Lyme Disease in New Jersey Outdoor Workers: A Statewide Survey of Seroprevalence and Tick Exposure

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Abstract: To evaluate the spread of Lyme disease in New Jersey, we conducted a statewide cross-sectional study of Lyme disease seroprevalence in a high-risk occupational group of outdoor employees. Of the 689 employees who participated in the study, 39 (5.7 percent) were positive for antibody to *B. burgdorferi*, the causative agent of Lyme disease. Seroprevalence varied markedly by county; unexpectedly high seroprevalence rates were found in several northern counties (Sussex, Hudson, and Hunterdon). Furthermore, some southern counties (Atlantic, Cape May, and Ocean) with large tick populations (as measured by self-reported exposure to ticks) had low seroprevalence rates which were inversely correlated with self-reported preventive practices. These data suggest that lyme disease, as measured by seroprevalence of antibody to *B. burgdorferi*, may be spreading beyond the southern portion of the state where it had been previously well documented and that preventive behaviors may play an important role in minimizing the risk of the disease. (*Am J Public Health* 1990; 80:1225–1229.)

Introduction

The incidence of Lyme disease is increasing in many areas of the United States. The disease is caused by the spirochete *Borrelia burgdorferi* and transmitted by the *Ixodid* ticks. Early reports of the disease in the United States were from Connecticut in the late 1970s[1] but the disease is now a public health concern in the surrounding states (New Jersey, New York, and Massachusetts) as well, and has been reported in at least 43 states.[2]

A series of investigations in New Jersey were performed during the period 1978–82 by Bowen and Schulze, *et al.*[3–7] They found that, of 117 reported Lyme disease cases during the period, 48 percent (57) had occurred in one centrally located county (Monmouth). Almost all cases (98 percent) had occurred in the central and southern portions of the state.[5] Furthermore, the statewide distribution of *Ixodes dammini* correlated with the location of reported cases and revealed a high density of *Ixodes dammini* in the southern two-thirds of the state and a particularly high concentration in Monmouth County. It should be noted that while *Ixodes dammini* is the primary vector of Lyme disease in the northeast United States, the causative agent, *B. burgdorferi* has been identified in a number of species of ticks including *Amblyomma americanum,* and *Dermacentor variabilis*.[8]

In an attempt to further evaluate the spread of Lyme disease in New Jersey, we conducted a statewide cross-sectional study of Lyme disease seroprevalence in a high-risk occupational group. We measured: 1) seroprevalence of antibody to *B. burgdorferi*, 2) self-reported tick exposure and, 3) self-reported preventive practices among outdoor workers in the Natural and Historic Resources divisions of the New Jersey Department of Environmental Protection.

Methods

Study Population

The New Jersey Natural and Historic Resources (NHR) Section consists of four divisions: Parks and Forestry; Coastal Resources; Green Acres; and Fish, Game and Wildlife. Employees work primarily in outdoor jobs in a variety of habitats including mountainous regions, grass lands, forests, and shoreline. Geographically, they are distributed across the state from Stokes State Forest on the state line with New York in the north to Cape May County across the bay from Delaware in the south. During October 1988, we conducted a Lyme disease evaluation of employees at 12 different sites across the state on 15 dates. The summer months of May through August are the highest risk months and antibody seroconversion generally occurs three to six weeks after infection.[9] Participation was voluntary and all participating employees gave informed consent. A total of 689 (69 percent) of an estimated 1,000 eligible employees participated in the study.

Data Collection

The evaluation consisted of venipuncture for a serum specimen and administration of a questionnaire. Whole blood specimens were centrifuged and then divided into as many as five equal aliquots. An initial fresh specimen was sent to a commercial laboratory for immunofluorescent antibody (IFA) titer to *B. burgdorferi*. A titer of 1:128 or greater was reported as positive by the laboratory. The remaining samples were frozen and then after the initial fresh specimen results were reported, all positives and a random sample of the negatives were sent to as many as three other laboratories for analysis. Samples were analyzed at one department of health laboratory and at two university research laboratories by IFA in one case and enzyme linked immunosorbent assay (ELISA) in the other two. To be defined as positive for antibody to *Borrelia burgdorferi* in the study, the worker had to have at least two positive tests in two independent laboratories.

