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Pet ownership increases human risk of encountering ticks

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Summary

We examined whether pet ownership increased the risk for tick encounters and tick-borne disease among residents of three Lyme disease-endemic states as a nested cohort within a randomized controlled trial. Information about pet ownership, use of tick control for pets, property characteristics, tick encounters and human tickborne disease were captured through surveys, and associations were assessed using univariate and multivariable analyses. Pet-owning households had 1.83 times the risk (95% CI = 1.53, 2.20) of finding ticks crawling on and 1.49 times the risk (95% CI = 1.20, 1.84) of finding ticks attached to household members compared to households without pets. This large evaluation of pet ownership, human tick encounters and tickborne diseases shows that pet owners, whether of cats or dogs, are at increased risk of encountering ticks and suggests that pet owners are at an increased risk of developing tickborne disease. Pet owners should be made aware of this risk and be reminded to conduct daily tick checks of all household members, including the pets, and to consult their veterinarian regarding effective tick control products.

Keywords

Ixodes; Lyme disease; pets; prevention; tickborne disease; ticks

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1 | INTRODUCTION

Lyme disease is caused by infection with certain species of *Borrelia burgdorferi* sensu lato and is transmitted through the bite of infected blacklegged ticks (*Ixodes* spp.). It is the most common vector-borne disease in the United States. Blacklegged ticks also transmit the causative agents of anaplasmosis, babesiosis and a Powassan virus variant. In the north-eastern United States, risk of exposure to the blacklegged tick is believed to be highest peridomestically due to land-use characteristics and human behaviour (Falco & Fish, 1988; Maupin, Fish, Zultowsky, Campos, & Piesman, 1991). Specific risk factors for exposure to blacklegged ticks have not been fully described.

Contact with pets, specifically cats and dogs, has been proposed as a risk factor for tickborne disease among humans (Rabinowitz, Gordon, & Odofin, 2007). Two early descriptions of Lyme disease cases suggested that owning pets and finding ticks on pets may be linked with disease (Curran & Fish, 1989; Lane et al., 1992). A subsequent case-control study demonstrated that the presence of pets (specifically cats) was a significant risk factor for Lyme disease and that cases found ticks on their pets more often than controls (Steere, Broderick, & Malawista, 1978). However, ensuing studies failed to demonstrate an association between pet ownership and Lyme disease (Cimmino & Fumarola, 1989; Connally et al., 2009; Eng, Wilson, Spielman, & Lastavica, 1988; Hanrahan et al., 1984; Lane et al., 1992; Ley, Olshen, & Reingold, 1995; Orloski et al., 1998; Schwartz & Goldstein, 1990; Steere, Taylor, Wilson, Levine, & Spielman, 1986). Pet ownership is increasing in the United States, and many pet owners allow their pets to share their living space, including beds and furniture (Chomel & Sun, 2011). To further explore pets as risk factors for tickborne disease, we examined the association between pet ownership and tick encounters and tickborne disease among residents of three Lyme disease-endemic states.

2 | MATERIALS AND METHODS

As part of TickNET (a collaborative public health effort established by CDC with several state health departments for coordinated surveillance, research, education and prevention of tickborne diseases), households were enrolled in a randomized controlled trial (RCT) to determine the effectiveness of a single springtime application of acaricide (tick pesticide) in preventing human tickborne disease (Hinckley et al., 2016). These households were located in counties with a high incidence of reported Lyme disease in Connecticut (Fairfield, Litchfield and New Haven Counties), Maryland (Baltimore, Harford, Howard and Carroll Counties) and New York (Dutchess County). Properties were selected based on landscape characteristics suggesting the potential for human exposure to blacklegged ticks. The study was conducted in 2011 and 2012 and households voluntarily participated during one of the 2 years (Hinckley et al., 2016).

Participants were asked to complete an initial survey administered by a study investigator over the phone, four brief monthly web-based surveys, and a final telephone survey administered by a study investigator. The initial survey contained questions regarding demographics, property and landscape characteristics, whether the household had a pet that went outdoors, and use of tick control on pets. The monthly web-based surveys asked about the number of ticks found on pets and found crawling on or attached to household members over the preceding month. The final survey was administered to the head of household 5–6 months post-treatment to capture incident tickborne diseases in household members. Self-reported cases were categorized as “verified” after a panel of three study team members, including two physicians, concurred with a diagnosis of tickborne disease following medical record review. With the approval of participants, we requested patient charts from medical provider offices and abstracted information, as described in Hinckley et al., 2016.

