**Chapter II:** Outdoor worker knowledge on ticks and Lyme disease across industries in Quebec

**Abstract**

Lyme disease is a well-known occupational risk across North America due to the exposure of the causal agent of Lyme disease (*Borrelia burgdorferi*) via blacklegged ticks. As the geographic range of B. burgdorferi advances with the increasing distribution of blacklegged ticks, more outdoor workplaces are at risk of contracting Lyme disease. This study analyzed the demography and personal perceptions within one framework to better determine the overall risk for those working in outdoor industries. By analyzing outdoor worker demographics and individual knowledge on ticks and Lyme disease, a comparison was made across age, sex, industry. If there is a specific industry or region that has a lower understanding relative to other outdoor sectors, then they are more vulnerable. A questionnaire was given to voluntary participants where risk scores were developed based on individuals’ answers to risk perception questions, which were then compared to their demographics via chi-square tests and a mixed effects logistic regression model. **[results]**.

By examining and acknowledging the specific vulnerabilities that individuals have while working, it will allow for better management and awareness programs to be put in place to remedy this situation.

**Introduction**

Outdoor workers face a variety of occupational hazards, including exposure to the causal agent of Lyme disease (spirochaete *Borrelia burgdorferi*) via blacklegged ticks (*Ixodes scapularis*; Ostfeld et al., 1996; Piacentino and Schwartz, 2002). Since Lyme disease is a well-known occupational risk across North America and Europe (Rudenko et al., 2011), several studies have examined outdoor workers’ susceptibility across industries. Outdoor workers working in the forest and sawmill sectors (Charante et al., 1998; Cinco et al., 2004; Tomao et al. 2005; Kaya et al., 2008; Bilski et al., 2009; Di Renzi et al., 2010; Chmielewska-Badora et al., 2012; Jovanovic et al. 2015; Rigaud et al., 2016; Panczuk et al. in 2016), agriculture (Bilski et al., 2009; Stawicki, 2017), as well as those in the public administrator sectors (Stamouli et al., 2000; Anna et al., 2012; Hurt et al., 2014; Jovanovic et al. 2015; Rossi et al. 2015) have been proven to have high risks for Lyme disease. Those involved in logging activities have been found to have the highest risk overall (Rigaud et al., 2016; Barrette, 2018).

Other industries with perceived risks – only considered perceived since the literature is lacking (Barette, 2016) - for Lyme disease include professional hunters (Cetin et al., 2006), and outdoor construction (Parkinson et al., 1996). It has also been suggested by the Committee on Standards, Equity, Occupational Health and Safety (CNESST) and Canadian Union of Public Employees (CUPE) that outdoor municipal and maintenance workers as well as provincial park workers (Barette, 2016), may also be at risk. Nonetheless, the literature is incomplete, with other industries such as emergency workers, biologists, camp counselors, mine, quarry, or oil field workers not considered in any studies (Barette, 2016). Likewise, seasonal workers have been considered at risk, however, since many of these individuals are migrant workers, they are often overlooked (Jenks & Trapasso, 2005; Heller et al., 2010).

Several factors account for why outdoor workers are more at risk for Lyme disease, particularly their proximity to endemic blacklegged tick populations (Adam-Poupart et al., 2021). Military training sites, for instance, may be situated in deciduous forest habitats where blacklegged ticks have established (Anna et al., 2012; AFHSC, 2013; Faulde et al., 2014). Similarly, individuals performing manual jobs in forests, rather than administrative positions tend to be more at risk due to their close and constant proximity to blacklegged ticks during work hours (Cisak et al., 2012).

As the geographic range of *B. burgdorferi* advances with the increasing distribution of blacklegged ticks, more outdoor workplaces are exposed to Lyme disease. Although the awareness of Lyme disease has improved (Aenishaenslin et al., 2016), workers remain vulnerable and can benefit from awareness campaigns (Forest-Bérard et al., 2021). Knowledge of prevention methods varies greatly across industries, with workers using improper tick removal techniques (Charante et al., 1998; Cisak et al., 2012), not being vigilant with body inspection after visiting an infected area (Charante et al., 1998), or being unaware of how long a tick was attached to them (Jovanovic et al. 2015).

