DURHAM REGION HEALTH DEPARTMENT

2025

CLIMATE CHANGE *and* HEALTH *in* DURHAM REGION

Assessing the impact of vector-borne disease

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The Region of Durham exists on lands that the Michi Saagiig Anishinaabeg inhabited for thousands of years prior to European colonization. These lands are the traditional and treaty territories of the Nations covered under the Williams Treaties, including the Mississaugas of Scugog Island First Nation, Alderville First Nation, Hiawatha First Nation, Curve Lake First Nation, and the Chippewa Nations of Georgina Island, Beausoleil and Rama.

We honour, recognize, and respect Indigenous Peoples as rights holders and stewards of the lands and waters on which we have the privilege to live. In our efforts towards reconciliation, we continue to build and strengthen relationships with First Nations, as well as the large Métis community and growing Inuit community here in Durham. We commit to learning from Indigenous values and knowledge, building opportunities for collaboration, and recognizing that we are all connected.

CLIMATE CHANGE AND HEALTH IN DURHAM REGION:

Assessing the impact of vector-borne disease

REPORT | May 2025

durham.ca/ClimateAndHealth

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We would also like to express our gratitude to the dedicated team members and advisors listed below. Their support and commitment to excellence have been instrumental and this report would not have been possible without their collective efforts. We appreciate their contributions and extend our genuine thanks to each of them.

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About this report

This vector-borne disease report is the third in a series of Durham Region Health Department climate change and health vulnerability assessments.

Climate change is projected to increase the number, intensity, and duration of climate hazards such as vector-borne diseases, extreme heat, and flooding. Action is required to both mitigate and adapt to climate change to protect the livability of our planet and the places we call home.

In Canada, federal and provincial vulnerability assessments have been completed to determine the impact of climate change on health. Less is known about local health risks and vulnerabilities faced by Ontario municipalities. To fill this knowledge gap, the Durham Region Health Department (DRHD) initiated a series of climate change and health vulnerability assessments (CCHVA) to determine current and future impacts of climate hazards on the health and wellbeing of Durham's residents. Each vulnerability assessment focuses on a specific climate hazard and has been written as a stand-alone report. **This vulnerability assessment explores current and projected health impacts of vector-borne diseases in Durham Region.**

The DRHD's vector-borne disease and health vulnerability assessment will help our region to:

- Better understand local health risks due to vector-borne diseases including those who may be most affected.
- Examine how climate change is expanding the range and seasonality of disease-carrying species.
- Develop strategies for protecting residents from vector-borne diseases. Examples include surveillance and health promotion on vector-borne disease health risks and prevention.
- Champion health equity by prioritizing measures to reduce impacts to at-risk groups.
- Improve public engagement and local knowledge on how to prepare for and protect against vector-borne diseases.
- Ensure a health lens is applied to broader regional climate action planning, policy, and program development.
- Promote community partnership development, including meaningful engagement with priority populations to understand barriers to climate adaptation measures as well as potential harms or unintended consequences of adaptation plans.
- Establish health indicators and metrics of community climate resilience to vector-borne diseases.
- Identify adaptation interventions.
- Find opportunities for working across municipal sectors to deliver health benefits to Durham residents.
- Facilitate collaboration with First Nations, Indigenous-led organizations, public health agencies in Durham, researchers, and policymakers to co-develop Indigenous-led solutions.
- Assess potential health burdens on MSIFN, including higher exposure risk for land users (e.g., hunters, harvesters, and fishers).
- Address cultural and subsistence activities affected by vector-borne disease risks, such as disruptions to seasonal harvesting and land-based practices.
- Help MSIFN advocate for health resources, such as early diagnosis and treatment access for vector-borne diseases.
- Facilitate the inclusion of MSIFN's voice and participation in regional climate action, including the development of adaptive capacity measures, related to vector-borne disease.

Detailed information about the CCHVA process, Durham Region's diverse environment and communities, and a high-level summary of the causes and impacts of our changing climate can be found in the previously published report: Climate Change and Health in Durham Region: Understanding the local health impacts of climate change, available at: **durham.ca/ClimateAndHealth**

Executive summary

This vulnerability assessment explores current and future local health impacts of vector-borne diseases (VBDs) associated with climate change. Findings will be used to support evidence-informed adaptation plans, policies, and programs to protect the health of Durham Region residents.

Vector-borne disease and health

Climate change is increasing the spread of VBDs, but infections are preventable.

- A warming climate is increasing the survival, spread, and exposure periods of disease carrying vectors and is associated with the increased incidence of VBDs, mainly Lyme disease (LD) and West Nile virus (WNv) disease.
- Climate change may also increase the spread and incidence of other VBDs such as anaplasmosis; Powassan virus disease, and babesiosis (tick-borne diseases), as well as, eastern equine encephalitis (EEEv), and California serogroup viral diseases (mosquito-borne diseases).
- In some cases, these diseases are mild. In other cases, they result in debilitating and disabling conditions, and in rare cases death.[1]
- Resources to respond to extensive outbreaks may be limited, stressing the importance for proactive health promotion and preventive measures to prevent infections.
- The health burden of LD in Durham Region is rapidly increasing and appears to be outpacing the provincial average.
- The health burden of WNv disease has increased over time and has exceeded the Ontario average since 2020.
- Climate-related VBDs can lead to mental, emotional, and spiritual health impacts, that are often underexplored by health systems. The relational approaches of Indigenous knowledge systems can help to guide methods for understanding, preventing, and addressing the broader range of health consequences of climate change, including VBDs.
- Prevention strategies require addressing the three main components of VBD vulnerability: exposure, sensitivity, and adaptive capacity.

1 It is important to note that humans are "dead-end hosts" of these diseases. This means that if a person is infected, they cannot pass the disease to another person.

