



Emergence of Lyme Disease in Hunterdon County, New Jersey, 1993: A Case-Control Study of Risk Factors and Evaluation of Reporting Patterns

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Reported cases of Lyme disease in Hunterdon County, New Jersey, increased almost 200% from 75 (67/100,000 population) in 1992 to 216 (193/100,000 population) in 1993. For evaluation of risk factors for Lyme disease and for determination of the cause of this increase, a case-control study was conducted, and the reporting practices of physicians' offices were evaluated. For cases reported in 1993, age and sex distribution, month of disease onset, and proportion of cases with erythema migrans rash were within expected limits. Analysis of age-matched case-control data showed that rural residence; clearing periresidential brush during spring and summer months; and the presence of rock walls, woods, deer, or a bird feeder on residential property were associated with incident Lyme disease. A review of physician reporting patterns suggested that the increase in reported cases in 1993 was due to improved reporting as well as to an increase in the numbers of patients diagnosed with Lyme disease. In addition, substantial underreporting of Lyme disease by physicians' offices was found. *Am J Epidemiol* 1998;147:391-7.

Borrelia burgdorferi; Lyme disease; *Spirochaeta*; zoonoses

Lyme disease, caused by infection with the tick-transmitted spirochete *Borrelia burgdorferi* is an important, emerging, vector-borne infectious disease in the United States (1). In 1990, the Council of State and Territorial Epidemiologists adopted a uniform case definition, and by 1994, reporting was mandatory in all 50 states. More than 71,000 cases of Lyme disease were reported during 1982-1994 in the United States (2). In 1994, New York, Connecticut, Pennsylvania, and New Jersey accounted for 78 percent of the more than 13,000 Lyme disease cases reported in the United States (2).

In New Jersey, Lyme disease was first documented in 1978 (3-5) and was made reportable there in 1981. From 1984 to 1993, New Jersey experienced a nearly fivefold increase in the number of reported cases (unpublished data). The disease was first recognized in the central coastal counties of Monmouth and

Ocean, and the highest reported rates have historically been reported by southern coastal counties (3-5).

Hunterdon County is located in west central New Jersey and is bordered by the Delaware River and Pennsylvania to the west; it occupies 275,400 acres and has a population of approximately 112,000. It has several urban centers, and parts of the county remain rural, with wooded hills and agricultural valleys. In 1993, 216 cases (193/100,000 population) of Lyme disease were reported among residents of Hunterdon County by physicians using a system of passive surveillance. This represented an increase of 188 percent over the 75 cases (67/100,000 population) reported in 1992 and of 315 percent over the 52 cases (46/100,000 population) reported in 1991. Therefore, in November 1993, we conducted a study to determine the cause of the increase in reported cases in Hunterdon County, as well as to evaluate risk factors for acquiring Lyme disease. This report describes the results of two studies, one summarizing the descriptive characteristics of patients with acute Lyme disease reported in Hunterdon County in 1993 and the results of a case-control study of risk factors for acquiring Lyme disease, and the second evaluating the Lyme disease-reporting practices of Hunterdon County physicians and possible reasons for the increase in reported cases during 1993.

Received for publication December 11, 1996, and accepted for publication July 14, 1997.

Abbreviations: CI, confidence interval; EIA, enzyme immunoassay; IgG, immunoglobulin G; OR, odds ratio.

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MATERIALS AND METHODS

Information regarding the age and sex of reported cases, the presence or absence of erythema migrans (the characteristic skin lesion of early Lyme disease) (6), and month of onset of disease was abstracted from all Lyme disease case report forms submitted by physicians to the Hunterdon County Department of Health in 1993.

A sample of 62 case report forms was selected from all reported cases of Lyme disease in Hunterdon County residents with documented erythema migrans with onset in the period January through November 1993. The sample was selected systematically by placing patient case report forms in alphabetical order by the last name and selecting every third report. Residence in Hunterdon County since April 1993 was an additional inclusion criteria. Cases were contacted by telephone and asked to schedule an appointment for collection of a blood sample for serologic testing for Lyme disease. Several different locations were made available for blood specimen collection, including the local hospital outpatient laboratory, private physicians' offices, and the county health department.

