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A School-Based Intervention to Increase Lyme Disease Preventive Measures Among Elementary School-Aged Children

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Abstract

Purpose: Educational interventions to reduce Lyme disease (LD) among at-risk school children have had little study. The purpose of this study was to evaluate whether a short in-class LD education program based on social learning theory and the Health Belief Model (HBM) impacted a child's knowledge, attitude, and preventive behavior.
Methods: Students in grades 2–5 in 19 elementary schools were selected in an area that was highly endemic for LD. The children received an educational intervention or were on a wait list as controls. Their knowledge, attitudes, and self-reported preventive behaviors were surveyed before implementing the program and 1 year later. General linear regression analyses adjusting for age, gender, and baseline variables were used to measure the impact of the intervention.
Results: There were 3570 participants in the study: 1562 received the intervention, and 2008 were controls. The mean age for both groups was 9.1 years, with 53% women in the intervention group and 50% women in the control group. The children in the intervention group increased their overall knowledge of LD more than the children in the control group (overall knowledge score improvement, mean difference (SD) 1.38 (1.3) vs. 0.36 (1.3) $p < 0.0001$). All children in classes receiving the intervention reported an increase in precautionary behavior, positive attitude toward taking precautions, and self-efficacy compared with the wait list controls. Two LD cases were confirmed during the follow-up period, one in the intervention group and one in the controls.
Conclusions: These findings demonstrate that a short in-class educational program that includes elements of the HBM, including: (1) awareness and knowledge about the disease, (2) benefits of preventive behavior, and (3) confidence in ability to perform preventive behaviors can improve knowledge, attitude, and self-reported precautionary behavior among at-risk children. www.clinicaltrials.gov: NCT00594997

Key Words: Ixodes—Lyme disease.

Introduction

Lyme disease (LD), the most common vector-borne illness in the United States, continues to grow as a public health problem (Poland 2001, Bacon et al. 2008). Since the United States Centers for Disease Control and Prevention (CDC) began tracking LD in 1981, the number of reported cases in the United States has increased to nearly 35,000 per year (Bacon et al. 2008). Massachusetts, with 3830 confirmed cases in 2014, ranks second in the number of reported cases by state in the United States. Although these incidence numbers are large, it has been estimated that the actual number of cases occurring may be more than 10 times the reported cases (Hinckley et al. 2014).

Although LD affects all age groups, children from 5 to 9 years of age have one of the highest incidence rates (Orloski et al. 2000, Poland 2001, Bacon et al. 2008). Tick bite prevention remains a challenge in this age group, but it is an

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important public health goal. Falco found that children less than 10 years old have a high risk of LD, because they receive more bites from the nymphal ticks that are harder to find on the body, and less likely to have ticks removed in time to prevent transmission (Falco et al. 1996). Furthermore, one study in the Netherlands demonstrated that among school children, moral norms, emotional attitude, anticipated regret, role models, and self-efficacy were positively associated with tick inspection behavior (de Vries and van Dillen 2002), indicating that simply educating children about the signs and symptoms of LD may not enhance tick bite prevention behavior.

We performed a school-based intervention based on elements of social learning theory and the Health Belief Model (HBM) in schools in a coastal area of Essex County on the North Shore of Massachusetts. Essex County, with a population of 743,167, is highly endemic for LD. The purpose of the study was to evaluate whether this short, in-class education program can increase the practice of precautionary behavior by enhancing the sense of risk, using modeling techniques and improving self-efficacy in elementary school-aged children.

Materials and Methods

School recruitment and study design

A randomized, controlled, pretest post-test design study was performed in nine school districts in Essex County, on the North Shore of Massachusetts (Fig. 1). The unit of randomization was the school district, and consent was obtained from the 19 elementary school principals and the parents of children in each school. Schools were selected based on community location (coastal region of Massachusetts) and a high rate of LD. Recruitment totaled ~2000 students per group. The sampling procedure included inviting nine school districts to participate, and then randomly assigning one school district to the intervention or control.

Schools were initially contacted by phone through the superintendents and followed up with presentations to elementary school principals, teachers, school nurses, and/or school boards. All schools ($n = 19$) agreed to participate. Before our research, the parents of each child received a letter in the mail briefly describing the study. All consent and other materials were reviewed and approved by the Institutional Review Board at the Brigham and Women's Hospital.