VBD exposure in Durham Region

- Durham Region should expect greater future exposure to VBDs due to warmer seasons.
- The areas of Durham Region with blacklegged ticks that carry LD has rapidly expanded and they are now established in all municipalities.
- The establishment of infective blacklegged ticks in Durham Region has occurred faster than historically reported trends.
- Local exposure to infective blacklegged ticks is increasing and expected to continue due to increased temperatures and precipitation.
- Exposure to infective ticks is greatest from May to July and from September to November but these windows of time may be expanding due to warmer seasons.
- Most Durham residents spend time outside in grassy tick-prone areas with greater possible exposure to LD among males, adults 44 years old and younger, those with moderate to high incomes and residents of rural areas.
- Mosquito surveillance indicates that cases of WNv are increasing in Durham Region and are expected to continue due to warmer temperatures.
- The future burden of WNv disease is expected to increase in all Durham Region municipalities but may be highest in Brock, Scugog, and Whitby.
- WNv exposure is highest from June to September with a peak usually in August.
- People who work or spend many hours outdoors may be more exposed to VBDs than other Durham residents.
- First Nations Peoples asserting their harvesting, gathering, and fishing Rights, face greater risk of VBD.

VBD sensitivity in Durham Region

- Some people are at greater risk of severe health outcomes from VBDs. Priority populations include: older adults; infants and young children; pregnant individuals; Indigenous Peoples; and people with a weakened immune system.
- Consideration of compounding risk factors is essential to assessing vulnerability and appropriate interventions. Priority populations experiencing low income may face greater health risks due to compounding health inequalities such as inadequate shelter, chronic illness, or a lack of access to protections such as insect repellant.
- Durham Region has a rapidly growing older adult population who are generally more susceptible to the growing risks of LD, WNv disease, and other VBDs.
- In Ontario, children ages 5 to 14 have a higher risk of acquiring LD compared to most other age groups. This group is often dependant on caregivers for protective measures.
- Changes to the immune system during pregnancy may increase health risks associated with some infections, and some tick-borne infections may affect perinatal outcomes.
- Indigenous Peoples are uniquely sensitive to the health impacts of VBDs. Processes of colonization have led to harmful outcomes including increased VBD within the lands that many First Nations depend on for livelihood, culture, identity, health, and well-being. Health inequities experienced by First Nations may impact access to VBD-related healthcare. In addition, Williams Treaties First Nations have constitutionally protected Rights in Durham Region; therefore, exposure is greater when they are asserting their harvesting, gathering, and fishing Rights.
- People who have a weakened immune system are at greater risk of serious illness and complications from VBD infections. The proportion and distribution of immunocompromised people in Durham Region is not known, however a weakened immune system is associated with many chronic health conditions, as well as socioeconomic risk factors such as low-income and insecure housing.

Adaptive capacity to VBD in Durham Region

- All Durham Region residents should have equal ability to protect themselves from VBDs; serious health outcomes can be prevented with the knowledge and ability to avoid disease carrying vectors, and access to timely healthcare.
- Local needs to increase awareness and prevention of VBDs include:[2]
  - Prevention strategies and health promotion to protect outdoor workers.
  - Targeted health promotion strategies to address the overall low awareness and poor uptake of LD prevention measures, particularly for young adults.
  - Targeted health promotion strategies to address the overall low awareness and poor uptake of WNv disease prevention measures.
  - Improved understanding of barriers to VBD prevention among equity deserving priority populations who are more susceptible to severe health outcomes.
  - Increased local awareness of the links between VBD risk and climate change. Community engagement and collaborative approaches to VBD prevention and response planning may help support context-specific and culturally appropriate solutions.
- Durham Region strengths and opportunities for VBD prevention include:
  - DRHD's VBD Prevention and Response Plan, established to provide surveillance and programming to prevent WNv disease, LD, and other emerging VBDs. The plan includes:
    - Mosquito surveillance and population reduction;
    - Site inspections in response to Durham Region resident complaints;
    - Active tick surveillance; and,
    - Health promotion to prevent infections.

2 Comprehensive community engagement is required to understand the full range needs and barriers to VBD prevention, particularly among priority populations and the organizations that serve them.

Next steps and priorities

This assessment helps residents and decision-makers to better understand current and future climate-related health risks of VBD in Durham Region. It supports adaptation planning to protect all community members, especially those worst affected and least protected. Next steps include exploring three main adaptation action areas to prevent VBD in Durham Region:

1. **Local knowledge and data** such as monitoring and reporting on vector prevalence, VBD cases and associated health burdens on residents and health systems.
2. **Health promotion and education** to support the ability of Durham Region residents to assess their risk and take action.
3. **Policies, programs, and services** to help residents avoid VBD exposures.

Table 6.1, "Examples of adaptation initiatives to prevent VBD" provides examples of adaptation initiatives for each category. These are illustrative examples only and have yet to be assessed for feasibility or priority.

1. Why prioritize vector-borne diseases?

Climate change is expected to increase the number and distribution of disease carrying vectors, resulting in an increased incidence of vector-borne infections in Durham Region.

Warmer and wetter seasons due to climate change are expected to increase the reproduction and survival rates, as well as the geographic range of disease-carrying ticks and mosquitoes. [1] This has led to an increase in the incidence of some VBDs such as WNv disease, LD and other tick-borne infections. For example, in Canada reported cases of LD in humans jumped from 144 cases in 2009 to a record-breaking 3,147 cases in 2021 with 1,756 cases reported in Ontario, making LD one of the fastest emerging infectious diseases in Canada. [2, 3, 4, 5]

