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Knowledge, Attitudes, and Behaviors Regarding Lyme Disease Prevention Among Connecticut Residents, 1999–2004

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Abstract

Lyme disease, caused by the tick-transmitted bacterium *Borrelia burgdorferi,* is the most common vector-borne disease in the United States. We surveyed residents of three Connecticut health districts to evaluate the impact of intensive community-wide education programs on knowledge, attitudes, and behaviors to prevent Lyme disease. Overall, 84% of respondents reported that they knew a lot or some about Lyme disease, and 56% felt that they were very or somewhat likely to get Lyme disease in the coming year. During 2002–2004, the percentage of respondents who reported always performing tick checks increased by 7% and the percentage of respondents who reported always using repellents increased by 5%, whereas the percentage of respondents who reported avoiding wooded areas and tucking pants into socks decreased. Overall, 99% of respondents used personal protective behaviors to prevent Lyme disease. In comparison, 65% of respondents reported using environmental tick controls, and increased use of environmental tick controls was observed in only one health district. The majority of respondents were unwilling to spend more than $100 on tick control. These results provide guidance for the development of effective Lyme disease prevention programs by identifying measures most likely to be adopted by residents of Lyme disease endemic communities.

Key Words: Lyme disease—Behavior—Prevention—Control—Ticks.

Introduction

Lyme disease, caused by infection with the bacterium *Borrelia burgdorferi* and transmitted to humans by the bite of infected *Ixodes* spp. ticks, is the most common vector-borne disease in the United States (CDC 2007). Early manifestations of Lyme disease include the characteristic erythema migrans rash, fever, headache, and fatigue. Left untreated, late manifestations involving the nervous system, joints, and heart may occur (Hayes and Mead 2004). Lyme disease is especially common in the northeastern United States, including Connecticut, where the disease was first described (CDC 2007).

Lyme disease can be prevented by using personal protective behaviors and environmental tick controls. Personal protective behaviors include performing tick checks after outdoor activities, tucking pants into socks, and using insect repellents (Schreck et al. 1986, Hayes and Piesman 2003, Stafford III 2004). Environmental tick controls include area-wide application of acaricides (Curran et al. 1993, Stafford III 2004), exclusion of deer (Wilson et al. 1984, 1988, Daniels et al. 1993, Deblinger et al. 1993), treatment of tick hosts (Deblinger and Rimmer 1991, Carroll et al. 2002, Dolan et al. 2004), and landscaping to reduce tick habitats (Schulze et al. 1995, Stafford III 2004). These prevention strategies are often inconsistently practiced by residents of Lyme disease endemic areas (Herrington et al. 1997, Orloski et al. 1998, Phillips et al. 2001).

From 1999 through 2002, three Connecticut health districts initiated intensive community-based intervention programs to increase awareness about Lyme disease and encourage use of prevention measures. These health districts—Westport Weston (WWHD), Torrington Area (TAHD), and Ledge Light (LLHD)—had a combined incidence of 328 cases/100,000 population in 2002, among the highest in the nation. We report results of surveys conducted before and during these interventions to assess their overall impact on knowledge, attitudes, and behavior related to Lyme disease pre-

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vention. We hypothesized that the use of protective behaviors by residents of these communities would increase over the course of the study period and following these interventions.

Materials and Methods

Study locations

The three study districts were selected to represent diverse circumstances. WWHD serves two towns in southwestern CT (Fig. 1) and has a population of 35,786 (1807 persons/mi^2). LLHD encompasses two towns in southeastern CT and has a population of 54,594 (786 persons/mi^2). TAHD serves 16 towns in rural northwestern CT and has a population of 120,947 (216 persons/mi^2) (U.S. Census Bureau 2000). Residents of WWHD have a higher median income (WWHD \$133,285, LLHD \$56,047, TAHD \$56,468) and higher level of education than residents of the other two health districts (U.S. Census Bureau 2000). In 2002, LLHD reported a Lyme disease incidence of 240 cases/100,000 persons, TAHD had an incidence of 356 and WWHD had an incidence of 411. Deer densities are estimated to be 25.3/mi^2 in WWHD, 14–21/mi^2 in LLHD, and 9–30/mi^2 in TAHD (Gregonis 2003).

