Vector-Borne Diseases and Health in Connecticut

A Yale Center on Climate Change and Health Issue Brief

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Introduction

Vector-borne diseases are infections transmitted from an infected person or animal to an uninfected person or animal by organisms called "vectors." Climate change has already been shown to affect the number and spread of vector-borne infections in many localities around the world.[1] This is because warmer temperatures can lead to more conducive environments for vectors, as well as longer seasons in which they can infect humans, pets, livestock, and other species. In Connecticut, mosquito- and tick- borne diseases are of greatest concern for humans.

The Connecticut General Assembly, state agencies, and municipalities have a responsibility to equitably protect human health from vector-borne diseases worsened by climate change. Building on recommendations made in the Governor's Council on Climate Change (GC3) *Taking Action on Climate Change and Building a More Resilient Connecticut for All: Phase 1 Report*, the Yale Center on Climate Change and Health puts forward the following recommendations:

1. **Support and strengthen monitoring and surveillance of vector populations and vector-borne diseases, including emerging vectors and diseases**
2. **Develop state vector-borne disease prevention and management guidelines and resources for schools and summer camps**
3. **Enforce the Connecticut Department of Labor's Division of Occupational Safety and Health (CONN-OSHA) requirement for tick bite prevention measures, and expand training and resources to support private employers to adopt tick bite prevention measures**
4. **Support municipalities and landowners to apply integrated vector management approaches to protect community health**
5. **Increase the knowledge base of healthcare professionals regarding vector-borne diseases through continuing education programs and by incorporating climate change into medical, nursing, public health, and veterinary curricula**

How has the environment changed?

Climate conditions — temperature, rainfall, and humidity — are important for determining the seasonality, prevalence, and geographic distribution of mosquito and tick species. Suitable conditions differ depending upon the species. For instance, Connecticut's historic climate has been conducive to the blacklegged tick (commonly known as the deer tick), while the lone star tick is the most common human biting tick in the southeastern United States, in part due to warmer temperatures. In general, mosquitos and ticks, which are cold-blooded, do better in a warmer world.

In *Climate Change and Health in Connecticut: 2020 Report*, we tracked a suite of environmental and climate conditions over time, largely at the county level. We report below key indicators that relate to vector survivability and habitat suitability.

- TEMPERATURE

In Connecticut, average annual temperature increased by 3.0–3.5 °F in each county from 1895 to 2019. Additionally, the number of frost days (days with minimum temperature at or below 32 °F) decreased from 1950 to 2018 in four of the eight counties: Middlesex, New London, Tolland, and Windham. Fewer frost days, an earlier winter-spring transition, and a later fall-winter transition create conditions for larger mosquito and tick populations that are active over a greater proportion of the year. Warming temperatures also allow for the introduction of new vector species.

- PRECIPITATION

From 1960 to 2019, the annual number of heavy rainfall events (3 consecutive days with cumulative precipitation of 3 inches or more) increased in New Haven, Hartford, Litchfield, Tolland, and Windham counties. We also tracked the number of drought days over time; we did not find a significant trend toward increased drought in any county, although Connecticut has recently experienced disturbing droughts, including a 46-week statewide drought in 2016–2017. The relationship between precipitation and vector abundance is complex. However, as an example, a study in Suffolk County (Long Island, New York) found that wet winters, warm and wet springs, and dry summers were associated with more mosquitos during that summer and fall of the *Culex* genus that transmit the West Nile virus (WNV).[2] These results are consistent with another study that found summertime drought to be strongly associated with higher numbers of WNV cases.[3]

Other environmental changes are important, too. For instance, over the course of the 20th century, suburban development brought human populations in closer proximity to the habitats where the mosquito or tick vectors live. Habitat changes also influence the abundance of other animal species critical to the mosquito or tick life cycle. In particular, Lyme disease, transmitted by the blacklegged tick, emerged due to, first, conversion of agricultural land to forests, which resulted in overabundance of white-tailed deer (a keystone host for blacklegged ticks) and burgeoning blacklegged tick populations; and second, suburban encroachment on forested areas, which resulted in increased human-blacklegged tick encounters.[4,5] Land use changes also are a likely factor that influenced the reemergence of Eastern equine encephalitis (EEE): suburban development brought human populations in closer proximity to the swampy habitats where the mosquito that carries the EEE virus and its bird hosts live.