All employees participating in the study completed a self-administered questionnaire. The administration of the questionnaire was supervised by the authors and checked for accuracy after completion. Study variables included demographic data, counties of work and residence, self-reported measures of tick exposure, and frequency of performance of six behavioral practices of potential benefit in minimizing the risk of *B. burgdorferi* infection.

For purposes of data analysis and description, the counties of the state have been defined as northern or southern based on a line which cuts New Jersey geographically in half. The line runs from the lower border of Mercer

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County through the middle of Monmouth County (Figure 1). Since the dividing line runs through Monmouth County, and because that county is unique in that it has a particularly well documented history of elevated Lyme disease risk, Monmouth will be discussed separately and not included with the northern or southern groupings.

Results

Seroprevalence

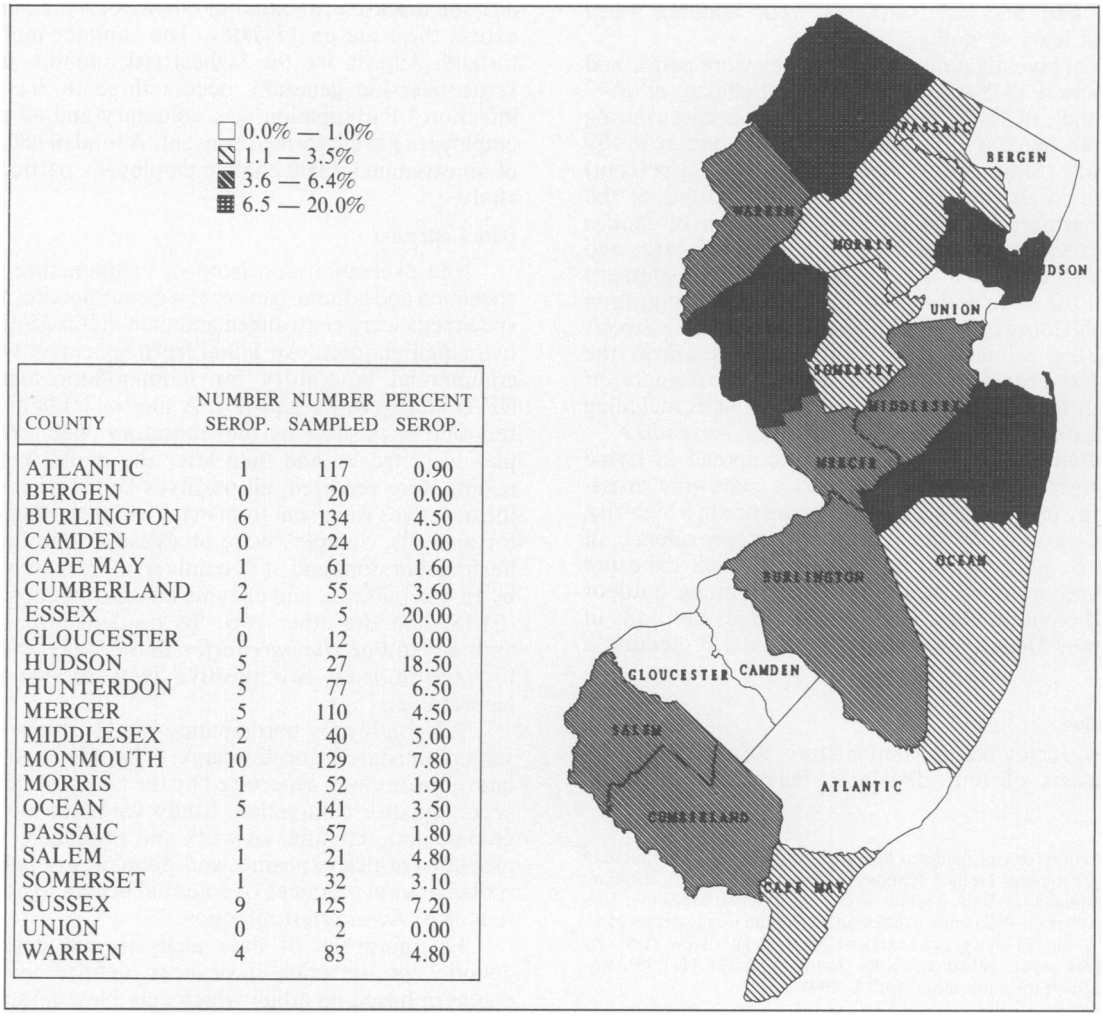
Statewide: A total of 689 employees of the NHR divisions of the NJ Department of Environmental Protection participated in the study. Thirty-nine employees (5.7 percent) had at least two positive tests for antibody to *B. burgdorferi,* the causative agent of Lyme disease. There were no differences in seropositivity based on years of outdoor state employment. The 39 seropositive subjects were found to have a mean (SD) of 16.5 (28.9) years of outdoor state employment while the seronegatives had a mean (SD) of 19.0 (28.0) years. There were no important differences based on job title or primary job habitat.