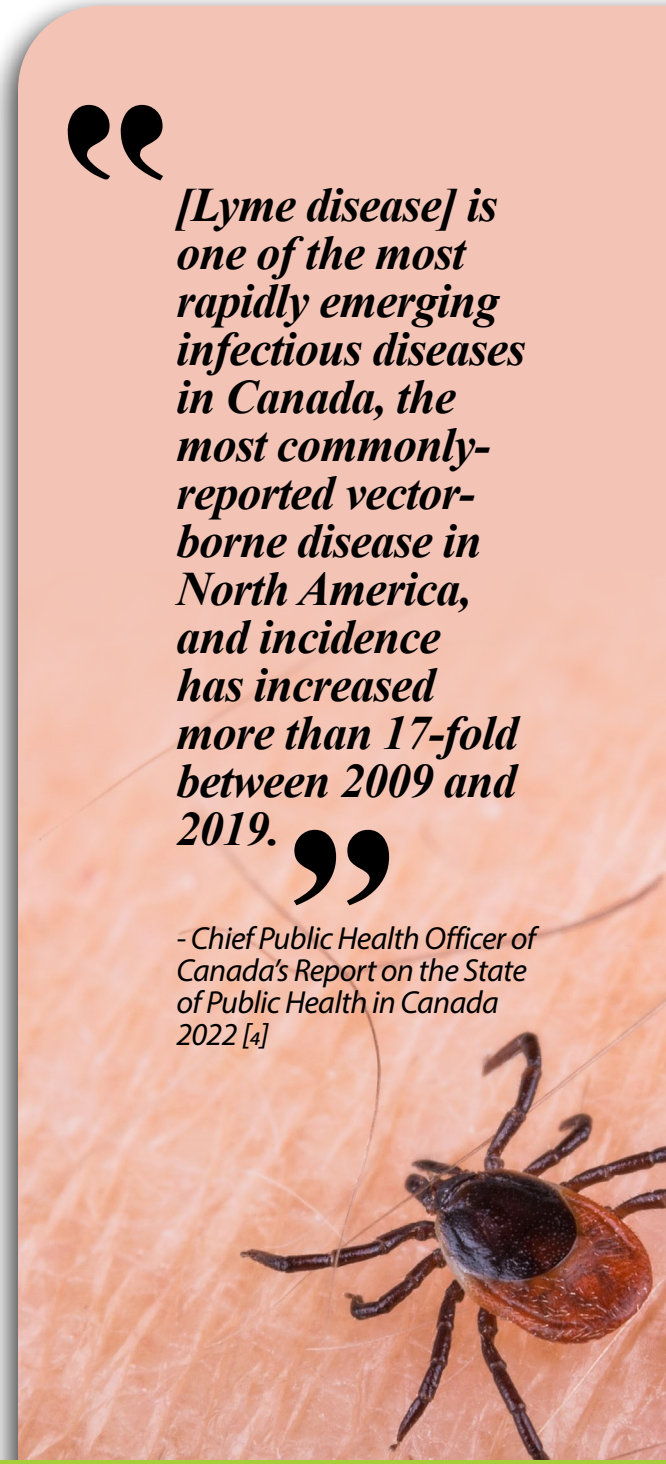
Climate change is also expected to increase the transmission of other VBDs. In 2023, Ontario began reporting several additional tick-borne diseases: anaplasmosis, babesiosis, and Powassan virus disease. [3, 6] Warmer temperatures also increase the risk that exotic mosquito vectors and related diseases such as malaria and dengue fever will become permanently established in Canada. [3]

In some cases, these diseases are mild. In other cases, they result in debilitating and disabling conditions, and in rare cases death. For example, while most people infected with WNv experience no symptoms, others experience fever, body aches, and fatigue and in severe cases disorientation, convulsions, and paralysis (also called neuro-invasive disease). One US study projected a near doubling of neuro-invasive WNv disease by the middle of this century. [7]

VBDs are transmitted from arthropod vectors (such as mosquitoes and ticks) to humans. Certain species of mosquitoes and ticks that ingest disease-producing microorganisms from an infected host can later transmit it to a human, or other animals. Although VBDs are highly preventable, local data shows that the uptake of preventive measures in Durham Region is generally low.

The Ontario Ministry of Health provides financial assistance to municipalities for the control of VBDs. However, additional financial and material resources to address more extensive outbreaks may be limited, stressing the importance for proactive health promotion and preventive measures to address the expected increase in disease-carrying vectors associated with warmer temperatures from climate change. [8]

> ***"[Lyme disease] is one of the most rapidly emerging infectious diseases in Canada, the most commonly-reported vector-borne disease in North America, and incidence has increased more than 17-fold between 2009 and 2019."***
>
> *- Chief Public Health Officer of Canada's Report on the State of Public Health in Canada 2022 [4]*



2. What is the purpose of this assessment?

Findings will be used to support evidence-informed adaptation plans, policies and programs to protect Durham residents from VBDs.

The purpose and objectives of this vulnerability assessment are outlined in **Figure 2.1**. The assessment will also support community and municipal partner's climate change and VBD planning and adaptation processes.

