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Closer Neighborhoods: APPENDIX A3

VECTOR BORNE DISEASE RISK IN A TIME OF CLIMATE CHANGE

CITY OF CAMBRIDGE, MASSACHUSETTS
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Vector Borne Disease risk in a time of climate change:

Drivers of Change, Risk of Emergence of VBDs and Recommendations for the city of Cambridge, MA

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OVERVIEW

In Massachusetts and in most of North America there are two primary vectors responsible for vector-borne diseases (VBDs): mosquitoes and ticks. While fleas are associated historically with outbreaks of plague (*Yersinia pestis*) and do deliver parasites to animals via ingestion (e.g. tapeworms in dogs and cats) they are primarily associated with allergic reactions in humans in the modern era. Mosquitoes can transmit infectious diseases while collecting a blood meal from a mammal – humans, horses, birds, etc., while ticks spread disease by latching on to mammals for approx. 24 hrs. The most prevalent mosquito-borne diseases in Massachusetts over the past century are West Nile Virus and Eastern Equine Encephalitis, while the most important public health threat from ticks is Lyme Disease. Although fleas are capable of transmitting zoonotic diseases such as typhus (*Rickettsia typhi*), plague (*Yersinia pestis*), Tularemia (*Francisella* tularensis), and parasitic tapeworms, to human, they are not nearly as important a vector of transmission to humans in the modern era. This summary of the regional VBD burden of disease will focus on mosquito-borne and tick-borne public health risks[1].

[1] https://www.who.int/docstore/water_sanitation_health/vectcontrol/ch24.htm

Although most individuals infected with West Nile Virus are asymptomatic, 20% of infected patients develop a high grade fever, headaches, body aches, joint pains, vomiting, diarrhea, or rash.[2] About 1 in 150 people develop a severe illness affecting the central nervous system such as encephalitis (swelling of the brain) or meningitis (inflammation of the membranes that surround the brain and spinal cord).[3]

PROBLEM STATEMENT

Vector-borne diseases (VBDs), or infectious diseases transmitted to humans via the bite of an infected living organism such as a mosquito or tick, account for 17% of all infectious diseases globally, resulting in more than 700,000 deaths annually. In Massachusetts, West Nile Virus (WNV) and Eastern Equine Encephalitis Virus (EEEV) transmitted to humans by mosquitoes (*Culex* spp. and *Culiseta* spp. respectively), and Lyme disease and Anaplasmosis transmitted to humans by *Ixodes* spp. ticks, are the most prevalent VBDs. These diseases cause significant morbidity and mortality both globally and in the highly populated state of Massachusetts, with regional variability in exposure risk.

With increases in mean ambient seasonal air temperatures, extreme weather events that create new vector habitat, and changes in precipitation levels due to climate change, it has become more important to consider three factors driving potential arboviral disease risk beyond our current burden. First, human arboviral disease will be subject to changes in habitat, population dynamics and infection patterns of VBD vectors that are already present in New England and already transmit WNV, EEE, Lyme disease and Anaplasmosis. Secondly, endemic vector-borne agents of disease that may currently only pose a minor public health risks might become more prevalent over time with changes in climate and land-use. Efforts to track shift in endemic host-pathogen patterns should be supported with the resources necessary to trap, identify and test vector species. At minimum, any capacity to update risk communication

[2] https://www.cdc.gov/westnile/symptoms/index.html
[3] https://www.cdc.gov/westnile/symptoms/index.html

depends on local data collected by over-stretched State and mosquito district field staff. Finally, we know that mosquitoes species of public health concern, like *Aedes albopictus*, have become established in the Boston area within the past decade. We also know that an even more notorious VBD vector, *Aedes aegypti*, which is endemic in many tropical and sub-tropical regions, have become more common as far north as New York City. We have far less insight into the extent to which we will see an increase in VBD risk from these regionally emerging species.