Certain demographics across industries may also be more susceptible to infections. For instance, men are more often bitten by ticks while working, although there is a gender bias in outdoor work sectors (Cetin et al, 2006; Bilski et al., 2009; Di Renzi et al., 2010). Lyme disease seroprevalence has also been positively correlated with age in exposed workers (Charante et al., 1998; Cinco et al. 2004; Cetin et al., 2006; Bilski et al., 2009; Rigaud et al., 2016). Ethnicity may also play a role as Fix et al. (2000) found more Lyme disease cases in Caucasians than African Americans, although this was most likely due to area of residence – a major risk factor for exposure to Lyme disease. However, African Americans appeared to have delayed diagnosis and treatment for Lyme disease, implying some disparity in risk awareness (Fix et al., 2000). One such factor that can affect risk-awareness is socioeconomic status, as this can affect lifestyle, education, and residency, thereby affecting an individual’s proximity to and preventative measures for blacklegged ticks (Ozdenerol et al., 2021). In general, the highest risk individuals are wealthier, predominantly white, higher educated professionals that are active outdoors and enjoy travel while the lowest risk individuals are ethnically diverse, from low-income neighbourhoods, educated to high school level or less, and engage in fewer outdoor activities (Ozdenerol et al., 2021). Although many studies have examined general demographics of at-risk groups for Lyme disease, there are clear gaps in the literature of outdoor workers’ knowledge on ticks and Lyme risks.

This study considered worker demographics and personal experiences within one framework to better determine the overall risk for those working in outdoor industries in Quebec. By analyzing outdoor worker demographics and individual knowledge on ticks and Lyme disease, a comparison can be made between and within industries.

If a certain demographic or industry has stronger tendencies (based on the developed risk score) that indicate they are more at risk for Lyme disease, then they should be more focused on for risk awareness campaigns and prevention methods. By examining the specific vulnerabilities within and across industries, it will allow for better management programs to be put in place to remedy this situation.

**Methods**

A questionnaire was given to voluntary participants asking for answers to demographic questions (age, sex, type of work) and individuals’ knowledge on ticks and Lyme disease like the survey conducted by Cisak et al (2012; Appendix 1). This survey was accessible online or as a hard copy. Collaborators from the Centre d'Enseignement et de Recherche Forestiers (CERFO) and the Nature Conservancy distributed these surveys to outdoor workers in industries they have partnerships with. The survey was approved by the McGill University ethics committee for health research, REB File #: 22-03-058.

*Risk Score*

This study was similar to Slunge et al. (2019), whereby questions related to risks via exposure to ticks, knowledge on tick and Lyme disease, protective behaviour related to tick bites, and recreational/work behaviour was asked. Behavioural risk scores were developed based on participants’ risk perceptions and knowledge on an ordinal scale. Although there are tick-based risk measures that have been implemented (Eisen and Eisen, 2016), Lyme disease risk scores that include human behaviour are limited. Several research projects have conducted survey studies to understand tick and Lyme disease risk perception (Aenishaenslin et al. 2014; Slunge and Boman, 2017; Bouchard et al., 2018; Fernandez et al., 2019; Slunge et al., 2019; Jore et al., 2020; Aenishaenslin et al. 2022), however, there appears to be no standard methodology for behavioural risk scores.

Scores were weighted based on their answers, with higher scores indicating greater risk for interacting with blacklegged ticks and potentially contracting Lyme disease (Appendix 1). In general, each question had a scoring between 0 and 3, with 0 indicating no risk, and 3 indicating high risk. For two questions, answers determined how risk would be affected by preventative measures, however, in these cases, preventative measures reduced risks but did not guarantee that an individual will have zero risk. Therefore, it was not possible to get a score of 0; with a total of 9 questions, scores could range from 2-27.

For risk analysis, these behavioural scores were considered ‘impact scores’, and so to determine overall risk, ‘likelihood’ scores needed to be accounted for as well (Pascarella et al., 2021). For this reason, likelihood scores based on participants’ work locations were also considered, whereby impact scores were considered in conjunction with the geographic risk level determined by INSPQ (i.e., likelihood scores; Institut National de Santé Publique Quebec, 2022) for these work site locations. Regions were determined to have possible risk, risk present, or significant risk for Lyme disease infections. Some individuals worked in multiple regions with differing risk levels; the mean of the risk levels of these regions was taken as the likelihood score. Total risk score analyses were then determined based on impact (behaviour risk) and likelihood (location risk) scores (Appendix 2; Pascarella et al., 2021). This way, the probability of an infection event occurring as well as the severity could be accounted for (Slunge et al., 2019).

*Statistical analysis*

The total risk score calculated was used as the response variable for chi square frequencies as well as a mixed effects logistic regression model, with region (RSS? RLS?) incorporated as a random effect.