Geographic Distribution: Figure 1 displays the distribution of seropositives based upon county(s) of employment (some employees worked in more than one county on a regular basis). Seroprevalence ranged from a low of zero percent in four counties (Bergen, Camden, Gloucester, and Union) to highs of 6.5, 7.2, 7.8, and 18.5 percent in Hunterdon, Sussex, Monmouth, and Hudson counties, respectively. The 20 percent seroprevalence found in Essex County is based upon only five workers sampled.

Self-Reported Tick Exposure

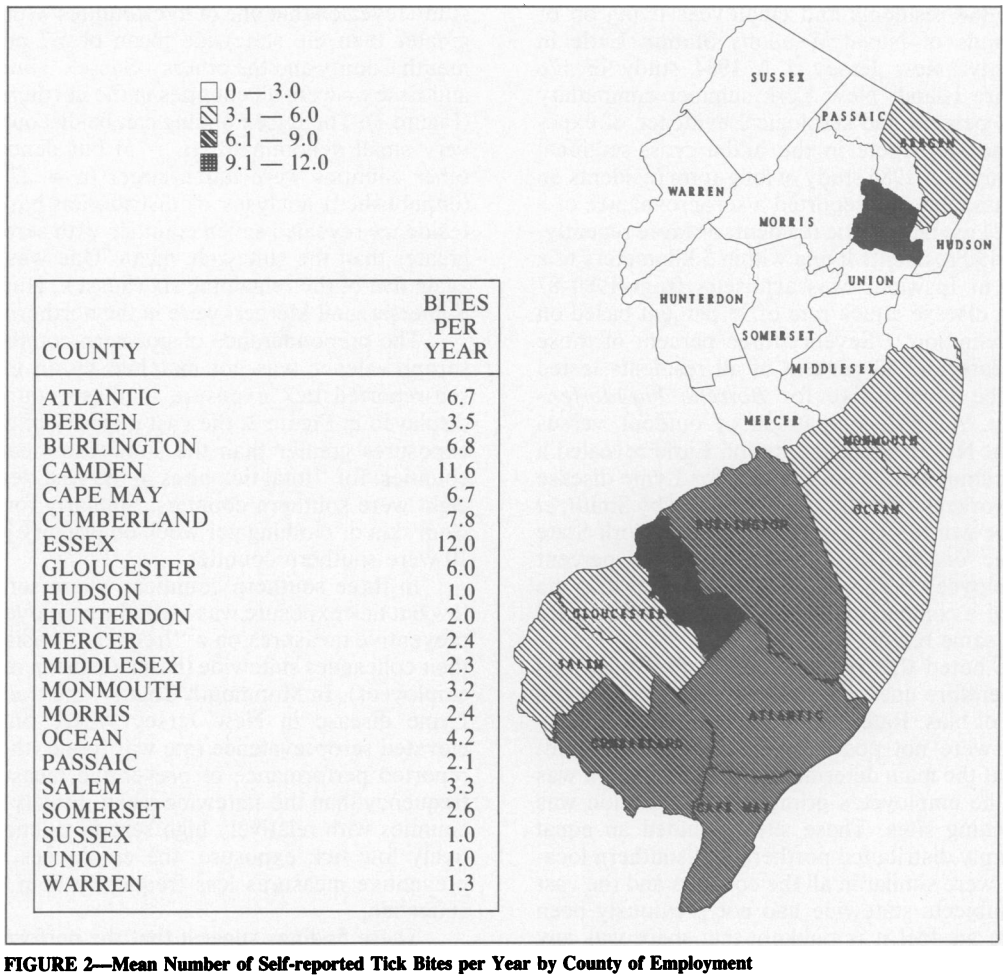
Statewide: Based on self-reports from the 689 employees who participated in the study, the workers reported a mean (SD) of 3.5 (7.6) and a median of 1.0 tick bites (ticks embedded in the skin) during the past year. The number of ticks removed from skin or clothing per week (during May–August 1988) on the primary job (some employees had other non-DEP jobs) was reported as a mean of 2.5 (SD ± 5.4) and a median of 2.0