As distribution patterns and population changes occur among key mosquito species, whether from higher seasonal temperature, fewer winter frosts, more frequent storms capable of altering habitat, or land-use policies, human-biting species capable of carrying and transmitting EEE virus and other agents may impact communities not previously affected by that risk. One recent example of this shift in geographic risk is the collection of EEE-infected mosquitoes (*Coquillettidia perturbans, Aedes vexans, Culiseta melanura*) in Worcester (Central MA) and Hampshire (Western MA) counties. The unpredicted and sudden shift in geographic risk posed by EEE serves as a reminder that Cambridge and Massachusetts should prioritize assessment of changes in VBD risk to humans consistent with all scenarios discussed above. This appendix to the Cambridge Climate Change Preparedness and Resiliency (CCPR) plan will provide general background information on these risks and will include a review the burden of disease for the most common VBDs. This summary will also include a discussion of the drivers of change – both environmental and anthropogenic, and the risk of an increase in the burden of VBDs in the city of Cambridge. Finally, this appendix will address the current existing surveillance and prevention measures, as well as evidence-based recommendations for the future.

BACKGROUND

Burden of Disease

Diseases transmitted via the bite of infected vectors have long posed a public health risk the state of Massachusetts, dating to the introduction of Yellow Fever with the arrival of trading ships from tropical regions in the 18th and 19th centuries[4]. Vector-borne disease (VBD), is a broad public health term for the various blood-feeding arthropod-borne pathogens which can spread to humans through mosquitoes, ticks, and fleas. These agents can cause a range of morbidities and mortality among infected individuals[5]. Although there are currently 14 VBDs of national public health concern in the United States, the four agents of greatest importance to public health in MA, and in the city of Cambridge, are West Nile Virus (WNV), Eastern Equine Encephalitis (EEE), Lyme disease, and Anaplasmosis.[1,28]

WNV, which first appeared in the Boston area in the summer of 2000, eventually became the leading cause of mosquito-borne disease in the US. In the Northeast US this virus is transmitted by the *Culex* spp. mosquitoes – primarily the *Cx. pipiens* subspecies. This virus is known to survive from year to year in various bird species that serve as "reservoir hosts", which can then transmit this viral agent to biting arthropod vectors every spring and summer.[23] EEE, on the other hand, was first identified in humans in MA in 1938 with *Culiseta melanura* as the most important vector within the bird population and *Coquilletidia perturbans* as the main "bridge vector" of EEE from birds to humans. Both Lyme disease (caused by the *Borrelia burgdorferi* bacterium) and Anaplasmosis (*Anaplasma phagocytophilum*) are transmitted by the *Ixodes scapularis*, the black legged deer tick. Tick borne diseases account for 77% of all VBD reports in

[4] https://www.cmmcp.org/mosquito-biology/pages/mosquito-species-mass

[5] https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases

the U.S., the number of cases more than doubling over the last decade, and Massachusetts is no exception.[1]

Fig. 1 Timeline charts of reported and confirmed Vector-Borne Disease cases in Massachusetts. Fig. 1a demonstrates the increase in reported cases of Anaplasmosis; Fig. 1b shows the change in prevalence of WNV in MA since 1999; Fig. 1c demonstrates the confirmed cases of Lyme disease in MA since 2009, however it is important to note that Lyme was no longer considered a notifiable disease by the CDC in 2016; and Fig. 1d shows the reported human cases of EEE in MA over the last 10 years.

to recognize how the pathogen lifecycles, availability of vector species and reservoir hosts, and the presence of bridge vectors will each be affected in different ways by climate change and ultimately either increase or decrease the incidence of arboviral zoonotic disease in the city of Cambridge.

Vulnerable Populations

The individuals currently at greatest risk for serious illness resulting from infection with VBDs are often the same groups that will be most impacted by climate change and its accelerating effects on VBD transmission. These at-risk populations include older residents, residents who live in homes with inadequate windows screens and nearby sources of standing water (e.g.

used tires, clogged gutters), workers and individuals who spend excess time in the outdoors during the summer and fall (landscapers, construction workers, wilderness guides, etc.), and individuals with already weakened immune systems (such as those occurring due to cancer treatments, advanced HIV infection, prior organ transplants, or some types of medications).