Mosquito species of concern to human health in Connecticut

There are approximately 50 mosquito species currently found in Connecticut.[6] However, not all species carry viruses that cause human disease. The Connecticut Agricultural Experiment Station (CAES) collects and analyzes mosquito samples every year. With these data, for years 2001 to 2019, we found that 28 mosquito species carried one or more of the following viruses that infect humans: Cache Valley, EEE, Jamestown Canyon, Trivittatus, or WNV.[7] Of these 28 species, we found that 10 showed trends of increasing abundance, while only three showed trends of decreasing abundance. For instance, we found that one *Culex* species (*Culex salinarius*), which transmits WNV, has exhibited an increasing trend, which may be influenced by warmer weather or changes in precipitation patterns caused by climate change. Mosquito abundance is a key factor that influences the capacity of a mosquito to transmit a virus and the rate at which infections spread; increases in the abundance of mosquito species that are vectors for these viruses is an early warning signal that human viral infections may increase.

Another species we found to display increasing abundance was *Aedes albopictus*, a mosquito species of concern in Connecticut. *Ae. albopictus* is one of the two main vectors for dengue virus, chikungunya virus, Zika virus, and yellow fever virus. It was first detected in 2006 in Connecticut, which is near the northern boundary of its current range.[8] Its abundance in Fairfield and New Haven counties has been increasing since then, probably due to mild winters. Although there has been no known spread of dengue, chikungunya, Zika, or yellow fever in Connecticut, as the climate warms, further increased abundance and range expansion of *Ae. albopictus* in Connecticut can be anticipated, making the possible introduction of these infections into the state an increasing concern.

Tick species of concern to human health in Connecticut

BLACKLEGGED TICK

Blacklegged ticks (i.e., deer ticks) are commonly found in Connecticut. The ticks feed on mammals (especially rodents), birds, and amphibians. Deer are an important host (source of a blood meal) but are not a source of infection for the bacterium that causes Lyme disease. However, white-footed mice and chipmunks serve as hosts and are also a source of infection. Risk of human infection from blacklegged ticks is most common in the late spring and summer, when the tick is in its nymphal stage; at this stage, the tick is the size of a pinhead and so is difficult to spot.

LONE STAR TICK

The lone star tick, which is the most common human biting tick in the southeastern United States, is expanding into Connecticut, likely due to abundant hosts such as white-tailed deer, and climatic and environmental factors including warming temperatures, and especially, warmer winters.[9,10] CAES reports that the number of lone star ticks submitted to its Tick Testing Laboratory and acquired in Connecticut increased by 75% between 1996–2006 and 2007–2017, with most originating in Fairfield County.[10] Importantly, confirmed breeding populations have been discovered in Fairfield and New Haven counties, meaning that the ticks are not transient, but have become established populations.[9]

OTHER NON-NATIVE TICK SPECIES

CAES reported the first established population of the Gulf Coast tick in both Connecticut and the Northeast, found in Fairfield County in 2020.[11] This tick species carries *Rickettsia parkeri*, an emerging pathogen in the U.S. Also in Fairfield County in 2020, CAES found a major population of the invasive Asian longhorned tick.[11] In its native range, this tick species is a vector for several pathogens that have not yet been found in the U.S. Research is ongoing to understand whether the Asian longhorned tick is capable of transmitting these pathogens in the U.S., and whether it is capable of transmitting other tick-borne pathogens that are transmitted by other tick species in the U.S.[12]

What does this mean for our health?

MOSQUITO-BORNE DISEASE

Mosquitos in Connecticut have been found to carry the following viruses that infect humans: Cache Valley, EEE, Jamestown Canyon, Trivittatus, and WNV. More detail on EEE and WNV is provided below. As mentioned, the increasing abundance in Connecticut of the *Ae. albopictus* mosquito is of concern because this species transmits the viruses that cause dengue fever, chikungunya, Zika virus disease, and yellow fever. Fortunately, to date, none of these viruses have been detected in *Ae. albopictus* mosquitos in Connecticut.