Controls were recruited prospectively during November 1993 and were age-matched to cases within 5 years of age. To facilitate collection of a blood sample for serologic testing for Lyme disease, we recruited controls from either the physician's office that had reported the matched case or, if that was not possible, from persons presenting to the local hospital outpatient laboratory. Persons who met the age-matching criteria, who had lived in Hunterdon County since April 1993, and who had had blood drawn at the above sites for reasons other than a test for Lyme disease were asked to participate. Persons with a previous or current diagnosis of Lyme disease were excluded from participation.

A questionnaire was administered to cases and controls. Questionnaires for cases were completed by telephone; controls were interviewed in person. Participants were asked about the clinical details of their illness (cases only), the characteristics of their residential property, the frequency of observing deer on their residential property, outdoor activities, practices to avoid ticks, and cat ownership. For questions about outdoor activities and practices to avoid ticks, the reference period was June through August 1993.

Two $\times n$ contingency tables were used to examine categorical variables from the case-control study using Epi Info software (7). Univariate and multivariate conditional logistic regressions were performed using EGRET software (8). Variables with $p \leq 0.10$ in univariate analysis were evaluated for inclusion in the multivariate model. All possible interaction terms

were evaluated for seven variables that gave significant univariate results ($p < 0.05$) and that had strong biologic plausibility as a risk factor for infection with *B. burgdorferi*.

Blood samples were collected and separated, and serum was refrigerated before being shipped to the Centers for Disease Control and Prevention laboratory, Division of Vector-Borne Infectious Diseases, in Fort Collins, Colorado, for testing for antibodies to *B. burgdorferi*. All samples were tested by using a two-step approach consisting of a flagellar, antigen-based enzyme immunoassay (EIA) and Western immunoblot (9), with the modifications that only those serum samples with equivocal or positive results by EIA were tested by Western immunoblot (10) and for immunoglobulin G (IgG) antibodies only. Western immunoblots were interpreted by using published criteria (11).

The name of the reporting physician was collected from Lyme disease case report forms submitted to the Hunterdon County Department of Health in 1992 and 1993. Physicians' offices that had at least a 200 percent increase in reported Lyme disease cases from 1992 to 1993 were contacted. Physicians or office managers were interviewed about reporting procedures and were specifically asked whether their office had changed procedures for reporting Lyme disease between 1992 and 1993.

RESULTS

Of the 216 Lyme disease cases reported in 1993, 122 (56 percent) were in males. The median age of persons with reported cases was 41 years (range, 1–89 years); the age distribution was bimodal, with a peak in children less than age 11 years and a second peak in persons aged 41–60 years (figure 1). A physician-diagnosed erythema migrans rash was noted in 187 (87 percent) cases. Most persons (81 percent) experienced onset of disease during May, June, or July.

Of the 62 cases sampled, 51 (82 percent) participated. Reasons for nonparticipation included refusal (four patients), no longer resident in Hunterdon County (two patients), unable to be contacted (two patients), and a claim not to have had Lyme disease (three patients). The mean and median ages of cases were 44 and 46 years (range, 5–82 years), respectively. All cases were Caucasian, and 24 (47 percent) were female. Fifty-one controls participated in the study. The mean and median ages of controls were 44 and 45 years (range, 1–82 years), respectively; 50 controls were Caucasian, one was African American, and 35 (69 percent) were female.

Five (10 percent) cases recalled a prior tick bite at the rash site. According to case estimates, the median maximal diameter of the rash was 10.0 cm (range,