Interventions and questionnaire

Intervention programs were developed by individual health districts based on perceived needs, the demographic features of their population, and with the input of community-based advisory committees. All districts conducted intensive education campaigns promoting the use of personal and environmental prevention strategies. These campaigns used a multitude of diverse educational methods, including billboards, flyers, newspaper articles, presentations at schools and community events, demonstration projects, and Internet postings. In one district, a health educator leased a lime-green Volkswagen Beetle, affixed giant artificial ticks to the outside, and drove it to presentations at fairs, schools, and other outdoor events. Overall, these programs stressed use of insect repellent and protective clothing, performance of tick checks, avoidance of tick habitat, and control of ticks through landscaping practices and use of area and rodent-targeted acaricides. Target audiences included the general public, school children, gardeners and outdoors enthusiasts, landscapers, and pest control companies.

The WWHD intervention program was initiated in 1999, the TAHD and LLHD programs in 2002. A baseline survey was conducted just before implementation in each district, and follow-up surveys to assess changes were administered in WWHD in 2002 and 2004 and in LLHD and TAHD in 2004. The survey instrument was developed by the Connecticut Department of Public Health, the Centers for Disease Control and Prevention, and the participating health districts based on previous surveys in Connecticut (Cartter et al. 1989, CDC 1992, Herrington et al. 1997). The survey was administered by telephone by the Center for Survey Research and Analysis at the University of Connecticut.

The survey included approximately 20 questions about demographics, diagnosis of Lyme disease in the past year, knowledge about and perceived risk of getting Lyme disease, and use of and approval for personal protective behaviors and environmental tick controls. Respondents were asked to categorize their level of knowledge about Lyme disease (a lot, some, a little, nothing), how much of a problem they felt Lyme disease was in their town (very serious, somewhat serious, not much of, not a problem at all), and their likelihood of getting Lyme disease in the coming year (very, somewhat, not very, not at all likely). The questionnaire asked whether respondents "always," "sometimes," or "never" used personal protective measures (i.e., performing tick checks, avoiding wooded areas, wearing long pants, tucking pants into socks, using insect repellents). Respondents were asked whether they ever used specified envi-

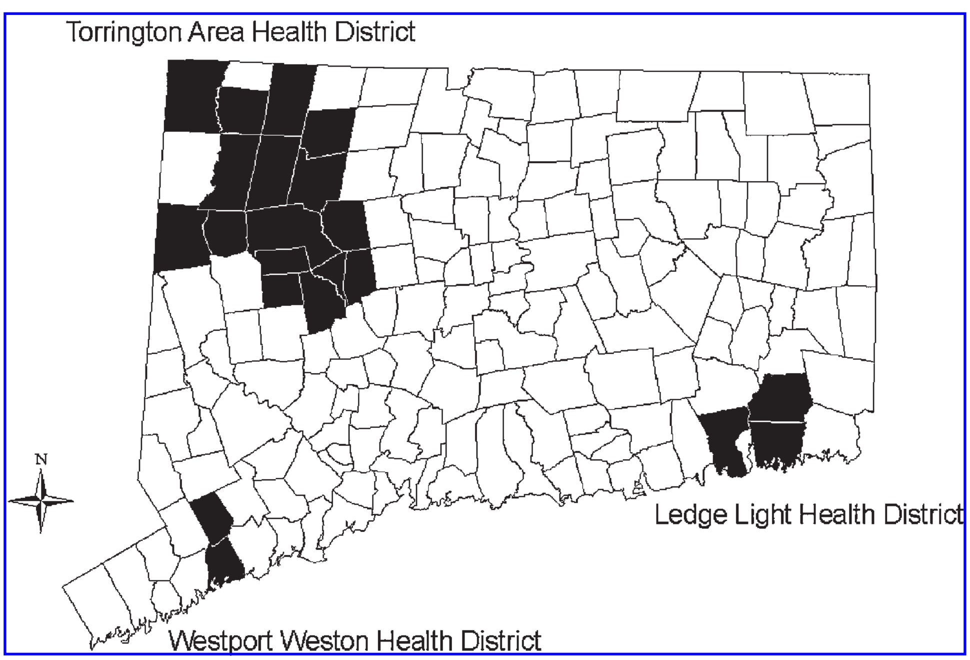

FIG. 1. Map of Connecticut with participating health districts indicated.

ronmental tick controls (i.e., pesticides, removal of brush or leaf litter, placement of wood chip or gravel barriers near wooded areas, fences to exclude deer). Respondents were also asked whether they approved of their community taking measures to prevent Lyme disease by reducing the deer population, providing information on Lyme disease, using pesticides to control ticks on deer, and using area-wide pesticides on public property to kill ticks.

