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AN ENVIRONMENTAL SCAN AND NEEDS ASSESSMENT
OF TICK-BORNE DISEASE PREVENTION EFFORTS
IN THE GREATER DANBURY, CONNECTICUT AREA

BY

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Degree to be awarded: M.P.H.
Executive MPH

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M.P.H., Emory University, 2014
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An abstract of
A Thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Master of Public Health in the Executive MPH program
2014

Abstract

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Diseases transmitted by *Ixodes scapularis* (blacklegged ticks), including Lyme disease, anaplasmosis, and babesiosis, are all of great public health concern. The geographic distribution of these tick-borne disease cases is highly specific to the northeastern and upper Midwestern United States. Tick-borne disease rates in the ten-town Greater Danbury, Connecticut area are further exacerbated as compared to the already high state rates. Greater Danbury is particularly primed to investigate tick-borne diseases and act upon suggested courses of action given the high rates of disease as well as the local interest in tick-borne disease prevention. The number of reported tick-borne disease cases continues to increase, thus underscoring the need for targeted prevention strategies, early disease recognition and treatment, and a sustainable surveillance system.

Through an in-depth environmental scan using interviews with key informants as well as surveys, this tick-borne disease prevention needs assessment sought to 1) catalog existing tick-borne disease prevention efforts and resources in Greater Danbury, Connecticut; 2) investigate Greater Danbury residents' knowledge of, beliefs about, and barriers to use of tick-borne disease prevention measures; and 3) recommend additional measures to prevent and reduce tick-borne disease rates in Greater Danbury using a social ecological approach. The primary goal of answering these questions is to provide tick-borne disease prevention practitioners at all levels of influence with the full scope and context of current tick-borne disease prevention efforts in Greater Danbury to create a practical, comprehensive framework for reducing the rates of tick-borne diseases in the area.

Given the range of tick-borne disease prevention challenges at all levels of influence, evidence-based recommendations for reducing the burden of disease in Greater Danbury are outlined. Where appropriate, recommendations are tailored to address more specifically the challenges present in and resources available within Greater Danbury.

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EXECUTIVE SUMMARY

Diseases transmitted by *Ixodes scapularis* (blacklegged ticks), including Lyme disease, anaplasmosis, and babesiosis, are all of great public health concern. In particular, Lyme disease is the most commonly reported vector-borne illness in the United States and in 2012 it was the seventh most common Nationally Notifiable disease. The geographic distribution of these tick-borne disease cases is highly specific to the northeastern and upper Midwestern United States. Tick-borne disease rates in the ten-town Greater Danbury, Connecticut area are further exacerbated as compared to the already high state rates. Greater Danbury is particularly primed to investigate tick-borne diseases and act upon suggested courses of action given the high rates of disease as well as the local interest in tick-borne disease prevention. The number of reported tick-borne disease cases continues to increase, thus underscoring the need for targeted prevention strategies, early disease recognition and treatment, and a sustainable surveillance system.

Primary personal prevention of each of these three tick-borne diseases—Lyme disease, anaplasmosis, and babesiosis—is focused around preventing *I. scapularis* bites. Decreasing tick-borne disease rates in Greater Danbury requires a broad understanding of evidence-based disease prevention methods and prevention efforts currently in place in this area, as well as an in-depth view of persistent barriers to prevention methods and efforts. As such, employment of the social ecological approach is necessary both to consider and to influence the individual, interpersonal, organizational, community, and policy levels that collectively shape behavior.

Through an in-depth environmental scan using interviews with key informants as well as surveys, this tick-borne disease prevention needs assessment catalogs existing tick-borne disease prevention efforts and resources in Greater Danbury, Connecticut; investigates Greater Danbury residents' knowledge of, beliefs about, and barriers to use of tick-borne disease prevention

measures; and recommends additional measures to prevent and reduce tick-borne disease rates in Greater Danbury using a social ecological approach. The primary goal of answering these questions is to provide tick-borne disease prevention practitioners at all levels of influence with the full scope and context of current tick-borne disease prevention efforts in Greater Danbury to create a practical, comprehensive framework for reducing the rates of tick-borne diseases in the area. Key findings of this assessment include:

- **Lyme disease rates are high.** The average rate of Lyme disease in Connecticut is 81.6 cases per 100,000 persons. Greater Danbury exhibits an average rate of 96.0 cases per 100,000 persons, while the rates of individual towns within this region reach as high as 156.0 cases per 100,000 persons.
- **Anaplasmosis rates are high.** While the nation sees an average of 0.6 cases of anaplasmosis per 100,000 persons, the rate in Greater Danbury is between 1.2 and 2.8 cases per 100,000 persons.
- **Tick-borne disease prevention is a local priority.** Directors of Health uniformly identified tick-borne diseases as a priority issue. Almost all towns provide information about prevention through their websites; many also are involved in active events such as health fairs.
- **Lack of funding is a barrier.** Lack of funding specified for preventive activities was the barrier to prevention efforts most frequently cited by Directors of Health and other key informants.
- **The BLAST program is integral to tick-borne disease prevention efforts.** The BLAST Tick-Borne Disease Prevention Program provides evidence-based recommendations for personal prevention, including bathing within two hours of being

outdoors, looking for ticks and rashes, applying repellent, spraying your yard, and treating your pets.

- **Residents are aware of Lyme disease.** Overall, area residents are knowledgeable about the transmission and signs and symptoms of Lyme disease. They are less well-informed about anaplasmosis and babesiosis.
- **Preventive behaviors are variably performed by the public.** Approximately 60% of survey respondents reported performing tick checks; 50% reported showering or bathing after being outdoors; 45% reported wearing protective clothing; 35% reported wearing tick repellent. The public perceives each of these methods to be approximately equally (highly) effective at preventing tick-borne disease and equally (moderately) burdensome.
- **Physicians frequently are not discussing tick-borne diseases on a primary prevention basis.** Primary care providers are twice as likely to counsel patients about tick-borne disease prevention after a possible tick bite than at wellness visits (82% and 39%, respectively). The most commonly identified barrier to having such discussions was lack of time.
- **Physicians largely are not utilizing existing patient resources.** Providers are aware of, but generally do not refer patients to, local health departments and national resources such as the CDC.

Given the range of tick-borne disease prevention challenges at all levels of influence, evidence-based recommendations for reducing the burden of disease in Greater Danbury are outlined. Where appropriate, recommendations are tailored to address more specifically the challenges present in and resources available within Greater Danbury. Recommendations include:

- Offering educational programs which target at-risk age groups;
- Encouraging discussion about tick-borne disease preventive practices among peers, between parents and their children, and between individuals and their healthcare providers;
- Encouraging parents to act as models for their children with respect to performing tick-borne disease personal preventive behaviors;
- Offering presentations to community groups;
- Maintaining and increasing health department and BLAST Program presence at health fairs;
- Using tick prohibitive yard designs and landscaping;
- Offering organization-sponsored clothing permethrin treatment for outdoor workers;
- Unifying the BLAST Program message;
- Hosting a tick-borne disease seminar for area healthcare providers;
- Involving tick-borne disease prevention in the annual Connecticut Trails Day;
- Mandating the posting of signage at park and trail entrances identifying possible exposure to ticks and options for personal prevention;
- Mandating age-appropriate coverage of tick-borne diseases in public school curricula;
- Reinstating funding to town-level health districts for the purposes of health promotion and education activities;
- Implementing an area- or state-wide tick-borne disease health educator; and
- Increasing the availability of Federal funding for tick-borne disease prevention research.

CHAPTER 1: INTRODUCTION

<u>Rationale for Needs Assessment</u>

Ixodes scapularis, commonly referred to as blacklegged or deer ticks, are widely distributed in the northeastern and upper Midwestern United States (CDC, 2014m). *I. scapularis* larvae and nymphs primarily feed on small mammals and birds, while adults feed on larger animals and humans. These ticks can transmit the organisms responsible for anaplasmosis, babesiosis, and Lyme disease.

Lyme disease is caused by the bacterium *Borrelia burgdorferi* (CDC, 2014e). Early signs and symptoms of Lyme disease may include a characteristic red, expanding rash called erythema migrans (EM) (commonly referred to as a bull's-eye rash) at the site of the bite, fatigue, chills, fever, headache, muscle and joint aches, and swollen lymph nodes (CDC, 2013k). If left untreated, the infection may spread to other parts of the body, resulting in symptoms such as additional EM lesions in other areas of the body, Bell's palsy, severe headaches and neck stiffness due to meningitis, pain and swelling in the large joints, shooting pains that may interfere with sleep, and heart palpitations and dizziness due to changes in heartbeat.

Lyme disease is the most commonly reported vector-borne illness in the United States (CDC, 2013f) and in 2012, it was the seventh most common Nationally Notifiable disease, with over 22,000 confirmed cases and more than 8,800 probable cases reported to the Centers for Disease Control and Prevention (CDC) (CDC, 2013i). Nationally Notifiable surveillance efforts in the United States were instituted in 1991 (CDC, 2013h). In 1992, approximately 9,900 cases of the disease were reported (CDC, 2008). Thus, there was a 222% to 311% increase in reported cases during the first 21 years of national reporting (Figure 1). Because the number of reported cases of Lyme disease continues to increase, the need for targeted prevention strategies, early disease recognition and treatment, and a sustainable surveillance system is underscored.

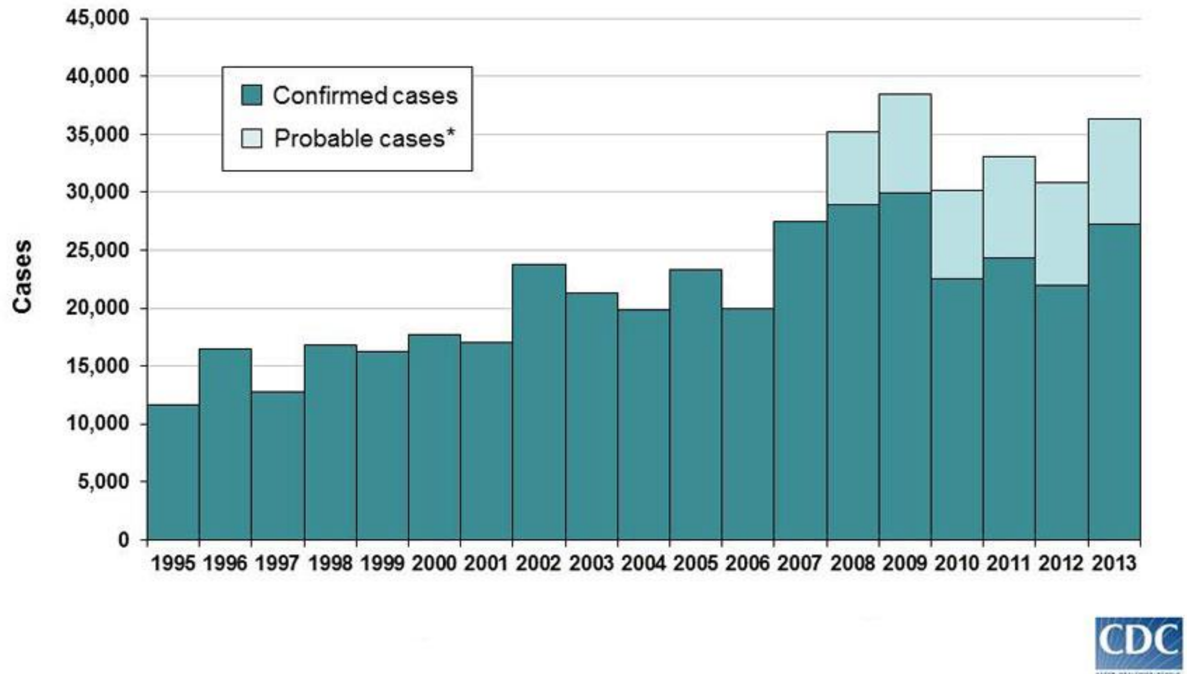

Figure 1. Number of reported Lyme disease cases, by year—United States, 1995-2013 (CDC, 2014j)

The geographic distribution of cases is highly specific; in 2012, 95% of cases were reported from just 13 states: Connecticut, Delaware, Maine, Maryland, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Vermont, Virginia, and Wisconsin (CDC, 2013f). This general distribution of disease has held true across years (CDC, 2008). See Figure 2 for a depiction of reported Lyme disease case distribution.

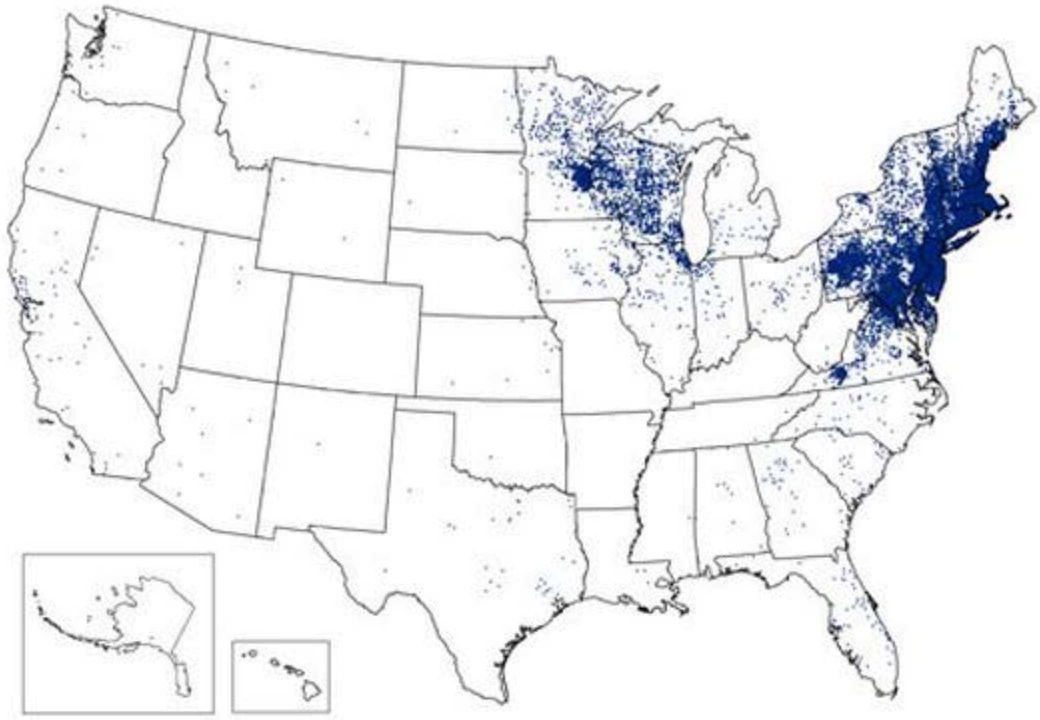

Figure 2. Reported cases of Lyme disease—United States, 2012 (CDC, 2013j)

I. scapularis are not only responsible for the transmission of *B. burgdorferi*; these ticks can also transmit other disease-causing agents, as described below.

Anaplasmosis

Anaplasmosis, caused by the bacterium *Anaplasma phagocytophilum*, did not become a reportable disease in the United States until 1999 (CDC, 2013a). Since then, the number of reported cases has increased steadily, from 348 cases in 2000 to 1,761 cases in 2010. The incidence has also increased, from 1.4 cases per million persons in 2000 to 6.1 cases per million persons in 2010.

Symptoms of anaplasmosis are similar to those of Lyme disease and may include fever, headache, muscle pain, malaise, chills, nausea, abdominal pain, cough, confusion, and, rarely, rash (CDC, 2013b). While patients who are treated early may recover quickly on outpatient medication, anaplasmosis can be fatal if not treated correctly, even in previously healthy people. Severe clinical presentations may include difficulty breathing, hemorrhage, renal failure, and neurological problems. The estimated case fatality rate is less than 1%.

Babesiosis

Babesiosis is caused by microscopic parasites, *Babesia microti*, that infect red blood cells (CDC, 2014i). In the United States, tick-borne transmission is most common, although babesiosis also may be transmitted via blood transfusion and rare cases of congenital transmission have been reported. Babesiosis is only reportable in 22 states, including Connecticut and its surrounding states; it did not become a Nationally Notifiable condition until 2011 (CDC, 2014g). Among the 22 states where babesiosis is reportable, the CDC was notified of 911 cases. All of these cases were reported in just 14 of the 22 states. Furthermore, 95% of these cases were reported by seven states: Connecticut, Massachusetts, Minnesota, New Jersey, New York, Rhode Island, and Wisconsin.

Many people with babesiosis do not have any symptoms (CDC, 2014h). Others develop symptoms similar to those of Lyme disease and anaplasmosis, including fever, chills, sweats, headache, malaise, loss of appetite, nausea, and fatigue. Because *Babesia* parasites infect and destroy red blood cells, babesiosis may also cause hemolytic anemia, leading to jaundice and dark urine. Complications of babesiosis may include low and unstable blood pressure; thrombocytopenia (very low platelet count); disseminated intravascular coagulation, which can lead to blood clots and bleeding; and malfunction of vital organs. Babesiosis can be a life-threatening disease, particularly in immunocompromised individuals. Among this population, the fatality rate is approximately 20%, even with appropriate antibiotic treatment (Columbia University Medical Center, n.d.).

Greater Danbury, Connecticut

The Greater Danbury, Connecticut area is comprised of 10 towns: Bethel, Bridgewater, Brookfield, Danbury, New Fairfield, New Milford, Newtown, Redding, Ridgefield, and Sherman (Figure 3). This area may also be referred to as the Housatonic Valley Region. In 2013, the incidence of Lyme disease in Litchfield County, where Bridgewater and New Milford are located, was 98.5 cases per 100,000 persons (Connecticut Department of Public Health, n.d.). The incidence for Fairfield County, which contains the other eight towns, was 48.2 cases per 100,000 persons in 2013. Between 2001 and 2010, the Connecticut statewide average annual incidence of anaplasmosis was 1.0 case per 100,000 persons (Connecticut Department of Public Health, 2011). Both Litchfield and Fairfield Counties exhibited rates higher than the state average, at 2.8 cases per 100,000 persons and 1.2 cases per 100,000, respectively. County-level data for babesiosis rates were not readily available at the time of publication of this document, likely due to the recent nature of reporting institution.

Figure 3. Greater Danbury, Connecticut (Hudson Valley Council of Elected Officials, n.d.)

Because primary personal prevention of each of these three tick-borne diseases—Lyme disease, anaplasmosis, and babesiosis—is focused around preventing *I. scapularis* bites, it is possible to discuss unified tick-borne disease prevention. Decreasing tick-borne disease rates in Greater Danbury requires a broad understanding of evidence-based disease prevention methods and prevention efforts currently in place in this area, as well as an in-depth view of persistent barriers to prevention methods and efforts. As such, employment of the social ecological approach is necessary both to consider and to influence the individual, interpersonal, organizational, community, and policy levels that collectively shape behavior.

Purpose Statement

Through an in-depth environmental scan using interviews with key informants as well as surveys, this tick-borne disease prevention needs assessment sought to 1) catalog existing tick-borne disease prevention efforts and resources in Greater Danbury, Connecticut; 2) understand Greater Danbury residents' knowledge of, beliefs about, and barriers to use of tick-borne disease prevention measures; and 3) recommend additional measures to prevent and reduce tick-borne disease rates in Greater Danbury using a social ecological approach. Specific questions this needs assessment will answer include:

- What are the current tick-borne disease rates in Greater Danbury?
    - How do these rates compare to national rates?
- What are the primary health implications of these data?
- What obstacles must be overcome to prevent tick-borne diseases in Greater Danbury?
    - What are Greater Danbury residents' perceptions, attitudes, and beliefs about the burden of tick-borne diseases and about tick-borne disease prevention?
- What resources are currently available to promote prevention of tick-borne diseases in Greater Danbury?
- What are the recommended strategies for preventing tick-borne diseases in Greater Danbury from a social ecological perspective?
    - How can these recommendations be leveraged at the local level?

The primary goal of answering these questions is to provide tick-borne disease prevention practitioners at all levels of influence with the full scope and context of current tick-borne disease prevention efforts in Greater Danbury to create a practical, comprehensive framework for reducing the rates of tick-borne diseases in the area.

Statement of Significance

During the 15-year period between 1992 and 2006, Connecticut had the highest mean annual Lyme disease case rate amongst all states at 73.6 cases per 100,000 persons, despite particularly variable rates year-to-year (CDC, 2008). It therefore becomes vital to understand what drives tick-borne disease rates in this region so that public health practitioners may combat these factors and reduce disease incidence.

