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Ticking Time Bomb: The Escalating Threat of Tick-Borne Diseases in Rural Farming Communities

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ABSTRACT

Objectives: Outdoor workers, particularly farmers and farmworkers, are at increased risk for tick encounters and subsequent tick-borne disease exposure due to daily work in tick habitats. Though well studied in Europe, farmer/worker risk is not well studied in the Northeastern United States. Given the increasing incidence of tick-borne diseases throughout the Northeast population, this study sought to identify risk factors and determine perceptions of risk for tick encounters and tick-borne disease diagnoses within agricultural communities.

Methods: Snowball sampling was utilized to recruit farmers and farmworkers for the study. Participants were surveyed about risk perceptions, farm practices, tick encounters, and tick-borne disease exposure. Tick-borne disease diagnosis was tested for association with farm characteristics and individual prevention practices. Associations with tick exposure, including tick encounters and tick bites, were also tested.

Results: A total of 53 individuals (representing 46 farms) from dairy and livestock operations in Southern Vermont were recruited for the study. Of participants, 12% reported ever being diagnosed with a tick-borne disease, and reported an average of three tick encounters over the prior 6 months (ranging from 0 to 70). There was a marginal association between grazing livestock and increased tick sightings on the farm, and participants believed their risk for tick-borne disease was higher than other occupations.

Conclusions: Farmers are a high-risk population, given their increased risk of exposures at worksites that are prime tick habitats. High numbers of tick encounters and perception of risk highlight the need for tick-borne disease prevention strategies to be tailored to farmers and farmworkers.

KEYWORDS
Dairy farm;
livestock farm;
prevention;
ticks;
tick-borne disease

Introduction

The abundance and distribution of ticks and incidence rates of tick-borne disease have been steadily rising throughout the Northeastern United States in recent years.[1] In the Northeast, the causative agents of Lyme disease, anaplasmosis, and babesiosis are transmitted to humans through the bite of an infected blacklegged tick (*Ixodes scapularis*).[2] It is estimated there are roughly 476,000 cases annually in the United States.[3] These tick-borne pathogens can cause debilitating illness, leading to time lost from work, hospitalization, or long-term sequelae.[4,5]

Outdoor workers are at an increased risk for contracting tick-borne diseases due to their extended exposure periods in habitats ideal for ticks.[6] They remain at-risk throughout the year, even during winter, as mid-winter thaws have been occurring more frequently, causing ticks to re-emerge and quest for a bloodmeal.[3] Studies have shown the risk for tick-borne disease exposure is higher in outdoor workers than indoor workers.[7,8]

Vermont has among the highest incidence rates of Lyme disease in the country at a rate of 202.8 per 100,000 population, second only to Rhode Island at 212 per 100,000.[1] Additionally, in 2020, Vermont also had the second highest incidence rates of anaplasmosis in the country (30.6 per 100,000 population), just behind Maine at 32.8 per 100,000.[9]

Given high rates of tick-borne disease incidence in Vermont, coupled with the risk of exposure for outdoor workers (there are over 500 dairy farms in Vermont),[10] Vermont farmers and farmworkers are a particularly vulnerable population to tick-borne disease exposure. Very little research has been done

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on tick-borne disease exposure with farmers in the Northeast in recent years. This study sought to determine farmers and farmworkers perceptions of risk, and determine risk factors for tick exposures in agricultural settings, hypothesizing that though there may be an understanding of risk, the utilization of prevention methods may be low. Perception of risk was expected to help inform the potential for deploying mitigation efforts targeted at farms and farm workers, and risk factors were expected to help guide specific mitigation efforts.

Methods

Study region

Vermont was chosen as the study site given its high incidence rates of both Lyme disease and anaplasmosis,[1,9] as well its high level of agricultural enterprise and abundant tick habitat.[10] Vermont's southernmost counties were included in the study (Bennington, Rutland, Orange, Windsor, and Windham counties); See Figure 1, as they have among the highest incidence rates of Lyme disease, anaplasmosis, and babesiosis in the state.[11,12]

Sampling

Inclusion criteria for participation were: farmers/workers in Southern Vermont aged 18+ and working on an active, year-round dairy and/or livestock farms, which make up the majority of farms in the study area.[13] Initially, participants were randomly selected and called or emailed after recruitment from listservs from agricultural organizations (e.g., Farm Bureau, Northeast Organic Farming Association of Vermont). After 2 months of recruitment, only two participants were enrolled in the study, so snowball sampling was used by directly visiting farms for a period of 2 weeks. Snowball sampling was immediately very successful, and the desired sample size of 46 farms was reached in that time.