Study design

A random cross-section of approximately 400 households in each health district was selected during each year of the study. The sample frame consisted of telephone exchanges covering the towns of interest, including all exchanges in which at least 95% of all numbers were part of the target geography. The final sample was selected using simple random sampling without replacement. Eligible phone numbers were selected with GENESYS sampling software (Genesys, Daly City, CA) using a single-stage equal probability selection method so that all residential telephone numbers in the sample frame had an equal chance of inclusion. Selected telephone numbers were contacted at least four times to reach an eligible respondent. A respondent was considered eligible if he or she was 18 years of age or older and the household healthcare decision maker. Persons who participated in one cycle of the survey were not excluded from future participation.

Statistical analysis

Statistical analyses were performed using SAS 9.1 (SAS Institute, Inc., Cary, NC). Samples were weighted by the town of residence and the number of residential telephone lines in each household. Chi-square tests were used to compare categorical variables, the Cochran-Armitage test for trend was used to measure changes over time in categorical variables, and the Wilcoxon rank-sum test was used to compare continuous variables. A value of $p < 0.05$ on two-tailed testing was considered statistically significant.

Results

Sample description

A total of 2806 interviews were completed (Table 1). Overall, the median age of respondents was 49 years (range, 18–95 years); 1755 (63%) respondents were female. Within each health district, there was no difference in the sex or age distribution of respondents between years. The median property size was 1 acre for respondents in each health district, but ranged from 0–398 acres in WWHD, 0–300 acres in LLHD, and 0–500 acres in TAHD. The proportion of respondents reporting that they had received a diagnosis of Lyme disease in the past year did not change over time in any of the three health districts (Table 1). In WWHD, the proportion of respondents who reported finding a tick attached to themselves in the past year decreased from 2002 to 2004 ($p < 0.01$); no difference was noted for respondents in LLHD and TAHD.

Knowledge and perceived risk of Lyme disease

The percentage of WWHD respondents who reported that they knew "a lot" or "some" about Lyme disease increased significantly from 84% to 89% ($p = 0.05$) from 1999 to 2004 (Fig. 2), while the percentage of WWHD respondents who considered Lyme disease a "very" or "somewhat" serious problem or felt that they were "very" or "somewhat" likely to get Lyme disease in the coming year did not change significantly. In LLHD, respondents in 2004 were less likely than respondents in 2002 to report that they knew "a lot" or "some" about Lyme disease ($p = 0.004$), and fewer respondents reported that they were "very" or "somewhat" likely to get Lyme disease in the coming year ($p = 0.003$). The percentage of TAHD respondents who reported knowing "a lot" or "some" about Lyme disease increased from 2002 to 2004 ($p = 0.004$), and more respondents felt that they were "very" or "somewhat" likely to get Lyme disease in the coming year ($p = 0.0002$).

Use of personal protective behaviors

Because of differences in how some questions in the 1999 survey were worded, analysis of personal protective behaviors was restricted to the 2002 and 2004 surveys. In WWHD, there was a significant increase in the proportion of respondents reporting "always" performing tick checks ($p = 0.01$); significant changes were not noted in the use of any other personal protective behaviors (Fig. 3). In LLHD, the proportion of respondents who reported "always" avoiding wooded areas and "always" tucking pants into socks decreased significantly ($p = 0.0002$ and $p = 0.0006$, respectively). In TAHD, the proportion of respondents who reported "always" performing tick checks and "always" using repellents increased significantly ($p = 0.02$ and $p < 0.001$, respectively), while the proportion of respondents who reported "always" avoiding wooded areas decreased significantly ($p = 0.003$). Most respondents reported using personal protective behaviors at least sometimes; overall, only 1% reported "never" using any of these personal protective behaviors.

Use of environmental tick controls

Whereas only 1% of respondents reported never using personal protective behaviors, 35% reported never using any environmental tick controls. In WWHD, self-reported use of all environmental tick controls increased significantly from 1999 to 2002, and while no additional increases were seen in self-reported use of these measures between 2002 and 2004, these increases from 1999 were sustained (Table 2). Use of environmental tick controls did not change in LLHD and TAHD ($p > 0.05$ for all control methods; Table 2).