Description of theory-based intervention

The HBM (Becker et al. 1974, Rosenstock 1974, Rosenstock et al. 1988), an explanatory model often cited as a descriptor of health behavior, formed the theoretical basis for the intervention (Rimer et al. 2001, Bandura 2004). The HBM predicts how likely an individual is to practice certain health behaviors using four components of perception: perceived susceptibility, perceived severity, perceived barriers, and perceived benefits, accounting for self-efficacy and socio-demographic variables. The questionnaires assessing students evaluated their beliefs across these four dimensions, as well as their perceived self-efficacy, both before and after the intervention.

The intervention intended to teach children that they are susceptible to LD, that the disease can be serious, that ticks can carry the pathogen, that they have the ability to perform preventive tick-checking behaviors, that the behaviors designed to prevent LD do not need to be time-consuming or difficult, and that performing the preventive behaviors will decrease the likelihood of getting sick (Becker et al. 1974, Rosenstock 1974, Rosenstock et al. 1988). The elements of the HBM and how it was presented to the children are outlined in Figure 2.

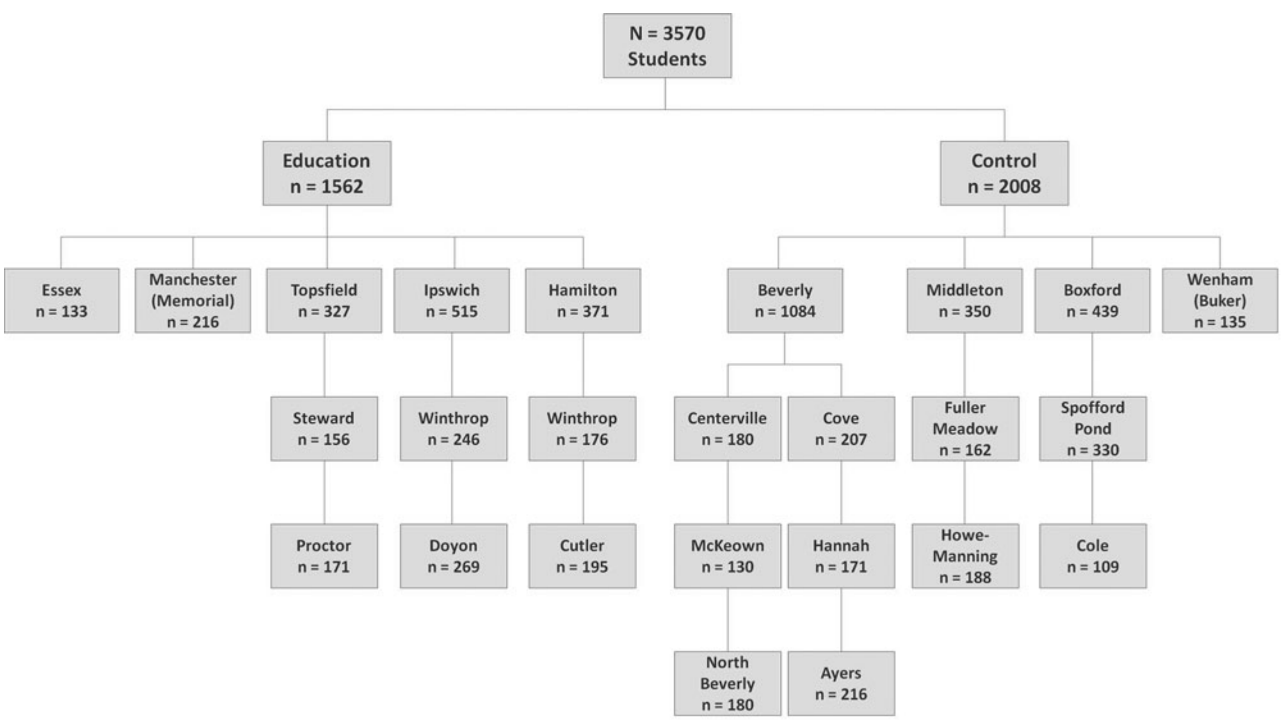

FIG. 1. Participants in elementary schools enrolled in the Lyme disease (LD) education program.