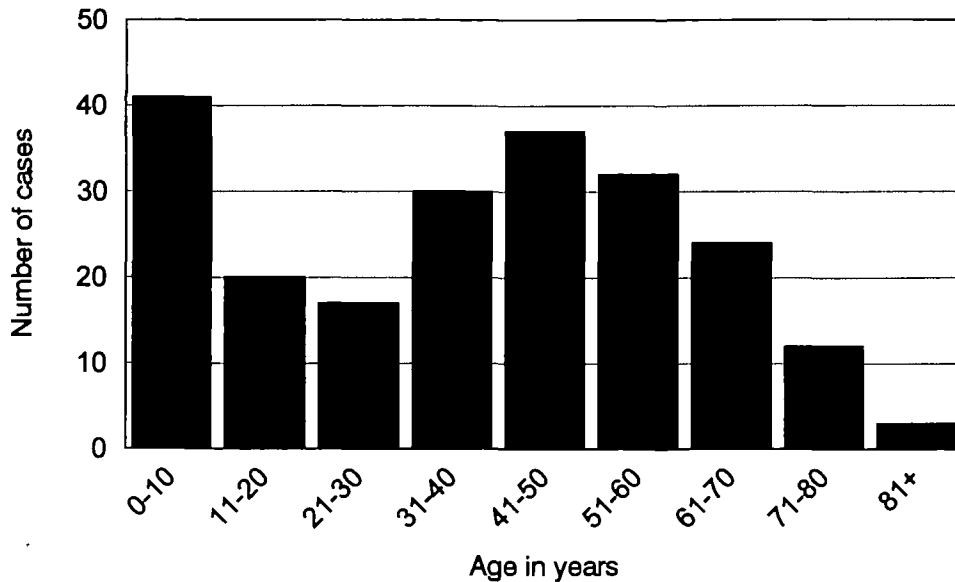


FIGURE 1. Age distribution of reported cases of Lyme disease, Hunterdon County, New Jersey, 1993.

3–30 cm). The most frequently reported rash sites were: leg, 13 (25 percent) cases; axilla, eight (16 percent) cases; abdomen, seven (14 percent) cases; and back, seven (14 percent) cases. The remaining 16 cases reported a rash at some other site. Twenty-six (51 percent) cases reported having at least one of three signs or symptoms accompanying their erythema migrans rash: 19 (37 percent) had a temperature of 99.0°F or more (median, 101.0°, range 99.0–104.6°); 14 (27 percent) had a stiff neck; and five (10 percent) had swollen lymph nodes. Twenty-five (49 percent) cases reported no signs or symptoms other than ery-

thema migrans. The majority of cases reported onset of illness between May and August 1993; no cases had onsets in January through March, November, or December 1993 (figure 2).

Results of a univariate conditional logistic regression analysis of risk factors for acute Lyme disease are shown in table 1. Forty-seven (92 percent) cases and 33 (65 percent) controls reported living in a rural setting as opposed to a suburban or urban setting (odds ratio (OR) = 15.0, 95 percent confidence interval (CI) 2.0–113.6). For the reference period June through August 1993, 29 (57 percent) cases but only 14 (27

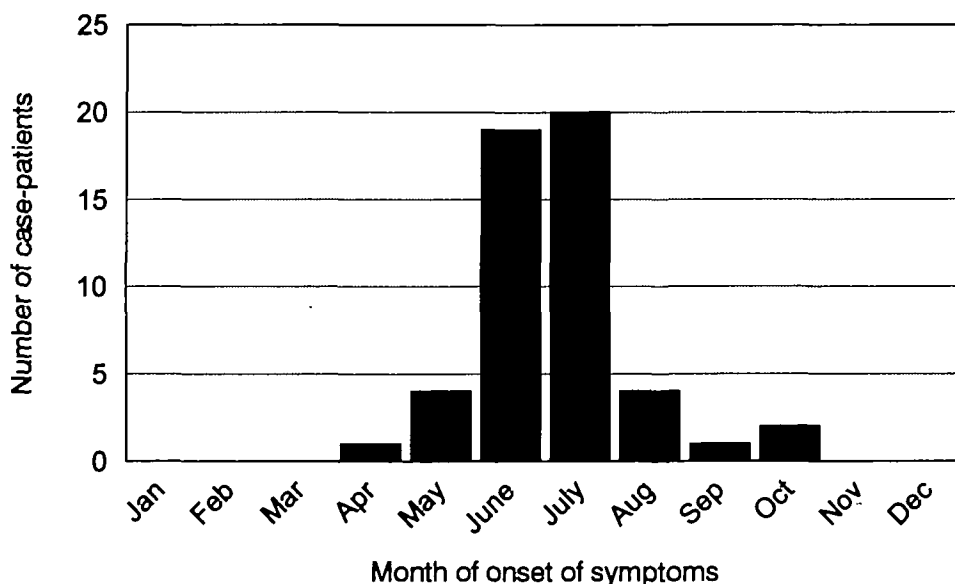


FIGURE 2. Month of onset of acute Lyme disease in 51 cases who participated in the case-control study, Hunterdon County, New Jersey, 1993.