In 2002 and 2004, respondents were asked whether they would be willing in the future to use environmental tick controls on their property. Willingness to use these methods did not differ by year or health district (data not shown). Most respondents were willing to remove brush or leaf litter (91%) and to place wood chip or gravel barriers (82%). Fewer were willing to use fences to exclude deer (52%) or to spray a chemical pesticide (47%). The most common reason cited for not being willing to use pesticides was safety concerns (61%), and the most common reason cited for not fencing property was cost (15%).

Overall, 19% of respondents said they would not spend any money on tick control, 44% were willing to spend up to $100, and 37% were willing to spend more than $100. In 2002, 58% of WWHD respondents, 30% of LLHD respondents, and

Table 1. Demographic Characteristics of Respondents by Health District and Year, Connecticut, 1999–2004

	Westport Weston			*Ledge Light*		*Torrington Area*	
Characteristic	*1999*	*2002*	*2004*	*2002*	*2004*	*2002*	*2004*
Number of interviews completed	402	400	401	400	400	400	403
Median age in years (range)	48 (19–92)	50 (19–86)	51 (24–89)	45 (19–95)	47 (19–91)	48 (18–84)	49 (20–94)
Female, *n* (%)	267 (66)	245 (61)	249 (62)	251 (63)	238 (60)	255 (64)	250 (62)
Median property size in acres (range)	1 (0–398)	1 (0–20)	1 (0–50)	1 (0–139)	1 (0–300)	1 (0–500)	1 (0–500)
Diagnosis of Lyme disease in past year, *n* (%)	20 (5)	28 (7)	19 (5)	12 (3)	16 (4)	14 (4)	13 (3)
Found attached tick in past year, *n* (%)	NA[a]	113 (28)	77 (19)	110 (28)	108 (27)	105 (26)	121 (30)

[a]Question was not asked in WWHD in 1999.