The Greater Danbury, Connecticut area is particularly primed to investigate tick-borne diseases and act upon suggested courses of action given the high rates of disease as well as the local interest in tick-borne disease prevention. In conducting this environmental scan and needs assessment to answer the research questions outlined under the Purpose Statement, data will be gathered to inform future tick-borne disease prevention efforts in the area. Further, it is the hope that successful interventions will serve as a model for other communities similarly affected by tick-borne diseases.

Needs Assessment

The most crucial element of program planning is a needs assessment (Community Tool Box, 2014). A needs assessment is a systematic process for determining and addressing the needs of a community, defined as a discrepancy between the current conditions and desired conditions. Considering a community context for any data gathered allows for a broad understanding of the health problem to be addressed as well as the resources available to address it.

Social Ecological Approach

Public health and health-promotion interventions that are based on social and behavioral science theories are more effective than those lacking a theoretical base (Glanz & Bishop, 2010). Because effective public health programs to help people maintain health and reduce disease risks require behavior change at many levels, the recommendations outlined in this document are based on the social ecological approach. This framework helps users to understand factors affecting behavior and provides guidance for developing successful programs through social environments. It emphasizes the multiple levels of influence on health and human behavior, as well as the idea that behaviors both shape and are shaped by the social environment. It suggests that creating an environment conducive to change is important to facilitate the adoption of healthy behaviors. Therefore, individual, interpersonal, organizational, community, and policy levels are all addressed. Proponents of this approach recognize the complex interplay between factors that impact health within the various levels of influence that cannot be addressed (as) successfully in isolation.

Summary

- Lyme disease is the most commonly reported vector-borne illness in the United States; the number of reported cases continues to climb.
- Rates of anaplasmosis and babesiosis also continue to increase.
- The Greater Danbury, Connecticut area is particularly primed to investigate tick-borne diseases and act upon suggested courses of action given the high rates of disease as well as the local interest in tick-borne disease prevention.

CHAPTER 2: REVIEW OF THE LITERATURE

This document seeks to provide tick-borne disease prevention practitioners at all levels of influence with the full scope and context of current tick-borne disease prevention efforts in Greater Danbury to create a practical, comprehensive framework for reducing the rates of tick-borne diseases in the area.

First, it is important to understand the current magnitude and severity of tick-borne diseases in this area as well as the political landscape of the region, particularly as it relates to Lyme disease and the local health department structure. The end of this chapter will also present current recommended tick-borne disease prevention strategies, along with an overview of their evidence base, where applicable.

Political Landscape Related to Tick-Borne Diseases

While there is general agreement over the optimal treatment for early Lyme disease, there is considerable controversy over the existence, prevalence, diagnostic criteria, and treatment of "chronic" Lyme disease (Tonks, 2007). This document does not seek to address chronic Lyme disease, specifically, in any capacity. Rather, **the focus of this document is intended solely to be on *prevention* of Lyme disease and other tick-borne diseases**. With that being said, it would be remiss not to provide a brief overview of the controversy in Connecticut, as this sometimes colors tick-borne disease prevention efforts.

Connecticut residents, including those residing in the Greater Danbury area, are no strangers to the controversy over chronic Lyme disease. In 2006, then Connecticut Attorney General Richard Blumenthal opened an antitrust investigation of the Infectious Diseases Society of America (IDSA), the body responsible for Lyme disease diagnosis and treatment guidelines, accusing the IDSA Lyme disease panel of unduly dismissing chronic Lyme disease, among other things (Landers, 2008). The State of Connecticut later enacted a law "to allow a licensed physician to prescribe, administer, or dispense long-term antibiotics for a therapeutic purpose to a patient clinically diagnosed with Lyme disease" (Connecticut General Assembly, 2009), as did a handful of other states.

The ongoing dispute over chronic Lyme disease, associated political controversy, and high emotions have been said to contribute to a "poisonous atmosphere" around Lyme disease (Landers, 2008).

Health Department Structure

Unlike other states, Connecticut's local health departments are on the town level, where almost every town has its own health department. Data from these local health departments are shared with the Connecticut Department of Public Health, which in turn shares select data with the CDC, and which may publish reports with town-, county-, or state-level data. Whenever possible, town-level data for the 10 Greater Danbury area towns are reported in this publication. As necessary, county- or state-level data are utilized in this document.

Selected Characteristics of the Greater Danbury Area

Selected demographic characteristics of the Greater Danbury area towns are reported in Table 1. All data are from 2011. These characteristics were chosen based on their association with disease rates and/or disease severity.

Table 1 Selected demographic characteristics of the Greater Danbury area towns (Connecticut Economic Resource Center, n.d.)

Town	Total Population	Population/ Square Mile	Median Age (years)	% Under 18 Years	% 18-64 Years	% 65+ Years	% Male
Bethel	18,493	1,101	41	23.7	63.2	13.1	50.8
Bridgewater	1,790	110	50	19.7	58.9	21.4	51.2
Brookfield	16,339	825	43	22.7	63.5	13.8	47.7
Danbury	80,101	1,902	36	21.3	67.4	11.3	48.6
New Fairfield	13,847	676	41	27.8	60.3	11.9	49.8
New Milford	28,122	457	41	24.3	64.5	11.2	49.2
Newtown	27,235	472	42	27.9	59.8	12.3	50.5
Redding	9,058	287	47	25.8	56.0	18.2	49.1
Ridgefield	24,469	711	42	30.1	56.9	13.0	49.8
Sherman	3,598	165	47	25.3	57.4	17.3	46.5
Greater Danbury	**22,305**	**670**	**43**	**24.9**	**60.5**	**14.6**	**49.3**

It is evident that the Greater Danbury towns vary widely in population size, from 1,790 persons (Bridgewater) to 80,101 persons (Danbury). As the only city in the area, Danbury's population size is more than 3.5 times that of the average Greater Danbury town. Likewise, Danbury's population/square mile is significantly greater than that of its surrounding towns. Danbury's median age is comparatively lower than that of other towns, while the median age in Bridgewater, Redding, and Sherman is higher than that of other towns. Bridgewater, Redding, and Sherman also have a greater percentage of residents aged 65 years and older. New Fairfield, Newtown, and Ridgefield all have a greater percentage of residents aged less than 18 years as compared to surrounding towns.

Lyme Disease

History of Lyme Disease

Lyme disease was first discovered as a distinct clinical entity in the United States in 1975 after a cluster of children and adults residing in Lyme, Connecticut began experiencing uncommon arthritic symptoms (Connecticut Department of Public Health, 2013; Stafford, 2007). By 1977, *Ixodes scapularis* (blacklegged ticks) were found to be the vector responsible for transmission of the disease and in 1982 *Borrelia burgdorferi*, the bacterium that causes the disease, was discovered (Connecticut Department of Public Health, 2013). Serology testing became widely available in Connecticut two years later.

Beginning in 1987, all Connecticut physicians were required to report any and all cases of Lyme disease (Connecticut Department of Public Health, 2013). Four years later, cases of the disease became Nationally Notifiable. Today, Lyme disease is the seventh most common Nationally Notifiable disease (CDC, 2013i) and the most commonly reported vector-borne illness in the United States (CDC, 2013f). Furthermore, these designations largely represent cases specific to northeastern and Midwestern states; 95% of cases are reported from the 13 states comprising these regions (CDC, 2013f), including Connecticut, although cases have been reported in all 50 states.

The emergence of Lyme disease in Connecticut largely can be liked to changing landscape patterns (Connecticut Department of Public Health, 2013; Stafford, 2007). By mid-nineteenth century, once forested land was cleared for agricultural use. As such, white-tailed deer were drastically reduced, in some places to the point of virtual elimination, due to habitat loss and unregulated hunting. Through the latter half of the twentieth century, this farming land became reforested and increasingly developed for suburban residential use. The reestablishment of animal hosts enabled the increase and spread of ticks that may have survived on islands off the southern New England coast. Furthermore, the development of residential areas favored transmission of tick-borne diseases from animals to people.

Life Cycle of the Tick

I. scapularis go through four life stages: egg, six-legged larva, eight-legged nymph, and adult (CDC, 2014d). After hatching from the eggs, ticks most eat a blood meal at each of the three remaining stages to survive. It can take up to three years for a tick to complete its full life cycle. Ticks can feed on mammals, birds, reptiles, and amphibians and typically prefer to have a different host animal at each stage of their life. See Figure 4 for a depiction of the typical life cycle of an *I. scapularis* tick.

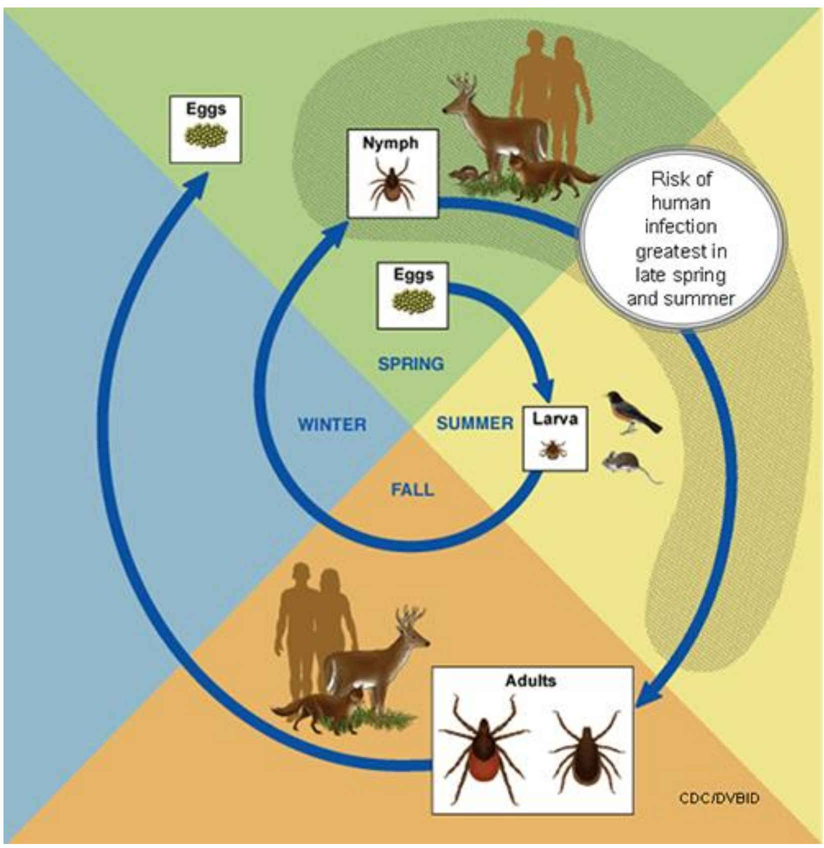

Figure 4. *I. scapularis* life cycle (CDC, 2014d)

Transmission of Lyme Disease

Human tick-bite studies have shown that only one to three percent of bites by nymphal *I. scapularis* ticks result in transmission of *B. burgdorferi*, despite a ten times higher prevalence of infection in this tick population (Shapiro et al., 1992; Sood et al., 1997). This effect is largely due to the removal of ticks before completion of feeding. Because they are larger and more likely to be found, bites from adult ticks are less likely to result in *B. burgdorferi* transmission (Falco et al., 1999). Laboratory studies have shown that nymphal *I. scapularis* do not transmit *B. burgdorferi* during their first day of feeding, rarely do so during the second day of feeding (12% probability of transmission), and efficiently do so only during and after the third day of feeding (79% probability of transmission at 72 hours; 94% at 96 hours) (Piesman, 1993; Piesman et al., 1987; Shih & Spielman, 1993).

B. burgdorferi reside in the midgut of the tick until a critical event happens during a blood meal, allowing the bacteria to disseminate and infect the salivary glands (De Silva & Fikrig, 1995). It is from here that the bacteria enter the host's bloodstream, causing infection with Lyme disease. This process generally takes at least 24 hours (Piesman et al., 1991; Piesman et al., 1987), thus the lack of transmission in the first day of feeding.

Clinical Course of Lyme Disease

Early symptoms of Lyme disease may include a characteristic red, expanding rash called erythema migrans (EM) (commonly referred to as a bull's-eye rash) at the site of the bite (Figure 5), fatigue, chills, fever, headache, muscle and joint aches, and swollen lymph nodes (CDC, 2013k). If left untreated, the infection may spread to other parts of the body, resulting in symptoms such as additional EM lesions in other areas of the body, Bell's palsy, severe headaches and neck stiffness due to meningitis, pain and swelling in the large joints, shooting pains that may interfere with sleep, and heart palpitations and dizziness due to changes in heartbeat.

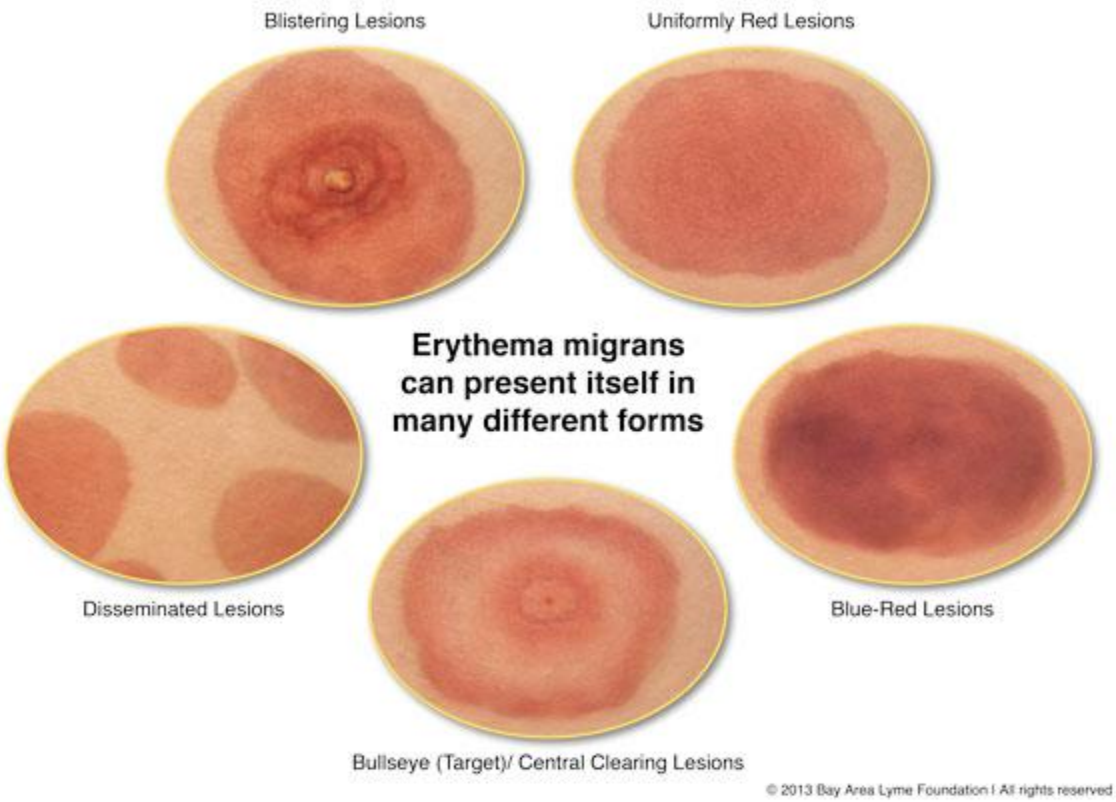

Figure 5. Erythema migrans examples (Bay Area Lyme Foundation, 2014)

Epidemiology of Lyme Disease

As introduced in the Rationale for Needs Assessment in Chapter One of this document, Lyme disease is the most commonly reported vector-borne illness in the United States (CDC, 2013f). In 2012, it was the seventh most common Nationally Notifiable disease, with over 22,000 confirmed cases and more than 8,800 probable cases reported to the CDC (CDC, 2013i).

In 2013, 2,108 confirmed cases and 810 probable cases of Lyme disease were reported in Connecticut (Connecticut Department of Public Health, n.d.). Contributing cases from each of the Greater Danbury towns are detailed in Table 2.

Table 2 Lyme disease cases and rates by town, 2013

Town	**Confirmed Cases**	**Probable Cases**	**Total Cases**	**Rate per 100,000**
Bethel	17	5	22	118.4
Bridgewater	1	0	1	57.9
Brookfield	10	3	13	79.0
Danbury	30	11	41	50.7
New Fairfield	7	4	11	79.2
New Milford	13	6	19	67.5
Newtown	27	16	43	156.0
Redding	9	4	13	142.0
Ridgefield	24	7	31	125.8
Sherman	2	1	3	83.8
Greater Danbury	**140**	**57**	**197**	**96.0**
Connecticut	2,108	810	2,918	81.6

It is evident that the incidence of Lyme disease is higher in the Greater Danbury area than in the State of Connecticut overall. This effect is largely driven by particularly high rates in four towns: Bethel, Newtown, Redding, and Ridgefield. Danbury is the only city in the region; its urbanization likely contributes to the lower rate of disease as compared to surrounding towns and the State.

It has long been recognized that surveillance data are subject to limitations. Studies published in 1990's indicated that the true number of Lyme disease cases was likely between 3- and 12-fold higher than the number of reported cases (CDC, 2013d). The CDC recently embarked on three complimentary studies in an attempt to better estimate the burden of Lyme disease (CDC, 2013d; CDC, 2013e):

- Project 1 estimates the number of people diagnosed with Lyme disease based on medical claims information from a large insurance database;
- Project 2 estimates the number of people who test positive for Lyme disease based on data obtained from a survey of clinical laboratories; and
- Project 3 uses survey data to estimate the number of people who report that they've been diagnosed with Lyme disease in the previous year.

Preliminary results from each of the three studies suggest that the incidence of Lyme disease each year in the United States is approximately ten times what is reported, totaling approximately 300,000 cases per year. These preliminary results mirror the geographic distribution of cases that is shown by national surveillance efforts.

Lyme disease patient ages follow a bimodal distribution, with most cases occurring among persons aged five to 14 years and 45-54 years (CDC, 2007). Males are disproportionately affected by Lyme disease. Between 2003 and 2005, males accounted for 54% of reported cases overall and 61% of cases among children aged five to 14 years. During the first 15 years of national reporting, these trends were consistently seen, although rates of disease increased disproportionately among young males compared to young females; the reasons for this difference are not known (CDC, 2008).

Costs of Lyme Disease

Costs associated with Lyme disease vary widely depending on disease severity. *Healthy People 2010* reported that "A typical case of Lyme disease diagnosed in the early stages incurs about $174 in direct medical treatment costs. Delayed diagnosis and treatment, however, can result in complications that cost from $2,228 to $6,724 per patient in direct medical costs in the first year alone" (U.S. Department of Health and Human Services, n.d.). However, on January 18, 2013 the Food and Drug Administration (FDA) reported a shortage of doxycycline, (CDC, 2014b) the recommended therapy for Lyme disease in adults and children over eight and for anaplasmosis in patients of all ages (CDC, 2014l). This shortage caused a reported 6,000 percent increase in cost of the medication (Katz, 2013). Although the FDA placed doxycycline on the resolved drug shortage list as of October 23, 2013, (CDC, 2014b) at the time of publication of this document there was no associated drop in price of doxycycline. Therefore, direct medical treatment costs of Lyme disease are expected to be significantly higher than those reported in *Healthy People 2010*. A recent CDC-supported study of direct, indirect, and nonmedical costs and expenses estimated that each case of Lyme disease may be as high as $8,000 (Zhang et al., 2006).

Healthy People 2010

Healthy People 2010's objective 14-8 was to reduce incident Lyme disease cases to 9.7 per 100,000 persons in endemic states (U.S. Department of Health and Human Services, n.d.). Of note, this was the first time that Lyme disease reduction was included as a defined public health objective; inclusion of this objective speaks to the significant magnitude and severity of the disease. This target was derived from a baseline of 17.4 cases per 100,000 persons reported to the CDC between 1992 and 1996 and was "established in anticipation of widespread use of a Lyme disease vaccine, licensed in 1999" (LYMErix™, manufactured by SmithKline Beecham, now called GlaxoSmithKline) (CDC, 2007). New initiatives to prevent Lyme disease were planned to include the implementation of community-based prevention programs, host-target acaricides to reduce the numbers of vector ticks, and appropriate use of the Lyme disease vaccine

(U.S. Department of Health and Human Services, n.d.). However, the vaccine was withdrawn from the market by the manufacturer in 2002 (CDC, 2007). Citing dependency on the availability of a vaccine, the objective was archived (CDC, n.d.) and no mention of Lyme disease is made in *Healthy People 2020*. By 2008, the average Lyme disease incidence in endemic states increased by 188% from 17.4 cases per 100,000 persons to 50.1 cases per 100,000 persons. In the same year, the incidence of Lyme disease in Connecticut was 78.2 cases per 100,000 (CDC, 2013g).