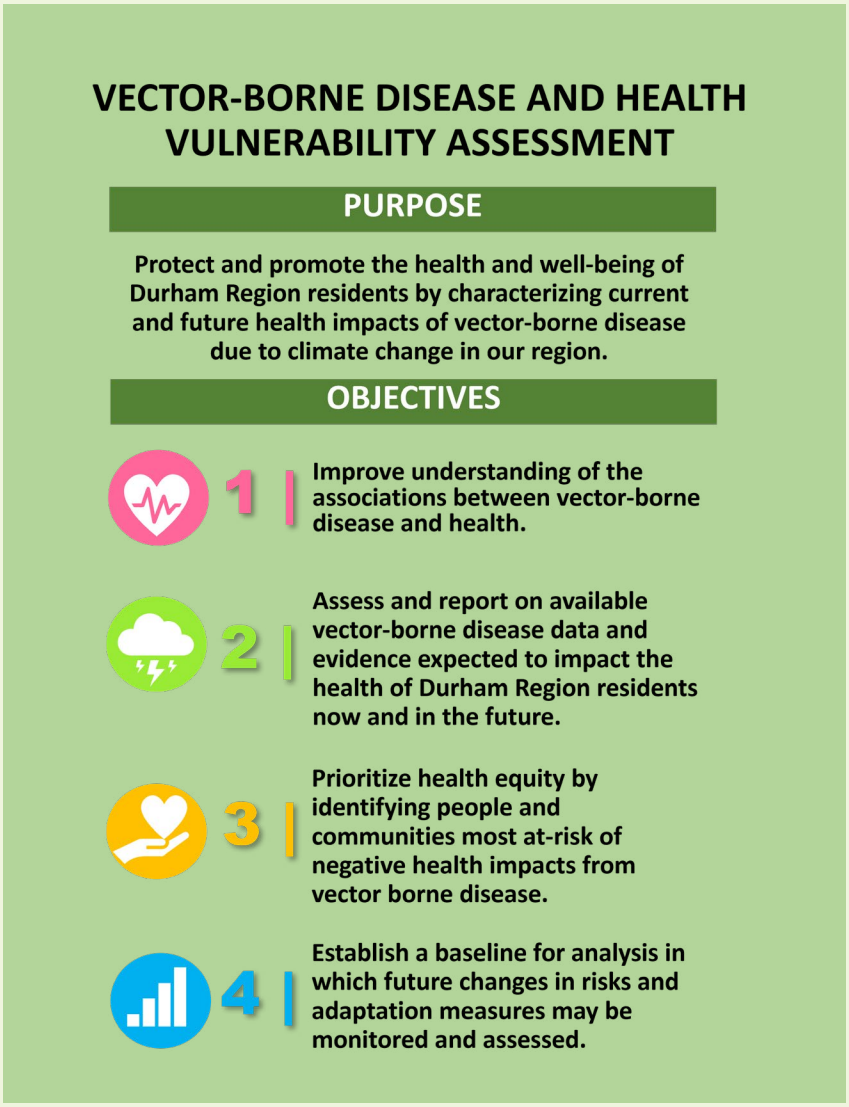


Figure 2.1 | Purpose and objectives of DRHD's VBD and health vulnerability assessment

3. What determines vulnerability to vector-borne diseases?

Health impacts of VBDs are influenced by exposure, sensitivity, and adaptive capacity.

Figure 3.1[3] illustrates three main factors of VBD vulnerability: **(1) exposure** to a VBD depends on the number of infectious vectors in the environment and the rate of human contact with these vectors; **(2) sensitivity** to health impacts from VBDs depends on factors such as age, genetics, health status or community health disparities, (for example, a person with a weakened immune system or a pre-existing health condition may be more susceptible to poor health outcomes from a vector-borne infection); and **(3) adaptive capacity** is the ability for a person or community to take protective measures to prevent VBDs (for example, a person's knowledge or ability to use insect repellant, manage their environment and avoid high-risk areas).

Vulnerability to VBDs is influenced by many upstream factors such as housing and working conditions, as well as a person's ability to earn sufficient income, access healthcare, find safe and stable housing, and live in a healthy, supportive community. [9] Although factors of vulnerability are important for assessing health risk, the term vulnerable as a label for people can be stigmatizing and harmful and should be avoided.

3 For a more detailed overview of this framework, please refer to the DRHD primer report: Climate Change and Health in Durham Region, available at durham.ca/ClimateAndHealth