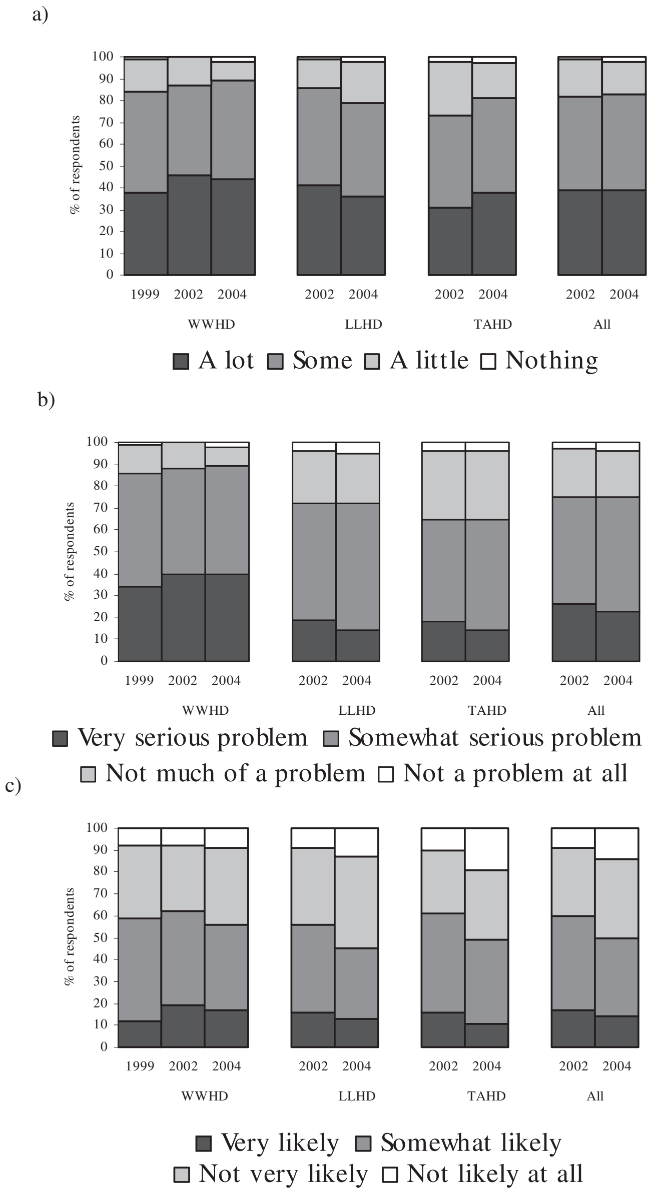

FIG. 2. Levels of knowledge about Lyme disease, perceived severity of Lyme disease problem, and perceived likelihood of getting Lyme disease were assessed with the following questions: (**a**) How much would you say you know about Lyme disease? (**b**) How serious a problem would you say Lyme disease is in your town? (**c**) How likely do you think it is that you or someone in your household will get Lyme disease in the coming year?

22% of TAHD respondents were willing to spend more than \$100 on tick control. In 2004, the percentage of respondents willing to spend at least \$100 increased to 32% ($p = 0.0022$) in TAHD, but did not change in the other two health districts. Twenty-seven percent of respondents willing to spend \$0–\$100 reported using at least two environmental tick controls, compared with 48% of respondents willing to pay more than \$100 ($p < 0.0001$).

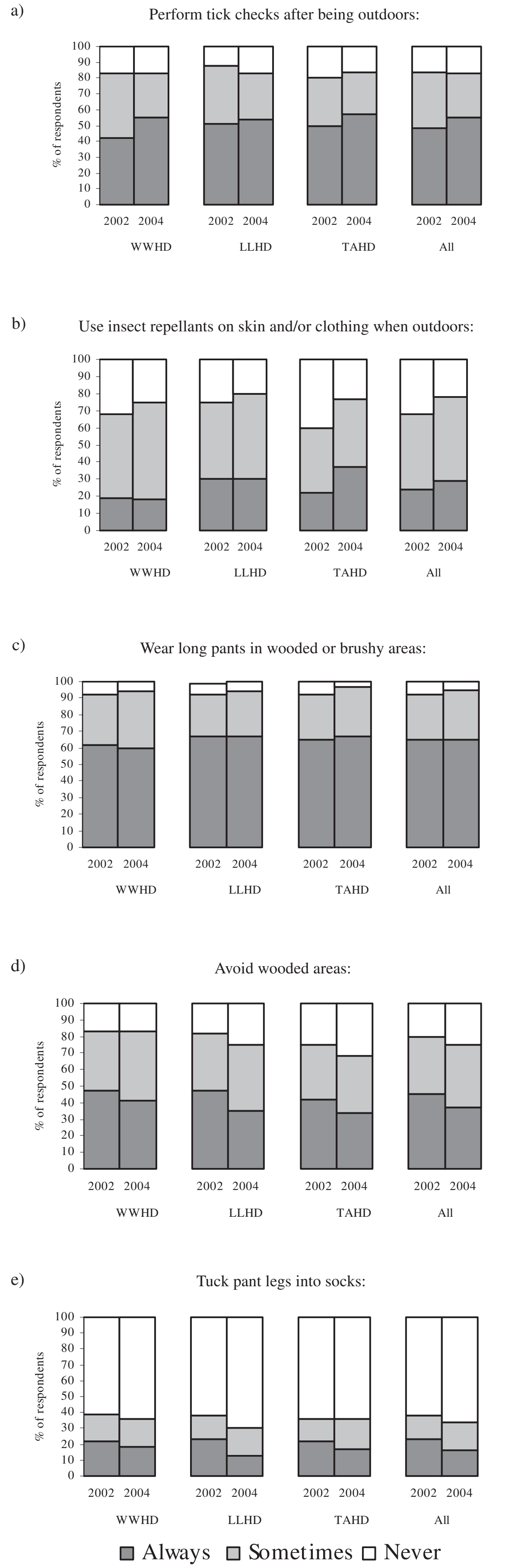

FIG. 3. Frequency of use of personal protective behaviors to prevent Lyme disease.

