFU has launched a survey on ticks and tick-borne diseases and wants to hear from you!
Complete the survey at: tinyurl.com/sfuvet or scan the QR Code


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