History of the Lyme Disease Vaccine

With the support of advocacy groups and research funding provided in response to concerns about Lyme disease, three candidate Lyme disease vaccines were developed approximately 15 years ago (Van Hoecke et al., 1996). Of these, two were pursued through clinical trials (Poland, 2011). LYMErix, manufactured by SmithKline Beecham (now called GlaxoSmithKline), was administered intramuscularly as a three-dose series at 0, 1, and 12 months in a phase III clinical trial involving 10,906 individuals aged 15-70 years of age (Steare et al. 1998). Participants were observed for one year, during which time no significant adverse effects were reported. Vaccine efficacy after three doses was 76% (95% confidence interval [CI], 59%-86%) against symptomatic disease and 100% (95% CI, 26%-100%) against asymptomatic disease. Of note, vaccine recipients reported a greater prevalence of local reactions, systematic reactions, and transient arthralgias than did placebo recipients.

In May of 1998, an FDA panel met to review LYMErix after concerns were raised about the vaccine's potential safety (Poland, 2011). The panel concluded that the vaccine did not protect against Lyme disease, as other *B. burgdorferi* subspecies exist outside the United States and full protection did not come into effect until one year after the start of the vaccine series. Concerns were also raised about the cost-effectiveness of the vaccine, the lack of long-term safety data, the lack of data to determine whether booster doses might be necessary, the inability to use the vaccine in young children (who are at highest risk for the disease), the fact that immunized individuals would test positive by enzyme-linked immunosorbent assay (ELISA) for antibody to Lyme disease (which could be confusing to clinicians), and a possible relationship to autoimmune arthritis. Yet, after discussion of these concerns, the panel gave unanimous support for licensure of LYMErix. The vaccine was released in December 1998.

The Advisory Committee on Immunization Practices (ACIP) of the CDC gave a permissive recommendation for the use of LYMErix in persons aged 15-70 who lived or worked in *B. burgdorferi*-infected woody and grassy areas (CDC, 1999). Problems with these recommendations included the fact that neither physicians nor patients were likely to be able to effectively or precisely estimate an individual or personal risk for tick exposure as well as a lack of geographic data on tick populations and density in a given area (Poland, 2011).

After a series of articles investigating the possibility that the vaccine itself could cause arthritis in certain vaccine recipients were published, significant media coverage and the development of anti-Lyme vaccine groups, and a number of class action lawsuits ensued (Poland, 2011). As a result, an FDA panel was convened in January 2001 to further review the alleged safety concerns. The panel concluded there was no evidence of an association between LYMErix and arthritis and that the benefits of vaccination outweighed the theoretical risks. Even so, the panel requested a phase IV safety study. Some 2,568 vaccinated participants and 7,497 control participants were enrolled in this study, which found no differences in adverse reactions between the study groups. Furthermore, a retrospective study of the vaccine adverse events reporting system (VAERS) database found the arthritis incidence of vaccinated persons was not different than the background rate among unvaccinated persons and that there was no evidence of a dose-response relationship (Lathrop et al., 2002).

Despite these studies suggesting relative safety of LYMErix, the public perception of the vaccine seemed to be irreparably damaged. Because of the hypothesis of molecular mimicry and autoimmune responses to the vaccine, anti-vaccine sentiment and class action lawsuits, a complicated vaccine administration schedule, diminishing physician support for the vaccine, and low public demand for the vaccine, the manufacturer voluntarily removed LYMErix from the market in 2002 (Poland, 2011). This marked the first time in the modern era than an FDA-licensed vaccine was withdrawn because of low public demand and lawsuits, despite the continuing significant public health burden of the disease.

Pasteur Merieux Connaught was the other company with a Lyme disease vaccine in clinical trials around the turn of the millennium (Poland, 2011). Despite efficacy in their phase III clinical trial, Pasteur Merieux Connaught decided against pursuing a biologic license application for its own vaccine candidate given the events experienced by SmithKline Beecham. Today there are no vaccines available to prevent Lyme disease, although early clinical trials are underway for at least one new candidate (Clinicaltrials.gov, 2014). Recently published results of a phase I/II trial indicated that the vaccine is well-tolerated and immunogenic in individuals previously infected with *B. burgdorferi* (Wressnigg et al., 2014). However, it seems unlikely that a vaccine will be developed and licensed in the near future. Unfortunately, this is not due to a lack of interest, but because of the precedent set by LYMErix's failure in the court of public opinion (The College of Physicians of Philadelphia, 2014). The consequence of the lack of a vaccine against Lyme disease is the continuing, increasing, significant morbidity and cost related to disease, both at the public health and individual levels (Poland, 2011).

Anaplasmosis

Clinical Course of Anaplasmosis

Symptoms of anaplasmosis may include fever, headache, muscle pain, malaise, chills, nausea, abdominal pain, cough, confusion, and, rarely, rash (CDC, 2013b). While patients who are treated early may recover quickly on outpatient medication, anaplasmosis can be fatal if not treated correctly, even in previously healthy people. Severe clinical presentations may include difficulty breathing, hemorrhage, renal failure, and neurological problems. The estimated case fatality rate is less than 1%.

Epidemiology of Anaplasmosis

Since becoming a reportable disease in the United States in 1999, the number of reported anaplasmosis cases has increased steadily, from 348 cases in 2000 to 1,761 cases in 2010 (CDC, 2013a). The incidence has also increased, from 1.4 cases per million persons in 2000 to 6.1 cases per million persons in 2010. Between 2001 and 2010, the Connecticut Department of Public Health received 7,439 reports of positive anaplasmosis tests (Connecticut Department of Public Health, 2011). Of these, 366 (5%) were classified as confirmed and 1,227 (16%) as probable cases. The average annual number of confirmed and probable cases was 37 and 123, respectively. The remaining 79% of reports either contained information that did not satisfy surveillance criteria or that was insufficient for case classification.

Statewide, the average annual incidence of anaplasmosis between 2001 and 2010 was 1.0 case per 100,000 persons (Connecticut Department of Public Health, 2011). Both Litchfield and Fairfield Counties exhibited rates higher than the state average, as 2.8 and 1.2 cases per 100,000 persons, respectively. Town-level data for anaplasmosis cases are not readily available.

Of the confirmed cases in Connecticut between 2001 and 2010, the ages of patients ranged from 2 to 88 years (mean = 54) (Connecticut Department of Public Health, 2011). Unlike the age distribution for Lyme disease cases, age-specific confirmed case rates were highest among those ≥ 60 years of age (2.3 cases per 100,000 persons), and lowest for children ≤ 9 years (0.2 cases per 100,000 persons). Similar to the effect seen with Lyme disease, males accounted for 59% of anaplasmosis cases in the state.

Babesiosis

Clinical Course of Babesiosis

Not all patients with babesiosis experience any symptoms (CDC, 2014h). In the case of asymptomatic patients, it is not necessary to treat for babesiosis. Other patients develop symptoms such as fever, chills, sweats, headache, malaise, loss of appetite, nausea, and fatigue. Because *Babesia* parasites infect and destroy red blood cells, babesiosis may also cause hemolytic anemia, leading to jaundice and dark urine. Complications of babesiosis may include low and unstable blood pressure; thrombocytopenia (very low platelet count); disseminated intravascular coagulation, which can lead to blood clots and bleeding; and malfunction of vital organs. Babesiosis can be a life-threatening disease, particularly in immunocompromised individuals. Among this population, the fatality rate is approximately 20%, even with appropriate antibiotic treatment (Columbia University Medical Center, n.d.).

Epidemiology of Babesiosis

Within the United States, tick-borne transmission of babesiosis is most common transmission method, although babesiosis may also be transmitted via blood transfusion and rare cases of congenital transmission have been reported (CDC, 2014i). Among the 22 states where babesiosis is reportable, the Centers for Disease Control and Prevention was notified of 911 cases in 2012 (CDC, 2014h). All of these cases were reported in just 14 of the 22 states, with 95% of these cases being reported by seven states: Connecticut, Massachusetts, Minnesota, New Jersey, New York, Rhode Island, and Wisconsin.

Of babesiosis cases reported in 2012, the ages of patients ranged from less than 1 year to 98 years (median = 62) (CDC, 2014h). Much like anaplasmosis, 63% of babesiosis cases were male.

State, county, and town-level data were not available at the time of publication of this document, likely due to the very recent nature of reporting initiation.

Tick-Borne Disease Prevention Practices

Given the lack of pharmacologic tick-borne disease prevention method, risk management focuses on reducing the likelihood of tick bites. This section explores potential tick-borne disease prevention practices and their evidence base, or lack thereof. In the case of some interventions, evidence has not supported their effectiveness but likely because of a lack of better alternatives, perceived effectiveness, ease of implementation, and free or low cost, these methods are still suggested by respected bodies (Macauda, 2007).

Personal prevention methods include: avoiding areas with a high density of ticks, wearing protective clothing, application of tick repellents, checking the body, bathing, and proper removal of ticks in the case of a tick bite. Potential peridomestic measures include: lawn maintenance, use of a wood chip or gravel barrier between lawns and wooded areas, pesticide application to the lawn, use of fencing, and use of rodent bait boxes. Associated community measures may also include deer control and application of acaricides to deer.

In all cases, the choices about which prevention methods to use should be considered in the context of the individual, household, and/or community. In particular, the use of chemical pesticides and acaricides as well as deer control may be controversial. This document does not intend to suggest that all methods detailed below are appropriate for all individuals.

Outdoor Work and Leisurely Activities

Because ticks prefer cool, damp habitats, it is recommended that brushy areas, tall grasses, and leaf litter are avoided whenever possible (CDC, 2011a; CDC, 2012b). Likewise, one should walk in the center of trails when hiking. Gardening for greater than four hours per week, using trails for greater than five hours per week, sitting on logs and resting against trees in forests, and collecting firewood have all been identified as significant risk factors for exposure to ticks (Smith et al., 2001) and Lyme disease (Ley et al., 1995). People engaging in these behaviors should be particularly vigilant about tick-borne disease prevention efforts.

Clothing

When engaging in activities in potential tick habitats, the CDC recommends wearing light-colored long-sleeved shirts, long pants, socks, and a hat when possible (CDC, 2011a), though results of previous studies have yielded varying results with regard to the effectiveness of these measures (Connally et al., 2009; Smith et al., 2001; Vazquez et al., 2008). Clothes should be removed after being outdoors and should be dried on high heat for one hour to kill any ticks crawling on them (CDC, 2011a).

Tick Checks and Bathing

Daily tick checks are integral to tick-borne disease prevention (CDC, 2011a; Connally et al., 2009). Showering or bathing as soon as possible after being outdoors is recommended; not only will this wash away any ticks that may be crawling on the skin, but it will also allow for more thorough checking of areas such as the underarms, groin, and hair (all of which are areas in which ticks typically attach). One study found that people who did not contract Lyme disease were nearly twice as likely to shower or bathe within two hours of spending time in their yards as compared to those who did get Lyme disease (Connally et al., 2009). Care should also be taken to examine in and around the ears, inside the belly button, behind the knees, and around the waist (CDC, 2012b). Multiple studies have shown that tick checks were performed more frequently amongst people who did not get Lyme disease than those who did get the disease (Connally et al., 2009; Orloski et al., 1998; Smith et al., 2001).

Tick Removal

If a tick is found to be attached, it is important to remove the tick immediately (CDC, 2011a). Using fine-tipped tweezers one should grasp the tick firmly as close to the skin as possible and pull straight out in a steady motion (Figure 6). The area should be cleaned with rubbing alcohol or soap and water and should be watched for approximately one month for any signs of rash. Because it generally takes at least 24 hours for an infected tick to transmit *B. burgdorferi* (Piesman et al., 1991; Piesman et al., 1987), immediate removal is of paramount importance. Therefore, folklore methods designed to cause the tick to release itself, including the use of heat, petroleum jelly, and nail polish, should not be employed. Use of these methods, or other irritation of the tick, could cause it to regurgitate the contents of its midgut, thereby increasing the changes of disease transmission.

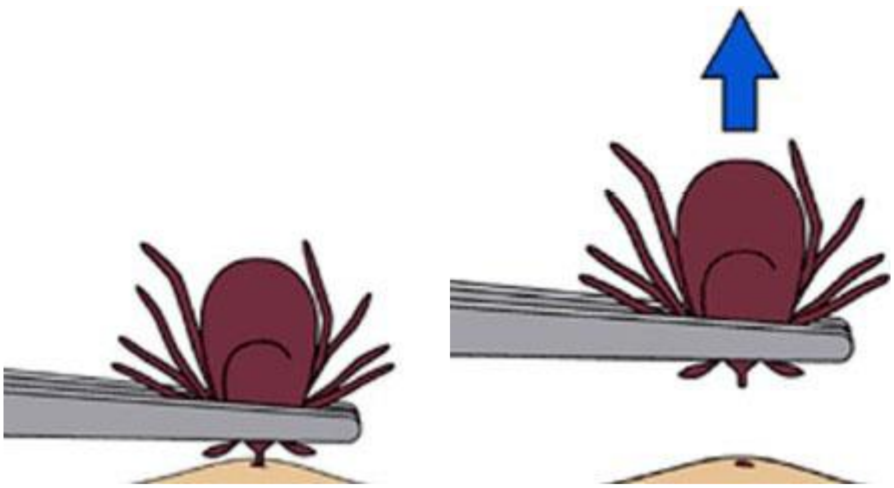

Figure 6. Tick removal (CDC, 2014k)

Lyme Disease Prophylaxis

For prevention of Lyme disease after a recognized tick bite, the IDSA does not recommend routine use of antimicrobial prophylaxis or serologic testing (Wormser et al., 2006). However, they do suggest that a single dose of doxycycline may be offered to adults and children over eight years of age when *all* of the following circumstances are met: 1) the attached tick can be reliably identified as an adult or nymphal *I. scapularis* tick that is believed to have been attached for at least 36 hours based on engorgement; 2) prophylaxis can be started within 72 hours of the time the tick was removed; 3) Lyme disease is endemic in the area (*B. burgdorferi* infection rate is at least 20%); and 4) doxycycline treatment is not contraindicated. Amoxicillin should not be substituted for doxycycline in persons for whom doxycycline is contraindicated. Antibiotic treatment following a tick bite is not recommended as a means to prevent anaplasmosis or babesiosis.

Personal-Use Repellents

Repellents are substances which induce a movement of the tick (and other arthropods) away from the host, thereby preventing the tick from successfully biting the host (Cisak, 2012). The registered and recommended active repellent ingredients for application to the skin and/or clothing include: N,N-diethyl-m-toluamide (DEET), 1-methyl-propyl-2-(hydroxyetyl)-1-piperidinecarboxylate (picaridin), p-menthan-3,8-diol (PMD), ethyl butylactyloaminopropiionate (IR3535), iS,2S-2-methylpiperidinyl-3-cyclohexane-1-carboxamide (SS220), racemic 2-methylpoperidinyl-3-cyclohexane-1-carboxamide (AI3-37220), and synthetic pyrethroid – 3-phenoxybenzyl-cis-trans-3(2,2 dichlorovinyl)-2,2-dimethylcyclopropancarboxylate (permethrin).

DEET

The current standard and most efficient general arthropod repellent is DEET (Cisak, 2012; Lupi et al., 2013; Stafford, 2007). DEET repels ticks, mosquitoes, fleas, biting flies, and chiggers and is available in products of many forms, such as lotions, creams, gels, aerosols, pump sprays, and towelettes. Repellents containing DEET are considered safe; rare toxic reactions such as dermatitis, allergic reactions, neurologic and cardiovascular side effects, and encephalopathy have been described, largely as a result of inappropriate use of the repellent (Lupi et al., 2013). The Environmental Protection Agency (EPA) conducted a review of DEET and believes that normal use of DEET does not present a health concern to the general public when used according to label directions (Stafford, 2007). The American Academy of Pediatrics and the CDC recommend use of products containing DEET in children as young as two months of age (American Academy of Pediatrics, 2014). DEET should be used with precaution, as it may damage fabrics such as spandex, rayon, acetate and pigmented leather, and can dissolve plastic and vinyl.

Up to a certain concentration, DEET exhibits a dose-dependent relationship where higher concentration is associated with longer protection (Lupi et al., 2013). DEET 20-25% is the conventional concentration used in commercial products; at least 20% is recommended for repellent of ticks (CDC, 2011a; CDC, 2012b). Such products should be reapplied every two to five hours (Lupi et al., 2013).

Icaridin

Icaridin, also known as Picaridin, has been widely used as a mosquito repellent; while few studies have been conducted on its protection from tick bites, Icaridin is also used as a tick repellent (Lupi et al., 2013). Icaridin is odorless, non-sticky or greasy, and does not damage plastic or fabric. No adverse toxic reactions have been recorded in animal studies. Protection time against mosquitoes varies widely based on species (generally one to six hours); protection time against ticks is unknown.

Permethrin

Currently, the most effective and widely-used tick repellent is treatment of clothing with acaricides, particularly permethrin (Roma et al., 2009). The CDC recommends use of repellents containing 0.5% permethrin on clothing (CDC, 2011a; CDC, 2012b). The most commonly used form of self-applied permethrin for clothing treatment is a self-applied permethrin aerosol spray (Vaughn et al., 2014). Appropriate application can provide nearly 100% protection against questing ticks (Evans et al., 1990; Jordan et al., 2012; Schreck et al., 1986). However, this high rate of protection is not sustained over long periods of wear or multiple washings; self-applied spray and dipping methods lose effectiveness unless reapplied every three to five washes (Schreck et al., 1982; Lane, 1989).

In contrast, a factory-based method for long-lasting permethrin impregnation of textiles has been shown to retain tick-repellent activity over 70 washes (Insect Shield, n.d.; U.S. Environmental Protection Agency, n.d.). In a double-blind randomized controlled trial of this factory-based treatment of uniforms among workers from North Carolina State Divisions of Forestry, Parks and Recreation, and Wildlife, tick bites were reduced by greater than 80% in the first year of wear (Vaughn et al., 2014). Another study showed that permethrin-treated socks were particularly effective in preventing tick bites (Miller et al., 2011). In fact, subjects wearing permethrin-treated sneakers and socks were 73.6 times less likely to have a tick bite than subjects wearing untreated footwear; subjects wearing permethrin-treated shorts and t-shirts were 4.74 and 2.17 times, respectively, less likely to have a tick bite them in areas related to those garments than subjects wearing untreated clothing (Millner et al.,2011). Pages et al. (2014) further suggest that factory impregnated clothing should be preferred over self-application given that permethrin is toxic for the environment. Studies have not yet been conducted to examine the direct relationship between permethrin use and tick-borne disease incidence.

Permethrin should be applied to clothing and fabric only; not to skin. Permethrin can cause mild skin and eye irritation, although reactions appear to be uncommon (Stafford, 2007). Permethrin has a relatively low mammalian toxicity; it is poorly absorbed through the skin and is quickly metabolized and excreted by the body. As a note of caution, however, the EPA does list permethrin as a potential carcinogen.

Natural Repellents

Despite their effectiveness, increasing concerns regarding development of acaricide resistance and environmental safety issues call for other, less aggressive but equally effective tick bite prevention methods (Cisak, 2012). These concerns have driven the study of natural insect repellents (Amer & Mehlhorn, 2006). *Eucalyptus citriodora*, *Corymbia citriodora*, P-menthane-3,8-diol (PMD), for example, is derived from lemon-scented eucalyptus (Lupi et al., 2013). It has a low volatility and has a longer protection time compared to other plant-derived compounds (Barasa et al., 2002). Only one study has been conducted on the use of a Citriodiol formulation against *Ixodes*, though this study was done in a subspecies other than *I. scapularis* (Semmler et al., 2011). In this study, PMD provided two to three hours of protection, while another formula that also contained *Vitex agnus castus* extracts provided five to six hours of protection.