To explore the association between pet ownership and human tick encounters and tickborne disease, we conducted a nested cohort study within the RCT. Reported pets that were not dogs or cats (e.g., guinea pig or rabbit) were excluded from all analyses. We evaluated differences in household and property characteristics between households with and without pets using chi-squared tests for all households enrolled in the study. We evaluated differences in human tick encounter outcomes (ticks found crawling and ticks found attached) between households with and without pets for all participants who answered at least one monthly survey, and for human tickborne disease (selfreported illness and verified illness) for all participants who completed a final survey. The associations between pet ownership and human outcomes were assessed using univariate and multivariable logistic regression models. Potential confounders of these associations included property and household characteristics, RCT treatment group and year. Univariate analyses were conducted at the household level. Multivariable outcomes of ticks found crawling or attached were conducted both at the household level and offset by the number of household members. These models were built manually and using backward, forward and stepwise selection procedures in SAS 9.3 (Cary, NC). The final models from each of these procedures were reviewed for convergence to a single parsimonious model.

The study protocol was reviewed and approved by ethics committees at CDC, Yale University, Connecticut Department of Public Health, Maryland Department of Health and Mental Hygiene, and New York State Department of Health.

3 | RESULTS

Among the 2,727 households enrolled in the study, over half (n = 1,546, 56.7%) reported owning a dog or a cat (or both) that was allowed outside in the yard and inside the house; of these, 1,010 (65.3%) had dogs only, 231 (14.9%) had cats only, and 305 (19.7%) had at least one cat and at least one dog (Table 1). Of the 2,590 households that completed at least one monthly survey, 1,464 (56.5%) households had pets and 1,126 (43.5%) did not. Of the 2,541 households that completed the final survey, 1,438 (56.6) households had pets and 1,103 (43.4) did not.

Of 1,546 households with a pet, 1,362 (88.1%) reported using some form of tick control on their pet; 1,193 (90.7%) dog-owning households and 338 (63.1%) cat-owning households reported using tick control on their dog or cat, respectively. There was no difference between pet-owning households and those without pets with respect to property treatment, study site and income level; however, heads of households with pets more commonly owned properties larger than two acres, had completed at least some college education and were white.

In total, 20.0% of pet-owning households reported finding ticks on their pets, 31.4% found ticks crawling on household members, and 19.2% found ticks attached to household members during the study period (Table 2). No significant difference in self-reported tickborne disease was observed between pet-owning households as compared to households without pets (p = .60). Medical records were available for 44 of 80 tickborne disease reports, of which 39 were verified as provider-diagnosed tickborne disease based on review by the panel. Additionally, verified tickborne disease reports did not differ between pet-owning households and households without pets (p = .32).

Owning only a dog, only a cat, or both a dog and a cat were all associated with tick encounters among pet-owning households compared to households without pets (Table 3). Because having any type of pet explained the outcomes as well as each individual type of pet (dog versus cat versus both), we proceeded using any pet ownership as our predictor of interest. Pet-owning households had a significantly increased risk of finding ticks crawling on household members (odds ratio [OR] = 1.83; 95% confidence interval [CI] = 1.53, 2.20) and a significantly increased risk of finding ticks attached to household members (OR = 1.49; 95% CI = 1.20, 1.84) as compared to households without pets. In addition to the pet variables, certain property characteristics, including having a vegetable garden, compost pile, log pile, bird feeder, stone walls and children's play equipment, had strong positive and significant associations with finding ticks both crawling and attached to household members.

After controlling for lot size and children's play equipment, risk of finding ticks crawling on household members remained elevated (adjusted OR [aOR] = 1.79; 95% CI = 1.45, 2.16) for pet-owning households as compared to households that did not own pets (Table 4). Similarly, after controlling for lot size and having a vegetable garden, bird feeder and children's play equipment, risk of finding ticks attached was still increased (aOR = 1.43; 95% CI = 1.15, 1.77) for pet-owning households. Controlling for number of household members yielded similar findings for ticks crawling (aOR = 1.37; 95% CI = 1.15, 1.62) and attached (aOR = 1.21; 95% CI = 0.99, 1.49).