- **West Nile virus**

During 2000–2018, the number of reported symptomatic cases per year of WNV infection varied from 0 (2004 and 2009) to over 20 (2012 and 2018). More than half of these cases were located in Fairfield County. Most have occurred during August and September.[13]

Only about one in five people infected with WNV show symptoms, which can include fever, headache, muscle pains, and rash. For this reason, cases of WNV are underreported, since those who do not experience symptoms (or those who experience very mild symptoms) will not go to the doctor and be diagnosed.[5] Fewer than 1% of infected people experience a serious illness that affects the central nervous system, such as meningitis or encephalitis.[14] In rare cases, the infection can lead to death.

- **Eastern equine encephalitis**

EEE is a rare mosquito-borne disease. Nationally, on average only seven cases are reported per year.[15] The first human case of EEE was reported in Connecticut in 2013.[16] In 2019, four human cases were reported, three of which were fatal. All four cases were clustered in southern Connecticut.[16] Infections typically occur in warm weather months. In 2019, the majority of infected mosquitos were found in August and September; the onset of symptoms in the four human cases also occurred during this period.[17] Concern over EEE during Fall 2019 led officials in some Connecticut towns to change the time of high school sporting events, among other precautionary actions.

Most people infected with EEE virus have no symptoms. In only rare cases (estimated less than 5%) does the infected person develop an infection of the central nervous system (i.e., meningitis or encephalitis);[18] in these cases, EEE can be fatal. Based on a national surveillance dataset, the fatality rate for those officially diagnosed with EEE was found to be 41%.[18] However, the real fatality rate is much lower when considering the cases in which people have mild or no symptoms and do not seek medical attention.

TICK-BORNE DISEASES

Blacklegged ticks transmit several diseases to humans: Lyme disease, anaplasmosis, babesiosis, Powassan virus, and ehrlichiosis, which are described further below. It is possible for two or more of these diseases to co-occur in the same person due to a single tick bite. Lone star ticks do not transmit Lyme disease;[19] however they are associated with other diseases and medical conditions, including tularemia, ehrlichiosis, Heartland virus disease, southern tick-associated rash illness, red meat allergy, and likely, Bourbon virus disease.

- **Lyme disease**

Lyme disease, caused by the bacterium *Borrelia burgdorferi* and transmitted by the blacklegged tick, is the most commonly reported vector-borne disease in the U.S., as well as in Connecticut. It is generally cured with antibiotic treatment, but particularly without treatment, symptoms can progress to severe joint pain and swelling, facial palsy, heart palpitations, inflammation of the brain and spinal cord, and nerve pain or numbness.[20] Transmission occurs seasonally, with the most cases reported in June and July in Connecticut.[21] This coincides with when ticks (especially those in the nymphal stage) are most active and when humans spend time outdoors in areas where tick bites are more likely to happen. Reported cases of Lyme disease in Connecticut declined from about 3,700 per year in 2008–2010 to about 1,900 per year in 2016–2018.[21] This may be due to cases not being reported by medical providers to health officials or to the population taking more preventive measures. Nevertheless, in 2017–2019, Connecticut's incidence rate of Lyme disease was the ninth highest in the U.S.[22]

- **Anaplasmosis**

Anaplasmosis is caused by the bacterium *Anaplasma phagocytophilum* and is transmitted by the blacklegged tick. Symptoms of anaplasmosis are similar to the flu, including fever, headache, chills, muscle ache, and nausea. Most cases are mild and do not require medical treatment. However, the elderly and people with compromised immune systems may experience moderate or severe symptoms. Cases of anaplasmosis increased from 111 reported cases per year in 2014–2018 to 315 reported cases in 2019 alone.[23]

- **Babesiosis**

Babesiosis is caused by the protozoan parasite *Babesia microti* and is transmitted by the blacklegged tick. Those infected generally experience mild flu-like symptoms, but the illness also can be life-threatening in the elderly, the immune-compromised, and people without spleens. It also is possible to be infected with both Lyme disease and babesiosis at the same time, which can result in more severe Lyme disease and a longer recovery. In 2017–2019 in Connecticut, 293 cases per year were reported, the fourth highest incidence rate of babesiosis in the U.S. during that period.[24]