Dodecanoic acid (DDA) is a carboxylic acid derived from coconut oil or palm kernel oil (Pages et al., 2014). One study found that 10% DDA exhibited 6 hours of 80-100% repellency, as compared to picaridin. 11 carbon methyl ketone, 2 undecanone, an active ingredient derived from wild tomato plants, was similarly found to have an equivalent repellency of 98.11% DEET against *I. scapularis*, among other tick species. Also found to be effective against *I. scapularis* in laboratory studies were dihydronepetalactone, an active compound isolated from the essential oil of Catmint, as well as isolongifolenone, a sesquiterpene isolated from the pine tree.

Landscaping and Lawn Care

As referenced above, ticks prefer cool, damp habitats and typically reside in tall grasses and brushy areas. Therefore, the CDC recommends clearing tall grasses and brush around homes, mowing lawns frequently, and keeping leaves raked (CDC, 2011b; Stafford, 2007). Also recommended is placing a three-foot wide barrier of wood chips or gravel between lawns and wooded areas, thereby restricting tick migration into recreational areas (Figure 7). Similarly, keep playground equipment, decks, and patios away from yard edges and trees; place them in a sunny location, if possible. To discourage habitation by rodents that ticks feed on, stack wood neatly in a dry area; also remove any old furniture, mattresses, or trash from the yard.

Studies have shown that even one application of pesticide in the appropriate locations of the yard at the appropriate time of year can reduce tick populations by 85-90% (Curran et al., 1993; Stafford, 1991; Stafford, 1997). Options are available for professional application or homeowner application. These pesticides have been approved for safety and efficacy if applied appropriately. A listing of acaricides with products labeled for the control of ticks in the residential landscape may be found in the Tick Management Handbook (Stafford, 2007).

Figure 7. Suggested landscaping to reduce tick exposure (Stafford, 2007)

Deer-Related Measures

White-tailed deer (*Odocoileus virginianus*) are important hoses for adult blacklegged ticks seeking blood meals (Grear et al., 2014). Numerous researchers have correlated tick abundance with deer abundance (Rand et al., 2003; Stafford et al., 2003). However, there is considerable uncertainty about the impact of deer abundance on Lyme disease risk (Grear et al., 2014); yet despite this, the overabundance of deer in the eastern United States is frequently assumed to be a significant determinant of Lyme disease (Spielman et al., 1985).

Deer Density Control

Several studies have documented the impact of reduced deer density on blacklegged tick activity (Kilpatrick et al., 2014), although it is unclear how low deer densities must be to sufficiently reduce the incidence of human tick-borne disease. A 13-year study of one Connecticut community found that reducing deer density to 5.1 deer per square kilometer resulted in a 76% reduction in tick abundance and an 80% reduction in resident-reported cases of Lyme disease (Kilpatrick et al., 2014). However, another study found no effect of deer reduction to 3.8 deer per square kilometer on EM rash incidence (Garnett et al., 2011). There is still little consensus on the feasibility or effectiveness of specific management techniques for deer population control (Brown et al., 2000). Factors such as limited hunter access to deer habitat, movements of deer from adjacent areas, and acceptability of the intervention to the public are potential barriers to success and all must be considered. Furthermore, deer capacity for reproduction is high; management would be an ongoing process (Stafford, 2007).

4-Posters

An alternative (or supplement) to direct population control is the use of deer-targeted pesticide application via “4-poster” feeding stations to control tick populations (Grear et al., 2014). These 4-posters are corn-baited deer feeding stations with four pesticide-treated rollers that surround the bait troughs (Figure 8). Visitors to these stations receive an automatic topical application of acaricide, which kills ticks before they can reproduce. The impacts of 4-posters include direct mortality to larvae or nymphs attached to 4-poster deer visitors and reduced numbers of eggs due to reductions in adult populations. Several studies have found reductions in tick abundance (Grear et al., 2014; Carroll et al., 2009; Pound et al., 2009) as well as a reduced EM rash incidence (Garnett et al., 2011).

Figure 8. 4-poster deer treatment bait station (American Lyme Disease Foundation, 2010)

Fencing

The presence of any type of fence, including short fences, those that do not entirely enclose the yard, and split-rail fences, has been associated with reduced risk for tick-borne disease (Connally et al., 2009). Hypotheses for the cause of this association include the presence of any barrier being sufficient to reduce the number of deer visiting the property and the possibility that fences keep people away from wooded areas, thus lowering risk of tick exposure, among others. It should be noted, however, that a deer fence does not stop small animal movement and tick movement (Stafford, 2007).

Rodent-Related Measures

Rodent Vaccination

During development for human use, a vaccine was extensively tested in mice and was shown to protect mice from Lyme disease (Scheckelhoff et al., 2006). Therefore, an orally available delivery system for a vaccine that would be suitable for field use in vaccinating mice is of interest to interrupt transmission of the disease. Scheckelhoff et al. (2006) have developed such a single-dose vaccine that reportedly delivered 100% protection of vaccinated mice from infection with *B. burgdorferi* and significant clearance of *B. burgdorferi* from infected ticks fed on vaccinate animals.

Telford et al. (2011) went on to develop candidate bait preparations that were designed to be environmentally stable, attractive to mice, and non-nutritive. They determined that a peanut butter-scented hardened bait placed within simple wood nest boxes would effectively deliver vaccine to mice. However, no commercial product is currently available.

Pesticide Application

Another potential method to interrupt disease transmission includes the application of pesticide application to mice, much like 4-posters are used for deer. The CDC, along with the Connecticut Emerging Infections Program, the Connecticut Department of Public Health, and Western Connecticut State University, is currently involved in a study investigating whether tick-borne diseases can be prevented with the use of commercially available SELECT TCS Tick Control System bait boxes (Figure 9) (CDC, 2013c). These bait boxes contain a bait that is attractive to mice, along with a pesticide-soaked wick. As mice enter the box, the wick lightly brushes the mouse and applies a small amount of low-dose fipronil, an EPA-registered pesticide that is effective against ticks.

Figure 9. Mouse bait box (CDC, 2013c)

Other commercially available products, such as Damminix Tick Tubes (Brookline, Massachusetts), for example, use cardboard tubes filled with permethrin-treated cotton balls (Damminix Tick Tubes, n.d.). Mice collect these cotton balls to build their nests, and ticks that feed on these mice are exposed to the permethrin and die, thereby reducing human exposure to the ticks. Studies in Connecticut and New York failed to show any reduction in the number of infected *I. scapularis* nymphs when these tubes were used for a three-year period in areas of four acres of less (Stafford, 2007). However, a Massachusetts study of an 18-acre tract did report reductions in tick numbers.

Tick Control in Pets

Ticks do not only cause disease among humans; dogs and cats can contract Lyme disease as well. While pets cannot transmit tick-borne diseases to humans, pets can bring ticks into the home, thereby increasing a person's chance of tick encounter. In fact, one study demonstrated an increased incidence of Lyme disease among dog and cat owners (Wormser et al., 2006). Therefore, it is important to use a tick preventive product on dogs (CDC, 2011c). Cats are extremely sensitive to a variety of chemicals; therefore acaricides or insect repellents should not be used on cats without first consulting a veterinarian. One should also check pets for ticks daily, especially after time spent outdoors.

Summary of the Current Problem and Study Relevance

This chapter has demonstrated the effects of tick-borne disease on public health and has detailed the many, varied options for tick-borne disease prevention. As the body of evidence about the efficacy of prevention methods expands, however, there continues to be a dearth of information about which methods people are choosing to utilize, why those methods are chosen, and why others do not receive widespread acceptance by the public. Therefore, this assessment seeks to investigate current use of and barriers to tick-borne disease prevention practices.

Summary

- Risk management for tick-borne diseases focuses on reducing the likelihood of tick bites.
- Personal prevention methods include:
    - Avoiding areas with a high density of ticks,
    - Wearing protective clothing such as long sleeves and long pants,
    - Application of tick repellents such as DEET (for use on skin) or permethrin (for use on clothing),
    - Performing tick checks,
    - Bathing or showering within two hours of being outdoors,
    - Proper removal of ticks with fine-tipped tweezers in the case of a tick bite,
    - And prophylactic treatment for Lyme disease.
- Peridomesic prevention measures include:
    - Lawn maintenance,
    - Use of a wood chip or gravel barrier between lawns and wooded areas,
    - Pesticide application to the lawn,
    - Use of fencing,
    - And the use of rodent bait boxes.
- Community prevention measures may include:
    - Deer control and
    - Application of acaricides to deer.

CHAPTER 3: METHODOLOGY

Primary methodologies for this needs assessment included interviews with key informants; surveys of key populations; and an in-depth environmental scan of peer-reviewed literature, state and local health department reports, and information from respected health organizations such as the CDC. Recommendations derived from this needs assessment are meant to be comprehensive and should be tailored locally to each social ecological level within the Greater Danbury community.

Research Design

Interviews

To gain a multidimensional perspective about tick-borne disease prevention practices and available resources, semi-structured interviews were conducted with key informants, including the Directors of Health for each of the 10 Greater Danbury towns as well as the heads of local programs involved in tick-borne disease prevention (Appendix A). Whenever possible, interviews were conducted in-person at participants' offices. When this was not feasible, interviews were conducted over the phone. These individuals were identified as key informants given their involvement in tick-borne disease prevention and frequent interaction with the larger public.

All interviews were recorded, transcribed, and summarized. A deductive approach to content analysis was utilized. That is, a pre-defined structure was used to analyze interview transcripts. This approach was chosen given that probable participant responses were identified prior to the initiation of data collection and interviews were utilized to explore common functions of tick-borne disease prevention. Themes were identified and are reported in Chapter Four.

Physician Survey

A physician survey was designed to elucidate local primary care providers' current practices and beliefs related to tick-borne disease prevention counseling and awareness of tick-borne disease prevention resources (Appendix B). The design of this survey was informed by preceding brief interviews with a small convenience sample of local primary care providers. Primary care providers are involved in health promotion, disease prevention, and patient education and therefore can be integral to tick-borne disease prevention efforts. Given the ever-growing strain on primary care providers, however, it is unknown whether providers focus on tick-borne diseases with patients. Inclusion of physicians' points-of-view was designed to complement the perspective shared by public health officials.

Western Connecticut Health Network (WCHN) is the primary health system responsible for serving the Greater Danbury area and beyond. Therefore, the WCHN Find-A-Doc service was used to identify 158 pediatric, family medicine, and internal medicine outpatient physicians affiliated with the Network. The survey was distributed to these 158 physicians utilizing a SurveyMonkey (Palo Alto, California) link sent via e-mail three times between July 2014 and August 2014. Responses were collected anonymously. All data are reported using descriptive statistics.

The Emory University Institutional Review Board (IRB) determined that this portion of the study did not require IRB review because it does not meet the definition of "clinical investigation" as set forth in Emory policies and procedures and federal rules.

Public Survey

There is, of course, no substitute for seeking information about public health practices and barriers directly from the public. Therefore a survey was designed to investigate the general public's knowledge about endemic tick-borne diseases, current tick-borne disease prevention practices, and beliefs about tick-borne disease prevention efficacy and burdensomeness (Appendix C). This survey was informed by several existing surveys described in the literature and was largely modeled after three surveys that previously were well described in the literature (Valente et al., 2014; Gould et al., 2008; Beaujean et al., 2013).

Participants were identified at local health fairs and similar community events. Only those individuals under the age of 18 were excluded from survey participation. Responses were collected anonymously. All data are reported using descriptive statistics.

The Biomedical Research Alliance of New York (BRANY) Institutional Review Board, the IRB utilized by WCHN, determined this portion of the study to be exempt from IRB review, under category #2, as detailed in 45 CFR 46.101(b) and the BRANY Standard Operating Procedures.

Environmental Scan

A series of PubMed and Google Scholar searches using combinations of the following search terms were conducted to obtain peer-reviewed articles related to tick-borne disease rates and tick-borne disease prevention practices:

Acaricide	Deer	Pesticide
Anaplasmosis	Education	Prevention
Babesiosis	Fence	Prophylaxis
Bait box	Icaridin	Repellent
Bathing	*Ixodes scapularis*	Tick
Blacklegged tick	Landscape	Tick check
Blumenthal	Lyme disease	Tick-borne disease
Borrelia burgdorferi	LYMErix	Transmission
Chronic	Mice	Treatment
Connecticut	Peridomestic	Vaccine
Cost	Permethrin	
DEET	Personal	

All results were limited to English-language articles. Articles related to tick-borne disease prevention methods in other countries were excluded, unless they were transferrable to practices within the United States.

The Connecticut Department of Public Health and CDC websites were also reviewed for tick-borne disease rates and other pertinent information.

Limitations

In its attempt to include a wide variety of perspectives, this work is subject to several limitations. Interviewees were selected based on the author's knowledge of existing local programs and resources. While attempts to identify additional resources did not reveal further programs of interest, it is possible that such resources may in fact exist. For instance, individuals with a particular interest in tick-borne disease prevention may operate on a small scale and would not be identified through online searches. The use of a deductive approach to interview analysis is also a limitation in that it is inflexible and the analysis process may have been biased, as the coding framework was decided in advance. This may have limited theme and theory development.

Where surveys were used to gather information from a large number of physicians and members of the general public, the additional use of interviews or focus groups would have been beneficial to gain further insight. However, time and other resources, as well as the limited availability of physicians, inhibited the ability to utilize a mixed methods approach. Resource restrictions similarly limited the public survey in that a sufficiently large, representative sample of the general public was not deemed to be readily attainable. Instead, a sampling of health fair and similar local event participants was used to elucidate the knowledge and opinions of likely health-conscious individuals. Although these events were held in the Greater Danbury area, not all survey completers reside in one of the 10 Greater Danbury towns.

Overall, this assessment is limited in that its findings are applicable only to Greater Danbury and are not generalizable to other areas of the state, country, or world in which tick-borne diseases are endemic.

Summary

- Interviews were conducted with local Directors of Health and heads of local programs involved in tick-borne disease prevention to gain a multidimensional perspective about tick-borne disease prevention practices and available resources.
- Surveys were conducted among primary care physicians to investigate their current practices and beliefs related to tick-borne disease prevention counseling and awareness of tick-borne disease prevention resources.
- Members of the public were also surveyed to elucidate their knowledge about endemic tick-borne diseases, current tick-borne disease prevention practices, and beliefs about tick-borne disease prevention efficacy and burdensomeness.

CHAPTER 4: RESULTS

To understand fully the unique perspective of tick-borne diseases in Greater Danbury, this chapter will summarize interviews with key informants, followed by a presentation of the findings of the public and physician surveys. This chapter will attempt to answer the following questions:

- What obstacles must be overcome to prevent tick-borne diseases in Greater Danbury?
  - What are Greater Danbury residents' perceptions, attitudes, and beliefs about the burden of tick-borne diseases and about tick-borne disease prevention?
- What resources are currently available to promote prevention of tick-borne diseases in Greater Danbury?

Interview Findings

All but one of the Directors of Health reported that tick-borne diseases are of major concern to residents and that tick-borne disease prevention is a priority area for their Health Department. For one Director of Health, tick-borne diseases are identified as one of the top three issues in town, along with cardiovascular disease and substance abuse. Another Director of Health has gone so far as to name tick-borne diseases *the* priority issue. However, some of the Directors of Health postulated that residents were more alarmed about Lyme disease, in particular, about a decade ago, but that they have since "gotten used to dealing with it." Conversely, as anaplasmosis and babesiosis are emerging, residents are becoming increasingly concerned with tick-borne diseases other than Lyme disease. This recognition of the problem by both the public and public health leadership undoubtedly acts as a facilitator to the implementation of tick-borne disease prevention programs and educational efforts. Further facilitators, including the availability and dissemination of materials, tick testing, and participation in research studies, as well as barriers to efforts are identified below.

Availability and Dissemination of Print and Electronic Materials

High-quality, accurate print and electronic resources are vital to dissemination of information. The primary points of contact that make such materials available are local Health Departments and the BLAST Tick-Borne Disease Prevention Program.

<u>BLAST</u>

In 2008 the State funded a grant application submitted on behalf of the Ridgefield Health Department to create the BLAST Tick-Borne Disease Prevention Program. This program is based on the work of Dr. Neeta Connally from Western Connecticut State University, as well as other available evidence. The basic recommendations of this program are as follows (BLAST Lyme Disease Prevention Program, 2014):

Bathe or shower soon after coming indoors

Look for ticks and rashes

Apply repellents

Spray your yard

Treat your pets to prevent tick bites

At the time of program creation, the Hudson Valley Council of Elected Officials (HVCEO) Tick-Borne Disease Prevention Task Force voted to use the BLAST message region-wide, with the intentions of utilizing collaboration and single-message power to maximize benefit while minimizing costs through shared printing and advertising. Since then, some Health

Departments have begun utilizing a BLAST acronym that has been modified from the original one. In speaking with the Directors of Health who modified the message, it became clear that their intentions were not malicious, but rather that they were responding to feedback from residents, with regards in particular to the use of chemical prevention measures. Adjusted BLAST messages are as follows:

New Milford:

Be aware

Look for ticks

Avoid areas with ticks

Safeguard your yard and pets

Get early medical **treatment**

Newtown:

Bathe soon after spending time outdoors

Look for ticks and rashes

Avoid ticks when possible; **apply** repellent

Safeguard your yard; **spray** your yard

Treat symptoms early; **treat** your pets

Through its website, in-person trainings, and health fair attendance, the BLAST program makes available resources pertaining to each of the BLAST tips. Resources include institutions such as the CDC, Connecticut Department of Public Health, the Connecticut Agricultural Experiment Station (CAES), and the National Pesticide Information Center.

Health Departments

Many towns offer tick-borne disease prevention materials to residents, either in print at the Health Department office and/or on the Health Department's website. Some Health Departments also host an annual health fair where tick-borne disease prevention materials are distributed to residents. Available materials frequently reviewed signs and symptoms of Lyme disease, anaplasmosis, and babesiosis; listed personal prevention recommendations; identified the BLAST message and/or included a link to the BLAST website; and/or included links to additional local, regional, and national resources.

At least one Director of Health stated that the Connecticut Departments of Public Health and Environmental Protection used to provide local Health Departments with pamphlets and other materials, but claimed that these materials are now dated and no longer distributed widely. Specific attention was given to the materials' focus on Lyme disease, with little or no mention of other tick-borne diseases.

The New Milford Health Department has also implemented a creative and successful measure referred to as the 'tick mobile.' Modeled after a similar measure utilized in the Torrington Health District (northwest of Greater Danbury), the tick mobile is a car salvaged from another Town of New Milford government agency which was painted green with tick decals. The car is driven around town, parked outside local institutions such as the Visiting Nurse Association, physicians' offices, and daycares, and used as a delivery point for tick-borne disease education. The tick mobile has been in operation since 2010 and receives widespread recognition amongst residents of New Milford and surrounding towns.

Tick Testing

Each Director of Health identified tick testing for the presence of *B. burgdorferi* by CAES as a service available to residents. All residents of Connecticut are invited to submit ticks to their local Department of Health, who in turn will submit the ticks to CAES (The Connecticut Agricultural Experiment Station, 2014). CAES will accept all ticks for identification, but will only test *I. scapularis* that have ingested human blood for the presence of *B. burgdorferi*. Directors of Health commonly reported taking advantage of tick drop-off for testing as a "teaching moment" to educate residents about tick-borne disease prevention.

Since Dr. Goudarz Molaei inherited responsibility for the CAES tick testing lab as of July 31, 2014, he has implemented updated methodology to test for the presence of *B. burgdorferi* in engorged ticks. As a result, the average turnaround time has been reduced from approximately three weeks to a maximum of three days (bearing in mind that testing is not conducted on weekends). Of further interest, Dr. Molaei is now also testing engorged ticks for the presence of *A. phagocytophilum* and *B. microti*. In the cases of positive results where Dr. Molaei and his team are unable to reach the appropriate Director of Health, he and his team will also make efforts to contact the resident who submitted the tick.