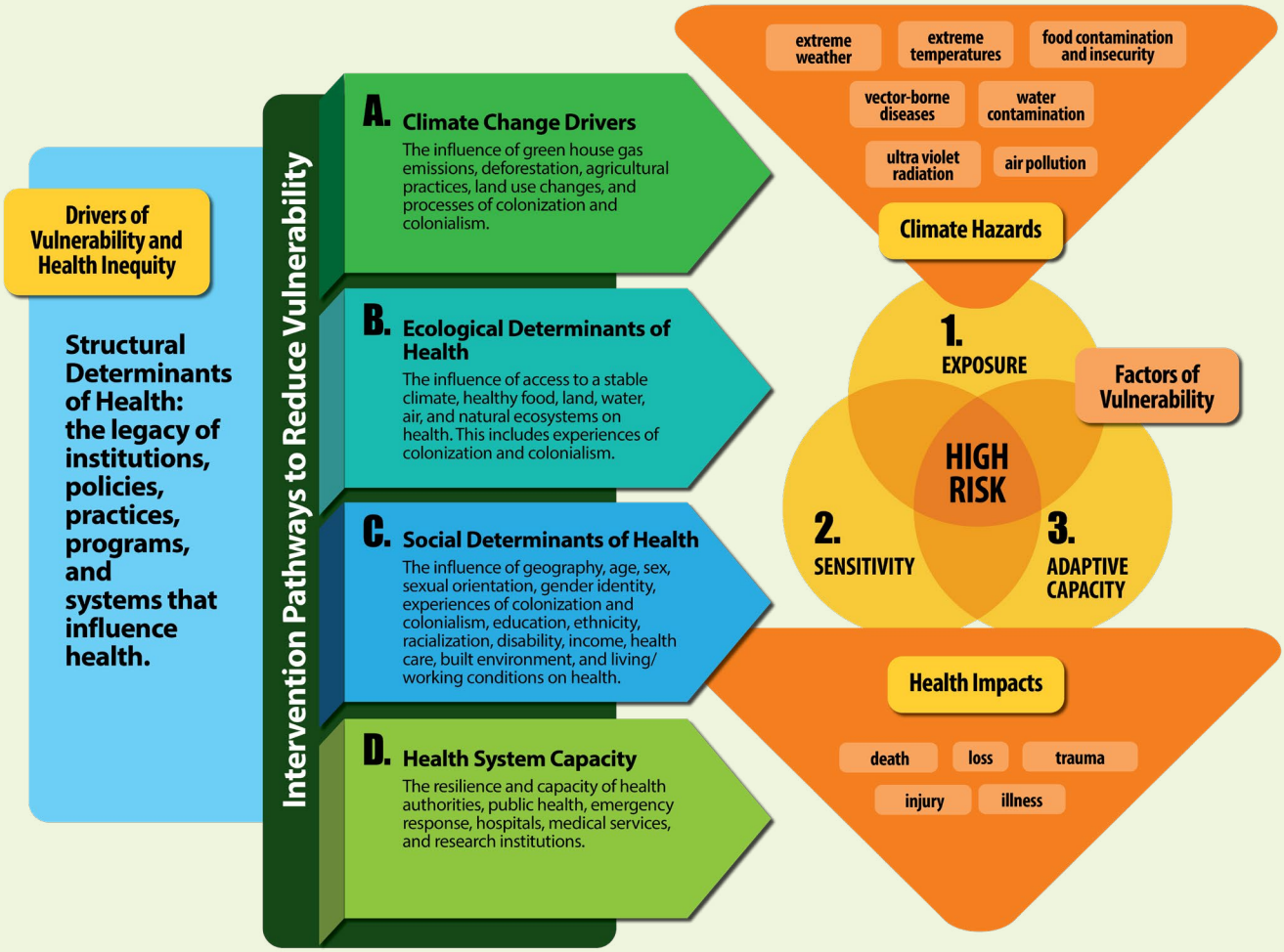


Figure 3.1 | Climate Change and Health Vulnerability Adaptation Framework (Developed under guidance of Schnitter et al. 2022) [9]

4. How do vector-borne diseases impact health?

A warming climate is increasing the survival, spread and exposure periods of disease carrying vectors and is associated with the increased incidence of VBDs, mainly Lyme disease and West Nile virus.

Increased reproduction and survival rates, as well as increased geographic range of disease-carrying ticks and mosquitoes are associated with increased incidence of VBDs that are endemic to Canada and the United States. [2, 3] While there are many VBDs, this vulnerability assessment focuses mainly on WNv disease and LD, while also noting other emerging climate-related VBD trends.

It is important to note that humans are "dead-end hosts" of these diseases. This means that if a person is infected, they cannot pass the disease to another person.

LD is a bacterial infection transmitted to people through the bite of a blacklegged tick (*Ixodes* spp.) infected with the bacterium *Borrelia burgdorferi*. [3, 10]

WNv is a flavivirus transmitted to people through the bite of a mosquito that fed from an infected bird (often the American Crow, *Corvax brachyrynchos*). [3, 11]

Figure 4.1 lists the direct negative health outcomes associated with these VBDs. Indirect health impacts of VBDs are beyond the scope of this assessment but include negative impacts to the health of ecosystems and wildlife that we depend on and value.

Vector-borne diseases

- Lyme disease
- West Nile virus
- Zoonotic diseases

Lyme disease: [10,47]

- Multi-systemic bacterial infection that causes fever, joint pain, headaches, sleep disturbance, and depression.
- If caught early, can be treated to prevent neurological symptoms and impacts.
- Untreated cases can cause neurological and cardiac symptoms such as myocarditis, pericarditis, and heart failure.

West Nile virus: [11, 59, 60]

- Infections can be asymptomatic, non-neurological, or neurological.
- About 20 per cent develop symptoms but less than one per cent are severe
- Non-neurological symptoms include fever, joint pain, chills, and weakness.
- Neurological symptoms include meningitis, encephalitis, acute flaccid paralysis, and other neurological sequelae.
- Although rare, WNv disease can be fatal.

Figure 4.1 | Direct negative health outcomes associated with VBDs in Ontario

Climate change may also increase the spread and incidence of other VBDs.

In Durham Region, LD is the main tick-borne disease of public health significance (DOPHS), however there are other diseases carried by ticks in Ontario and Canada. In 2023, the Province of Ontario identified and began reporting several additional tick-borne DOPHS: anaplasmosis; Powassan virus disease; and babesiosis. [6, 3] Appendix C provides a list of tick-borne illnesses reported in humans in Ontario.

WNv disease is the main mosquito-borne DOPHS, however other potential mosquito-borne diseases that may increase under future climate change scenarios include eastern equine encephalitis virus (EEEv), and California serogroup viral diseases. Warmer and wetter conditions due to climate change may also result in increased survival, reproduction and long-term establishment of exotic vectors and the diseases they carry such as dengue fever, chikungunya, Zika, and malaria. [3]

The health burden of LD in Durham Region is rapidly increasing and appears to be outpacing the provincial average.

In 2023, there were 110 confirmed and 15 probable cases of LD in Durham Region (**Figure 4.2**). The number of new LD cases has been rapidly increasing in both Durham Region and Ontario since 2017. **Figure 4.3** shows that over a ten-year period, between 2013 and 2022, LD incidence has followed a steep upward trend; LD cases in 2021 were two times higher than 2019 and three times higher than 2018. The incidence rate of LD in Durham Region compared to Ontario is also shown in **Figure 4.3**.[4] Since 2016, the incidence rate of LD has been higher in Durham Region compared to Ontario, with the difference widening over time. During this period there were overall more cases among males compared to females (**Figure 4.4**).

Ontario recently began reporting several additional tick-borne diseases, listed as DOPHS under the *Health Promotion and Protection Act*. [12] In 2023, there was one confirmed case of babesiosis in Durham Region, but no confirmed cases of anaplasmosis or Powassan virus (**Figure 4.2**).