- **Powassan virus**

Powassan virus (or Powassan encephalitis virus) is transmitted by both the blacklegged tick and the woodchuck tick (also found in Connecticut). Reported cases are rare in the U.S., though they are increasing. While some people who are infected experience no symptoms, others experience serious symptoms associated with encephalitis, including fever, convulsions, and disorientation, as well as in some cases, partial coma and paralysis. The fatality rate is approximately 10% of reported cases, and some survivors develop long-term or permanent neurological problems. In Connecticut, 10 cases were reported from 2011 to 2020; nine of those cases occurred in 2018–2020.[25]

- **Ehrlichiosis**

Ehrlichiosis is the general name for a group of diseases caused by *Ehrlichia* bacteria and transmitted primarily by lone star ticks, but also by blacklegged ticks. When treated early, symptoms are usually mild or moderate and may include headache, nausea, fever and chills, and in some cases, a rash (more common in children). Without antibiotic treatment, the disease can cause severe illness, with greatest risk to those very young or very old, as well as those with a compromised immune system. The number of cases nationwide has increased steadily over the past 20 years, with over 2,000 cases reported in 2019.[26] Cases remain uncommon in Connecticut (2 cases in 2019),[26] though it should be considered an emerging concern as the lone star tick becomes more common in the state.

Who is most at risk?

Outdoor workers: Outdoor workers can be at greater risk for exposure to both mosquitos and ticks, though it varies by sector and location. In 2020, CONN-OSHA reported that its inspections revealed that most employers did not have active tick-borne disease prevention strategies in place, such as trainings, repellant use, and tick checks.[27]

Suburban and rural residents: The majority of tick bites in Connecticut are estimated to occur outdoors at home, particularly from playing and doing yard work.[28] Residential yards near forested areas or other tick habitat can increase exposure. Residents near water bodies are at higher risk for mosquito-borne diseases; in particular, EEE mosquitos breed in hardwood freshwater swamps.[29]

Urban and suburban residents: The main WNV mosquito vector, *Culex pipiens*, breeds in habitats created by human disturbance, which puts urban and suburban residents especially at risk; breeding sites can include stagnant water collected in discarded containers, tires, open ditches, and storm drains or catch basins.[5] The *Ae. albopictus* mosquito also prefers urban and suburban areas for habitat,[30,31] and its population is increasing in Connecticut. As mentioned, the mosquito is known to carry dengue, Zika, chikungunya, and yellow fever viruses, and while the spread of these diseases has not yet been observed in Connecticut, it is a significant future concern, particularly as climate change worsens and impacts human health.

Uninsured or underinsured individuals: Early diagnosis and treatment of mosquito- and tick-borne diseases, including Lyme disease, is important to limiting the severity of illness. Those without health insurance (or with insufficient health insurance) may be less likely to receive early and sufficient medical treatment.

Residents in substandard housing: Housing with undamaged and well-fitting window and door screens reduces the residents' exposure to mosquitos.

People experiencing homelessness: People experiencing homelessness may be more exposed to disease-carrying vectors; in particular, since many mosquitos are more active at dusk or night, those who sleep outside are at higher risk.[32] Additionally, people experiencing homelessness may be more susceptible due to pre-existing conditions, and also have fewer resources to protect themselves and to seek prompt medical treatment.

Children: In Connecticut, Lyme disease is most frequently reported for children ages 5–9.[33] Young children (and the elderly) appear to be at greatest risk for developing severe disease when infected with EEE virus.[18]

Elderly and people with underlying conditions: The elderly and people with underlying conditions are more vulnerable to severe disease from some vector-borne diseases, including WNV and EEE.[18,34]

What can we expect in the future?