Participation in Research Studies

Many Directors of Health identified the availability of participation in tick-borne disease prevention studies for residents. The Connecticut Emerging Infections Program: Lyme and Other Tick-Borne Diseases Prevention Study is organized by the Connecticut Department of Health, the Yale School of Public Health, and the CDC. Operating in conjunction with the local Health Departments, this study enrolled residents of the Greater Danbury area, in addition to residents of Maryland and New York, to a prospective, blinded, placebo-controlled trial to evaluate the efficacy of a single springtime application of commercially available, EPA-registered acaricide to prevent tick-borne diseases in humans (CDC, 2012a). The Directors of Health expressed gratitude for opportunities for residents to take part in studies such as this.

The Town of Redding is further involved as the sole site in another CDC-funded study in cooperation with CAES entitled An Integrated and Individual Tick Management Program to Reduce Risk of Lyme Disease in a Residential Endemic Area (Stafford et al., n.d.). In this study, one neighborhood serves as a control site; another was sprayed with the biological tick control agent *Metarhizium anisopliae* and rodent bait boxes were distributed; in a third neighborhood the local white-tailed deer population was reduced; and a fourth received *M. anisopliae* spray, bait boxes, and deer reduction. Preliminary results from the first year of this study suggest a 58.3% greater reduction in nymphal tick densities in areas where bait boxes and *M. anisopliae* applications were used compared to those where they were not. Ongoing data collection will assess effects of all treatment measures on tick-borne disease risk-associated outcomes. A second arm of the Integrated Tick Management Program seeks to compare the efficacy of an oral rodent Lyme disease vaccination pellet with other preventive measures (The Connecticut Agricultural Experiment Station, 2014b).

During Dr. Neeta Connally's time at Western Connecticut State University (WCSU), the University has become an integral partner to the CDC, Connecticut Department of Public Health, and Yale University in the conduct of tick-borne disease prevention studies locally. WCSU is a welcomed community partner to the local Health Departments, as Dr. Connally's expertise in part helps make Greater Danbury the ideal region for such research activity to occur.

Barriers Identified

Unfortunately, although the Greater Danbury area is in many ways primed for tick-borne disease prevention efforts, barriers remain in place at the local and state levels.

Lack of Funding

One of the most consistently identified barriers to public education about tick-borne disease prevention was lack of funding tied specifically to this objective. Whereas all Connecticut towns used to all receive per capita money from the State for community health education and prevention activities, now only those districts with a total population of 50,000 or more receive this money (State of Connecticut, 2014). For those Directors of Health who shared details related to this funding, this translates to a loss of $20,000 or more for prevention activities per year. Because of the lack of monetary resources dedicated to prevention, Directors of Health report needing to "be strategic" and to "as much as possible weave some basics of protection and prevention into our routine services." Some also report relying on volunteer services, in-kind support, and partnerships with local institutions such as WCSU or Danbury Hospital to offer educational and preventive services to their residents.

Likewise, funding for the BLAST Program was only for a period of 6 months; they have since been operating off of in-kind support from the Town of Ridgefield for office space and utilities, volunteer services, and occasional small local grants. Ms. Jennifer Reid reported volunteer efforts being "haphazard" and suggested that it is difficult to find volunteers who are "really committed to the prevention mission."

The Controversy over Prevention

While the controversy surrounding chronic Lyme disease and related topics is well-established, Ms. Reid suggests that tick-borne disease prevention is host to controversy as well. In addition to deer reduction, use of chemical acaricides is contentious. She further reports that "partnering with anyone who wants to reduce deer population, anyone who produces repellent, anyone who talks about spraying yards generates a lot of hostility." An important aspect of the BLAST program is its strong evidence base. To those who don't like to use chemicals, Ms. Reid says they are simply describing what works against ticks and insists that people must make choices about what works for their families. The BLAST program also offers an abundance of resources for those who are interested in researching various options.

It also seems that making residents aware of tick-borne disease risks isn't always well received, either. At least one Director of Health had been involved in posting tick-borne disease prevention signs at the entrances to local trails, with the approval of the local conservation committee chairman. However, another committee member was reportedly "upset that these signs would discourage people from using the trails." Some of the signs were therefore taken down.

Further, although the BLAST program is limited to tick-borne disease prevention and early symptom recognition, it is not exempt from the chronic Lyme disease controversy. Health care providers in the Greater Danbury community largely have a poor reputation amongst the 'chronic Lyme disease community' for supposed misdiagnosis and refusal to treat with long-term antibiotics. As an organization that welcomes Lyme disease patients as volunteers, Ms. Reid suggested that if BLAST partners with medical groups, they have done these patients a "disservice," causing them to lose credibility amongst this community. Even within the chronic

Lyme disease community, there are multiple activist groups and organizations, some of which have funding opportunities. However, the BLAST program has had difficulty in obtaining some of this funding for reasons believed to be tied to a lack of 'allegiance' to one group or another. Ms. Reid suggests that "there's an implication that when you partner with people that you're in agreement with them…about everything" but that she doesn't agree with this sentiment. In short, she "thought it would be easier to find volunteers…to find financial support…to work together as towns."

Lack of Inclusion in School Curricula

Although many Directors of Health indicated that they would like for tick-borne disease prevention education to be incorporated formally into school curricula, only one town reports having success in doing so. At least one other has taken the less formal approach of performing educational interventions on a class-by-class basis. Ms. Geri Rodda, the Public Health Nurse for the New Milford Health Department, authored the book *Lyme in Rhyme* (2013). Some health departments have donated copies of this book to the public school libraries and/or daycares. For those who have been able to insert tick-borne disease prevention education in the school system, it is reported that teachers and students alike are receptive to the lessons.

Underreporting

Underreporting, particularly for Lyme disease, was thought to exist across the towns. Although Lyme disease, anaplasmosis, and babesiosis are all reportable diseases, at least one Director of Health reported receiving more reportable forms for anaplasmosis than for Lyme disease, despite the fact that Lyme disease is actually far more common. Underreporting of

Lyme disease is consistent with national data and the general trend for 'common things to be underreported and uncommon things to be over-reported.' It was suggested that getting an accurate picture of the Lyme disease burden is of interest to everyone, but that we have yet to establish a surveillance system that captures the true burden.

Public Survey

To date 263 participants have completed the public survey across three local health fairs and related events. The majority (79.7%) of respondents is female; the average age of respondents is 54.1 years (SD 15.0). Nearly all are Connecticut residents (94.2%) and have lived in Connecticut for an average of 32.9 years (SD 20.4). Of those who provided responses, 28.6% reported having been diagnosed with a tick-borne disease at any point and 50.2% reported a family member having been diagnosed with a tick-borne disease. Education level was relatively evenly split between high school, Bachelor's, and Master's degrees (28.0%, 27.6%, and 24.1%, respectively); 18% of respondents' highest level of education was an Associate's degree.

Tick-Borne Disease Knowledge

The majority of residents (83.3%) knew that ticks which cause Lyme disease feed on white-tailed deer and 51-54% recognized that such ticks feed white-footed mice, cats and dogs, and humans; only 27.0% knew that such ticks can feed on birds.

Some 80.6% of residents knew blacklegged ticks carry the disease-causing agent for Lyme disease. Less commonly recognized as being carried were the disease-causing agents for babesiosis (20.7%) and anaplasmosis (10.6%). When asked approximately what percentage of blacklegged ticks in Connecticut carries the disease-causing agent for Lyme disease, 24.5%

correctly identified the answer as being 25-50%. A similar proportion (25.7%) believed the figure to be 50% or more and 7.8% believed all blacklegged ticks carry *B. Burgdorferi*. Some 12.5% believed the figure to be less than 25%. The highest proportion of respondents (29.6%) selected “I don’t know.”

Some 59.1% of participants recognized that blacklegged ticks prefer to live in damp, shady areas; 69.2% correctly identified May through August as being the most common months for Lyme disease infections. Less well understood by residents was the approximate length of time a blacklegged tick must be attached before it can transmit *B. burgdorferi* and cause Lyme disease. While 26.3% correctly identified this time period as 24 hours or more, an equal proportion thought Lyme disease could be transmitted within one to two hours. Some 10.4% and 12.4% believed the disease could be transmitted in two to ten hours and 20-24 hours, respectively.

Early signs and symptoms of Lyme disease were relatively well-recognized, as were late symptoms of untreated Lyme disease (Table 3). Respondents were equally able to recognize listed symptoms that are unrelated to Lyme disease, including difficulty breathing (77.4%), depression (67.3%), and pneumonia (90.4%).

Table 3 Recognized signs and symptoms of early and late Lyme disease

Symptom	**Percentage correctly identified**
Early signs and symptoms	
Fever	65.3
Headache	61.8
Stiff neck	55.7
Fatigue	75.1
Muscle aches	69.5
Rash that may have a bull's eye appearance	82.8
Late symptoms	
Joint pain	80.2
Nervous system effects	69.1
Muscle weakness	71.8
Cardiac problems	46.9

Engagement in and Beliefs about Protective Behaviors

Some 44.1% of respondents reported wearing protective clothing during exposure to potential tick areas at least most of the time; 33.6% reported wearing tick repellent; 60.8% reported performing a tick check after exposure to potential tick areas; and 50.6% reported showering or bathing within 2 hours of exposure (Figures 10-13, respectively).

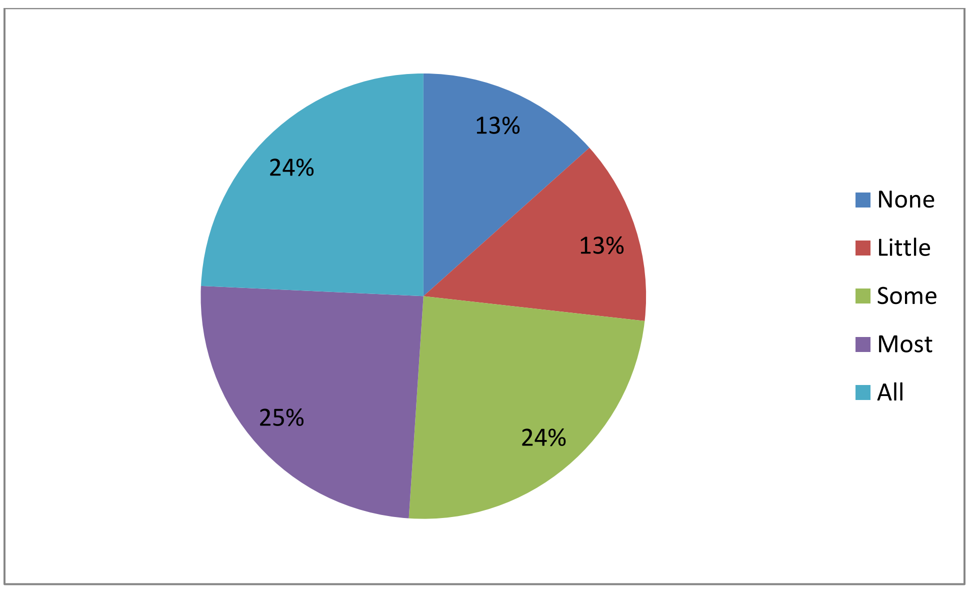

Figure 10. Approximate amount of time respondents wear protective clothing during exposure to potential tick areas

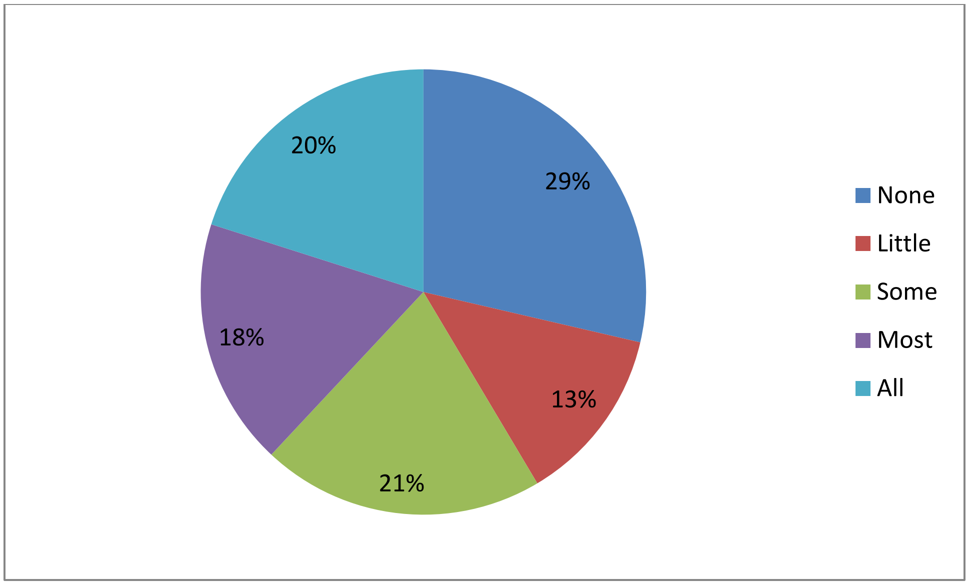

Figure 11. Approximate amount of time respondents wear tick repellent during exposure to potential tick areas

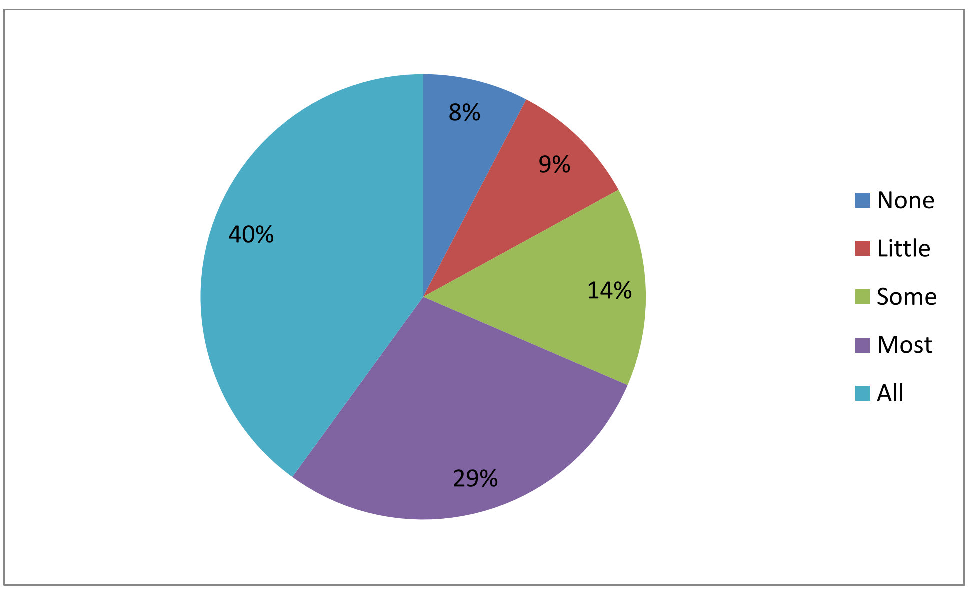

Figure 12. Approximate amount of time respondents perform a tick check after exposure to potential tick areas

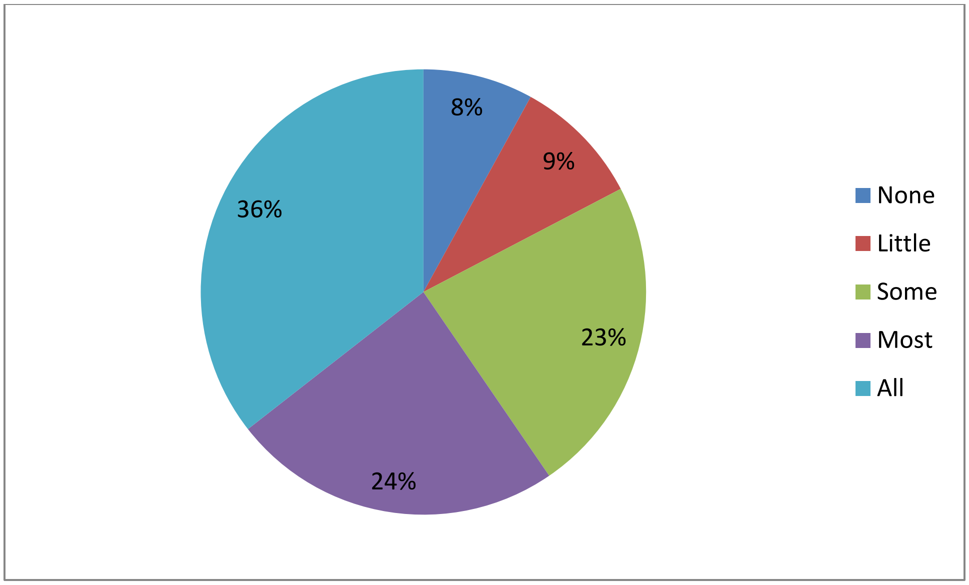

Figure 13. Approximate amount of time respondents shower or bathe within two hours after exposure to potential tick areas

On a scale from one to five where one is not at all effective and five is very effective, respondents' average rating of the effectiveness of wearing protective clothing was 4.3 (SD 1.0), wearing tick repellent was 4.2 (SD 1.0), performing a tick check was 4.5 (SD 0.9), and showering or bathing was 4.2 (SD 1.1) (Figure 14).

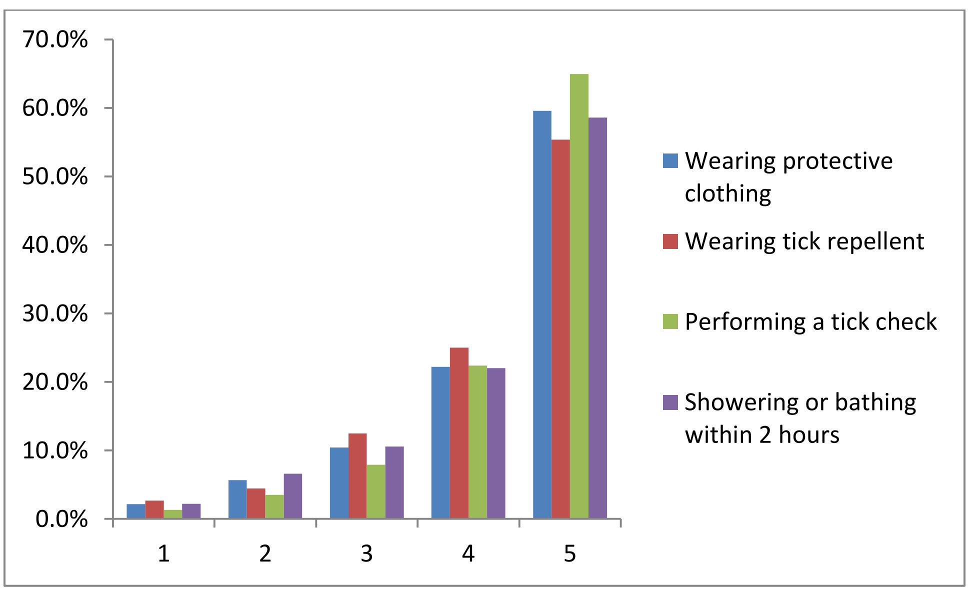

Figure 14. Perceived effectiveness of protective behaviors at reducing the risk of tick-borne disease (1=not at all effective, 5=very effective)

Using a similar scale, respondents' average rating of the burdensomeness of wearing protective clothing was 2.5 (SD 1.4), wearing tick repellent was 2.4 (SD 1.5), performing a tick check was 2.3 (SD 1.4), and showering or bathing was 2.3 (SD 1.2) (Figure 15).

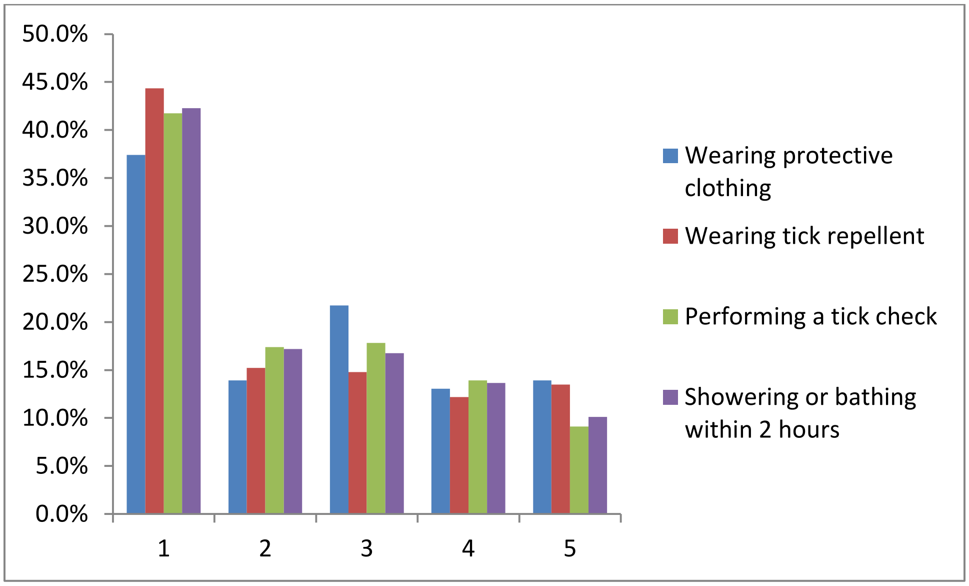

Figure 15. Perceived burdensomeness of performing protective behaviors (1=not at all effective, 5=very effective)

Finally, when asked to rate how confident respondents were that each behavior protected from tick-borne disease, the average confidence in wearing protective clothing was 3.8 (SD 1.2), wearing tick repellent was 3.7 (SD 1.2), performing a tick check was 3.9 (SD 1.1), and showering or bathing was 3.8 (SD 1.2) (Figure 16).