TABLE 1. Univariate conditional logistic regression analyses of risk factors for Lyme disease, Hunterdon County, New Jersey, 1993

	Cases*		Controls*		OR†	95% CI‡
	No.	%	No.	%		
Female	24	47	35	69	0.5	0.2-1.0
Own pet cat	25	49	21	41	1.4	0.6-3.4
Clear brush	29	57	14	27	4.0	1.5-10.7
Rural residence	47	92	33	65	15.0	2.0-113.6
Residential property characteristics						
Garden	34	67	33	65	1.1	0.5-2.4
Woodpile	37	73	32	63	2.0	0.7-5.9
Bird feeder	27	53	18	35	2.1	0.9-4.9
Rock wall	29‡	58	16	31	2.6	1.2-5.9
Woods	35	69	24	47	3.2	1.2-8.7
Deer damage landscape	30	59	21	41	2.1	0.9-4.9
Deer on property	36	71	15	29	2.5	1.1-5.7
Personal protective measures						
Use insect repellent	8	16	8	16	1.0	0.4-2.9
Wear long pants	24	47	22	43	1.2	0.5-2.6
Wear light-colored clothing	26‡	52	36	71	0.4	0.2-1.1
Tuck pants into socks	2	4	8	16	0.3	0.1-1.2
Perform tick check	28	55	37	73	0.5	0.2-1.1

* $n = 51$, except where noted.

† OR, odds ratio; CI, confidence interval.

‡ $n = 50$.

percent) controls reported clearing brush on their residential property (OR = 4.0, 95 percent CI 1.5-10.7). Univariate conditional analysis indicated that cases were more likely than controls to have woods and rock walls and to observe deer on their residential property (table 1). There was no significant difference between cases and controls with respect to cat ownership; the presence of a garden, woodpile, or bird feeder on residential property; or report of frequent damage to residential landscape by deer. No significant difference was found between cases and controls with respect to the following outdoor activities: gardening, mowing the lawn, picnicking, walking or jogging in grassy areas, walking or jogging in wooded areas, and playing on mowed fields (data not shown). Fewer than 5 percent of the cases and controls camped, fished, or hunted.

Very few study participants reported regularly performing practices to avoid ticks, such as applying insect repellent or tucking their pants into their socks (table 1). Fewer cases than controls reported regularly performing a tick check on themselves after being outdoors (OR = 0.5, 95 percent CI 0.2-1.1), although a higher proportion of cases than controls reported a history of finding a tick on themselves in the previous 12 months (OR = 3.5, 95 percent CI 0.8-16.0) (data not shown).

All possible interactions between seven variables were examined: sex; presence of woods, rock walls, or

deer on residential property; rural residence; clearing brush on residential property; and history of tick attachment. No interaction terms were statistically significant. Three variables were significant in a multivariate conditional logistic regression analysis: rural residence (adjusted OR = 14.0, 95 percent CI 1.7-116.4), performing brush-clearing activities (adjusted OR = 4.0, 95 percent CI 1.4-14.4), and the presence of a bird feeder on residential property (adjusted OR = 3.2, 95 percent CI 1.0-10.2).

A blood sample was obtained from 37 of 51 (73 percent) cases and 44 of 51 (86 percent) controls ($p = 0.14$). Eight (22 percent) cases were negative for antibodies to *B. burgdorferi*, nine (24 percent) had equivocal results, and 20 (54 percent) had positive results by EIA. Of the 44 blood samples from controls, 31 (70 percent) were negative for antibodies to *B. burgdorferi*, eight (18 percent) gave equivocal results, and five (11 percent) had positive results by EIA ($p < 0.01$, chi-square). Of the 29 positive or equivocal samples from cases, nine (31 percent) showed positive results by Western immunoblot; of the 13 positive or equivocal samples from controls, one (8 percent) was positive by Western immunoblot ($p = 0.13$, Fisher's exact test). Overall, nine (24 percent) of 37 cases and one (2 percent) of 44 controls were positive for IgG antibodies to *B. burgdorferi* ($p < 0.01$, Fisher's exact test).

In 1993, 39 physicians' offices in Hunterdon County reported at least one case of Lyme disease. Of these 39 offices, eight key offices (seven multiphysician offices and one solo practitioner) were identified as having reported at least 200 percent more cases in 1993 relative to 1992. These eight offices reported 145 (67 percent) of 216 cases; most of the remaining 31 offices reported only one or two cases each. By comparison, in 1992, 29 physicians' offices reported at least one case, with the same eight key practices reporting only 25 (33 percent) of 75 cases ($p \leq 0.01$, chi-square); similar to 1993, the remaining offices reported only one or two cases each. Of these eight key practices, two had changed reporting procedures in 1993 and collectively had reported only one case in 1992 and 48 cases in 1993. Four key practices noted no changes in reporting practices; these four practices had collectively reported 16 cases in 1992 and 67 in 1993. The remaining two key practices acknowledged an increased awareness of reporting requirements, but also believed that they were seeing more patients with Lyme disease; these practices collectively reported eight cases in 1992 and 30 in 1993.