TABLE 2. USE OF ENVIRONMENTAL TICK CONTROLS BY HEALTH DISTRICT AND YEAR, CONNECTICUT, 1999–2004

	Westport Weston, n (%)			*Ledge Light*, n (%)		*Torrington Area*, n (%)	
Control measure	*1999*	*2002*	*2004*	*2002*	*2004*	*2002*	*2004*
Sprayed a chemical pesticide	82 (23)	151 (38)[a]	173 (44)	105 (27)	94 (24)	85 (21)	95 (24)
Removed brush or leaf litter	129 (35)	213 (54)[a]	208 (52)	194 (50)	187 (47)	161 (41)	177 (44)
Placed wood chip or gravel barriers	34 (10)	110 (28)[a]	107 (29)	69 (18)	74 (19)	58 (15)	69 (17)
Fenced property to keep out deer	53 (14)	121 (30)[a]	101 (25)	74 (19)	62 (16)	47 (12)	48 (12)

[a]$p < 0.001$.
Within each health district, the percentage of respondents who reported using each control measure was compared from the baseline year (1999 in WWHD, 2002 in LLHD and TAHD) to the subsequent years using a χ^2 test.

Respondents in all three health districts approved of community interventions to prevent Lyme disease (Table 3). In 2004, 97% approved of providing information and education, 70% approved of using pesticides on deer, 65% approved of using pesticides in the community, and 63% approved of reducing the deer population. In WWHD, there was a significant increase in the proportion of respondents who supported reducing the deer population, and in LLHD there was a significant increase in the proportion or respondents who approved of pesticide use (Table 3).

Discussion

In this multiyear survey of residents in an area highly endemic for Lyme disease, nearly 5% of respondents reported a diagnosis of Lyme disease and 28% reported finding a tick attached to themselves in the past year. Respondents in all three health districts reported being knowledgeable about Lyme disease, felt they had a high likelihood of getting Lyme disease, and believed Lyme disease was a serious problem, consistent with previous studies in Lyme disease endemic areas (Cartter et al. 1989, CDC 1992, Herrington et al. 1997, Shadick et al. 1997, Mawby and Lovett 1998, Orloski et al. 1998, Phillips et al. 2001, Malouin et al. 2003, Herrington 2004). Respondents to this survey thus represent a population which should be highly motivated to take measures to prevent Lyme disease and other tick-borne diseases.

Nearly all respondents used personal protective behaviors to prevent Lyme disease at least some of the time. In each health district, different behaviors changed in use during the course of the study period. In both WWHD and TAHD, there was an increase in the proportion of respondents who reported performing tick checks, and in TAHD there was also an increase in the proportion of respondents who reported using repellents. Both tick checks and repellent use are easy, quick, and inexpensive behaviors to perform. In LLHD, no personal protective behaviors increased in use, while both tucking pants into socks and avoiding wooded areas decreased in use. The reasons for these decreases are unknown, but may reflect decreased personal preference regarding these methods or the relative emphasis placed on these behaviors by each health district's educational program. Although we emphasized "always" use of these personal protective behaviors in this analysis, it should be noted that "sometimes" use of several personal protective behaviors also increased and may confer some degree of protection (Daltroy et al. 2007). Protective behaviors should be performed regularly and consistently for the duration of the Lyme disease transmission season (e.g., summer months) to be most effective (Corapi et al. 2007).

In contrast to personal protective behaviors which must be performed regularly and consistently, environmental tick controls may require only a one-time or once-yearly effort. For example, a single pesticide application at the beginning of the Lyme disease transmission season can reduce tick populations by 68%–100% (Stafford III 2004). Environmental tick controls may also provide some protection to neighboring properties (Hayes et al. 1999). Despite these advantages, fewer respondents reported use of environmental tick con-

TABLE 3. APPROVAL OF INDICATED COMMUNITY INTERVENTIONS TO CONTROL LYME DISEASE BY HEALTH DISTRICT AND YEAR, CONNECTICUT, 1999–2004

	Westport Weston, n (%)		*Ledge Light*, n (%)		*Torrington Area*, n (%)	
	2002	*2004*	*2002*	*2004*	*2002*	*2004*
Reduced deer population	261 (71)	290 (78)[a]	237 (64)	216 (59)	198 (55)	201 (54)
Provide information	394 (99)	386 (98)	393 (98)	393 (99)	379 (96)	377 (95)
Use pesticides on deer	288 (80)	258 (74)[a]	251 (69)	255 (71)	248 (69)	227 (64)
Use pesticides	239 (68)	256 (70)	226 (60)	246 (68)	215 (61)	209 (57)

[a]$p < 0.05$; [b]$p < 0.01$.
Within each health district, the percentage of respondents who reported approving of each community intervention was compared between 2002 and 2004.

trol measures compared with personal protective behaviors, and increased use was observed in only one health district. This difference may be because environmental tick controls tend to be more expensive and initially require more time and effort to implement. In addition, concerns about safety may limit use of methods involving pesticide applications. Brush removal, which is inexpensive and technically simple, was used more than any of the other methods we surveyed, suggesting that affordable and accessible control options are most likely to be widely used.