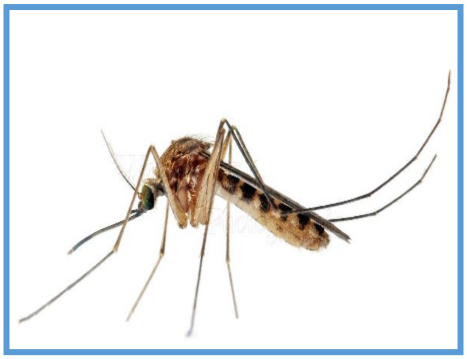
CLIMATE CHANGE, ROUTES OF TRANSMISSION, AND RISK OF EMERGENCE

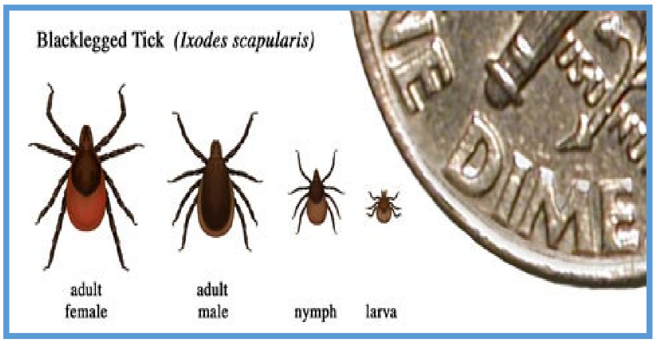
Climatic change may indeed result in an increased distribution of VBDs, however the actual magnitude and type of risk within Cambridge will be governed by epidemiological, behavioral, environmental, and anthropogenic dynamics. It is useful to regard shifts in climate as a "change magnifier" with uncertain effects, resulting in new habitat, fewer hard frosts, and warmer and wetter winters. These changes, when combined with tourism and familial ties to regions with endemic pathogens (e.g. Zika and Chikungunya), describe the scenario of concern for introduction and expansion of arboviruses in temperate climates like New England. Introduction of new pathogens and vector species finding sustaining habitat, has already been observed up and down the East Coast of the US. When discussing the risk for increased incidence of VBDs in Cambridge, it is important to first understand the vector species, bridge vectors, and reservoir hosts that, when impacted by environmental and anthropogenic changes, may influence the transmission rates of infectious disease-causing pathogens.

Vector Species, Bridge Vectors, and Reservoir Hosts

In Massachusetts, the infectious agents which cause the major mosquito-borne diseases – West Nile Virus and Eastern Equine Encephalitis, are transmitted by various species of mosquito. As identified by the East Middlesex Mosquito Control, *Culex pipiens* and *Culex restauns* are the two most important vectors within the bird population as well as between birds and humans (bridge vectors) for WNV. Enzootic transmission of EEE in passerine bird populations throughout the state is primarily facilitated by *Culiseta melanura,* while *Coquillettidia perturbans* act as the major bridge vector of EEE between birds and humans.[6] For

[6] http://www.vdci.net/vector-borne-diseases/eastern-equine-encephalitis-virus-education-and-integrated-mosquito-management-to-protect-public-health





tick-borne diseases within the state, *Ixodes scapularis*, commonly referred to as the deer tick or black-legged tick, is the primary vector for both bacterial species *Borrelia burgdorferi* and *Anaplasma phagocytophilum* which cause Lyme disease and Anaplasmosis respectively.[7,8] As the common name implies, these ticks are closely, though not exclusively, associated with the deer population during the adult phase of their lifecycle. However, unlike WNV and EEE, the pathogens causing Lyme and Anaplasmosis have complex lifecycles that involve the various stages of *I. scapularis* (e.g. larvae and nymph stages) with small mammalian reservoir host such as the white-footed mouse playing a critical role during the nymphal stage of the tick.

Challenges in projecting emerging VBD risk

Due to the multiple factors influencing transmission of VBDs it is not feasible to reliably model shifts in VBD risk to human that emerge from climate and habitat changes. It is the pathogen's basic reproduction number, R0, that determines how efficiently the pathogen will spread (R0>1), when introduced into a fully susceptible population. The R0 of VBDs is impacted by the vector population size, daily survival rate, biting rate, transmission efficiencies, vector

[7] http://www.vdci.net/vector-borne-diseases/lyme-disease-education-and-tick-management-to-protect-public-health

[8] https://www.cdc.gov/anaplasmosis/transmission/index.html

competency (entomological inoculation rate), and the duration of the extrinsic incubation period.[9]

Factors of Emergence

As mentioned previously, factors of emergence that influence an increased risk of VBDs in Cambridge fall into two categories both of which are amplified by climate change: environmental factors and anthropogenic, or human caused, factors.