One key multiphysician office completed a record review of all patients diagnosed with Lyme disease in 1992 and 1993. In 1992, three (10 percent) of 31 diagnosed cases were reported to health authorities. In 1993, 15 (36 percent) of 42 diagnosed cases were reported ($p = 0.02$, chi-square). Practice growth from 1992 to 1993 was estimated at 11 percent.

DISCUSSION

Reported cases of Lyme disease in Hunterdon County in 1993 met the expected clinical and epidemiologic profile. Most patients had an erythema migrans rash (87 percent), and most had onset of disease during May through August. This seasonality is typical for acute Lyme disease (12–15) and is explained by a corresponding peak in seasonal nymphal *Ixodes scapularis* activity (16). Previous studies have shown that 21–70 percent of patients with erythema migrans recall a tick bite at the rash site (12–14). In our study, only 10 percent of cases recognized a tick bite prior to developing an erythema migrans rash. This may be due in part to diminished recall, since most cases were interviewed 3–6 months after their illness.

I. scapularis is the vector of *B. burgdorferi* in the northeastern and north central United States (16). During November 1993, 26 *I. scapularis* ticks were collected from six locations in Hunterdon County (T. Schulze, New Jersey Department of Health, personal communication, 1993). Of these, 11 (42 percent) were positive for *B. burgdorferi* when tested by polyclonal fluorescent antibody (J. Piesman, Centers for Disease

Control and Prevention, personal communication, 1994). These results are similar to the proportion of infected *I. scapularis* collected from Lyme disease-endemic regions of the northeastern and north central United States (17, 18).

The multivariate results of the current case-control study showed that cases were more likely than controls to live in a rural setting, participate in brush-clearing activities during summer months, and have a bird feeder on their residential property. Cases were also more likely than controls to have woods and rock walls and to observe deer on their residential property. Only a small proportion of both cases and controls reported participating in outdoor recreational activities (camping, hunting, or fishing). These findings strongly suggest periresidential transmission of *B. burgdorferi* in Hunterdon County.

Studies conducted in New York (17, 19) and Rhode Island (18, 20) have suggested that persons frequently encounter *B. burgdorferi*-infected *I. scapularis* in a periresidential setting, although outdoor workers in Lyme disease-endemic areas have also been shown to be at increased risk (3, 21, 22). Residential proximity to a nature preserve and the presence of deer have been shown to be risk factors for *B. burgdorferi* infection (15). Previous studies of residential properties in Lyme disease-endemic areas have found that the greatest *I. scapularis* densities occur in wooded and ecotonal (unmaintained edge between lawn and woods) habitats, although a small proportion of these ticks are found in lawn and ornamental areas (17, 18). Persons who reside on properties with woods or who enter woods or ecotone to perform brush-clearing or other landscaping activities would therefore potentially be at high risk of encountering *I. scapularis* ticks. Woodpiles and rocks walls provide periresidential harborage for rodents, in particular the white-footed mouse, *Peromyscus leucopus*, the preferred host of *I. scapularis* nymphs in the Northeast (16). Bird feeders may play a role in increasing the risk of periresidential exposure to *I. scapularis* ticks. Several bird species common to residential settings in the northeastern United States have been found to be heavily parasitized with immature *I. scapularis*, suggesting that birds may contribute to nymphal *I. scapularis* populations found on lawns (23), and bird food spilled from feeders can be a source of food for periresidential rodents. However, it is not known if the presence of a bird feeder significantly increases either the number of rodents or *I. scapularis* ticks in periresidential habitats.