Changes in the use of environmental tick controls were seen only in WWHD, and respondents in WWHD were more knowledgeable about Lyme disease and were willing to spend more money on tick control. Anecdotally, WWHD put more emphasis on programs promoting the use of environmental tick controls. WWHD also began interventions 3 years earlier than LLHD and TAHD, and it is possible that a longer response period is needed to evaluate efficacy; however, the largest gains in usage were actually observed between the first and second surveys, after which usage remained constant through the last year of follow-up. Our study suggests that other factors, including socioeconomic status, may help explain these findings. Residents of WWHD have a higher median annual income (WWHD $133,285 vs. LLHD $56,047, TAHD $56,468) and a higher level of education than residents of the other two health districts (U.S. Census Bureau 2000). Use of environmental tick controls thus may be constrained in part by the ability to afford and implement these measures.

This study was subject to several limitations. Past diagnoses of Lyme disease and use of personal protective behaviors were self-reported and not validated independently. Persons who had had Lyme disease or a family member with Lyme disease may have been more willing to participate in this study, potentially creating selection bias of persons more likely to use prevention behaviors (McKenna et al. 2004). Because this study was limited to persons over 18 years of age, we could not evaluate use of protective behaviors by children, one of the highest incidence and at-risk age groups (CDC 2007), and could not evaluate whether the interventions influenced the behaviors of this age group. Connecticut residents have been previously exposed to extensive public outreach and education focused on Lyme disease and other vector-borne diseases, and their knowledge, attitudes, and behaviors may not reflect those of residents of other states (CDC 2003). Additionally, preexisting knowledge about Lyme disease may have limited the impact of the programs implemented during this study. The changes observed in this study may thus underestimate the efficacy of programs conducted in an area without a history of past education regarding Lyme disease prevention. Because of the design of the study, the influence of the interventions on individual respondents could not be measured directly. Similarly, because all three districts used multiple interventions simultaneously, it is not possible to dissect the impact of individual interventions. Rather, this study was designed to assess the overall ability of an intensive, diverse, community-based program to affect changes in knowledge, attitudes, and behaviors related to Lyme disease prevention.

Although this and other studies (Herrington et al. 1997, Malouin et al. 2003) have found a significant correlation between knowledge about Lyme disease and use of protective behaviors, we found that certain behaviors are less consistently practiced than others. Despite extensive education and awareness, behaviors such as tucking pants into socks remain unacceptable to the majority of residents of these health districts and may not be modifiable. When asked by interviewers their reasons for not using personal protective behaviors more often, respondents who did not use personal protective behaviors most commonly cited forgetting to use these measures, not feeling at risk for Lyme disease, or said that performing the method was too troublesome. To be most effective, educational programs and interventions should address the reasons that people do not perform certain behaviors. A recent intervention found that messages which remove practical barriers to a desired behavior can influence the use of protective behaviors to prevent Lyme disease (Daltroy et al. 2007). For example, drawing parallels between daily activities such as taking a shower and performing a tick check, will help to incorporate tick avoidance behaviors into routine behaviors which are easy to remember and require little additional time or effort (Daltroy et al. 2007).

Sustainable Lyme disease and tick-borne disease prevention and control programs should focus on promoting measures most likely to be adopted by residents of endemic areas. Future interventions should promote personal protective behaviors which were most consistently accepted and practiced, and those which showed the largest gains in use. For example, tick checks were widely practiced and their use increased significantly, making them a good candidate behavior to emphasize in future interventions. Although we found changes in the use of environmental tick controls in only one health district, these findings suggest that intensive campaigns can indeed increase usage. Intensive educational campaigns about environmental tick controls that are appropriately targeted to the socioeconomic status and demographics of a particular community may represent the greatest opportunity for future prevention programs. Although this study did not find large changes in the use of many behaviors, educational programs and interventions are well received, reinforce prevention messages, and might have increased prevention effectiveness in areas of Lyme disease emergence.

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