Among pet-owning households, finding ticks on pets significantly increased the likelihood of finding ticks crawling on household members (OR = 2.69, 95% CI = 2.14, 3.37) and attached to household members (OR = 2.5, 95% CI = 1.92, 3.25) as compared to pet-owning households that did not find ticks on their pets (Table 3). Finding ticks on pets was not significantly associated with verified illness in household members. The reported use of tick control on cats (OR = 1.45; 95% CI = 0.92, 2.26), dogs (OR = 0.79; 95% CI = 0.51, 1.22), or any pet (OR = 1.03; 95% CI = 0.70, 1.52) was not protective against finding ticks on pets, nor against finding ticks crawling on or attached to humans.

4 | DISCUSSION

We present the largest analysis to date that explores the association between pet ownership and tick encounters and tickborne disease. Owning indoor-outdoor pets increases human risk of encountering ticks, and finding ticks on pets further increases the likelihood of household members encountering ticks. Pets may bring ticks onto the property and even into the home where humans can encounter them. In addition, pet owners may engage in activities with their pets that take both themselves and their pets into tick habitat, increasing the risk of tick encounters for both the pet and the humans.

While we demonstrated consistently strong and significant associations between pet ownership and tick encounters, we failed to demonstrate an association between pet ownership or finding ticks on pets and human tickborne disease. As with previous studies, this was possibly a result of inadequate study power due to the infrequency of tickborne disease among study subjects (Cimmino & Fumarola, 1989; Connally et al., 2009; Eng et al., 1988; Hanrahan et al., 1984; Lane et al., 1992; Ley et al., 1995; Orloski et al., 1998; Schwartz & Goldstein, 1990; Steere et al., 1986). A separate analysis conducted using data from the same RCT suggests that self-reported tick encounters may be a robust surrogate for disease risk at the household level (Hook et al., 2015). Therefore, we believe the greater risk of encountering ticks in pet-owning households reflects a true increase in risk of tickborne disease in these households.

Our result that finding ticks on pets significantly increases the likelihood of household members encountering ticks is also consistent with previous findings (Ley et al., 1995; Steere et al., 1978) and substantiates earlier observations (Curran & Fish, 1989; Lane & Lavoie, 1988). However, we were surprised to find that the reported use of tick control on pets did not have a protective effect on tick encounters. We asked about tick control on pets during enrolment rather than on our monthly surveys throughout tick season, and therefore, it is possible that the reported use did not reflect actual application throughout the study period. In addition, we did not collect the brand of tick control product that was purportedly applied to know its effectiveness when used according to the product label. In the light of these limitations, and given the strong association between finding ticks on pets and tick encounters among household members, we encourage pet owners to consult their veterinarians regarding effective tick control products.

In addition, we identified certain property characteristics (bird-feeder, children’s play equipment) that independently increased the risk of tick encounters in households with those features. These findings are intriguing, and, other than one study that demonstrated increased risk associated with rock walls (Orloski et al., 1998), are in contrast to a previous study which failed to demonstrate increased risk associated with property features (Connally et al., 2009). It is reasonable to think that birdfeeders might attract rodents and other animals that may introduce ticks to the property. Having children’s equipment might be a proxy measure for frequent use by a high-risk population (i.e., children) of all areas of the yard, irrespective of tick habitat. This analysis was designed to explore pets as risk factors for tickborne disease, and we included the significant property characteristics in our multivariable models to control for their effect as potential confounders. The results of our analysis, therefore, should not be considered a full characterization of the association between property features and tick encounters and further investigation into these possible associations is warranted.

There were a number of limitations to this study. First, these data were not collected specifically for this analysis but rather as part of an RCT to assess effectiveness of a tickborne disease intervention. Future studies could be designed specifically to explore the association between pet ownership and tick encounters and disease. For instance, to clarify the effects of tick control products, investigators should collect the type of tick control product used and verify owner compliance with timeliness and method of application. In addition, we collected and analysed data at the household level. Individual level data, including the number of ticks found on each household member and each pet as well as individual behaviours (e.g., sleeping with a pet), would help elucidate the role of pets in increasing human risk of encountering ticks and could help identify modifiable behaviours that can reduce tick encounters.