Environmental Factors

- Increased Ambient Air Temperatures
- Changes in Vector Species Range and Abundance
- Vector Competency
- Pathogen Adaptations – New Vector Species
- Reservoir Host movement
- Above OR below average precipitation
- Seasonality of diseases

Anthropogenic Factors

- Urbanization
- Deforestation
- Reestablishment of Wetlands/Forest Fragmentation
- Human Behaviors
- Lack of Preventative Measures
    - e.g. Surveillance and Monitoring, PPE, etc.
- Low-Socioeconomic Status

Environmental factors that increase risk of VBDs in Cambridge include increased mean ambient air temperatures in the city, duration and extent of freezing during the winter, changes in precipitation during critical developmental stages of vectors during the spring and summer, alterations in vector and bridge vector species ranges and competency, pathogen adaptation to new more competent vector species, reservoir host movement, emergence of new reservoir host species, and the seasonality of each infectious disease. Increased mean ambient air temperatures, along with changes in precipitation (either above or below the mean), as modeled in the city of Cambridge's Climate Change and Vulnerability Assessment, may increase the frequency and duration of standing water (undisturbed for more than a week), which allows for adequate mosquito breeding habitat and growing mosquito populations in close proximity to humans and passerine birds. Additionally, these predicted environmental changes

[9] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4369930/

may result in changes in vector species ranges and the introduction of new competent vectors such as *Cx. salinarius* which is currently a secondary vector of EEE in MA and has been steadily increasing in abundance over the last four years in the Cambridge area, and the expansion of range of the black-legged tick and small mammal reservoir hosts which transmit Lyme disease.[10]

The anthropogenic factors impacting the risk of VBD emergence, other than the underlying human activity causing climate change, are urbanization, deforestation, reestablishment of wetland forests, and human behaviors such as a lack of adherence to mitigation measures, reluctance to pay for habitat control and larviciding on privately-owned property, and unmaintained and abandoned properties, and a large proportion of renters who may not directly control proximal environmental risk factors discussed above. Urbanization, deforestation and high-frequency travel to and from areas with endemic VBD risk have brought humans in closer contact with VBD vectors and has expanded the habitat ranges of potentially competent vectors.

CURRENT AND EMERGING VBD VULNERABILITIES

WNV (2000) and EEEV (1938) are well establish as the mosquito-borne diseases with the highest disease prevalence in MA, and Lyme disease and anaplasmosis are the tick-borne diseases most commonly found in New England.[8,10] It is worth noting that while the four diseases primarily discussed throughout this white paper may appear to be the most prominent regional VBDs, additional consideration is included on possible new and emerging VBDs such as Zika, Dengue fever, Chikungunya, and Powassan.[14]

Risk of Local Emergence

- Projections based on models of temperature increases and changing precipitation for:
    - *Rocky Mountain Spotted Fever (RMSF)* – Dog tick → *Dermacentor variabilis*
    - *Zika, Dengue, CHIKV (Chikungunya virus)*
    - *Powassan*
    - *Babesiosis*

[10] Doug Bidlack, Public Health Entomologist, Massachusetts Department of Public Health

Clear evidence that the incidence vector-borne disease will increase in the city of Cambridge due to climate change is not yet established. Some local factors mitigate against rapid changes in local risk. Nevertheless, it is apparent that we do not have a highly predictive model for VBD risk.

- The population density, geography, and urban landscape of Cambridge suggest that even with increased mean ambient air temperature, increased precipitation and draught, and potential increased vector range, changes in vectors of concern and the VBDs they carry will be limited by the urban environmental that primarily support species that have adapted to that habitat. Several important species mentioned herein, such as *Culex pipens* and *Aedes albopictus*, are sustained in urban habitats, since these are "container-breeding" species that are known to thrive in nutrient-rich stagnant water found in small containers and clogged roofline gutters.

EXISTING SURVEILLENCE, MONITORING, AND CONTROL METHODS

East Middlesex Mosquito Control Project (EMMCP https://sudbury.ma.us/emmcp/) provides mosquito control services to each community within its designated area, but does not require communities to participate. EMMCP is supported largely through funds from collected from each community, based on specific levels of service agreed upon. Some communities receive no services, though trapping may occur within municipal limits. Other communities pay for source control (targeted dredging), adulticide spraying, larvicide applications, and surveillance (trapping and testing).