Geographic Distribution: Figure 2 displays the mean number of tick bites over the past 12 months by county of employment. The mean yearly bite totals ranged from less than 1.5 in Hudson, Sussex, Union, and Warren counties to greater than 7.5 in Essex, Cumberland, and Camden counties. The mean number of ticks removed from skin or clothing per week on the primary state job by county of employment ranged from less than 1.5 ticks per week in Bergen, Passaic, Sussex, and Union counties to greater than 4.0 ticks per week in Burlington, Cape May, Cumberland, and Salem counties.



COUNTY	NUMBER SEROP.	NUMBER SAMPLED	PERCENT SEROP.
ATLANTIC	1	117	0.90
BERGEN	0	20	0.00
BURLINGTON	6	134	4.50
CAMDEN	0	24	0.00
CAPE MAY	1	61	1.60
CUMBERLAND	2	55	3.60
ESSEX	1	5	20.00
GLOUCESTER	0	12	0.00
HUDSON	5	27	18.50
HUNTERDON	5	77	6.50
MERCER	5	110	4.50
MIDDLESEX	2	40	5.00
MONMOUTH	10	129	7.80
MORRIS	1	52	1.90
OCEAN	5	141	3.50
PASSAIC	1	57	1.80
SALEM	1	21	4.80
SOMERSET	1	32	3.10
SUSSEX	9	125	7.20
UNION	0	2	0.00
WARREN	4	83	4.80

FIGURE 1—Percent Seropositive by County of Employment



COUNTY	BITES PER YEAR
ATLANTIC	6.7
BERGEN	3.5
BURLINGTON	6.8
CAMDEN	11.6
CAPE MAY	6.7
CUMBERLAND	7.8
ESSEX	12.0
GLOUCESTER	6.0
HUDSON	1.0
HUNTERDON	2.0
MERCER	2.4
MIDDLESEX	2.3
MONMOUTH	3.2
MORRIS	2.4
OCEAN	4.2
PASSAIC	2.1
SALEM	3.3
SOMERSET	2.6
SUSSEX	1.0
UNION	1.0
WARREN	1.3

FIGURE 2—Mean Number of Self-reported Tick Bites per Year by County of Employment

Preventive Measures: Self-reported behavioral practices are displayed in Table 1 on a statewide basis and by selected counties in Table 2. These behaviors were performed more frequently on the job than in non-occupational settings. Additionally, although workers frequently checked themselves for ticks, a minority of workers reported the other behaviors. In an effort to account for the unexpectedly high seroprevalence rates found in three northern counties (Sussex, Hudson, and Hunterdon) we chose to compare the preventive behavior performance frequencies in these counties with the frequencies found in three southern counties with relatively low seroprevalence rates. Table 2 reveals that these preventive behaviors were performed more frequently by employees in Monmouth County and three selected southern counties (Atlantic, Ocean, and Cape May) than they were in the three northern counties (Sussex, Hudson, and Hunterdon). The results for the other northern and southern counties were similar to those for the selected northern and southern counties reported.