In summary, this large evaluation of pet ownership, human tick encounters and tickborne diseases shows that pet owners, whether of cats or dogs, are at increased risk of encountering ticks and suggests that pet owners are at an increased risk of developing tickborne disease. Pet owners should be made aware of this risk and be reminded to conduct daily tick checks of all household members, including the pets, and to consult their veterinarian regarding effective tick control products.

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Impacts

- In the largest evaluation to date to explore the association between pet ownership and risk for tick encounters and tickborne disease, we demonstrated that pet owners, whether of cats or dogs, are at increased risk of finding ticks both crawling and attached to household members.
- Among pet-owning households, finding ticks on pets significantly increased the risk of encountering ticks on household members, as compared to pet-owning households that did not find ticks on their pets.
- Pet owners should be made aware of this risk and be reminded to conduct daily tick checks of all household members, including the pets, and to consult their veterinarian regarding effective tick control products.

TABLE 1

Household demographic and property characteristics by pet ownership, *n* (%)

Characteristics	All households[a] *N* = 2,727	Pets[b] 1,546 (56.7%)	No Pets 1,181 (43.3%)	*p*-Value*
Acaricide	1,362 (49.9)	774 (50.1)	588 (49.8)	.9077
Year 2011	1,615 (59.2)	858 (55.5)	757 (64.1)	<.0001
State				.2363
Connecticut	1,002 (36.7)	586 (37.9)	416 (35.2)	
Maryland	692 (25.4)	376 (24.3)	316 (26.8)	
New York	1,033 (37.9)	584 (37.8)	449 (38.0)	
Race				
White	2,534 (93.8)	1,475 (95.4)	1,059 (89.7)	<.0001
Family income				
>$70,000	1,824 (78.7)	1,069 (69.1)	755 (63.9)	.3112
Education				
At least some college	2,356 (86.7)	1,314 (85.0)	1,042 (88.2)	.0066
Property size				
>2 acres	742 (27.2)	446 (28.8)	296 (25.1)	.0260
Woods on property	2,330 (85.4)	1,343 (86.9)	987 (83.6)	.1055
Pet ownership				
Any pet	1,546 (56.7)	1,546 (100)		
Only dog	1,010 (37.0)	1,010 (65.3)		
Only cat	231 (8.5)	231 (14.9)		
Both cat and dog	305 (11.2)	305 (19.7)		
Dog	1,315 (48.2)	1,315 (85.1)		
Cat	536 (19.7)	536 (34.7)		
Use tick control on pet	1,362 (49.9)	1,362 (88.1)		
Found tick on pet	309 (11.4)	309 (20.0)		

[a]All households is the total number of households enrolled in the study (2,727), including the 137 households that did not complete at least one monthly survey.

[b]Analysis restricted to indoor/outdoor dogs and cats; other indoor/outdoor pets were excluded ($n = 10$).

*Based on Chi-squared analyses.

TABLE 2

Outcome measures[a] by pet ownership, *n* (%)

	All households $N = 2,590$	Pets[a] 1,464 (56.5%)	No Pets 1,126 (43.5%)	*p*-Value[*]
Tick encounters				
Ticks Crawling	680 (26.3)	459 (31.4)	221 (19.6)	<.0001
Ticks Attached	434 (16.8)	281 (19.2)	153 (13.6)	.0002
	All households $N = 2,541$	**Pets 1,438 (56.6%)**	**No Pets 1,103 (43.4%)**	***p*-Value[*]**
Illness				
Self-reported Illness	80 (3.1)	43 (3.0)	37 (3.4)	.6023
Verified Illness	39 (1.5)	19 (1.3)	20 (1.8)	.3174

[a]The denominator for ticks crawling and attached in all households is 2,590 (those participants who answered at least one monthly survey); of these, 1,464 households had pets and 1,126 did not. The denominator for self-reported and verified illness in all households is 2,541 (those participants who completed a final survey); of these, 1,438 households had pets and 1,103 did not.

[*]Based on Chi-squared analyses.