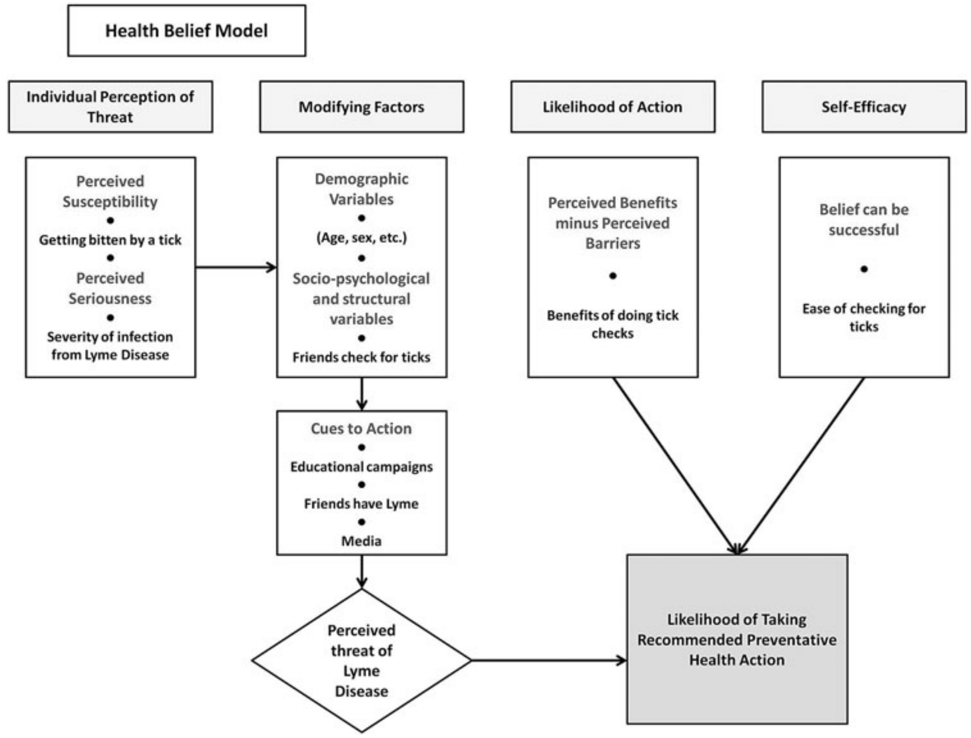

FIG. 2. Health Belief Model elements within the LD education program.

Additionally, the intervention used learner-centered teaching strategies that have been shown to improve the learning process for children and to build better personal competence. In learner-centered teaching, ''teachers do less telling; students do more discovering'' (Cheang 2009, Weimer 2013). Instructors model behavior and then encourage children to learn through discovery, feedback, and interaction with each other.

The curriculum devised, using the ''Feel, Find, Free'' slogan, consisted of a PowerPoint presentation teaching about the tick lifecycle, how ticks and humans interact, where ticks are found in nature, what steps to take to prevent tick bites, and a series of follow-up activities that encourage interaction between students and teachers to reinforce the knowledge gained. Students in grade two watched and discussed a video, compared ticks with other bugs, and searched for hidden ticks in a coloring book. Students in grades three through five played word-finding games with LD and tick lifecycle terms and discussed effective preventive measures in groups. A life-sized mannequin arm with deceased deer ticks from different stages in the life cycle was passed around so that children could see and feel ticks. Children received a supplemental packet to take home to their parents with an informational brochure, a tick check shower card, a tick dock card (card for documenting removal of an attached tick and for preserving the tick), and a tick feel card. Throughout the presentation and activities, students were repeatedly asked questions to reinforce what they were taught. For more details, please see the website www.BWHPreventLyme.org.

Several weeks after the presentation, students viewed a 45 min vaudeville-type performance, modified from a previous LD prevention program given by professional health educators to reinforce educational messages about LD prevention (Daltroy et al. 2007). The performers, ''Dr. Bull's Eye'' and his assistant ''Rusty Tweezers,'' employed song, juggling, and dance to engage children in a fun way about LD prevention.

Procedures

Questionnaires asking about prior knowledge of LD, attitudes toward prevention, and self-reported preventive behaviors were distributed to the intervention and control groups before implementing the program. During the late fall/winter (October or November) of each year from 2004 to 2006, researchers from Brigham and Women's Hospital distributed the baseline survey to children in the classroom in grades 2–5.

The classroom intervention was delivered in the early spring (March or April) by research personnel while the teachers were in the classroom and in the late fall administered the same survey as a post-test. The control students received the educational presentation after the follow-up survey was completed.