TICKS

Climate change may affect the risk of being infected with a tick-borne disease in a few ways. First, climate change is likely a factor in the northward expansion and emergence in Connecticut of new tick species, including the lone star tick. Second, the warmer winters and earlier springs projected under climate change may cause the tick-borne disease season to begin earlier, and this extends the period of disease transmission. For instance, under a high greenhouse gas emissions scenario, it is projected that by 2065–2080, the Lyme disease season would begin approximately 1.5 weeks earlier in Connecticut compared to 1992–2007.[35] Third, shorter and milder winters and earlier springs make it more likely that ticks will survive the winter, leading to larger tick populations.[36] But extreme heat and drought increase tick mortality, so climate change also may lead to a countervailing force on tick abundance.[37]

MOSQUITOS

As Connecticut continues to warm, disease-carrying mosquitos may become even more abundant, absent control measures. As warm seasons lengthen, so might the transmission seasons for the diseases these mosquitos carry. Furthermore, changes in precipitation, which are expected to occur in Connecticut due to climate change, could influence mosquito abundance in complex ways. Under a high greenhouse gas emissions scenario, an additional 490 severe WNV infection per year are projected in the Northeast in 2080–2099 compared with 1986–2005.[38]

Finally, warmer conditions may allow for mosquito species to expand their habitats northward into Connecticut; this is particularly a concern for the *Aedes aegypti* mosquito, which is the main vector for dengue virus, chikungunya virus, Zika virus, and yellow fever virus (*Ae. albopictus* is the secondary vector for these viruses). While *Ae. aegypti* is generally only found in tropical and subtropical locations, it was recently discovered in Washington, DC, where it survives winter in underground urban structures.[39]

Recommendations

The Yale Center on Climate Change and Health evaluated policy measures found in the GC3 *Phase 1 Report* and in national best practices. We identified the following five recommendations, which elevate measures that protect human health from emerging and worsening vector-borne diseases and prioritize equity. We emphasize actions at the state policy level, while recognizing that individual behavioral adaptation is also important for reducing the preventable adverse health impacts of vector-borne diseases.

1. **Support and strengthen monitoring and surveillance of vector populations and vector-borne diseases, including emerging vectors and diseases**

CAES operates a highly respected mosquito surveillance program through which mosquitos are trapped at sites around the state and then tested for pathogens. Trapping and testing of mosquitos gives advanced warning of potential outbreaks; once human cases of disease are later identified, it is difficult to effectively combat the outbreak. The surveillance program also monitors for new viruses or new (invasive) mosquito species. Importantly, this program needs to be maintained and supported with sufficient state funding. In addition, municipalities contract with companies who conduct local field surveillance to identify mosquito breeding sites or other problem areas; municipalities bear these costs, and they also need funding support to effectively continue.

CAES also operates a tick surveillance program that is comprised of both passive surveillance (residents submit ticks to be testing for pathogens) and active surveillance (similar to the mosquito program above; ticks are systematically collected from the environment and then tested for pathogens).[40] Both require state support in order to continue; CAES relies on federal funding to operate these programs, but it is insufficient. Additionally, tick-borne disease prevention in Connecticut would greatly benefit from stronger coordination at the state level between state agencies, CAES, and local health departments. The GC3's Public Health and Safety Working Group recommended establishment of a State Public Health Entomologist position to serve in this important coordination role. The Connecticut Department of Public Health's new Office of Climate and Public Health also could provide coordination support.

2. **Develop state vector-borne disease prevention and management guidelines and resources for schools and summer camps**

Currently, there are no Connecticut state guidelines for schools or summer camps to prevent vector-borne disease and manage risks, particularly associated with outdoor activities including sports. Providing guidelines and resources is important to support school and camp administrators, teachers, coaches, camp counselors, and other staff to balance the health risks and benefits of outdoor activity. Experts from the Connecticut Departments of Education and Public Health and CAES should work together with school and camp representatives to develop the guidelines and resources. We recommend drawing on resources from neighboring states. For instance, the New York State Center for School Health developed a Tick and Tick-borne Disease Resource Toolkit, which includes resources such as a webinar to educate boards of education, school staff, and others; sample lesson plans and other education resources; and a sample field trip notification. Maine's Mosquitoes in Schools: Guidance for the School Nurse provides guidance on grounds management and repellent use, as well as a "Mosquito Prevention and Response Action Chart." The Connecticut Department of Education also should encourage vector-borne disease education to be included in Pre-K through 12 health education programs. Finally, schools and camps should employ integrated vector management strategies (see recommendation 4 below), particularly through their landscape management practices, to reduce youth and staff exposure to tick and mosquito vectors and to minimize insecticide exposure; the CAES Tick Management Handbook and the EPA Tick Safety in Schools can serve as resources.