TABLE 3

Pet ownership and potential confounders in relation to human tick encounters and disease

Characteristic	Ticks crawling OR (95% Cl)	Ticks attached OR (95% Cl)	Verified illness OR (95% Cl)
Independent variables			
Pet ownership	1.83 (1.53, 2.20)	1.49 (1.20, 1.84)	0.72 (0.38, 1.36)
Dog only	1.82 (1.49, 2.22)	1.37 (1.08, 1.73)	0.59 (0.27, 1.26)
Cat only	1.65 (1.19, 2.28)	1.83 (1.28, 2.62)	1.30 (0.48, 3.49)
Both cat and dog	2.08 (1.58, 2.76)	1.71 (1.24, 2.38)	0.57 (0.17, 1.95)
Potential confounders (univariate analyses)			
Treatment	1.15 (0.97, 1.37)	1.11 (0.91, 1.37)	1.05 (0.56, 1.98)
Year	1.08 (0.91, 1.29)	0.89 (0.71, 1.09)	0.64 (0.32, 1.27)
Vegetable garden	1.32 (1.10, 1.58)	1.40 (1.13, 1.72)	1.10 (0.57, 2.12)
Flower garden	1.29 (1.07, 1.56)	1.22 (0.98, 1.53)	1.60 (0.76, 3.39)
Compost pile	1.74 (1.45, 2.09)	1.37 (1.10, 1.71)	1.62 (0.84, 3.12)
Log pile	1.49 (1.24, 1.79)	1.48 (1.19, 1.84)	1.15 (0.60, 2.23)
Bird feeder	1.35 (1.13, 1.61)	1.33 (1.08, 1.63)	1.43 (0.76, 2.69)
Fencing	1.05 (0.87, 1.25)	0.92 (0.74, 1.14)	0.75 (0.38, 1.48)
Stone walls	1.50 (1.26, 1.79)	1.68 (1.36, 2.08)	1.19 (0.62, 2.28)
Children’s equipment	1.31 (1.10, 1.57)	1.37 (1.11, 1.68)	1.34 (0.71, 2.54)
Dining area	1.30 (1.04, 1.63)	1.19 (0.92, 1.55)	0.40 (0.12, 1.31)
Sitting area	1.40 (1.18, 1.68)	1.23 (1.00, 1.51)	1.32 (0.70, 2.50)
Lawn sport area	1.27 (1.05, 1.53)	1.22 (0.98, 1.52)	0.97 (0.48, 1.97)
Found ticks on pets	2.69 (2.14, 3.37)	2.50 (1.92, 3.25)	1.77 (0.72, 4.39)
Tick control for cat	1.17 (0.80, 1.74)	1.21 (0.78, 1.89)	1.12 (0.28, 4.53)
Tick control for dog	1.12 (0.72, 1.74)	0.99 (0.59, 1.67)	-
Tick control for any pet	1.12 (0.79, 1.57)	1.06 (0.71, 1.59)	1.15 (0.26, 5.11)

OR, Odds ratio.

TABLE 4

Final multivariable logistic regression models for the association between pet ownership and ticks crawling and ticks attached

Outcome	Potential risk factor	Adjusted OR	95% CI	*p*-Value
Ticks crawling	Pet ownership	1.79	(1.45, 2.16)	<.0001
	Lot size	1.58	(1.31, 1.91)	<.0001
	Children's equipment	1.31	(1.09, 1.56)	.0038
Ticks crawling adjusted for number of household members	Pet ownership	1.37	(1.15, 1.62)	.0003
	Race white	1.74	(1.16, 2.74)	.0116
	Lot size	1.46	(1.23, 1.72)	<.0001
	Bird feeder	1.35	(1.15,1.58)	.0002
Ticks attached	Pet ownership	1.43	(1.15, 1.77)	.0014
	Lot size	1.43	(1.14, 1.78)	.0018
	Vegetable garden	1.31	(1.06, 1.63)	.0131
	Bird feeder	1.27	(1.03, 1.57)	.0251
	Children's equipment	1.35	(1.09 1.67)	.0052
Ticks attached adjusted for number of household members	Pet ownership	1.21	(0.99, 1.49)	.0650
	Lot size	1.38	(1.12, 1.69)	.0022
	Bird feeder	1.38	(1.14, 1.68)	.0012