Analysis plan

Three outcome measures, knowledge of LD transmission, self-reported tick bite precautionary behaviors, and attitudes toward taking precautions, were measured (Tables 2, 3, and 5). A LD knowledge score was created from totaling the number of correct answers on the six knowledge questions (Table 4). Precautionary behavior outcomes were graded on a linear scale quantifying the amount of practice (see Table 2 as an example). A score with a higher value indicated an increase in the desired behavior.

Children were asked whether they ever had LD, how many of their friends may have had LD, how many tick bites they believed that they had got in the past summer, and how often they wore long pants to keep ticks off. The children were also asked at their follow-up survey whether they had had LD in the past year since their last questionnaire. If they answered

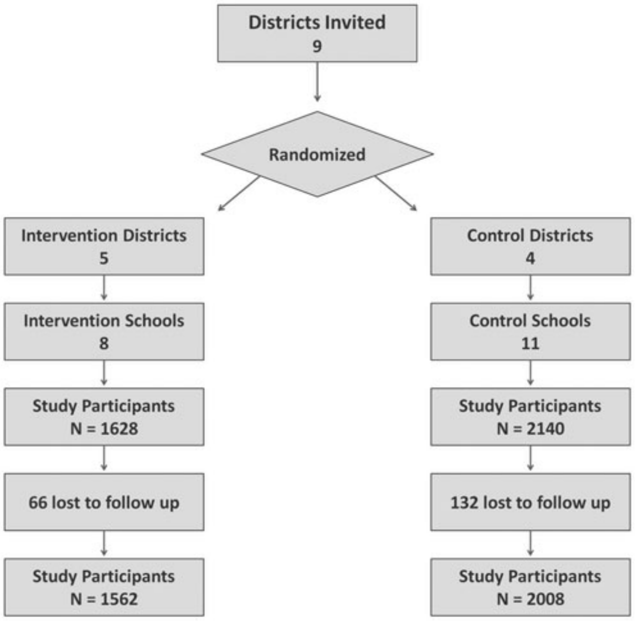

FIG. 3. Flow chart of the LD education program.

yes, we mailed a letter to their parents asking to confirm that they had a new case of LD and if so, we then requested permission to review their medical records.

Descriptive statistics were tabulated and compared to determine the demographic and outcome measure balance between intervention and controls. T tests or chi-squared analyses were performed as required. Questions with linear or Likert scales were graded with higher scores indicating a better outcome. Linear regression modeling (PROC GLM) was used to compare linear outcomes that were measured as a change of each outcome (an increase, no change, decrease, or reduction in the behavior), adjusting for age, sex, and pretest variable value to account for the differences in student age, gender, and baseline variable value. Outcomes of the intervention and control groups were presented adjusted for covariates. Effect-size estimates were calculated as standardized mean difference controlling for covariates. We also performed an intent-to-treat analysis to evaluate whether values carried forward for drop-outs changed the outcomes. All analyses were done using SAS v. 9.4 (SAS Institute, Cary, NC).

Results

Baseline characteristics

Figure 3 details the recruitment of subjects; 3768 enrolled in the program, and 1562 intervention students and 2008 control students completed the protocol (5% dropped out) (Table 1). There were five intervention and four control school districts. The cohort had an average age of 9.1 years (standard deviation ±1.2) 51.1% female overall. There was a relatively even overall distribution of participants across grades (23.1% in second grade, 25.9% in third grade, 25.1% in fourth grade, and 25.9% in fifth grade). The intervention group had slightly more students in higher grades ($p = 0.05$). All baseline behaviors and knowledge measures were slightly higher in the intervention group versus the waitlist controls (Tables 2, 3, and 5).

Practice of precautionary behaviors pre- and postintervention in intervention and control students

In questions based on the four precautionary practices taught to prevent tick bites, the intervention group showed significant improvement postintervention over the controls in all questions (Table 2). After the intervention, more students (15% increase) in the intervention group said they checked behind their knees, compared with students (5.4% increase) in the control group ($p < 0.0001$). There also was an increase in the frequency of the children's ''checking behind the ears'' in the intervention group compared with the control group ($p < 0.0001$). Both groups saw a decrease in the number of students responding that they ''always'' wear long pants to keep the ticks off and an increase in the number of students responding that they ''never'' wear long pants to keep the ticks off, but the control students reported these behaviors significantly more frequently ($p = 0.002$).