**Inference on the association between behavioral risk factors and reported tick exposure by the respondents (adjusting for spatial heterogeneity and socio-demographic confounders) was carried out in two ways: with a mixed-effects logistic regression model including random effects for RLS (without applying sampling weights) and with a quasi-binomial model with logit link, accounting for the stratified survey design. Variables of primary interest were included in all multivariable models. These were time spent outdoors for primary occupation, practice of hiking, gardening, camping, adoption of tick repellent, showering and tick checks. All models controlled for public health risk index at the residency location and whether the respondent’s home was near a high-risk area. Additional potential confounders were age, sex, and education. Model selection was based on subject matter expertise and the literature rather than statistical criteria. However, we assessed the importance of confounders by determining whether their inclusion changed the odds ratios of the other variables by more than 10% [25]. All analyses were carried out with R software version 4.1.0 and R library “survey”, version 4.0 [26]. Maps were created with ArcGIS version 10.6.1. – (**Aenishaenslin et al., 2022)

-Chi-square tests

Predictors for this model were based on worker demographics given, including sex, age, education, work locality, and job position/industry. A normality test and VIF scores were determined. Based off the results of this linear model, and extrapolating from the behavioural risk scores, a Lyme disease risk map for outdoor workers across Quebec was developed as an estimate for general risk across the province. Stats Canada census information was used to determine the level of risk for outdoor workers in Quebec across census divisions.

-include map showing where most surveys came from, descriptive statistics: table that includes percentages, much like Stats Canada tables

-map based on significant results? Overlay using stats Canada data – giving each census division its own behaviour risk score based on established tick populations across Quebec along with % of outdoor workers in measured job industries

-map or risk score based on tick establishment rates for areas where tick establishment levels varied; use behaviour scores based on locations (that correlate with diff tick establishment) to determine average risk score for these outdoor workers across regions; need to consider if differing industries affect risk score

-search for risk score literature

-risk assessment

**Results**

**Discussion**

St. Pierre et al. (2020) found that there was no significant difference in prevention efficacy or methods between individuals who are outdoors for recreation versus those who are outdoors for work. However, outdoor workers are likely to spend more time outdoors, potentially exposed to vectors (Rudenko et al., 2011). St. Pierre et al.’s (2020) results suggested that there is a general low level of knowledge on Lyme disease. Therefore, it is necessary to compare outdoor worker demographic and Lyme disease knowledge information with individuals of the public, to determine a more accurate understanding of the severity of this risk.

-males were found in outdoor work industries to be more likely to be infected by ticks (\*\*\*), however, many of these industries are male-biased and when considering the general public, a positive correlation was found between women and the risk perception for Lyme (Borsan et al., 2021).

-In general, behaviour has been shown to affect infection spread (Funk et al., 2010).

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**Figures and Tables**

**Table 1. Descriptive characteristics of the study participants (n = 198).**

|  |  |  |
| --- | --- | --- |
| **Variable** |  | **n (%)** |
| **Sex** | Male | 117 (59) |
|  | Female | 79 (40) |
|  | Prefer not to answer | 2 (1) |
| **Age** | 18-24 | 10 (5) |
|  | 25-34 | 72 (36) |
|  | 35-44 | 53 (27) |
|  | 45-54 | 26 (13) |
|  | 55+ | 37 (19) |
| **Education** | No certificate, diploma, or degree | 5 (2) |
|  | High school diploma/GED | 9 (5) |
|  | College diploma/CEGEP | 63 (32) |
|  | Trade school graduate | 10 (5) |
|  | Undergraduate degree | 59 (30) |
|  | Postgraduate degree | 52 (26) |
| **Industries** | Agriculture | 11 (6) |
|  | Biology | 54 (27) |
|  | Forestry | 51 (26) |
|  | Maintenance | 11 (6) |
|  | Education | 6 (3) |
|  | Environment | 25 (12) |
|  | Government | 5 (2) |
|  | Recreation | 17 (9) |
|  | Unknown | 17 (9) |

**Appendix 1.** The survey that participants answered as well as the score breakdown for the behavioural risk score using individuals’ answers to tick and Lyme disease knowledge questions only. The English questionnaire is presented, but participants had the option of completing the survey in French or English.

**Knowledge of ticks and Lyme disease:**

1. While working outdoors, do you notice ticks on your body?

a) no (0)

b) yes, sporadically (1.5)

c) yes, frequently (3)

2. Are ticks present at your work site?

a) Yes (3)

b) No (0)

c) Don't know (1.5)

3. If yes, how many ticks do you notice on your body during one work shift?

a) None (0)

b) 1-3 ticks (1)

c) 4-6 ticks (2)

d) more than 6 ticks (3)

4. Have you ever been bitten by a tick at work?

a) Yes (3)

b) Unsure (1.5)

c) No (0)

5. How do you remove ticks from your body?

◻Spray with repellent or sanitizer (3)

◻Tweezers (1)

◻ Remove by hand (3)

◻Unsure (2)

◻Other method (2)

-if multiple methods, use mean score (e.g., tweezers + other method = 1.5); in this case knowing how to remove a tick will greatly reduce chance of being infected with *B. burgdorferi*, but does not guarantee that an individual will avoid ticks, so it is not possible to get a score of 0.

6. What preventative measures do you use to avoid ticks?

◻ Bug repellent (-0.5)

◻Long socks (-0.5)

◻Body checks/survey (-0.5)

◻Layers (-0.5)

◻ None (3)

-For every preventive measure they use, minus 0.5 from 3; in this case preventative measures reduce risks, but do not guarantee that an individual will avoid ticks, so it is not possible to get a score of 0.