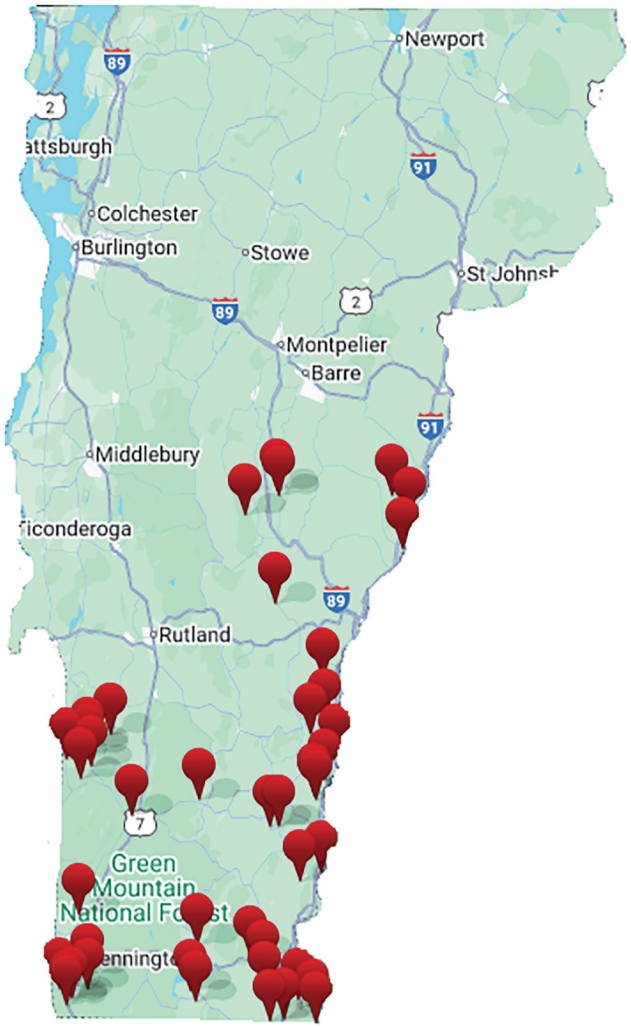

Figure 1. Map of Vermont noting the 46 farms that enrolled in the study.

Survey instrument

Appropriate Human Subjects approvals were obtained by the Mary Imogene Bassett Hospital's Institutional Review Board under protocol #1948405. A questionnaire was developed (see Supplemental Materials) to collect data on tick encounters/bites, health history, prevention practices, farm activities, and demographic data. This questionnaire was modified from Roome et al. 2022,[8] which sought to understand risk perceptions of forestry workers. Questionnaires have been shown to be utilized in measuring perceptions of risk.[14] Since tick encounters can be used as a proxy for disease risk,[15]

participants were asked how many tick encounters they had in the last 6 months. We defined encounters as having contact with a tick, either attached or crawling. Paper copies of surveys were given to each participant, and they either completed it while the research team was there or mailed it in after.

Statistical analyses

Data collection was performed with REDCap and analyzed using R version 4.3.1.[16] Survey responses were summarized for the full sample using frequencies and proportions or means and standard deviations (or medians and interquartile ranges) as appropriate. Associations between variables measured on a continuum (i.e., number of ticks found, number of tick bites) were compared between groups using t-tests or analysis of variance, as appropriate. Associations between categorical variables were analyzed using chi-square or Fisher's Exact test as necessary for small cell sizes.

Results

Demographics

A total of 53 were asked to participate in the study. Of those, three declined and an additional four dropped out after completing initial intake. This yielded 46 farms (53 individuals) completing the initial questionnaire for an overall participation rate of 87%. Four records were excluded due to missing or blank values on key variables ($n = 49$ total responses used for analyses in this manuscript).

Of respondents, 98% were white, with a higher proportion of males (59.2%) versus females (38.8%). This is in line with county demographics in Vermont, which range from 90.1% to 92.1% white in Windham and Orange Counties, respectively, and being a male dominated industry in the United States.[17,18] The average age of respondents was 57.9 years (SD = 13.4), with an average of 31.9 years (SD = 16.9) spent working on farms. Most participants reported their commodity as dairy (38.7%) or combined dairy and livestock operations (28.6%), with 32.7% focused on livestock only. The majority of respondents (87.8%) lived off the farm, and 42.9% reported using pesticides (general use, not specific to ticks) on their farm (see Table 1 for additional respondent characteristics).