TABLE 1—Percent of Workers Who Report Performance of Preventive Behaviors Statewide

Specific Behavior	Percent Who Perform Behavior While Outdoors: Frequently (Usually or Always)	Sometimes	Never
Wear long pants in the summer			
At work	85.7	10.7	4.3
Not at work	47.9	44.3	7.7
Wear long sleeves in the summer			
At work	13.7	37.8	48.5
Not at work	6.7	48.7	44.6
Tuck pants into socks or shoes			
At work	8.2	21.4	71.0
Not at work	3.6	17.3	79.2
Use insect repellent on skin			
At work	22.6	47.0	30.6
Not at work	17.7	50.4	31.8
Use insect repellent on clothes			
At work	19.3	43.2	37.5
Not at work	16.2	44.6	39.1
Check self for ticks			
At work	74.9	14.4	10.7
Not at work	65.9	22.8	11.3

Discussion

To our knowledge, the present study is the first to investigate the seroprevalence of antibody to *B. burgdorferi* on a statewide basis.

Several studies have investigated the seroprevalence or the seroconversion rate of populations residing or working in endemic areas. An early investigation in 1982 reported a one-year clinical Lyme disease cumulative incidence rate of

1.1 percent in 1,364 residents and employees living on or around the grounds of Naval Weapons Station Earle in Monmouth County, New Jersey.[10] A 1984 study of 176 residents of a Fire Island, New York summer community revealed that 9.7 percent had serological evidence of exposure to the Lyme spirochete in the initial cross-sectional portion of the study.[11] A 1986 study of long-term residents on Great Island, Massachusetts reported a seroprevalence of 8 percent among 121 asymptomatic residents.[12] More recently, an evaluation of 190 residents living within 5 kilometers of a nature preserve in Ipswich, Massachusetts from 1980–87 revealed a Lyme disease attack rate of 35 percent based on a clinical case definition.[13] Seventy-three percent of those with clinical disease and 23 percent of all residents tested were found to be seropositive for *Borrelia burgdorferi*-specific antibody. A 1982 comparison of outdoor versus indoor workers at Naval Weapons Station Earle revealed a five-fold higher cumulative incidence rate for Lyme disease among outdoor workers.[3] Finally, a recent study by Smith, *et al*, of 414 outdoor workers in southeastern New York State revealed a Lyme disease seroprevalence of 6.5 percent among these employees.[14] This was 5.9 times higher than the seroprevalence of a comparison group of anonymous blood donors from the same region.

It should be noted that participation in the study was voluntary and therefore unequal participation by county is a potential source of bias. Rates of participation on a county-by-county basis were not possible to determine. We did, however, find that the main determinant of participation was whether or not the employee's primary work location was one of the screening sites. These sites included an equal number of randomly distributed northern and southern locations. Job duties were similar in all the counties and the vast majority of all subjects statewide had not previously been tested. Therefore we feel it is unlikely that there was any specific county characteristic which resulted in a differential degree of study participation.

Our statewide seroprevalence of antibody to *B. burgdorferi* (5.7 percent) in a high-risk group of outdoor workers is comparable to the 6.5 percent seroprevalence found by Smith, *et al*, in New York State. When examined on a county-by-county basis, however, there were some unexpected findings. Earlier studies by Bowen and Schulze of Lyme disease distribution in New Jersey (1978–82) had reported a large number of case reports, as well as a high density of *Ixodes dammini*, in Monmouth County and the southern half of the state. Their results revealed a paucity of cases and ticks in the northern half of the state.[3–7] The present study revealed that one of five counties with seroprevalences greater than the statewide mean of 5.7 percent was Monmouth County and the others—Sussex, Hunterdon, Hudson, and Essex—were all counties in the northern half of the state (Figure 1). The Essex finding can be discounted because of a very small denominator (n = 5) but denominators for the other counties were much larger (n = 27 to 129). Similar (unpublished) analyses of distribution based on county of residence revealed seven counties with seroprevalence rates greater than the statewide mean. One was Monmouth, but again five of the remaining six (Sussex, Hudson, Middlesex, Somerset, and Mercer) were in the northern half of the state.