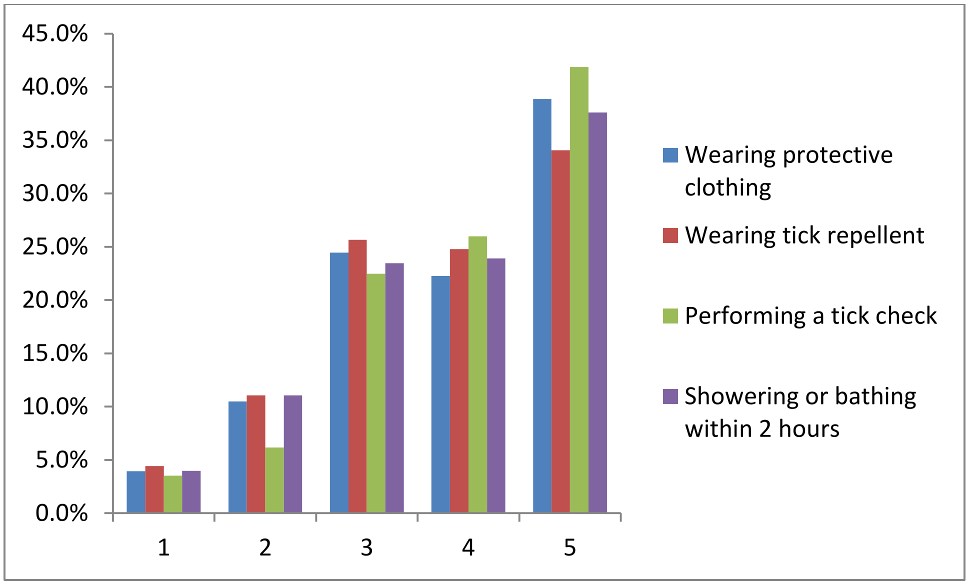

Figure 16. Perceived confidence that protective behaviors protect from tick-borne disease (1=not at all confident, 5=very confident)

Participants agreed that Lyme disease is relatively serious. On a scale from one to five where one is not serious and five is terrible, the average rating was 4.6 (SD 0.7), with only 7.4% of respondents rating it three or less.

Physician Survey

Of the 158 primary care providers contacted, 39 (24.7%) responded to the survey. The majority (43.6%) reported their specialty as internal medicine; 23.1% are pediatricians; 20.5% practice medicine and pediatrics; 12.8% are family medicine practitioners. Some 15 respondents (38.5%) primarily practice in Danbury. Exclusive of Sherman and Bridgewater, all other Greater Danbury towns were represented by one to four physician respondents. Six of the respondents primarily practice in towns outside of the Greater Danbury area, as defined for this assessment, but were included because they very likely serve residents of Greater Danbury towns.

The majority of providers (82%) reported counseling patients about tick-borne disease prevention during acute visits for complaints possibly related to tick-borne disease, such as those occurring after the removal of a tick or after the diagnosis of Lyme disease. Some 38.5% and 35.9% of providers indicated counseling all patients at wellness visits or high-risk patients such as children and outdoor workers at wellness visits, respectively. In contrast, 10.3% reported providing information only to those patients who specifically requested it.

The most commonly identified barrier to discussing tick-borne disease prevention was lack of time (61.5%); 33.3% of providers reported there being no barriers. Only one respondent (2.6%) suggested that patients not believing tick-borne diseases are important and/or serious is a barrier to education.

Providers largely (79.5%) are aware of the CDC's webpage about tick-borne diseases, although only 38% report referring their patients to this resource. About half of providers (51.3%) are aware of each free printed materials available through the CDC and local health departments as a resource; approximately one-quarter (20.5% and 28.2%, respectively) refer patients to these resources. Less well-known by providers was the BLAST program; only 12.8% claimed to be aware of the program, where only one provider (2.6%) reported utilizing this as a reference for patients.

With regard to prophylactic treatment for Lyme disease, 56.4% of providers report providing prophylaxis to most or all patients meeting guideline conditions; an additional 25.6% report providing prophylaxis to most or all patients who report having removed a tick recently, regardless of other factors such as possible attachment time. One provider further elaborated that most patients are not sure of the tick type and/or engorgement status, thus making it difficult to restrict treatment to only those meeting guidelines. One provider prescribes prophylaxis only to those patients who request it. Some 7.7% of providers reported almost never or never prescribing prophylactic treatment and an additional 7.7% reported not being aware of prophylactic treatment for Lyme disease being recommended for anyone. Of note, none of the providers who are unaware of prophylaxis are pediatricians (called to attention because children under eight are not recommended to receive prophylaxis).

When asked about what action they would take if a new Lyme disease vaccination were to be approved, about half (46.2%) of providers indicated they would recommend vaccination to all indicated patients; another 10.3% suggested they would recommend to high-risk patients only. Some 38.5% of respondents wanted more information about the vaccination's safety and/or expressed reservations about a future vaccine due to the "failure" of the last one. Several providers would wait for long-term studies before considering administration to their patients.

Summary

- Directors of Health uniformly identified tick-borne diseases as a priority issue. Almost all provide information about prevention through their websites; many also are involved in active events such as health fairs.
- Lack of funding was the barrier to prevention efforts most frequently cited by Directors of Health and other key informants.
- Tick testing for the disease-causing agents for Lyme disease, anaplasmosis, and babesiosis is available for free to all Connecticut residents through the Connecticut Agricultural Experiment Station. Improvements to this program have been implemented recently.
- The BLAST program is integral to tick-borne disease prevention efforts, although the future of the program is uncertain given a lack of substantial financial support.
- Overall, area residents are knowledgeable about the transmission and signs and symptoms of Lyme disease. They are less well-informed about anaplasmosis and babesiosis.
- Preventive behaviors are variably performed by the public: approximately 60% report performing tick checks; 50% shower or bathe after being outdoors; 45% wear protective clothing; 35% wear tick repellent. The public perceives each of these methods to be approximately equally (highly) effective at preventing tick-borne disease and equally (minimally) burdensome, so these factors are not likely to contribute to poor compliance.
- Primary care providers are significantly more likely to counsel patients about tick-borne disease prevention after a possible tick bite than at wellness visits (82% and 39%, respectively). The most commonly identified barrier to having such discussions was lack of time.
- Providers are aware of, but generally do not refer patients to, local health departments and national resources such as the CDC. Less well-known was the BLAST program.

CHAPTER 5: CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

The rates of Lyme disease, anaplasmosis, and babesiosis are particularly high for Connecticut compared to national rates. Although town-specific data are not available for anaplasmosis and babesiosis, the rate of Lyme disease is even higher among towns in the Greater Danbury area. Reducing these rates is a priority among local public health officials. Despite the availability of various prevention methods, rates appear to be worsening. Reversing these trends requires continued understanding of the current scope of tick-borne diseases and recommended prevention practices in order to develop and implement effective interventions.

To highlight the importance of understanding the currently available prevention practices and barriers to their use, the following chapter summarizes the key findings and recommends strategies for preventing tick-borne disease in Greater Danbury from a social ecological perspective.

Summary of Major Findings

Chapter Four provided an overview of currently available tick-borne disease prevention resources in Greater Danbury as well as challenges to reducing the rates of tick-borne diseases. Key findings include:

- **Tick-borne disease prevention is a local priority.** Directors of Health uniformly identified tick-borne diseases as a priority issue. Almost all towns provide information about prevention through their websites; many also are involved in active events such as health fairs.
- **Lack of funding is a barrier.** Lack of funding specified for preventive activities was the barrier to prevention efforts most frequently cited by Directors of Health and other key

informants. As a result, Directors of Health are forced to creatively couple tick-borne disease prevention efforts with other, funded, programs which engage the public.

- **Tick testing is a widely used resource.** Tick testing for the disease-causing agents for Lyme disease, anaplasmosis, and babesiosis is available for free to all Connecticut residents through the Connecticut Agricultural Experiment Station. Improvements to this program have been implemented recently, including a reduction in the turn-around time from three weeks to three days and the addition of testing for Anaplasma and Babesia.
- **The BLAST program is integral to tick-borne disease prevention efforts.** Representatives from this program are available for group presentations and participate in local health fairs. However, the future of the program is uncertain given a lack of substantial financial support.
- **Residents are aware of Lyme disease.** Overall, area residents are knowledgeable about the transmission and signs and symptoms of Lyme disease. They are less well-informed about anaplasmosis and babesiosis.
- **Preventive behaviors are variably performed by the public.** Approximately 60% of survey respondents reported performing tick checks; 50% reported showering or bathing after being outdoors; 45% reported wearing protective clothing; 35% reported wearing tick repellent. The public perceives each of these methods to be approximately equally (highly) effective at preventing tick-borne disease and equally (minimally) burdensome, so these factors are not likely to contribute to poor compliance.
- **Physicians frequently are not discussing tick-borne diseases on a primary prevention basis.** Primary care providers are significantly more likely to counsel patients about tick-borne disease prevention after a possible tick bite than at wellness

visits (82% and 39%, respectively). The most commonly identified barrier to having such discussions was lack of time.

- **Physicians largely are not utilizing existing patient resources.** Providers are aware of, but generally do not refer patients to, local health departments and national resources such as the CDC. Less well-known was the BLAST program.

Conclusions

Local support for tick-borne disease prevention is made evident by the Directors of Health identifying the issue as a priority on par with more nationally-recognized issues such as cardiovascular disease. Residents confirmed their concern about Lyme disease by rating its seriousness as a 4.6 on a scale of one to five. Although there is significant room for improvement, more than one-third of local primary care providers discuss tick-borne diseases with their patients at wellness visits. This suggests that tick-borne diseases bear weight among the myriad of preventive issues to be discussed in a limited amount of time.

The BLAST program is a long-standing, evidence-based, important part of tick-borne disease prevention efforts in this area. Although it was agreed that the BLAST message would be applied regionally, the uptake has been variable. Furthermore, physicians largely are unaware of this valuable patient resource.

As testament to the pervasiveness of tick-borne diseases, residents are fairly knowledgeable about Lyme disease, although their knowledge of anaplasmosis and babesiosis is more limited. Residents are more likely to engage in protective behaviors such as tick checks, showering, and wearing protective clothing than they are to wear tick repellent. This is supportive of comments made by key informants about residents being reluctant to use chemical preventive measures, although reasons for using or not using particular preventive methods were not requested. Given that residents rated all four of these measures as being approximately equal with respect to perceived effectiveness and burdensomeness, it is not believed that these factors contribute to their differential rates of use. Further, residents rated these measures as being very effective and minimally burdensome, suggesting that these issues do not account for low rates of use.

In addition to the successes experienced locally, barriers to prevention have also been encountered. For example, many towns have had difficulty implementing tick-borne disease education into public school curricula. Efforts to post signs warning of the dangers of tick-borne disease at the entrances to trails have also been met with opposition. This is because some proponents of recreational trail use believe such signs would discourage use altogether.

Unfortunately, the local focus on and need for tick-borne disease prevention resources are not supported on the state level. The Connecticut Department of Public Health does not offer personnel resources and instead relies on local resources such as the BLAST program. Although a review of state-wide resources was not conducted, it seems that there are few, if any, programs similar to BLAST. The program is run completely by volunteers and relies on in-kind support from the Ridgefield Department of Health and small local grants for supplies. It is becoming increasingly difficult to sustain the BLAST program using this model.

Further, the State does not offer financial resources to the towns. Where they used to receive per capita money for community health education and prevention activities, only cities now have a population large enough to qualify for this money. Within Greater Danbury, the city of Danbury is the only town eligible for per capita money. With no money contributed to tick-borne disease prevention, funding does not match the towns' priorities. This lack of monetary resources forces Directors of Health to find creative ways to approach this important issue, often coupling it with other, funded, programs. As a result, it may be that tick-borne disease programs are not being directed at their primary audience, but rather the most readily available audience.

Finally, print resources offered by the State have been criticized for being outdated. Where Lyme disease used to be the only tick-borne disease of public focus, the rising rates of anaplasmosis and babesiosis warrant the addition of this information to pamphlets distributed.

One area in which the State does provide support is through the Connecticut Agricultural Experiment Station. Given the historical turn-around time of three weeks for tick testing, the utility of such testing was questionable. It was feared by some that residents would wait for results before consulting a healthcare provider, which could have been detrimental. Now that Dr. Molaei has implemented a three-day turn-around time, this testing can be highly useful as an addition to the clinical picture, in addition to more accurately estimating the burden of disease state-wide. Furthermore, the addition of testing for the disease-causing agents for anaplasmosis and babesiosis increases the potential utility of testing, as this information can aid in formulating differential diagnoses. It remains important, however, for Directors of Health to counsel residents that positive tick test results do not necessarily mean the tick has transmitted an infection.

National recognition of Greater Danbury as an area in which tick-borne diseases are of concern has been impressive. Several CDC-funded prevention studies have been offered to local residents to a positive end. It is also likely that residents benefit from the feeling that something is being done to address the tick-borne disease problem. Furthermore, these studies are typically orchestrated through several local institutions, contributing to enhanced collaboration and a bolstered sense of community. To this end, the number and diversity of community partners is impressive.

Recommendations

Because effective public health programs to help people maintain health and reduce disease risks require behavior change at many levels, the recommendations outlined in this chapter are based on the social ecological approach. Current best practices for tick-borne disease prevention focus on many levels of influence and offer a variety of choices. Although many of these strategies are applicable to any community in which tick-borne diseases are prevalent, where appropriate, recommendations are tailored to address more specifically the Greater Danbury area. It is important that multiple strategies across the levels of influence be implemented, as the complex interplay between factors that impact health cannot be addressed as successfully in isolation.

Individual

While there are many factors that may influence a person, ultimately the decision to engage in tick-borne disease preventive behaviors is a choice made by an individual. By considering residents as individuals with unique sets of personal risk factors, characteristics, and beliefs, specialized intervention efforts will be successful.

Theoretical Framework

At the individual level, personal characteristics that may influence behavior, such as knowledge, attitudes, beliefs, motivation, self-concept, developmental history, past experience, and skills, are taken into account (Glanz & Rimer, 2005). The individual level interventions and outcomes outlined below are based on two health behavior theories: the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB). The application of these two theories will address the key determinants by focusing on promoting and increase in awareness and knowledge of tick-borne disease and tick-borne disease prevention methods, and by motivating positive behavior change via improving perceived self-efficacy for performing these behaviors.

The HBM suggests that there are six main constructs which influence a person's decision to take action in preventing illness (Glanz & Rimer, 2005):

1. Perceived susceptibility: an individual's beliefs about their level of susceptibility to the condition;
2. Perceived severity: an individual's beliefs about the seriousness of a condition and the potential consequences of the condition;
3. Perceived benefits: an individual's beliefs about the effectiveness of taking risk-reducing action;
4. Perceived barriers: an individual's beliefs about the challenges or costs related to taking risk-reducing action;
5. Cues to action: the factors that activate an individual's readiness to change; and
6. Self-efficacy: the confidence an individual has in their ability to take action.

The TPB explores the relationship between a behavior and an individual's beliefs, attitudes, and intentions for controlling that behavior. There are four main concepts outlined by Glanz and Rimer (2005):

1. Behavioral intention: an individual's perceived likelihood of performing the behavior;
2. Attitude: an individual's personal evaluation of the behavior;

3. Subjective norm: an individual's beliefs about whether key people approve or disapprove of the behavior; motivation to behave in a way that gains their approval;
4. Perceived behavioral control: an individual's belief that they have, and can exercise, control over performing the behavior.

The application of these theories will address the key determinants by focusing on Greater Danbury residents' awareness, knowledge, and beliefs, and by motivating positive behavior change by improving their perceived self-efficacy and current social norms.

Key Determinants

The key determinants of positive behavior change will focus on educational programs to increase knowledge about tick-borne disease prevention methods as well as increasing the self-efficacy of residents to perform preventive behaviors. These key determinants are described in further detail below.

D-1 Increase the proportion of residents who wear protective clothing when engaging in activities in potential tick habitat: The CDC recommends wearing light-colored long-sleeved shirts, long pants, socks, and a hat when possible (CDC, 2011a). Results of this study suggest that approximately 44% of residents wear protective clothing. (Note that this figure may be inflated, as this study was conducted among presumably health-conscious individuals attending health fairs.) Some 13% reported never wearing protective clothing. This strategy for reducing tick bites is free, is not time-consuming, and is believed by residents to be effective. It was, however, ranked to be the most burdensome of the surveyed behaviors, presumably because residents find it too hot to wear such clothing during the months in which ticks are most active.

D-2 Increase the proportion of residents who bathe or shower within two hours after engaging in activities in potential tick habitat: Showering or bathing within two hours has been associated with a reduction in Lyme disease incidence by almost half (Connally et al., 2009). Currently, one-half of residents reports showering or bathing within two hours of being outdoors. Although only slightly less so, showering or bathing was rated least effective by residents. It was, however, rated the least burdensome.

D-3 Increase the proportion of residents who perform a tick check after engaging in activities in potential tick habitat: Daily tick checks are integral to tick-borne disease prevention given that it generally takes at least 24 hours before a tick can transmit any infectious agents it may be carrying (CDC, 2011a; Connally et al., 2009). Particular care should be taken to examine in and around the ears, inside the belly button, behind the knees, and around the waist (CDC, 2012b). This behavior is reportedly most frequently performed by residents, with about 60% of residents performing a tick check at least most of the time. Only 8% reported never performing a tick check. Furthermore, residents rated this highest with respect to perceived effectiveness and lowest with respect to perceived burdensomeness.

D-4 Improve self-efficacy related to tick removal: Early tick removal in the event of a bite is of paramount importance given the 24-hour window between bite and transmission of infectious agents (CDC, 2011a). Residents must be prepared with fine-tipped tweezers and must know proper protocol for removing a tick.

D-5 Increase the proportion of residents who use a tick repellent when engaging in activities in potential tick habitat: There are many options with respect to personal-use repellents, including some that are used on skin and others that are used on clothing. DEET (for use on skin) is the most efficient general arthropod repellent (Stafford, 2007). Permethrin is applied to clothing;

appropriate application can provide nearly 100% protection against questing ticks (Jordan et al., 2012). Although these products have been demonstrated to be safe for use by individuals of almost all ages, public health practitioners have reported poor acceptance of chemical measures by the public. Accordingly, only one-third of survey respondents reported wearing tick repellent. Natural repellents are available, although they are not as effective as DEET. With that in mind, use of these repellents should be considered for those individuals who are opposed to chemical use. Given the results of this study, perceived efficacy and perceived burdensomeness do not account for under-utilization of repellents.

D-6 Increase the proportion of residents who spray the perimeter of their yard with an acaricide annually: Studies have shown that even one application of pesticide in the appropriate locations of the yard at the appropriate time of year can reduce tick populations by 85-90% (Curran et al., 1993; Stafford, 1991; Stafford, 1997). Options are available for professional application or homeowner application.

D-7 Increase the proportion of dog owners who treat their dogs for ticks on a regular basis: Pet owners demonstrate increased incidence of Lyme disease (Wormser et al., 2006) and should take care to prevent entry of ticks into the home.