Table 1. Respondent characteristics.

Characteristic	N	% of Respondents
White race	48	98.0
Female	19	38.8
Male	29	59.2
Age, mean ±sd	57.90 ± 13.39	
Years in farming, mean ±sd	31.9 (±16.94)	
County		
Bennington	8	16.3
Orange	9	18.4
Rutland	5	10.2
Windham	18	36.7
Windsor	9	18.4
Commodity		
Dairy + livestock	14	28.6
Dairy only	19	38.7
Livestock only	16	32.7
Farm activities		
Lives on farm	6	12.2
Lives off farm	43	87.8
Uses pesticides	21	42.9

Tick-borne disease diagnoses & tick encounters

A total of six respondents (12.2%) reported ever being diagnosed with a tick-borne disease. Among those, three were diagnosed with Lyme disease, two with anaplasmosis, and one with both Lyme and anaplasmosis (see Table 2).

Examining trends in the number of ticks a participant removed from themselves in the past 6 months, those exposed to 1) animal grazing, 2) personal prevention strategies, 3) non-use of pesticides, 4) non-use of farm prevention strategies, and 5) presence of barn cats generally tended to find more ticks (see Table 3). In several instances, these differences approached statistical significance using independent samples t-tests, but

Table 2. Summary/prevalence of tick-borne disease and tick encounters among survey respondents ($n = 49$).

Diagnoses & Tick Encounters	N	% of Respondents
Diagnosed with tick-borne disease	6	12.2
Lyme disease	3	6.1
Anaplasmosis	2	4.1
Lyme+anaplasmosis	1	2.0
# Ticks found in past 6 months, mean (±sd) [range]	2.98 (10.35) [0–70]	
# Ticks attached in past 6 months, mean (±sd) [range]	0.71 (1.21) [0–6]	

Table 3. Number of ticks removed in the past 6 months (how many ticks have you removed from yourself) compared across farm characteristics and personal strategies using independent samples t-tests.

	Group mean			
Variable	Yes	No	*t*	*p*-value (t-test)
Farm animals grazing	3.29	0.40	1.67	0.10
Personal prevention strategy	6.53	0.97	1.36	0.19
Pesticide use	0.95	4.52	−1.35	0.19
Farm-wide prevention strategy	1.50	3.37	−0.90	0.37
Barn cats	3.70	0.30	1.77	0.08

they did not reach the cutoff probability of 0.05 due to the small sample size and limited statistical power.

Prevention strategies & farm characteristics

Using chi-square and Fisher's Exact tests where appropriate for small cell sizes, there were no statistically significant associations found between having had a tick-borne disease diagnosis and farm-wide (i.e., acaracide spray, "buffer" zones at property edges, etc.) or personal (DEET, permethrin spray, tick checks, etc.) prevention strategies, pesticide use, seeing ticks on the farm, finding ticks on oneself at work, participating in animal handling activities, or having barn cats. In fact, among those ever diagnosed with a tick-borne disease, zero respondents reported a farm-wide tick prevention strategy, and only 33.3% reported using a personal tick prevention strategy.

Among respondents whose animals grazed, 100% had seen ticks on their farm compared with 75% whose animals did not graze ($p = .08$). Associations between tick sightings on the farm or finding ticks on yourself while at work and pesticide use, farm-wide tick prevention strategies, animal handling activities, and presence of barn cats were not statistically significant (see Table 4).

Personal prevention strategies & perception of risk

Farmers ranked their perception of risk to tick-borne disease exposure compared to other outdoor industries, with 59.2% reporting "Yes, the risk is often or sometimes higher than others", and 38.8% reporting

Table 4. Associations between seeing ticks on the farm and farm characteristics, compared across response options using chi-square or Fisher's Exact test.

Ever Seen Ticks on Farm	N	%	p-value (chi-square)
Uses pesticides (general use, not specific to ticks)	20	95.2	.45
Does not use pesticides	26	100	
Farm-wide prevention strategy used	9	100	.99
No farm-wide prevention strategy used	37	97.4	
Animal handing farm activities	14	100	.48
Non-animal handling farm activities	12	92.3	
Farm animals graze	44	100	.08
Farm animals do not graze	3	75.0	
Has barn cats	36	97.3	.99
Does not have barn cats	11	100	
Ever Found Ticks on Yourself at Work	N	**%**	p-value (chi-square)
Uses pesticides	17	85.0	.08
Does not use pesticides	26	100	
Farm-wide prevention strategy used	6	75.0	.07
No farm-wide prevention strategy used	37	97.4	
Personal prevention strategy used	15	93.8	.99
No personal prevention used	29	93.5	
Animal handing farm activities	11	84.6	.99
Non-animal handling farm activities	11	91.7	
Check for ticks often/sometimes	39	97.5	.05
Never checks for ticks	5	71.4	
Farm animals graze	39	92.9	.99
Farm animals do not graze	5	100	