Methods to prevent Lyme disease are limited; vaccination is not yet available, and methods for decreasing or eliminating ticks from the periresidential environment (e.g., broad application of acaricides, burning

of underbrush, or clearing of woods) are expensive and often undesirable. Personal protective measures are the recommended first line of defense against tick bites, but the effectiveness of these practices has not been evaluated systematically. In this study, few participants reported regularly practicing either some or all of available methods to protect themselves, such as applying tick repellent or tucking pants into socks, both of which deter tick attachment. Since *I. scapularis* must, experimentally, remain attached for 24–36 hours to transmit an infective dose of *B. burgdorferi* (24, 25), prompt removal of attached ticks is also likely to be an effective means of avoiding infection. In our study, cases and controls reported regularly performing tick checks after being outdoors more frequently than using other personal protective measures. Although the difference was not statistically significant in either univariate or multivariate analyses, a higher proportion of controls than of cases performed regular tick checks on themselves. In contrast, cases reported finding ticks (unidentified tick species) on themselves more frequently than did controls, but this could be explained by recall bias.

Results of our investigation into physician reporting suggested that both improved reporting practices and an increase in the number of patients diagnosed with Lyme disease were responsible for the increase in reported cases in Hunterdon County in 1993. Several large practices reported substantially more cases in 1993 after changing their reporting procedures. Other practices reported more cases in 1993 without any change in reporting procedures. One multiphysician practice documented a 35 percent increase in diagnosed cases from 1992 to 1993; during the same period, the practice grew approximately 11 percent. Additionally, the number of physicians' offices that reported a case of Lyme disease in 1993 increased 34 percent from 1992. Evidence of underreporting of cases was also found; a record review performed by one office revealed that only 10 percent of diagnosed cases were reported in 1992 and 36 percent in 1993. Improved reporting in 1993 was probably attributable to a Lyme disease awareness campaign by the Hunterdon County Department of Health, in which information about Lyme disease, the distribution of infected *I. scapularis* ticks within the county, and the importance of reporting was sent to physician offices both prior to and during the peak 1993 Lyme disease season.

In our study, 24 percent of cases had positive serologic results for antibodies to *B. burgdorferi* using a two-test approach. These results are similar to the findings of Aguero-Rosenfeld et al. (26), in which 22 percent of patients with culture-proven erythema migrans developed IgG antibodies that fulfilled the cri-

teria of Dressler et al. (11). Possible reasons for false-negative serologic results include testing early (within 2 weeks of rash appearance) in the course of the disease, low test sensitivity, and misdiagnosis. In our study, cases were tested 3–6 months after onset of symptoms, excluding early testing as an explanation for the small number of seropositive specimens. Aguero-Rosenfeld et al. (26) found that antibody persistence was related to the duration and stage of disease (localized vs. early disseminated) prior to treatment. In particular, they found immunoglobulin M immunoblot criteria to be more sensitive than IgG in persons with erythema migrans. Since all cases in the study had early Lyme disease and only IgG immunoblot testing was done, it is likely that the low number of positive serologic results is due to the low sensitivity of this test.

Controls were recruited from physicians' offices or the local hospital outpatient laboratory, which may have introduced selection bias into the study. First, the controls may have been more likely than the general population to have a chronic illness or disability that limited their physical abilities or affected their choice of residence. For example, a person with a chronic illness, such as osteoarthritis, may be less likely to perform activities such as brush clearing or to live at a residence with larger acreage. This bias would be expected to accentuate the differences between cases and controls, particularly with respect to hypothesized risk factors involving physical and outdoor activities. Second, even though a previous or current diagnosis of Lyme disease was an exclusion criterion for participation by controls, some may have had undiagnosed previous or current Lyme disease, although we would have expected these individuals to be seropositive. This type of misclassification would be expected to bias point estimates toward the null, i.e., to mask differences between cases and controls.

This study revealed several risk factors for Lyme disease in Hunterdon County: rural residence; the presence of woods, rock walls, and deer on residential property; and participation in peri-residential brush clearing. The increase in reported cases of Lyme disease in Hunterdon County from 1992 to 1993 is probably due to a true increase in incidence, as well as to improved reporting by some area physicians. The importance of surveillance for the purposes of detecting and evaluating emerging infectious diseases has recently been highlighted, and surveillance has played a key role in identifying the three principal Lyme disease-endemic regions in the United States (27–29). The results of this study further document the importance of uniform surveillance in public health and the need for continued vigilance with respect to emerging

infectious diseases. In Hunterdon County, reporting of Lyme disease by physician offices improved in 1993 and has continued to be exemplary, in large part because of the cooperative relationship that exists between the county health department and the medical community and the willingness of the medical community to comply with reporting requirements.

ACKNOWLEDGMENTS

The authors thank Dr. Henry R. Rolka, Epidemiology Program Office, Centers for Disease Control and Prevention, for his assistance with the statistical analysis.

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