<u>Interventions</u>

At this level, the recommended intervention program will be focused on promoting tick-borne disease prevention among individual area residents. As described in Chapter Two, tick-borne disease rates vary with age. Lyme disease follows a bimodal distribution, where most cases occur among persons aged five to 14 years and 45-54 years (CDC, 2007). In contrast, the incidences of anaplasmosis and babesiosis both increase with age (Connecticut Department of

Public Health, 2011; CDC, 2014h). Males are disproportionately affected by each of these diseases (CDC, 2007; Connecticut Department of Public Health, 2011; CDC, 2014h). Obviously, these factors cannot be altered, but they can inform target audiences for prevention programs. As such, programs will be directed towards elementary school-aged children, middle-aged individuals, and elderly individuals.

I-1 Educational program targeting elementary and middle school-aged children (five to 14 years): This program will increase children's knowledge about tick-borne diseases and their symptoms and promote personal preventive practices. Children will be taught that they are particularly at risk of contracting a tick-borne disease given the amount of time spent outdoors, thus increasing their perceived susceptibility. Through exposure to personal preventive practices such as bathing and looking for ticks and rashes, children will be taught that their risks are easily modifiable through behaviors they may perform by themselves (although parents and guardians may assist, particularly for younger children). Furthermore, children will be encouraged to discuss the use of repellents such as DEET and permethrin with their parents or guardians, as these behaviors should be done under parental supervision. It is also anticipated that children will discuss these teachings with their parents, thus propagating the knowledge to an additional target group.

I-2 Educational program targeting middle-aged individuals (45-54 years): This program will focus in part on increasing perceived susceptibility to tick-borne diseases among this age group. The average age of respondents to the survey conducted among residents for this needs assessment was 54 years, thus the results of that survey are applicable to this demographic. Lyme disease was uniformly rated to be severe; the average severity rating was 4.6 out of five. Thus, perceived severity is not an obstacle. With relation to bathing or showering within two hours of being outdoors, performing a tick check, applying repellent, and wearing protective clothing, survey respondents did not find tick-borne disease prevention behaviors to be overly burdensome and believed them to be effective. According to the HBM, it therefore seems that lack of cues to action and self-efficacy are contributing to poor uptake of personal preventive behaviors. Further work must be done to elucidate factors that may activate individuals' readiness to begin employing these behaviors to ensure success of this intervention.

I-3 Educational program targeting elderly individuals (>65 years): While individuals in this age group do not exhibit a particularly high Lyme disease rate, they do show high rates of anaplasmosis and babesiosis. Thus, this intervention will aim to educate residents about these other tick-borne diseases. Individuals will be informed about the high incidence of these diseases among their peers, as well as the potential for more severe symptoms and effects among their age group, including the possibility of death. This education will serve to increase perceived susceptibility and severity. Individuals will further be informed that performance of relatively easy, inexpensive or free interventions can drastically reduce their chances of infection to bolster self-efficacy and perceived benefits of performing preventive behaviors.

I-4 Offer information about tick-borne disease prevention on local health department websites: This is already being done across most of the local health departments, although there are a few towns where pertinent information is lacking. Furthermore, efforts should be unified so that all websites include information about, or a link to, the BLAST prevention program and its evidence base.

Conclusion

The four interventions outlined above will target the most at-risk age groups with educational interventions. Although these interventions are designed to affect change at the individual level, they cannot exist in isolation. Therefore, further description of application of these interventions will be described as appropriate at higher levels of the social ecological model.

Interpersonal

The determinants of health at the individual level are important as they provide insight on the personal factors driving the high tick-borne disease rates among Greater Danbury residents. However, individuals are influenced by their surrounding environment, including various interpersonal relationships.

Theoretical Framework

Humans operate within a broad network of structural influences and a dynamic inter-relationship exists between the individual and subsystems of the environment. The interpersonal level of this overarching framework refers to the individual's relationships with their physicians, peers, and young children, when applicable. Prevention strategies at this level are theoretically designed to target the importance of observational learning and reinforcements.

The interpersonal level of health behavior "assumes that individuals exist within and are influenced by a social environment" (Glanz & Rimer, 2005). Further, individuals are influenced by "opinions, thoughts, behavior, advice, and support of the people" in their immediate surroundings. The Social Cognitive Theory outlines the social context in which there is a dynamic interaction of the person, environment, and behavior (Glanz & Rimer, 2005). The concepts of the Social Cognitive Theory are outlined in Table 4. Social Cognitive Theory is based on the idea that people can learn new information and behaviors by watching other people. Behavior can be understood as mediating between cognition and the environment, particularly the social environment with outlined expectations and norms (Bandura, 1989).

Table 4 Social Cognitive Theory

Concept	Definition	Potential Change Strategies
Reciprocal determinism	How the individual, environment, and behavior influence each other	Use multiple approaches to address individual needs Adjust the environment or influence personal attitudes
Behavioral capability	Knowledge and skill to perform a given behavior	Identify the actions required Identify the knowledge required Create problem-based learning scenarios to help acquire necessary skills
Expectations	Individual's perception of the outcome of change	Model positive outcomes Use stories that demonstrate success
Self-efficacy	Individual's confidence in the ability to act and overcome challenges	Approach behavior change in small steps Use progressive goal-setting
Observational learning	Individual watches the actions of others	Model correct behaviors Demonstrate positive outcomes Show how problems can be overcome
Reinforcements	Conditions that encourage or discourage change or likelihood of reoccurrence	Promote rewards or incentives Provide support

<u>Key Determinants</u>

Interpersonal relationships may be utilized to contribute positively to tick-borne disease prevention practice uptake in the community. In this intervention, promoting observational learning, such that children will learn from their parents and individuals of all ages will learn from their peers about the importance and benefits of practicing tick-borne disease preventive behaviors is essential. Individuals' relationships with their physicians will also be leveraged to enhance behavioral capability and provide reinforcement for protective behaviors.

D-1 Increase the proportion of primary care providers who talk to their patients about tick-borne disease prevention: Primary care providers are involved in health promotion, disease prevention, and patient education and therefore can be integral to tick-borne disease prevention efforts. A nationally-representative sample of U.S. moms found that, overall, pediatricians are the source trusted by the greatest percentage of mothers; likewise a physician's office was the fifth most trusted source (Bailey, 2008). For information about health issues, nutrition and diet, and parenting, these sources were top rated by moms. Thus, physicians are a natural source from which parents may elicit information about tick-borne disease prevention.

D-2 Increase the number of parents and children who engage one another in discussions about tick-borne disease prevention: The family generally is considered the most important agent of socialization, particularly among children (Lau et al., 1990). These relationships should therefore be utilized to promote and reinforce healthy behaviors, including tick-borne disease prevention.

D-3 Increase the proportion of parents engaging in tick-borne disease preventive behaviors: Lau et al. (1990) further found that across multiple preventive health behaviors, parents' explicit training efforts were associated with their children's behavior but that parents' behavior and their children's behavior were even more highly correlated. Thus, the impetus for parents to perform tick-borne disease preventive behaviors is ever-present for children to learn through observational learning.

D-4 Increase the number of adult peers who discuss tick-borne disease prevention: As we age, peer norms become increasingly important and should also be addressed as agents of change (Lau et al., 1990). In the study referenced in the first interpersonal level determinant, Bailey (2008) accordingly found that friends and family are the second most trusted source by U.S. moms for information. It stands to reason that adult individuals may be seeking advice from friends about health promotion and disease prevention. Peers may exchange personal anecdotes about experience with tick-borne disease and tips about tick-borne disease prevention. The approval of peers will further serve as reinforcement as performance of preventive behaviors becomes the norm.

Interventions

The interventions described below are intended to complement one another while addressing various relationships with individuals from whom residents may seek health advice.

I-1 Encourage discussion about tick-borne disease preventive practices among peers: This overarching objective involves several related interventions. The educational interventions previously described at the individual level will be utilized not only to impart information on direct recipients of the programs, but also will encourage learners to discuss this information with others. Engaging residents in tick-borne disease education programs and posting prevention information in key locations will serve to continuously improve behavioral capability and encourage discussion among at-risk groups. For example, programs may be delivered or pamphlets may be made available at local dog parks, moms' groups, parks and trail entrances, golf clubs, etc. Fact sheets targeting outdoor workers, parents, pregnant women, hikers, and golfers are all available for free on the CDC's website, as are other communications materials such as brochures and bookmarks.

I-2 Encourage discussion about tick-borne disease preventive practices between parents and their children: This overarching objective involves several related interventions. Parents and children may engage in programs together or individually; both parties will be empowered to bring up tick-borne disease prevention with the other. Educational programs for children may be delivered at pediatrician visits, in classrooms, at summer camps, among youth sports teams, among Boy and Girl Scout troops, etc. In addition to the materials listed above, the CDC also makes available for free a comic and crossword puzzle for children. The BLAST program has already created a badge program for scouts. Venues for parent-targeted programs were suggested above.

I-3 Encourage parents to act as models for their children with respect to performing tick-borne disease personal preventive behaviors: Beyond discussing tick-borne disease prevention with their children, parents will be encouraged through the previously described intervention to model protective behaviors as observational learning informs behaviors children perform and carry with them into adulthood.

I-4 Encourage discussion about tick-borne disease preventive practices between individuals and healthcare providers: While many area providers claimed to be discussing tick-borne disease prevention with their patients, this frequently is happening after individuals have been exposed to tick-borne disease. Therefore, primary prevention will be emphasized, with wellness visits presenting an opportunity to discuss preventive measures practiced. As an alternative to physicians being responsible for such discussions, alternative providers such as nurses may be utilized to counsel patients. Further, patients will be encouraged to broach the subject if their provider does not. This will be promoted by making tick-borne disease pamphlets available in the waiting room and exam rooms. Likewise, materials may be placed in veterinary offices to encourage discussions about preventive practices related to residents and their pets.

Conclusion

The interventions described at the interpersonal level leverage personal relationships to promote tick-borne disease prevention. By promoting discussion about and modeling of preventive behaviors, these behaviors will become socially accepted norms.

Organizational

Factors which contribute to tick-borne disease risk have aspects that can be addressed or influenced by the "behavior" of organizations. There are varied public health organizations which have specific charges to prevent certain negative health outcomes, including at least one local organization which focuses entirely on tick-borne disease prevention.

Theoretical Framework

The intervention for the organizational level will be constructed using the Stage Theory of Organizational Change. According to this theory, adoption of an innovation by an organization typically follows several stages (Glanz & Rimer, 2005). Each stage requires a set of strategies that is specific to the organization's stage of adopting, implementing, and sustaining new approaches, as well as on socioenvironmental factors that may be outside the organization's control. Beyer and Trice (1978) developed a seven-stage model that Kaluzny and Hernandez (1988) later condensed into four stages (Table 5). The strategies an organization will use depends on its stage of change and whether the social environment surrounding the intervention is supportive (Glanz & Rimer, 2005).

Table 5 Stage Theory of Organizational Change models

Beyer & Trice (1978)	Kaluzny & Hernandez (1988)
1. Sense unsatisfied demands on the system 2. Search for possible responses 3. Evaluate alternatives 4. Decide to adopt a course of action	1. Define the problem
5. Initiate action within the system	2. Initiate action
6. Implement change	3. Implement change
7. Institutionalize change	4. Institutionalize change

Key Determinants

Tick-borne diseases are identified as a problem by local residents and public health officials alike. The determinants below, in conjunction with those described at the individual and interpersonal levels, are possible responses to this issue.

D-1 Decrease resident contact with ticks: The best way to prevent tick-borne disease transmission is to reduce exposure to ticks. In the peridomestic environment, this can be accomplished in part by strategic yard layout and landscaping, such as the use of a three-foot barrier of woodchips or gravel between woods and the lawn, clearing of brush, and keeping lawns mowed short (CDC, 2011b; Stafford, 2007). Homeowners may also choose to use pesticides on the perimeter of yards (Stafford, 2007).

D-2 Increase the proportion of residents utilizing repellents such as DEET and permethrin: As previously described, DEET and permethrin are highly effective at repelling ticks and are safe on individuals of virtually all ages. Some Directors of Health have been met with resistance by residents when promoting chemical preventive measures, so investment and engagement will be necessary in convincing the public of these measures' safety and efficacy. It should be noted that natural repellents are alternatively used, but their efficacy has not been as well established. Residents may be more open to using permethrin, as it is applied to clothing rather than the skin. While appropriate use of permethrin has been shown to be nearly 100% effective, treatment of socks and footwear, in particular, has dramatic protective effects (Millner et al., 2011). Therefore, organizations may choose to promote treatment of footwear as a sort of compromise with individuals who are hesitant to use chemicals. In focus groups and interviews conducted among approximately 200 Ridgefield residents by the CDC and Ms. Reid of the BLAST program, residents had virtually no knowledge of permethrin, but reportedly expressed strong interest once it had been described (Zielinski-Gutierrez et al., 2008). The idea of using a product on clothing was seen as more acceptable than use on skin but few residents knew where to locate permethrin.

<u>Interventions</u>

Interventions at the organizational level seek to build off interventions proposed at the individual and interpersonal levels. The interventions below present possible courses of action that may be initiated as the second stage in Kaluzny & Hernandez's Stage Theory of Organizational Change model (1988).

I-1 Offer presentations to community groups: Presentations may be offered by Directors of Health, BLAST representatives, or other formal or informal health educators. As detailed under the intrapersonal interventions, presentations may be offered to at-risk groups such as moms' clubs, Boy and Girl Scouts, youth sports teams, golfers, hikers, and hunters. Given residents' previously reported lack of knowledge about and inability to locate permethrin (Zielinski-Gutierrez et al., 2008), particular attention may be paid to addressing these factors.

I-2 Maintain and increase health department and BLAST presence at health fairs: Much like community presentations, presence at health fairs is a great opportunity for organizations to reach a large number of individuals whom are likely to be receptive to disease prevention efforts.

I-3 Use of tick prohibitive yard designs and landscaping among home builders and landscaping companies: Builders and landscapers may market tick prohibitive measures as a benefit to customers. In doing so, they will also be educating homeowners about tick-borne diseases and encouraging discussion about disease prevention. Furthermore, in order to pass this information along to customers, outdoor workers will be educated in the process.

I-4 Organization-sponsored clothing treatment for outdoor workers: Outdoor workers are at high risk of acquiring tick-borne diseases. Disease contraction negatively affects the employer due to lost productivity. It is therefore in the employer's best interest to encourage tick-borne disease prevention. In part, this can be accomplished through treatment of clothing with permethrin. Employers may also offer and encourage use of DEET by employees, along with other personal preventive measures.

Conclusion

Interventions at the organizational level can positively influence the utilization of tick-borne disease prevention methods, thus reducing the rates of tick-borne diseases. Organizations are responsible for the majority of tick-borne disease prevention efforts, while seeking to impart change at the individual and interpersonal levels. Ways in which organizations can coordinate efforts will be detailed in the next section under community measures.

Community

The community can play a very important role in reducing tick-borne disease risk. Successful prevention of tick-borne diseases in the Greater Danbury area can only be achieved through community engagement in the planning and implementation of community-based programs. Furthermore, cooperation among various stakeholders, including health departments, the BLAST program, physicians, and the public is vital to capitalize on prevention efforts.

<u>Theory</u>

At the community level, interventions are driven by how social systems change and by how to mobilize community members (Glanz & Rimer, 2005). In order for interventions to be effective at this level, it is vital that planning be based around the community's unique characteristics. The community level interventions presented here are based on the Community Organization Theory, the process by which community groups identify common problems and goals, mobilize resources, and develop and implement strategies (Hernandez, 2011). This theory emphasizes active participation and development of communities to better evaluate and solve health and social problems. Key concepts of the Community Organization Theory include empowerment, community competence, participation, and relevance. These concepts help stakeholders maintain a central focus for better health while working towards a common goal.

<u>Key Determinants</u>

The determinants below represent suggested goals that should be common to stakeholders. Active participation by stakeholders will enable more effective and efficient efforts to combat tick-borne diseases in the Greater Danbury area.

D-1 Increase coordination of local tick-borne disease prevention efforts: To date community groups largely have identified tick-borne diseases to be a problem and ultimately have the goal to reduce the pervasiveness of this issue. There have been some efforts to jointly mobilize resources and develop and implement strategies, but these efforts have been met with variable success. Coordination among organizations such as state and local health departments and BLAST can help reduce duplication of efforts as well as costs.

D-2 Increase the proportion of primary care providers who are aware of and who refer patients to available local and national tick-borne disease prevention resources: Results of the physician survey administered as part of this assessment demonstrated underutilization of available resources. Although primary care providers are encouraged to provide information to patients in person at wellness visits, they are also encouraged to refer patients to other resources such as the BLAST program, local and state health departments, and the CDC. Furthermore, the CDC makes available free patient education materials that can be placed in waiting rooms and exam rooms. Use of the BLAST message at physicians' offices will also serve to enhance visibility of the message.

<u>Interventions</u>

The interventions proposed at the community level utilize existing resources and organizational strengths within the community while seeking to bring these resources together to jointly address tick-borne diseases.

I-1 Unify the BLAST message: Use of a unified message such as BLAST will help ensure that residents are given consistent information and repeated exposure may help the message "stick" better. In the case of the BLAST message, "BLAST" itself has nothing to do with tick-borne disease. Therefore it is important to maintain consistency so that residents will come to remember the acronym. BLAST is intended to offer evidence-based options for personal protection; it is thus expected that different groups will select options that align best with their lifestyle and values.

I-2 Host a tick-borne disease seminar for area healthcare providers: Several years ago Danbury Hospital held an annual tick-borne disease seminar for primary care and other healthcare providers. The seminar was reportedly discontinued after organizers felt there was a lack of change in the field, the same information was repeatedly being presented, and attendance declined. Infectious diseases staff at Danbury Hospital as well as staff at the WCHN Lyme Disease Registry have expressed an interest in offering such a seminar again. In particular, the rise in anaplasmosis and babesiosis cases has created the need for physician education. To avoid over-duplication of information year-to-year, the seminar could be offered every two to three years. In addition to a review of best practices for diagnosis and treatment of Lyme disease, anaplasmosis, and babesiosis, this seminar could involve local Directors of Health to discuss the importance of tick-borne disease surveillance, BLAST representatives to promote the BLAST message, and Dr. Molaei of the CAES to discuss changes in and the utility of tick testing.

I-3 Involve tick-borne disease prevention in annual Connecticut Trails Day: Each year the Connecticut Forest and Park Association hosts CT Trails Day Weekend, involving a few hundred events such as hikes and nature walks statewide. Promotion of these events offers a prime opportunity to promote tick-borne disease preventive behaviors among an at-risk group of residents. In particular, the weekend presents hundreds of opportunities to disseminate the BLAST message and encourage discussion about disease prevention between peers and parents and their children. Organizers of similar events should also be approached as events are identified.

Conclusion

The approach to tick-borne disease prevention should be multifaceted, culturally relevant, and should involve community-based interventions that recognize the problem and lead to action. By joining together the several organizations that are already working to address tick-borne diseases, the proposed interventions seek to capitalize on and enhance existing community resources.

Public policy

This section will continue to expound upon the social ecological perspective, as effective public health interventions work best when multiple levels of influence are applied to the community. In this case, the policy level interventions will supplement previously described efforts. Such combined efforts have a "reciprocal causation" to change the environment to support positive change (National Cancer Institute, 2005). At the policy level, the PRECEDE-PROCEED Model will inform interventions. PRECEDE stands for Predisposing, Reinforcing, and Enabling Constructs in Educational/Environmental Diagnosis and Evaluation, and is based on the premise that the "diagnosis" should precede an intervention plan (Glanz & Rimer, 2005). PROCEED stands for Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development, and was later added to the model to recognize the importance of environmental factors as determinants of health and health behaviors. The latest version of the model consists of four planning phases, one implementation phase, and three evaluation phases.

Like the theories utilized to inform previously described interventions, the PRECEDE-PROCEED Model suggests that success in achieving change is enhanced by the active participation of the intended audience in defining problems and goals and in developing and implementing solutions. This model was chosen for the public policy level given the focus on assessment of administrative and financial policies needed and on policy regulation in phases four and five, respectively, as depicted in Figure 17.