4 See Appendix B for detailed LD cases and incidence rates in Durham Region and Ontario from 2013 to 2022.

Figure 4.2 | LD cases in Durham Region, 2023

Data source: Durham Region Health Department [13]

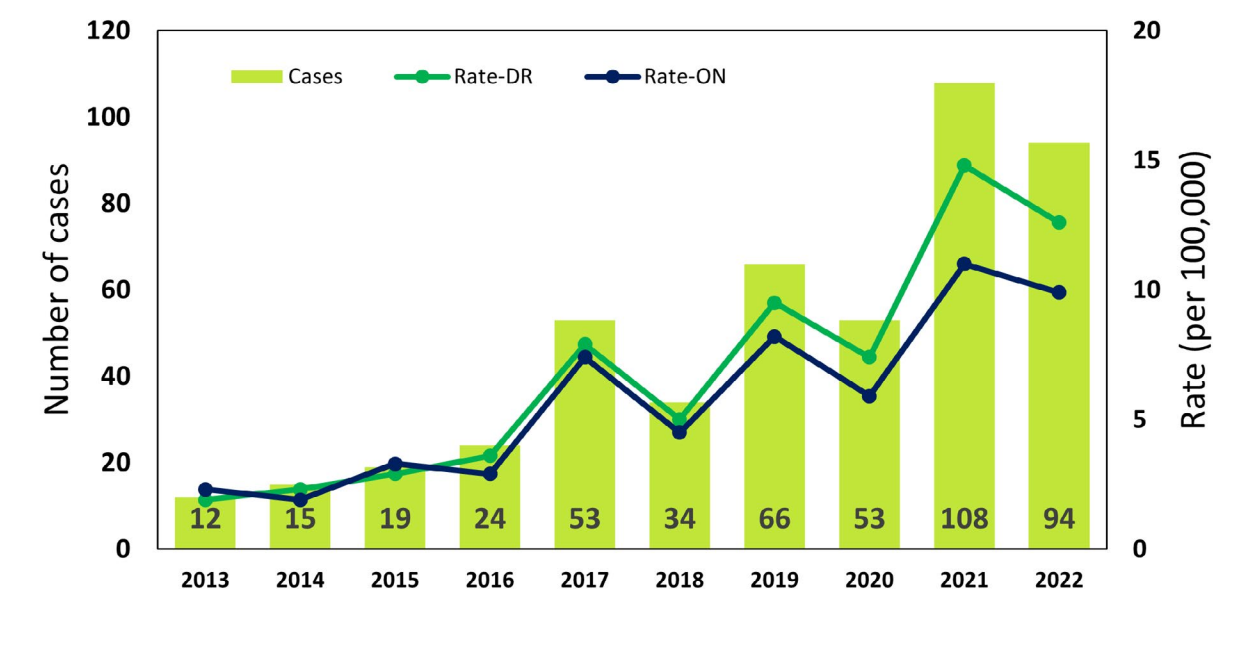


Figure 4.3 | LD incidence in Durham Region and Ontario from 2013 to 2022*

**Interpret 2020 and 2021 data with caution due to changes in the availability of health care and health care seeking behaviour at the beginning of the COVID-19 pandemic. Data source: Ontario Agency for Health Protection and Promotion (Public Health Ontario). Lyme disease [Internet]. Toronto, ON: King's Printer for Ontario; 202]. Available from: Infectious Disease Trends in Ontario | Public Health Ontario.*

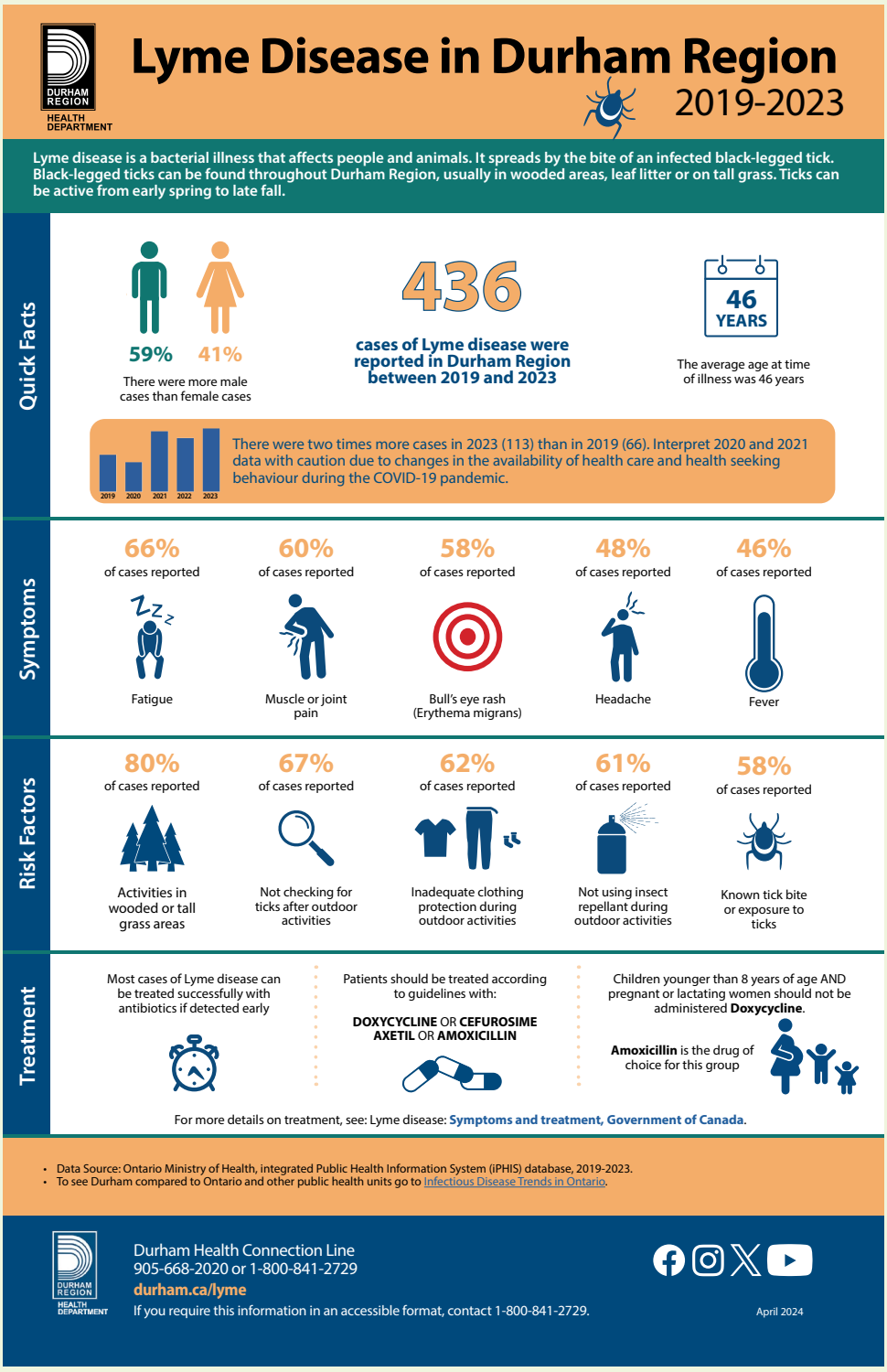


Figure 4.4 | Snapshot of LD cases in Durham Region, 2019 – 2023

Data source: Ontario Ministry of Health, integrated Public Health Information System (iPHIS) database, 2019-2023. [14]

The health burden of West Nile virus has increased over time and has exceeded the Ontario average since 2020.