The preponderance of northern counties with elevated seroprevalence was not matched by an increased level of self-reported tick exposure in these counties. In fact, as displayed in Figure 2, the vast majority of counties with tick exposures greater than the statewide mean were southern counties; for "total tick bites in the past year," seven out of eight were southern counties. Similarly for "ticks removed from skin or clothing per week on primary job," eight out of 10 were southern counties.

In three southern counties, where seroprevalence was low but tick exposure was high, the employees performed the preventive measures on a "frequent" basis more often than their colleagues statewide (based on mean results from all 689 employees). In Monmouth County, the traditional hotbed of Lyme disease in New Jersey where only a moderately elevated seroprevalence rate was found, the employees also reported performance of preventive measures at a greater frequency than the statewide mean. Finally in three northern counties with relatively high seroprevalence rates and relatively low tick exposure, the employees were performing preventive measures less frequently than other employees statewide.

These findings suggest that the performance of preventive behaviors may reduce the risk of exposure to *B. burgdorferi*. These results do not establish a causal relationship but do merit further investigation. It may be postulated that there has been a relatively recent spread of infected ticks to the northern counties and, although their numbers are still not great, the northern ticks are feeding on a more susceptible human population.[13] The well-publicized history of Lyme disease in the southern counties may have led to a better educated public in these counties and therefore a greater awareness of ticks and appropriate risk reduction behaviors. It is possible that a certain number of individuals from southern counties where Lyme disease had been better publicized responded with expected behavior rather than

TABLE 2—Percent of Workers Reporting Frequent Preventive Behavior Performance for Selected New Jersey Counties

	Specific Behaviors					
County	Long Sleeves (13.7)*	Tuck Pants (8.2)*	Skin Repellent (22.3)*	Clothing Repellent (19.3)*	Tick Check (74.9)*	Number of Behaviors Greater than Statewide Mean
Atlantic	14.0	15.6	32.5	34.2	86.9	5/5
Ocean	16.8	12.4	29.2	27.7	89.0	5/5
Cape May	13.1	16.6	42.6	41.0	93.4	4/5
Monmouth	17.5	10.4	27.8	27.8	84.9	5/5
Sussex	13.4	4.2	10.9	9.2	53.8	0/5
Hudson	7.6	11.5	22.0	11.5	69.2	1/5
Hunterdon	10.7	2.7	10.7	8.0	78.6	1/5

*Statewide mean percent for frequent performance (usually or always)

actual behavior leading to a potential source of bias. This differential Lyme disease awareness may have also resulted in an overreporting of tick exposure in the southern counties and a relative underreporting in the northern counties. A comprehensive statewide study of tick concentrations would help to resolve this last possibility. However, some limited statewide data (Schulze TL: unpublished data) suggest that tick concentrations are much lower in the northern part of the state and that differential reporting of tick exposure is, in fact, not likely to be the explanation for the observed differences in seroprevalence.

In summary, the findings suggest that Lyme disease, as measured by seroprevalence of antibody to *B. burgdorferi*, appears to be spreading beyond Monmouth County and southern portions of the state where it had been previously identified. This spread into the northern counties may not necessarily be solely from southern New Jersey but could also reflect the spread of disease from bordering Orange and Rockland counties in New York. Unexpectedly high seroprevalences were found in several northern New Jersey counties (Sussex, Hudson, and Hunterdon). These high seroprevalence rates in regions of relatively low tick exposure, coupled with low rates (Atlantic, Ocean, and Cape May) and surprisingly moderate rates (Monmouth) in areas of higher tick exposure may be related to preventive behaviors. These results suggest that simple preventive behaviors may have a significant impact on minimizing the risk of Lyme disease.

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