Mosquito Control: Massachusetts General Laws (https://malegislature.gov/laws/generallaws)

- c.252, §2, §5B, §14D State Reclamation and Mosquito Control Board
- c.129, §28 Notice of contagious diseases [in animals]

Massachusetts Emergency Operations Response Plan for Mosquito-Borne Illness
https://www.mass.gov/doc/massachusetts-emergency-operations-response-plan-for-mosquito-borne-illness-0/download

Massachuusetts Surveillance and Response Plan (2020)
https://www.mass.gov/doc/2020-arbovirus-surveillance-and-response-plan/download

Bureau of Infectious Disease Laboratory (arboviral mosquito testing)
https://www.mass.gov/state-public-health-laboratory-services

University of Massachusetts Laboratory of Medical Zoology - LMZ (arboviral tick testing)
https://tickdiseases.org/

Manditory Case Reporting of specific arboviral diseases in humans by clinician to MADPH

- Notifiable VBDs through NNDSS/CDC
- Mass General Laws Amended c. 111 §3, 6, 7, 109, 110, 111, 112
- Mass General Laws Amended c. 111D §6
- Code of MA Regulations 105 CMR 300 [Reportable Diseases, Surveillance, and Isolation & Quarantine Requirements]

LIMITATIONS IN CURRENT CONTROL, TRAPPING AND SURVEILLANCE CAPACITY

- Lack of consistent surveillance/monitoring for tick-borne illnesses
- Evidence suggests limit efficacy of truck-based ground-spraying in dense urban communities where buildings are closely packed Paul Reiter, CDC Entomologist (unpublished)
- Aerial spraying in urban areas, though potentially effective, is not likely to be welcomed by residents in those communities. If public health risk dictates
- Mosquito control is primarily a regional activity and participation by any given community is discretionary. There is no statewide funding to support comprehensive local surveillance and control by regional districts/projects.
- Mosquito control districts are not authorized by statute to address tick-borne disease risks
- Risk Communication strategies are complex when specific regional risks diverge from one uniform state risk messaging.
- Limited local data (city/regional level)
  - Local tickborne VBD risk is often difficult to assess as trapping, identification and testing for ticks is not coordinated or evaluated by the State.
  - Mosquito trapping and testing is dependent on available resources and willingness to fund testing services by each municipality.

RECOMMENDATIONS TO CITY

1. **Increase funding for the East Middlesex Mosquito Control to support expanded testing for emerging mosquito activity in addition to current surveillance, storm drain larviciding, targeted hand-held spraying in wetlands, and testing of mosquito populations of greatest concern. We recommend:**

a. Funding levels should support monitoring of previously known species of concern in areas where they are typically found and also support investigative trapping and testing to detect shifts in habitat range and species mix over time. Routine surveillance is not sufficient to track species and habitat changes that will be essential to local risk messaging and public health planning.
b. Operational efficiencies could be achieved with a merger of the East Middlesex and Suffolk Mosquito Control programs given the shared urban habitat, species of concern, and shared vector control strategies. These two programs have operated in close coordination and share a single management, but have not received permission to formally merge.

2. **Improved identification and management of vector breeding habitat on private property (e.g. undisturbed stagnant water collection sites; clogged roofline gutters, tires, birdbaths and other containers).** Public engagement in identification of standing water and other containers supporting species of concern has lessened over the 20 years since West Nile virus first arrived in the Boston area. **We recommend:**
    a. Identification and elimination or treatment of breeding habitat (enforcement) and larviciding (prevention) on non-public property should be communicated directly to larger property owners to raise awareness.
    b. Public concern about identification of urban breeding habitat has lessened since 2000, when WNV first appeared in the area. A more active effort to ask residents to identify high-risk conditions (yard debris, stagnant water sources) and to make reporting easier should be instituted. See-Click-Fix for standing water with photo submission as part of the reporting should be offered and promoted through the City's website and on social media.