For the question ''how often do you check yourself for ticks?'' the wait list control group reported a decrease post-intervention in the number of students reporting that they ''always'' check themselves for ticks; both groups reported an increase in the number of students reporting that they ''usually'' check themselves for ticks. There was a small but significant improvement in the reported frequency of tick checking in the intervention group versus the control group on this question (beta = 0.06, $p < 0.02$).

Postintervention change in LD knowledge in intervention and control students

A summed knowledge score for each student was created by totaling the number correct out of the six knowledge questions listed in Table 3. The intervention students improved their overall knowledge score more than the control students (mean improvement, 1.38 (SD1.31) vs. 0.35 (SD 1.30), $p < 0.0001$) at the end of the program. As the intervention students had a higher overall knowledge score

TABLE 1. SOCIO-DEMOGRAPHIC INFORMATION FOR INTERVENTION AND CONTROL STUDENTS

Variable	*Total population* (n = *3570*)	*Intervention* (n = *1562*)	*Control* (n = *2008*)	p-*Value*
Age, M (SD)	9.1 (±1.2)	9.1 (±1.2)	9.1 (±1.2)	0.53
Sex (*n*, % female)	1825 (51.1)	822 (52.6)	1003 (50.1)	0.13
Grade, *n* (% total)				
Second	824 (23.1)	335 (21.4)	489 (24.4)	0.05
Third	924 (25.9)	410 (26.3)	514 (25.7)	
Fourth	896 (25.1)	422 (27.1)	474 (23.6)	
Fifth	921 (25.9)	393 (25.2)	528 (26.3)	

Table 2. Practice of Precautionary Behaviors Pre- and Postintervention in Intervention and Control Students

	Intervention (n = *1562*)		*Control* (n = *2008*)				
	Pre	*Post*	*Pre*	*Post*	β	*Effect Size*	p-*Value*[a]
How often do you check yourself for ticks? *n* (%)							
Always	187 (12.0)	185 (12.0)	272 (13.6)	232 (11.6)	0.06	0.068	0.02
Usually	402 (25.8)	422 (27.2)	412 (20.6)	477 (23.8)			
Sometimes	883 (56.8)	861 (55.6)	1107 (55.2)	1083 (54.2)			
Never	81 (5.2)	82 (5.2)	211 (10.6)	205 (10.2)			
When you check yourself for ticks, do you usually, *n* (%)							
check behind your ears	1313 (84.4)	1372 (88.6)	1484 (74.2)	1582 (79.4)	0.06	0.13	<0.0001
check behind your knees	1075 (69.0)	1302 (84.0)	1302 (65.2)	1409 (70.6)	0.12	0.22	<0.0001
check your hands	768 (49.4)	721 (46.6)	1009 (50.4)	1047 (52.6)	–0.06	–0.09	<0.0001
How many days a week do you play in woods? *n* (%)							
Almost every day	188 (12.2)	179 (11.6)	229 (11.4)	196 (9.8)	–0.07	–0.08	0.01
3–4 days a week	195 (12.6)	185 (12.0)	200 (10.0)	193 (9.8)			
1–2 days a week	690 (44.6)	672 (43.4)	793 (39.8)	800 (40.2)			
Never	476 (30.8)	514 (33.2)	774 (38.8)	798 (40.2)			
How often do you wear long pants just to keep the ticks off you? *n* (%)							
Always	290 (18.6)	257 (16.6)	444 (22.2)	318 (16.0)	0.09	0.08	0.002
Usually	507 (32.6)	526 (34.0)	619 (31.0)	615 (30.8)			
Sometimes	611 (39.2)	593 (38.4)	703 (35.2)	781 (39.2)			
Never	148 (9.6)	172 (11.2)	232 (11.6)	277 (14.0)			

Missing data for each question range from 5 to 21.
[a]Comparing change from preintervention with postintervention between intervention and control students, adjusted for age, sex, and preintervention variable.