"No, the risk is not higher than others". There were no statistically significant differences between use of a personal prevention strategy at work and perception of tick-borne disease exposure risk ($p = .212$). However, perception of higher tick-borne disease exposure risk was significantly associated with checking yourself for ticks at work ($p = .011$).

Discussion & conclusion

Farmers and farmworkers are considered a high-risk group for tick-borne disease exposure, due to their outdoor work and consistent exposure to suitable tick habitats.[19–21] In this study, 12.2% of farmers and farmworkers reported ever having been diagnosed with a tick-borne disease, higher than *B. burgdorferi* seroprevalence rates reported in Belgian farmers/veterinarians (5.5%).[21]

All participants in the current study reported seeing ticks on the farm and having found ticks on themselves at work, very similar to farmworkers (fieldworkers) in Malaysia, who reported tick bites when they were working.[22] The current survey was given in late April/early May, meaning tick numbers were reported between late October/early November and through early spring. This is a known lower activity period for blacklegged ticks throughout the Northeast (with peaks in October/November and April/May and a lull through the winter).[23] The average number of tick encounters among farmers was very similar to that reported by forestry workers in a prior study (mean tick encounters = 3.25) over a 6 month period within the same time frame (November through May).[8]

A study with forestry workers in New York reported they believed their risk for tick-borne disease exposure was higher than other occupations,[8] which matched farmers' perceptions of risk in the current study. The association of a higher perceived tick-borne disease risk and checking for ticks observed in this study was also reported in Belgium, where farmworkers who perceived Lyme disease was a severe disease and were concerned about their risk reported actively using prevention strategies against tick bites.[24,25] Additionally, a recent study from Illinois assessed farmers' knowledge and practices regarding ticks and tick-borne diseases and found no significant association between the number of preventive behaviors reported for themselves and concern about contracting tick-borne disease or a history of a family member being impacted by a tick-borne disease.[26] Similarly, the current study found preventive behaviors and disease outcomes were not correlated.

In a study regarding knowledge, attitudes, and practices regarding ticks among Oklahoma beef producers (66.1%), participants believed ticks posed a low threat to themselves, their families, and those who worked with them.[27] In contrast, the current study showed 59.2% of farmers thought they often or sometimes had a higher risk of exposure to ticks than other outdoor workers.

Unfortunately, given the challenges of recruiting, it was not possible to randomly recruit farms to ensure a representative sample for the study. Additionally, to be eligible for participation in the study, participants had to work on an active farming operation. Given this, it is possible the results of this study were impacted by the "Healthy Worker Effect", whereby those who had had tick encounters and severe tick-borne disease outcomes were no longer farming. Additionally, given the challenge of spotting nymphal ticks, it is not possible to determine the accuracy of self-reported tick encounters.

Tick-borne diseases are a public health concern to farmers/workers and other outdoor workers, which is exacerbated in endemic areas like the Northeastern United States. This study provides an updated description of tick exposure and tick-borne disease risk in farmers/workers, noting that most are aware of their risk, though prevention practices were not significantly associated with the number of tick encounters reported. This suggests that those practicing a prevention strategy, such as checking for ticks, may be more likely to find ticks, remove them in a timely manner, and lessen the risk for disease exposure. Given the high rate of tick encounters, the small size of ticks, and the perceived risk of farmers, results from this study suggest the need for prevention methods to be tailored to this population. Future directions for this research will focus on implementing and evaluating an environmental intervention to mitigate tick bite exposures on farms.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Author contributions

Amanda Roome led efforts on concept development, research and survey design, recruitment, data collection, data analysis, interpretation and drafted the manuscript. Destiny Trombley assisted with data collection, data analysis, interpretation, and participated in preparing the manuscript. Megan Kern, Melissa Scribani and Paul Jenkins led database management, analysis and critically reviewed the manuscript. Richard Ostfeld assisted in the development of the research design, survey development and critical review of the manuscript. Julie Sorensen assisted in concept development, research and survey design, recruitment, and critical review of the manuscript.

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