3. **Coordinated tick surveillance and monitoring**. Current tick data is collected through resident submissions to UMass Laboratory of Medical Zoology for a fee. The submissions are collated by municipality, but there is some ambiguity about the place where the tick may have been encountered, rather than the home address of the individual submitting the sample. There is no statewide strategy for tick collection and surveillance beyond this fee-for-service option. Massachusetts needs a coordinated tick surveillance plan that relies on regular collection and testing, particularly in heavily populated areas where the tick population may be shifting. Questions about the prevalence of ticks carrying the agent responsible for Lyme Disease (*Borrelia burgdorferi*) in urban neighborhoods cannot be addressed sufficiently without more strategic data collection that includes more precise location information. **We recommend**:
   a. Focused surveillance efforts to characterize range of tick species and small and large mammal hosts . This surveillance does not need to be carried out seasonally (as with mosquitoes), but should include heavily populated areas where shifts in tick species and mammal host prevalence have shifted in the past few decades.
   b. Feasibility of establishing a coordinated tick surveillance program as an additional function of the regional mosquito control projects/districts should be evaluated and supported with appropriate budgetary resources. Assignment of this function to mosquito control projects/districts may require amendments to the statutes and/or regulations pertaining to these projects/districts. Current language creating these programs is specific to mosquitoes and expansion to include tick surveillance is not regarded as permissible under the current statutes.

4. **Better utilization of existing tick collection and testing system (until a state-coordinated tick surveillance program is established). We recommend:**

a. **Community participation in a coordinated specimen-submission effort**. Greater utilization of the UMASS Laboratory of Medical Zoology (LMZ) or other suitable entomology laboratories for community submissions to assess local tick species and tick-borne disease spread. Such a program might work best with local public health or community coordination, to establish precise location of ticks collected. Non-specific data on precise location weakens currently available data from individual submissions.

5. **Utilize Health Impact Assessment (HIA) framework**. **We recommend:**
   a. Developing a data-driven conceptual risk/policy framework which will focus on the linkages between ecosystem surveillance and management and human health with the ultimate goal of informing local Cambridge policymakers on the specific health risk factors that may be associated with current and future land-use policies.

6. **Support community-based participatory research into novel surveillance and control strategies with appropriate local buy-in** (e.g. GMO mouse studies on Martha's Vineyard and Nantucket) that are applicable in an urban community.

7. **Scenario planning with regional communities and MDPH staff for potential use of aerial spraying in the event of a major outbreak (e.g. EEE transmission become highly prevalent in metro Boston area)**

General Background Reference for recommendations

1. Threats F on M, Health B on G, Division H and M, National Academies of Sciences E. *Workshop Overview*. National Academies Press (US); 2016. Accessed May 4, 2020. https://www.ncbi.nlm.nih.gov/books/NBK390426/
2. Morse SS. Factors in the emergence of infectious diseases. *Emerg Infect Dis*. 1995;1(1):7-15.
3. The Climate Change and Vulnerability Assessment Report. *City of Cambridge, MA*. Published November 2015. Accessed May 4, 2020. https://www.cambridgema.gov/-/media/Files/CDD/Climate/vulnerabilityassessment/ccvareportpart1/cambridge_november2015_finalweb.pdf
4. Cambridge Public Health Department - Our Work. Accessed May 4, 2020. https://www.cambridgepublichealth.org/our-work/

5. Beard CB, Eisen RJ, Barker CM, et al. *Ch. 5: Vectorborne Diseases*. U.S. Global Change Research Program, Washington, DC; 2016:129-156. Accessed May 4, 2020. vectorborne-diseases
6. Rosenberg R. Vital Signs: Trends in Reported Vectorborne Disease Cases — United States and Territories, 2004–2016. *MMWR Morb Mortal Wkly Rep*. 2018;67. doi:10.15585/mmwr.mm6717e1
7. Massachusetts: Vector-borne Diseases Profile (2004-2016) | Vital Signs | DVBD | NCEZID | CDC. Accessed May 4, 2020. https://www.cdc.gov/ncezid/dvbd/vital-signs/massachusetts.html
8. Epidemiology and Statistics | Anaplasmosis | CDC. Published March 26, 2020. Accessed May 4, 2020. https://www.cdc.gov/anaplasmosis/stats/index.html
9. Brown CM. Update: Tick-borne Disease Surveillance in Massachusetts. *Department of Public Health – Bureau of Infectious Disease and Laboratory Sciences*. 2018. http://blog.mass.gov/publichealth/wp-content/uploads/sites/11/2018/07/Tickborne-Illness.pdf
10. Lyme Disease Charts and Figures: Historical Data | Lyme Disease | CDC. Published November 22, 2019. Accessed May 4, 2020. https://www.cdc.gov/lyme/stats/graphs.html
11. Patz Jonathan A., Daszak Peter, Tabor Gary M., et al. Unhealthy Landscapes: Policy Recommendations on Land Use Change and Infectious Disease Emergence. *Environmental Health Perspectives*. 2004;112(10):1092-1098. doi:10.1289/ehp.6877
12. Eastern Equine Encephalitis Virus: Public Health, Mosquito Management. *Vector Disease Control* Internationl. Published 2018. Accessed May 4, 2020. http://www.vdci.net/vector-borne-diseases/eastern-equine-encephalitis-virus-education-and-integrated-mosquito-management-to-protect-public-health
13. Demographics and Statistics FAQ - CDD - City of Cambridge, Massachusetts. Accessed May 4, 2020. https://www.cambridgema.gov/CDD/factsandmaps/demographicfaq
14. Climate Change Preparedness & Resilience Plan - CDD - City of Cambridge, Massachusetts. Published 2020. Accessed May 4, 2020. https://www.cambridgema.gov/CDD/Projects/Climate/climatechangeresilianceandadaptation.aspx