3. **Enforce the CONN-OSHA requirement for tick bite prevention measures, and expand training and resources to support private employers to adopt tick bite prevention measures**

In 2020, CONN-OSHA instituted a requirement for all regulated employers to "assess their workplaces for the known and recognized hazard of occupational exposure to tick-borne disease and to implement prescribed workplace control measures."[27] Such control measures should include the application of the existing CONN-OSHA standard 1910.132 "Personal Protective Equipment." Importantly, CONN-OSHA's requirements apply only to public sector employers; however, the agency also calls on private sector employers (which fall under federal OSHA's jurisdiction) to implement these actions. We recommend that CONN-OSHA enforce this new requirement for public sector employers through its annual oversight process and, in collaboration with the Connecticut Department of Public Health (CT DPH), provide resources and training to support compliance. We also recommend that CT DPH and federal OSHA provide similar training and resources to support private employers.

4. **Support municipalities and landowners to apply integrated vector management approaches to protect community health**

Integrated vector management (IVM; similar to integrated pest management or IPM) is an ecosystem-based strategy that is well-suited to managing mosquito populations. At its base is a monitoring program that tracks factors including 1) the conditions and habitats that are conducive to high mosquito prevalence; 2) mosquito abundance throughout the season; and 3) disease transmission activity in the environment (e.g. birds, horses) before human cases occur.[41,42] Managers use these data to inform mosquito control activities, such as habitat modification (e.g., cleaning out storm drains), larval mosquito control, community education, and — only as a final resort — adult mosquito control with insecticides.[41] Activities are designed to minimize risk to human health, beneficial and nontarget organisms, and the environment.[43] This approach of surveillance and targeted management is currently applied in Connecticut; the state has done aerial insecticide spraying only once in recent memory. However, state staff are limited in the tools and resources they can apply toward comprehensive management and education. For instance, Connecticut lacks mosquito control districts (like in Massachusetts), which are funded and can undertake regional mosquito management, disease surveillance, and public education.[44] As a result, Connecticut municipalities conduct most mosquito management activities. We recommend supporting municipalities with further funding and support to carry out this work, as well as providing education and support to municipalities and landowners to apply the principles of IVM effectively and correctly. Supporting this infrastructure now is especially important to be prepared for a warming climate.

IVM for ticks includes personal protection measures and educating the public on such measures; landscape and vegetation management to reduce tick, rodent, and deer habitat near populated areas; selected direct targeting of rodents and/or deer, such as by building fences to restrict deer from populated areas; and targeting the ticks themselves, preferably with relatively non-toxic acaricides (pesticides that kill ticks), such as biological agents.[28] Controlling ticks and tick-associated diseases is challenging, in part because ticks have complex life cycles that take place over multiple years, and human behavior importantly influences the likelihood of infection; therefore, management strategies are best when used in combination.[28] The state and CAES should provide resources and education to municipalities and landowners on best practices for integrated tick management, particularly in parts of the state that may have less experience with tick-borne diseases.

5. **Increase the knowledge base of healthcare professionals regarding vector-borne diseases through continuing education programs and by incorporating climate change into medical, nursing, public health, and veterinary curricula**

Most health professionals — including physicians, nurses, psychologists, community health workers, public health professionals, and veterinarians — did not learn about climate change and its health effects in their formal training. Although the situation is improving, climate change currently is covered in only a small proportion of U.S. health professional schools.[45,46] Incorporating lessons about climate change and its health impacts into health and other higher education curricula, as well as continuing education courses, would help close this key knowledge gap and prepare the health workforce to make informed decisions under a changing climate. The curricula should cover vector-borne diseases, and particularly identify the emerging threats. This challenge should be addressed through combined efforts of colleges and universities, public health agencies, and professional associations.

ABOUT THIS SERIES

YCCCH released *Climate Change and Health in Connecticut: 2020 Report* in September 2020. The comprehensive report tracks 19 indicators on climate change and health in Connecticut across four domains: temperature, extreme events, infectious diseases, and air quality. The issue brief series mirrors the four domains, summarizing key findings from the Report and extending it to include policy recommendations. To read the full report or the other issue briefs, visit:

https://ysph.yale.edu/yale-center-on-climate-change-and-health/policy-and-public-health-practice/connecticut/

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