Table 3. Knowledge of Lyme Disease Pre- and Postintervention in Intervention and Control Students

	Intervention (n = *1562*)		*Control* (n = *2008*)			
	Pre	*Post*	*Pre*	*Post*	*Effect size*	p-*Value*[a]
A tick can get on you when, *n* (%)						
You brush against it	444 (28.5)	1202 (77.2)	417 (20.8)	492 (24.6)	0.9	<0.0001
It flies into you	62 (4.0)	13 (0.8)	134 (6.7)	75 (3.7)		
It jumps onto you	1052 (67.5)	343 (22.0)	1455 (72.6)	1429 (71.4)		
Can you get sick from a tick bite? *n* (%)						
Yes	1435 (91.9)	1495 (96.0)	1674 (83.6)	1795 (89.8)	0.13	0.28
No	41 (2.6)	27 (1.7)	99 (4.9)	47 (2.4)		
Not sure	86 (5.5)	36 (2.3)	229 (11.4)	157 (7.9)		
Do you feel it when a tick bites you? *n* (%)						
Yes	246 (15.8)	117 (7.5)	415 (20.7)	285 (14.2)	0.23	0.0029
No	995 (63.8)	1222 (78.4)	1149 (57.3)	1279 (63.9)		
Not sure	318 (20.4)	219 (14.1)	440 (22.0)	437 (21.8)		
What is one way to find a tick? *n* (%)						
Smell it	5 (0.3)	8 (0.5)	13 (0.6)	9 (0.4)	0.12	0.13
Feel for it	1444 (92.6)	1526 (97.8)	1682 (83.8)	1857 (92.8)		
Hear it	15 (1.0)	3 (0.2)	57 (2.8)	20 (1.0)		
Cannot find it	95 (6.1)	24 (1.5)	255 (12.7)	116 (5.8)		
How long does a tick need to be on you before you get Lyme disease? *n* (%)						
1 h	188 (12.1)	68 (4.4)	342 (17.1)	264 (13.3)	0.59	<0.0001
1 day	684 (44.2)	1294 (83.8)	819 (41.0)	893 (45.0)		
4 days	677 (43.7)	182 (11.8)	835 (41.8)	828 (41.7)		
What time of year can you get Lyme disease? *n* (%)						
Spring	578 (37.0)	959 (61.6)	627 (31.2)	811 (40.4)	0.35	<0.0001
Summer	1087 (69.6)	1179 (75.7)	1457 (72.6)	1434 (71.4)		
Fall	614 (39.3)	1041 (66.8)	665 (33.1)	872 (43.4)		
Winter	418 (26.8)	833 (53.5)	504 (25.1)	663 (33.0)		
Anytime	410 (26.2)	825 (53.0)	497 (24.8)	653 (32.5)		
I do not know	178 (11.4)	112 (7.2)	262 (13.0)	248 (12.4)		

Correct answer in *italics*.
[a]Comparing change from preintervention with postintervention between intervention and control students, adjusted for age, sex, and preintervention variable.

TABLE 4. COMPOSITE KNOWLEDGE SCORE FOR INTERVENTION AND CONTROL STUDENTS POSTINTERVENTION

	Intervention students (n = *1562*)	*Control students* (n = *2008*)	p-*Value*
Preintervention mean knowledge score, M (SD)	3.47 (1.12)	3.11 (1.18)	<0.0001
Postintervention mean knowledge score, M (SD)	4.85 (1.09)	3.47 (1.18)	<0.0001
Difference, M (SD)[a]	1.38 (1.31)	0.36 (1.30)	<0.0001

Number of correct answers to the six knowledge questions listed in Table 3; effect size is 0.73.
[a]Comparing change from preintervention with postintervention between intervention and control students, adjusted for age, sex, and preknowledge score.

than controls before the program started, the mean differences between groups were adjusted for age, sex, and baseline score to account for these differences (Table 4).

Changes in perception of self-efficacy pre- and postintervention for intervention and control students

There were significant differences between the two groups in response to the self-efficacy questions (Table 5). More intervention students responded that they could find a tick on themselves after the intervention (3.6% change for intervention students, 2.4% change for control students, $p < 0.0001$) and reported doing their own tick checks after the intervention (5.8% change in the intervention group, 4.0% change in the control group, $p = 0.001$). More students in the intervention group also reported that it was ''very easy'' to find a tick when coming in from outside compared with the controls (4.8% change in the intervention group, 2.2% change in the control group, $p < 0.0001$).

LD cases

Thirty eight children in the intervention group compared with 34 children in the control group reported a new case of LD at follow-up. This represented 73 of 3570 (2%) children reporting a new case of LD. Forty four of the parents of the 73 children returned the questionnaire. Among five parents who reported LD, only two (one in the intervention group and one in the control group) were confirmed by their pediatrician's record. One case was a treated tick bite, and two were LD cases that occurred before the study enrollment. This rate (56/100,000) is similar to the overall incidence rate of LD physician reports to the Massachusetts Department of Public Health for 5–9 year-old children of 61.5/100,000 in 2005.