REFERENCES

1. https://www.who.int/docstore/water_sanitation_health/vectcontrol/ch24.htm
2. https://www.cmmcp.org/mosquito-biology/pages/mosquito-species-mass
3. http://www.vdci.net/vector-borne-diseases/eastern-equine-encephalitis-virus-education-and-integrated-mosquito-management-to-protect-public-health
4. http://www.vdci.net/vector-borne-diseases/lyme-disease-education-and-tick-management-to-protect-public-health

1. https://www.cdc.gov/mmwr/volumes/67/wr/mm6717e1.htm (CDC - VBD)

2. https://www.cdc.gov/ncezid/dvbd/vital-signs/massachusetts.html (CDC MA)

3. https://wonder.cdc.gov/nndss/static/2018/annual/2018-table1.html (CDC notifiable IDs, 2018)

4. https://annals.org/aim/article-abstract/2301403/borrelia-miyamotoi-newest-infection-brought-us-deer-ticks?doi=10.7326%2fM15-1219 (b. *miyamotoi*)

5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4517724/ (geographic distribution of Lyme Disease in the US)

6. https://www.cdc.gov/lyme/stats/graphs.html (confirmed cases of Lyme 1996-2018)

7. https://www.cdc.gov/westnile/statsmaps/cumMapsData.html#one (WNV reported cases by state and year 1999-2018)

8. https://www.cdc.gov/easternequineencephalitis/tech/epi.html (EEE reported cases by state and year 2009-2018 à missing some important data points from last year)

9. http://www.vdci.net/vector-borne-diseases/eastern-equine-encephalitis-virus-education-and-integrated-mosquito-management-to-protect-public-health

10. https://www.cdc.gov/anaplasmosis/stats/index.html (reported cases of anaplasmosis 2000-2017)

11. http://blog.mass.gov/publichealth/wp-content/uploads/sites/11/2018/07/Tickborne-Illness.pdf (MA specific Tick Borne Disease Transmission epi data)

12. https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases

13. https://www.nemassmosquito.org/surveillance/pages/adult-mosquito-surveillance

14. https://sudbury.ma.us/emmcp/servicessummary/

15. https://www.mass.gov/doc/massachusetts-emergency-operations-response-plan-for-mosquito-borne-illness-0/download

16. https://www.nejm.org/doi/full/10.1056/NEJMp1914328

17. https://wwwnc.cdc.gov/eid/article/14/10/07-1396_article

18. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3774453/

19. https://www.nature.com/articles/s41598-017-15742-6

20. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5877023/

21. https://royalsocietypublishing.org/doi/full/10.1098/rstb.2013.0551

22. https://wwwn.cdc.gov/nndss/conditions/notifiable/2020/infectious-diseases/

23. https://health2016.globalchange.gov/vectorborne-diseases/content/west-nile-virus

24. https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.6877

a. Policy recommendations

25. https://www.mass.gov/lists/infectious-disease-reporting-and-regulations-for-health-care-providers-and-laboratories

26. https://www.cpsd.us/UserFiles/Servers/Server_3042785/File/Migration/AdminGuidelines_InfectiousDiseases.pdf

27. https://www.cdc.gov/westnile/symptoms/index.html

28. https://health2016.globalchange.gov/vectorborne-diseases