The first human case of WNv disease in Ontario was recorded in 2001. The first recorded case in Durham Region came one year later, in 2002. [15, 16] The first confirmed locally acquired case of WNv disease in Durham Region occurred in Ajax in 2010. Since 2012, cases have been confirmed in all municipalities.

From 2013 to 2022, there were 34 WNv disease cases reported in Durham Region. **Figure 4.5** shows a relatively large increase in reported cases in 2020, comprising approximately one third of cases over the ten-year period. This may be due to a greater proportion of people spending extended periods of time outdoors while social distancing at the onset of the COVID-19 pandemic. In general, there are more reported cases among females compared to males (**Figure 4.6**).

The number of reported WNv illnesses varies by year, however in general the numbers remain quite low, averaging between two to three cases per year. Durham's rate was lower than the Ontario rate between 2015 to 2019 but has been higher than the Ontario rate since 2020 (see detailed table in **Appendix B**).

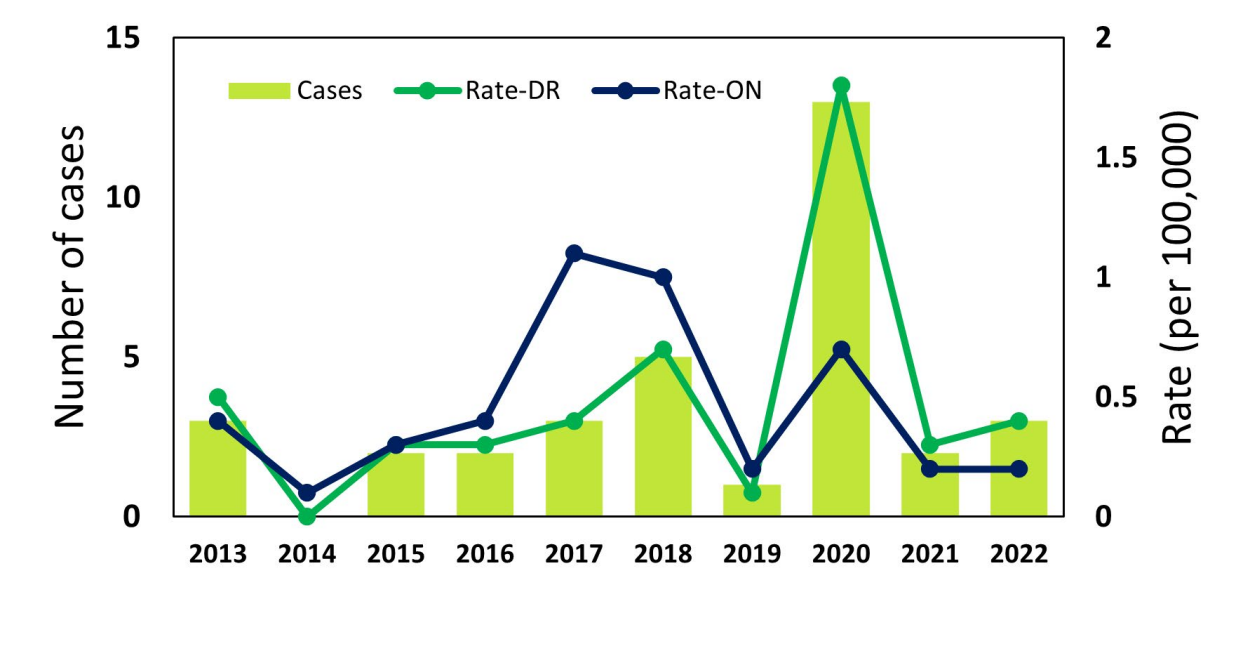


Figure 4.5 | WNv disease in Durham Region and Ontario, 2013 to 2022*

*Interpret 2020 and 2021 data with caution due to changes in the availability of health care and health care seeking behaviour during the start of the COVID-19 pandemic

Data source: Ontario Agency for Health Protection and Promotion (Public Health Ontario). West Nile virus illness [Internet]. Toronto, ON: King's Printer for Ontario; 2023 [Cited 2024 Jul 04]. Available from: Infectious Disease Trends in Ontario | Public Health Ontario.