Discussion

Tick bite control precautions are recommended to reduce the transmission of LD (Cartter et al. 1989, Poland 2001, de

TABLE 5. CHANGES IN PERCEPTION OF SELF-EFFICACY PRE- AND POSTINTERVENTION FOR INTERVENTION AND CONTROL STUDENTS

	Intervention (n = *1562*)		*Control* (n = *2008*)				
	Pre	*Post*	*Pre*	*Post*	β	*Effect Size*	p-*Value*[a]
Do you think you can find a tick on yourself? *n* (%)							
Yes	1200 (77.0)	1245 (80.6)	1343 (67.2)	1390 (69.6)	0.07	0.15	<0.0001
No	202 (13.0)	155 (10.0)	407 (20.4)	339 (17.0)			
Not sure	156 (10.0)	146 (9.4)	251 (12.6)	271 (13.6)			
How sure are you that you will get a tick bite this summer? *n* (%)							
Very sure	170 (11.0)	132 (8.6)	184 (9.2)	137 (6.8)	−0.11	−0.11	0.0002
Pretty sure	400 (25.8)	317 (20.4)	369 (18.4)	286 (14.4)			
Slightly sure	463 (29.8)	494 (31.8)	580 (29)	585 (29.4)			
Not so sure	523 (33.6)	608 (39.2)	864 (43.2)	983 (49.4)			
When you come in from playing outdoors, is it easy or hard to check yourself for ticks? *n* (%)							
Very easy	133 (8.6)	209 (13.4)	222 (11.0)	261 (13.2)	0.16	0.11	<0.0001
Easy	699 (45.0)	784 (50.6)	733 (36.6)	834 (42.0)			
Hard	430 (27.6)	315 (20.2)	525 (26.2)	425 (21.4)			
Very hard	46 (3.0)	30 (2.0)	87 (4.4)	69 (3.4)			
I do not check	247 (15.8)	214 (13.8)	435 (21.8)	396 (20.0)			
Who helps you check for ticks most of the time? *n* (%)[b]							
Do not check	43 (2.8)	84 (5.4)	134 (6.6)	165 (8.2)	0.05	0.09	0.001
Check myself	137 (8.8)	227 (14.6)	125 (6.2)	206 (10.2)			
Grownup at school	71 (4.6)	30 (2.0)	71 (3.6)	39 (2.0)			
Grownup at home	1311 (84)	1211 (77.8)	1690 (84.2)	1599 (79.6)			

Missing data for each question range from 0 to 23.
[a]Comparing change from preintervention with postintervention between intervention and control students, adjusted for age, sex, and preintervention variable.
[b]We ranked ''check myself'' as the highest score, ''grownup at school'' and ''grownup at home'' as the same score, and ''do not check'' as the lowest score.

Vries and van Dillen 2002, Daltroy et al. 2007 American Academy of Pediatrics 2000, Hayes and Piesman 2003, Clark and Hu 2008, Gould et al. 2008, Connally et al. 2009, Eisen and Mead 2014). Recent LD studies in adults indicate that understanding a population's risk factors, attitudes toward disease prevention, and past experience with LD are important in devising a successful prevention strategy, particularly enhancing self-efficacy for taking precautions (Cartter et al. 1989, Centers for Disease Control 1992, Ley et al. 1995, Shadick et al. 1997, Armstrong et al. 2001, Smith et al. 2001, Malouin et al. 2003, Herrington 2004, McKenna et al. 2004, Daltroy et al. 2007, Gould et al. 2008, Vazquez et al. 2008). School-aged children, in particular, are at great risk for contracting LD, because they frequently play outdoors—in their backyards, playgrounds, on school grounds. Research has demonstrated that infections likely occur in residential areas during routine activities (Poland 2001).

The prevention of pediatric LD is an important initiative, and school health programs are one of the most efficient modalities to enhance public health (Redican et al. 1979). This is one of the first studies to evaluate an in-class LD educational program using social learning theory and the HBM. In this study, we demonstrated that compared with control school children, the educational program produced modest improvements in the intervention school children's knowledge, perceived susceptibility, self-efficacy, and self-reported practice of precautionary behavior. The effect we demonstrated was durable months after the intervention.