7. How do people get infected with Lyme disease? Bold answers are incorrect.

◻**Unsure (2)**

◻ **Contact with animals (3)**

◻ **Contact with vegetation (3)**

◻Tick bites (0)

◻ **Mosquito bites (3)**

-if they chose 2+ wrong answers (3)

-if they chose multiple answers, including tick bites, use mean

-If participants are unsure of the answer, then they are just as vulnerable for potentially contracting Lyme disease. Note: only one participant chose the correct answer AND ‘Unsure’ as their answer.

8. What are some symptoms of Lyme disease? Bold answers are incorrect.

◻**Unsure (2)**

◻ Headaches (0)

**◻Sore throat (2)**

◻Fatigue (0)

◻**Sneezing (2)**

◻Fever (0)

**◻Itchiness (2)**

-if they chose both sore throat and sneezing or only one of those two options (3)

-if they chose headaches, fatigue, and fever (0)

-if they chose only two correct answer (1)

-if they chose all 3 correct answers, but with unsure as well (1)

-if they chose only one of the above correct answers (1.5)

-if they include one wrong answer with 1 correct answer (2)

-if they include one wrong answer with 2+ correct answers (1.5)

-if they include 2+ wrong answers with correct answers (3)

-if they chose correct, incorrect, and unsure (2)

-If participants are unsure of the answer, then they are just as vulnerable for potentially contracting Lyme disease

-if they chose unsure only (2)

-if they chose unsure and 1-2 correct answers (1.5)

-if they guess unsure with an incorrect answer (3)

9. Do you feel safe regarding Lyme disease while at work?

a) Yes (0)

b) Sometimes (1.5)

c) No (3)

**Demographic Questions:**

Job Title:

1. Age

a) 18-24 years b) 25-34 years c) 35-44 years d) 45-54 years e) 55+ years

2. Sex:

a) Male b) Female c) Prefer not to answer  
3. Are you a First Nation member?

a) Yes b) No c) Prefer not to answer \*Note: only 3 participants identified as First Nation.

4. Highest certificate, diploma, or degree

a) No certificate, diploma, or degree

b) High school diploma or equivalent

c) Apprenticeship or trades certificate or diploma

d) Certificate or diploma from a college, CEGEP, or other non-university institution

e) University certificate, diploma, or degree at undergraduate level

f) postgraduate degree

5. Years in job position

a) 0-3 years b) 4-7 years c) 8+ years

6. How many days per week on average are you working?

a) 1-3 days b) 4-5 days c) 6-7 days

7. How much time on average do you spend outdoors during a work shift per day (between April-October)?

a) 0-3 hours b) 4-7 hours c) over 7 hours

8. How much time on average do you spend outdoors for leisure in green spaces per week (between April-October)? Ex. Forests, parks, gardens, backyards

a) 0-3 hours b) 4-7 hours c) over 7 hours

9\*. Home postal code? First three digits only: \_\_\_\_

10\*. Work (office) postal code? First three digits only: \_\_\_\_

11\*. Work (site - outdoors) postal code? First three digits only: \_\_\_\_

12. How much are you travelling from your residence and base work per week (between April-October)?

a) never/I work from home b) I commute 1-2 days a week c) I commute over 3 days a week

\*For questions 9-11, if you are uncomfortable with, or do not know any of the postal codes, please include the region instead.

**Appendix 2.** Matrix for risk analysis of *Borrelia burgdorferi* infection for outdoor workers in Quebec. This matrix is based on Pascarella et al’s (2021) risk analysis methodology, considering impact and likelihood of a risk to determine risk level. Impact scores were based on behavioural scores of outdoor workers who participated in a tick and Lyme disease knowledge questionnaire. Likelihood scores were determined based on the participants’ answers to geographic location of their outdoor work sites and the corresponding risk score given to that region by INSPQ (Institut National de Santé Publique Quebec, 2022). Total risk scores for individuals were determined by the product of the likelihood and impact scores.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **LIKELIHOOD**  **(Location Risk Score; based on INSPQ data)** | | **IMPACT (Behaviour Risk Score)** | | |
| **Low Risk** | **Med Risk** | **High Risk** |
| **Slight risk of *Bb* infection** | **Moderate risk of *Bb* infection** | **Severe risk of *Bb* infection** |
| **2-9** | **10-19** | **20-27** |
| **No Risk/No data** | **N/A** | **Very Low** | **Low** | **Moderate** |
| **Risk possible** | **x1** | **Low** | **Moderate** | **Moderate** |
| **Risk present** | **x2** | **Moderate** | **Moderate** | **High** |
| **Significant risk** | **x3** | **Moderate** | **High** | **Very High** |