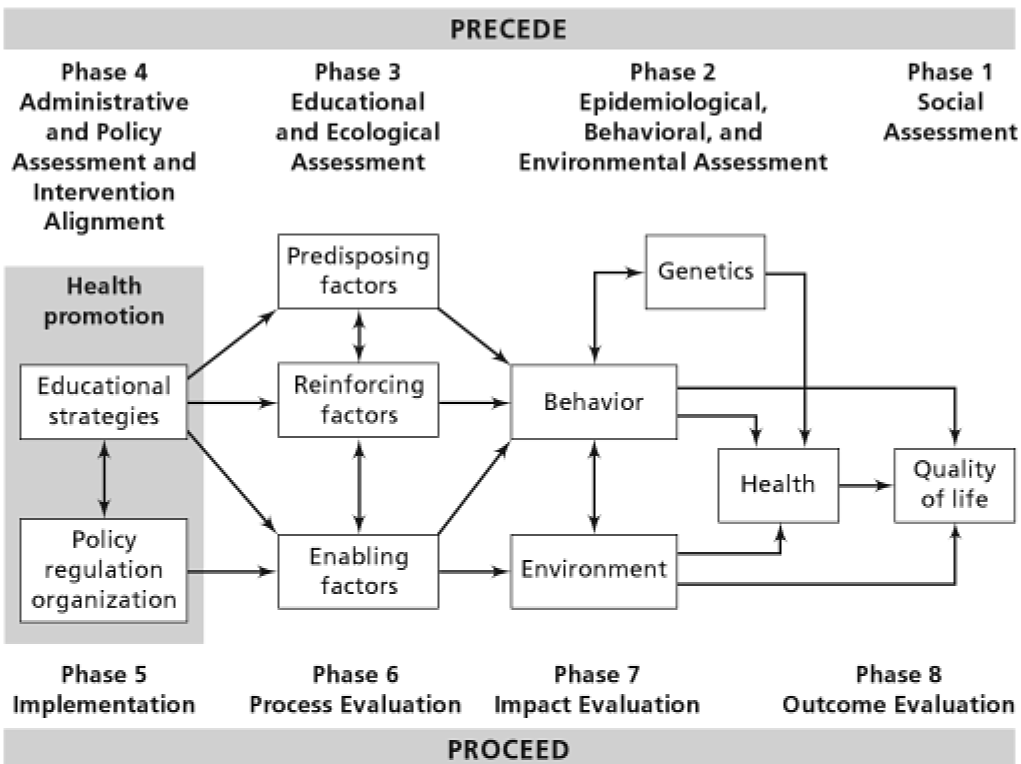

Figure 17. PRECEDE-PROCEED Model (Glanz & Rimer, 2005)

Key Determinants

Despite the pervasiveness of tick-borne diseases in Connecticut, little private, state, or federal funding is directed towards community-based prevention programs (Lyme Connection, 2014). In fact, as tick-borne disease rates continue to climb, many of the Directors of Health revealed during interviews that their funding by the State for educational programming has been eliminated in recent years. Thus, in addition to the suggested institution of policies which encourage safer choices, policies related to funding of activities will also be suggested.

D-1 Increase the proportion of individuals utilizing personal preventive measures such as bathing or showering, performing a tick check, and applying repellents when engaging in activities in possible tick habitats: The importance of performing these behaviors has been described extensively in Chapter Two and previously in this chapter.

D-2 Increase the number of elementary school-aged children educated about tick-borne diseases and exposed to the BLAST prevention message: Elementary school-aged children are a prime target for tick-borne disease education for a multitude of reasons, including the high rate of Lyme disease among this age group and the previously described ideas that children may share information they've learned with their parents and families and that children who perform healthy habits are more likely to carry these habits into adulthood.

D-3 Increase the number of residents educated about tick-borne diseases and exposed to the BLAST prevention message: Beyond educating children, the policies suggested below serve to educate the general population of Greater Danbury and beyond.

<u>Interventions</u>

Although residents of Greater Danbury are the primary targets of the interventions outlined in this document, just as an individual does not exist in isolation nor does the Greater Danbury area. Therefore, the interventions proposed below are focused at the town, state, and federal levels as appropriate.

I-1 Mandate signage be posted at park and trail entrances identifying possible exposure to ticks and options for personal prevention: Given funding constraints, it is important to note that such signs have already been designed and are available for free through the CDC. It will be important to engage outdoor groups prior to posting the signs; there previously has been resistance from such groups as they have felt these signs discourage use of outdoor facilities. In fact, these signs serve only to make residents aware of the risks associated with certain activities. Outdoor recreation is an important component of overall health, particularly as the nation sees increasing rates of obesity and associated diseases. While encouraging residents to engage in outdoor activities, messages about protecting from other health threats such as tick-borne disease and sun exposure should also be emphasized.

I-2 Mandate age-appropriate coverage of tick-borne diseases in elementary school health and/or science curricula: The benefits of early education have previously been discussed and several local Directors of Health mentioned failed attempts to implement tick-borne disease lessons. It has been suggested that teachers are already overwhelmed with the increasing scope of material they must cover, so creativity may be necessary to intertwine tick-borne disease education with other ongoing health or science lessons. There are also other opportunities to engage students and parents in discussions and to model preventive behaviors, such as during nature-related field trips.

I-3 Reinstate state funding to town-level health districts for the purposes of health promotion and education activities: While Directors of Health have found opportunistic ways to incorporate tick-borne disease education with other ongoing activities, funding for health promotion and education activities is vital to expand these opportunities. Unfortunately, multiple Directors of Health commented on how State funding drove their priorities, to some extent, whereas health priorities should ideally drive funding. In addition to the State's priorities, as identified in Healthy Connecticut 2020, individual towns should be allowed to identify and address other specific health issues.

I-4 Implement an area- or state-wide tick-borne disease health educator: This individual(s) may be employed directly by the State or funding may be dispersed to more concentrated areas (e.g. the ten-town Hudson Valley Region) for employment at a more local level. This position could also focus on other health needs. This would allow for greater coordination of prevention efforts, avoiding duplication of efforts while disseminating the BLAST message widely and uniformly.

I-5 Availability of Federal funding for research: Federal funding is integral to ongoing research efforts. Fortunately, grants have recently been awarded for work within the Greater Danbury area, as described in Chapters 2 and 4. The focus of this research around the nation includes human vaccination, rodent vaccination, rodent bait boxes, fungal sprays, and deer reduction. Without this funding, advancements in preventive practices largely would not be possible. For several years there has been legislation proposed to create a tick-borne disease task force and to bolster tick-borne disease research, but efforts to pass such legislation have been unsuccessful. The House recently passed H.R. 4701, the Tick-borne Disease Research Transparency and Accountability Act of 2014 (Sheehey, 2014), but it remains whether the bill also will be passed by the Senate.

Conclusion

Action at the public policy level is necessary to support and enhance efforts at the other social ecological levels of intervention. To date, tick-borne disease prevention efforts in the area and around the state and nation largely have been fragmented and underfunded. Implementation of supportive policies would serve to unify efforts to be more efficient and effective.

Summary of Key Determinants and Interventions

Table 6 summarizes the previously described key determinants and interventions for each social ecological level.

Table 6 Key determinants and interventions

Individual-level key determinants
D-1 Increase the proportion of residents who wear protective clothing when engaging in activities in potential tick habitat D-2 Increase the proportion of residents who bathe or shower within two hours after engaging in activities in potential tick habitat D-3 Increase the proportion of residents who perform a tick check after engaging in activities in potential tick habitat D-4 Improve self-efficacy related to tick removal D-5 Increase the proportion of residents who use a tick repellent when engaging in activities in potential tick habitat D-6 Increase the proportion of residents who spray the perimeter of their yard with an acaricide annually D-7 Increase the proportion of dog owners who treat their dogs for ticks on a regular basis
Individual-level interventions
I-1 Educational program targeting elementary and middle school-aged children (five to 14 years) I-2 Educational program targeting middle-aged individuals (45-54 years) I-3 Educational program targeting elderly individuals (>65 years)
Interpersonal-level key determinants
D-1 Increase the proportion of primary care providers who talk to their patients about tick-borne disease prevention D-2 Increase the number of parents and children who engage one another in discussions about tick-borne disease prevention D-3 Increase the proportion of parents engaging in tick-borne disease preventive behaviors D-4 Increase the number of adult peers who discuss tick-borne disease prevention

Interpersonal-level interventions
I-1 Encourage discussion about tick-borne disease preventive practices among peers I-2 Encourage discussion about tick-borne disease preventive practices between parents and their children I-3 Encourage parents to act as models for their children with respect to performing tick-borne disease personal preventive behaviors I-4 Encourage discussion about tick-borne disease preventive practices between individuals and healthcare providers
Organizational-level key determinants
D-1 Decrease resident contact with ticks D-2 Increase the proportion of residents utilizing repellents such as DEET and permethrin
Organizational-level interventions
I-1 Offer presentations to community groups I-2 Maintain and increase health department and BLAST presence at health fairs I-3 Use of tick prohibitive yard designs and landscaping among home builders and landscaping companies I-4 Organization-sponsored clothing treatment for outdoor workers
Community-level key determinants
D-1 Increase coordination of local tick-borne disease prevention efforts D-2 Increase the proportion of primary care providers who are aware of and who refer patients to available local and national tick-borne disease prevention resources
Community-level interventions
I-1 Unify the BLAST message I-2 Host a tick-borne disease seminar for area healthcare providers I-3 Involve tick-borne disease prevention in annual Connecticut Trails Day
Public policy-level key determinants
D-1 Increase the proportion of individuals utilizing personal preventive measures such as bathing or showering, performing a tick check, and applying repellents when engaging in activities in possible tick habitats D-2 Increase the number of elementary school-aged children educated about tick-borne diseases and exposed to the BLAST prevention message D-3 Increase the number of residents educated about tick-borne diseases and exposed to the BLAST prevention message
Public policy-level interventions
I-1 Mandate signage be posted at park and trail entrances identifying possible exposure to ticks and options for personal prevention I-2 Mandate age-appropriate coverage of tick-borne diseases in elementary school health and/or science curricula I-3 Reinstate state funding to town-level health districts for the purposes of health promotion and education activities I-4 Implement an area- or state-wide tick-borne disease health educator I-5 Availability of Federal funding for research

Community Action

The involvement of Greater Danbury residents is paramount to the success of the proposed interventions. In the case of any community needs assessment, community engagement is key. Therefore, the dissemination plan for the findings and recommendations detailed in this document is largely directed at the Greater Danbury population, including relevant institutions and organizations. Also included in the target audience are members of select institutions and organizations from the government and healthcare sectors, such as those listed in Table 7. These stakeholders have been identified based on their representation of the Greater Danbury community and/or their experience and expertise in designing, carrying out, and evaluating interventions. Some of these stakeholders may also be fundamental in securing funding and other resources for proposed interventions.

Continuous Improvement Process

This community needs assessment is intended to be an active tool for community health improvement planning and a framework for action. As no community health need remains static, and the evidence basis for population-level intervention is ever evolving, it is recommended that this document be viewed as in "perpetual beta." Intervention innovation and new and better sources of data should be added to this assessment as soon as they become available. In this way, short-, medium-, and long-term community health goals can be achieved through the foundation of continuous and iterative assessment processes.

Table 7 Working list of stakeholders

Stakeholder	Brief Description	Website
Public	The primary party of interest in tick-borne disease prevention	N/A
Local health departments	Responsible for public health promotion and disease prevention	See contact information for each health department in Appendix A
BLAST Tick-Borne Disease Prevention Program	Provides tick-borne disease education in the Greater Danbury area and beyond	http://www.ridgefieldct.org/content/46/6311/6347/8905.aspx
Primary care providers and other providers who see patients with tick-borne diseases	Involved in health promotion, disease prevention, and patient education for a variety of health issues	N/A
Hudson Valley Council of Elected Officials Tick-Borne Disease Prevention Task Force	Created in 2008 to enhance municipal efforts	http://www.hvceo.org/lymemain.php
Western Connecticut State University Department of Biological and Environmental Sciences	Dr. Neeta Connally's research focuses on peridomestic tick-borne disease prevention	http://people.wcsu.edu/connallyn/
Danbury Hospital	Local hospital responsible for patient care	www.westernconnecticuthealthnetwork.org
Western Connecticut Health Network Lyme Disease Registry	Registry designed to gain a greater understanding of Lyme disease; staff offer tick-borne disease education	www.lymeregisry.org
State of Connecticut Health Department of Public Health	Seeks to protect and improve the health of the people of CT	www.ct.gov/dph
Connecticut Agricultural Experiment Station	Responsible for tick testing; involved in tick-borne disease prevention research	www.ct.gov/caes

Conclusion

Greater Danbury, Connecticut, as well as other communities in tick-borne disease-endemic areas, will continue to face significant public health disparities unless current disease trends are halted and reversed. This needs assessment provides a range of practical, evidence-based strategies that can be implemented across many levels of influence to reduce the burden of tick-borne diseases. For maximal effectiveness, these recommendations require a comprehensive approach that considers the full social ecological perspective. Public health practitioners at all levels of influence should review the full scope of tick-borne disease trends and consider them in combination with community characteristics to assess the best process for implementing a combination of tick-borne disease strategies that ultimately will improve the health and well-being of the Greater Danbury community.

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APPENDIX A: KEY INFORMANTS

Name	Organization	Contact Information
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Jerry Murphy	Hudson Valley Council of Elected Officials Tick-Borne Disease Prevention Task Force	Website: http://www.hvceo.org/lymemain.php
Neeta Connally, PhD, MSPH	Western Connecticut State University Department of Biological and Environmental Sciences	Website: http://people.wcsu.edu/connallyn/
Goudarz Molaei, PhD, MSc	Connecticut Agricultural Experiment Station	Website: www.ct.gov/caes

APPENDIX B: PHYSICIAN SURVEY

1. With which patients do you typically discuss tick-borne disease (TBD) prevention? Select all that apply.
    - o All patients during wellness visits
    - o High-risk patients during wellness visits (e.g. children, outdoor workers)
    - o Patients with acute visits for complaints possibly related to TBD (e.g. after the removal of a tick, after diagnosis of Lyme disease)
    - o Only patients who ask for information
    - o None
    - o Other (please specify)
2. How burdensome would you say TBDs are on your practice during the summer months? Consider time spent discussing prevention, acute patient visits, patient follow-up, etc.
    - o Not at all burdensome
    - o A little burdensome
    - o Moderately burdensome
    - o Quite a bit burdensome
    - o Extremely burdensome
3. What are some of the barriers you feel exist to discussing TBD prevention with your patients? Select all that apply.
    - o Lack of time during visits
    - o I don't think TBD are important and/or serious
    - o Patients don't think TBD are important and/or serious
    - o I don't know enough about TBD prevention to feel comfortable discussing with my patients
    - o No barriers
    - o Other (please specify)
4. Are you aware of/do you refer your patients to any TBD prevention resources?

	Aware of	Refer to
CDC website	○	○
Free CDC printed materials such as fact sheets and bookmarks	○	○
Local health department	○	○
BLAST program out of local health departments	○	○

5. To whom do you prescribe prophylactic treatment for Lyme disease?
    - o Most/all patients who report having removed a tick recently (whether it was engorged or not)
    - o Most/all patients who report having removed an engorged tick recently
    - o Only patients who request it
    - o I only see patients for whom prophylactic treatment is not recommended
    - o I almost never/never prescribe prophylactic treatment
    - o I'm not aware of prophylactic treatment being recommended for anyone
    - o Other (please specify)

6. If a new Lyme disease vaccination were to be approved, would you:
   - Recommend to all indicated patients
   - Recommend to high-risk patients only
   - Administer vaccination only to those who requested it
   - Generally advise against Lyme disease vaccination
   - Other (please specify)
7. In what town do you primarily practice? ______________________
8. What is your specialty?
   - Pediatrics
   - Family medicine
   - Medicine and pediatrics
   - Internal medicine
   - Other (please specify)

APPENDIX C: PUBLIC SURVEY

Thank you for your participation in this study. For most questions there are no right or wrong answers; your honesty is greatly appreciated. Please note that you must be at least 18 years old to participate; do not complete this questionnaire more than once.

Section 1

1. Gender: ☐ Male ☐ Female

2. Age: _______ years

3. Education:
   ☐ Less than high school ☐ High school/GED ☐ Associate's degree
   ☐ Bachelor's degree ☐ Master's degree or higher

4. Principal employment:
   ☐ Home/office worker ☐ Outside worker ☐ Student
   ☐ Retired/unemployed/homemaker ☐ Other

5. Have you previously been treated for a tick-borne illness?
   ☐ Yes ☐ No ☐ I don't know

6. Has a family member of yours been treated for a tick-borne illness?
   ☐ Yes ☐ No ☐ I don't know

7. Do you live in CT? ☐ Yes ☐ No Number of years: _______ years

Section 2

1. Ticks that cause Lyme disease feed on (select all that apply):
   ☐ White-tailed deer ☐ White-footed mouse ☐ Humans
   ☐ Cats and dogs ☐ Birds ☐ I don't know

2. Deer ticks (blacklegged ticks) carry which disease(s) (select all that apply):
   ☐ Babesiosis ☐ Pneumonia ☐ Lyme disease
   ☐ Anaplasmosis ☐ I don't know

3. Deer ticks can be found anywhere but prefer to live in:
   ☐ Dry, sunny areas ☐ Damp, shady areas ☐ I don't know

4. Approximately what percent of deer ticks in Connecticut carries Lyme disease?
   ☐ All ☐ More than 50% ☐ 25%-50% ☐ Less than 25%
   ☐ I don't know

5. Approximately how long must a deer tick be attached to you for you to become infected?
   ☐ 1-2 hours ☐ 2-10 hours ☐ 10-24 hours ☐ At least 24 hours
   ☐ I don't know

6. Lyme disease infections in Connecticut occur throughout the year but are most common:
   ☐ March to May ☐ May to Aug ☐ Sept to Dec
   ☐ I don't know

7. Which of the signs and symptoms listed below may indicate early Lyme disease? (Select all that apply.)

- ☐ Fever
- ☐ Headache
- ☐ Stiff neck
- ☐ Difficulty breathing
- ☐ Fatigue
- ☐ Muscle ache
- ☐ Rash that may have a bull's-eye appearance
- ☐ I don't know

8. Early Lyme disease is effectively treated by 2-3 weeks of therapy with:

- ☐ Steroids (cortisone)
- ☐ Anti-inflammatory agents (aspirin)
- ☐ Antibiotics
- ☐ No medications can cure early Lyme disease
- ☐ I don't know

9. Late symptoms of untreated Lyme disease may include (select all that apply):

- ☐ Joint pain
- ☐ Nervous system pain
- ☐ Depression
- ☐ Muscle weakness
- ☐ Cardiac problems
- ☐ Pneumonia
- ☐ I don't know

Section 3

1. During/after exposure to potential tick areas, approximately how much of the time do you typically engage in the following behaviors?

	None of the time	A little bit of the time	Some of the time	Most of the time	All of the time
Wearing protective clothing					
Wearing tick repellent					
Performing a tick check					
Showering or bathing within 2 hours					

a. What type(s) of protective clothing do you typically wear? (Skip if you answered "none of the time".)

- ☐ Pants tucked into socks
- ☐ Long pants
- ☐ Long sleeves

b. What type(s) of tick repellent do you typically wear? (Skip if you answered "none of the time".)

- ☐ DEET
- ☐ Permethrin
- ☐ Natural/organic repellent
- ☐ Other
- ☐ I don't know

c. What is your usual method of tick check? (Skip if you answered "none of the above".)

- ☐ Examine entire body, including scalp
- ☐ Examine entire body but not scalp
- ☐ Examine exposed skin
- ☐ Briefly examine parts of body

Section 4

1. For each behavior, please **rate how effective** you think it is at reducing the risk for tick-borne disease during/after exposure to potential tick areas.

	1 Not at all effective	2	3	4	5 Very effective
Wearing protective clothing					
Wearing tick repellent					
Performing a tick check					
Showering or bathing within 2 hours					

2. For each behavior, please **rate how burdensome** you think it is to perform during/after exposure to potential tick areas.

	1 Not at all burdensome	2	3	4	5 Very burdensome
Wearing protective clothing					
Wearing tick repellent					
Performing a tick check					
Showering or bathing within 2 hours					

3. For each behavior, please **rate how confident** you are that it protects from tick-borne disease.

	1 Not at all confident	2	3	4	5 Very confident
Wearing protective clothing					
Wearing tick repellent					
Performing a tick check					
Showering or bathing within 2 hours					

4. On a scale from 1 to 5, how serious is Lyme disease? Please circle your response.

1	2	3	4	5
Not serious				Terrible