Our educational intervention used pedagogical theory of how students learn to impact changes in health behavior. This program incorporated question-and-answer sessions, hands-on activities, and engaging entertainment to reinforce learning and desired behavior, with the intention to provide children with usable actions. The design of the program gave students the opportunity to become active learners, to practice preventive behavior so that they are better prepared to transfer what they learned in the classroom into actions outside or at home (Payton et al. 2000).

The educational intervention also used a multi-faceted approach to embed elements of social learning theory and the HBM into the intervention (Rosenstock et al. 1988). The elements included observing tick-checking behavior (modeling), awareness of the consequences of having LD, and instilling the belief that each student is capable of carrying out preventive behaviors (self-efficacy). During the educational intervention, the health educator not only talked about tick-checking behavior but also demonstrated it and had children replicate it. The children were learning together with peers in their classroom, making it socially acceptable and reinforcing the tick-checking behavior. A similarly designed, active school educational program was successful in promoting sun protection behavior in children in grades 6–8 in Colorado, New Mexico, and Arizona (Buller et al. 2006).

Our study had several limitations. Because all school districts were located in endemic areas for LD and other tick-borne illnesses, there was already a high level of awareness of LD. This would have limited the intervention's ability to produce a large effect. In addition, although we randomly selected intervention towns and controls, our intervention group had slightly higher baseline scores. We adjusted our analyses to compensate for this difference. Additionally, our study did not incorporate parental attitudes. In a study by de Vries and van Dillen (2002), predictors of parental tick inspection were parental norms, having a positive attitude, anticipated regret, having role models, and stressing self efficacy. In a preliminary analysis of this study's parental attitudes (Zibit 2008), correlates of a child's practice of precautionary behaviors were found to be parents' tick check monitoring, higher tick check self-efficacy, and a positive attitude toward precautionary behaviors. Future LD school-based prevention programs would benefit from incorporating parental attitudes into their programs.

Another limitation of our program is that we did not have a control arm implemented to assess the differential impact of the live performance compared with the in-class curricular materials. It may be that the live performance had a larger effect on the children's knowledge and attitude change than the in-class curriculum, and our study design could not answer this question. Future trials could include an additional study arm to evaluate the differential benefits of these two different educational methods.

A further limitation of our study was that behaviors were self-reported and could not be independently validated. Children who underwent our educational intervention may have been more likely to report an increase in their precautionary behavior as a result of the study. Additionally, a better indicator of the impact of the intervention would be more directly measured outcomes such as the number of ticks found on study participants and the outcomes of the tick encounters. Daily diaries of tick encounters or reports from parents about the frequency of tick bites might also be a better direct measure of the intervention's effect. A suggestion for future studies would be to include parental input about the frequency of the children's precautionary behavior.

In addition, although the handouts in the intervention were made to be grade specific, we used the same intervention with all grade levels. Our results suggested that the intervention may have worked better in grades 3–5. In discussion with some of the school personnel, we found that the juggler performance worked well for all children but the younger children (grade 2) needed a shorter in-class session, that is, 15 min, which was more appropriate to their developmental level.

In addition, although there were many large statistical differences between our intervention and control groups due to the very large sample sizes, the clinical significance of these differences is more modest. We included the effect sizes for each change to help the reader determine the strength of these effects; only two out of six of the knowledge questions and none of the self-efficacy questions had improvements where the effect sizes were greater than 0.5, which indicates only modest improvements in many of the outcomes. Furthermore, we were unable to evaluate whether these changes significantly impacted the incidence of LD, since only two cases were confirmed by the study children's pediatricians, a number too low to detect an effect of our intervention. Some of the children in the younger grades who reported having had LD had parents who reported that they actually had a tick bite and were given prophylactic antibiotics. Although the general knowledge score about LD improved, there was still some confusion about the difference between an infection and prophylaxis for a tick bite.

Conclusions

In summary, LD affects school-aged children at a particularly high rate. Educational interventions to reduce LD among at-risk school children have had little study. This intervention demonstrated that a short in-class LD education program based on social learning theory and the HBM can impact a child's knowledge, attitude, and self-reported preventive behavior. The program was well received by the students and parents (there was a high rate of participation and follow-up); teachers and school administrators appreciated the help. The study suggests that this educational initiative may be successfully used in other at-risk communities. Future studies might focus on whether this intervention can reduce the rate of tick-borne illness, how long the intervention impacts self-reported tick bite prevention behavior, and to what extent parental attitudes impact a child's risk and their self-reported behaviors.

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Author Disclosure Statement

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