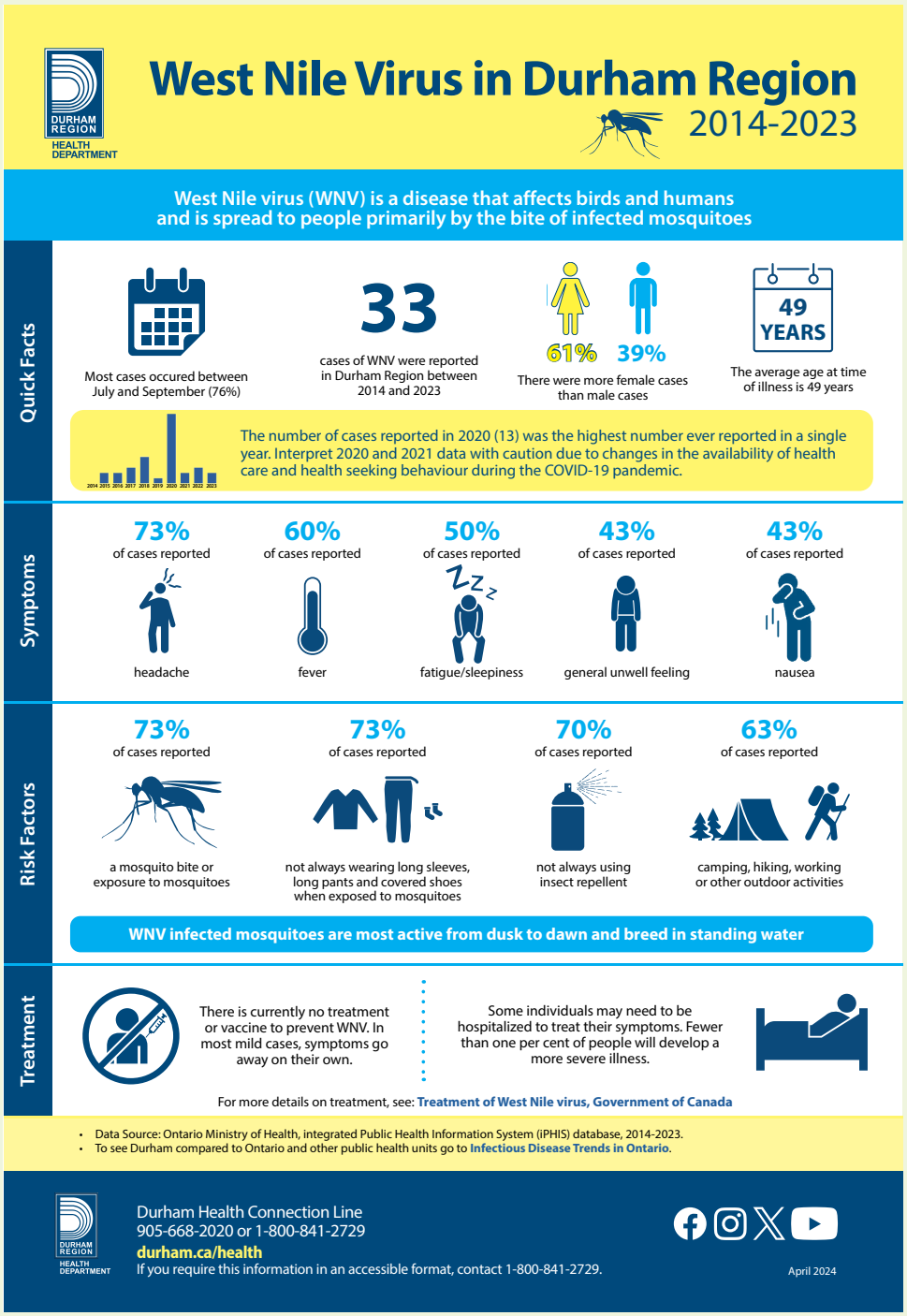


Figure 4.6 | Snapshot of WNv disease cases in Durham Region, 2014 – 2023

Data source: Ontario Ministry of Health, integrated Public Health Information System (iPHIS) database, 2014- 2023. [17]

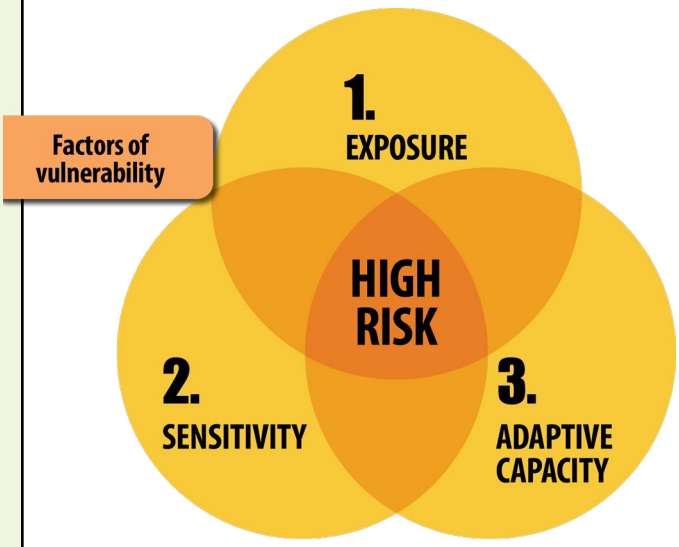
Although VBDs can harm everyone, some people are at greater risk of life-threatening outcomes due to multiple and compounded health risks and socioeconomic barriers.

Some people are at greater risk of severe outcomes from VBDs than others. For example, while most individuals infected with WNv will have mild or no symptoms, the case-fatality rate can be as high as 15 per cent in hospitalized cases. Young children, older adults and people with weakened immune systems are among those most likely to be severely affected by WNv. [8]

Our understanding of VBD vulnerability is incomplete and evolving. **Table 4.1** outlines factors of VBD vulnerability and at-risk groups. These groups are not distinct and risk categories often overlap. VBD vulnerability depends on three main factors: the rate of human contact with a diseased vector in the environment (exposure), combined with individual and community risk factors (sensitivity and adaptive capacity). Those who experience all three factors of VBD vulnerability are at greatest risk of negative health outcomes from infection. These priority populations may experience greater exposure and sensitivity to VBDs, as well as barriers that limit their capacity to protect themselves.

> ***"Risk is likely to be compounded by an aging population affected by chronic diseases, which results in greater sensitivity to infectious diseases."***
>
> *- Climate change and infectious diseases: What can we expect? [32]*

Table 4.1 | Factors of VBD vulnerability and at-risk populations [3, 18, 19]

Factors of VBD vulnerability	Priority populations*
 **Exposure:** The degree to which an individual or community is exposed to VBDs. Underlying social and economic conditions can result in some individuals or communities experiencing more exposure to VBDs than others. **Sensitivity:** The degree to which an individual is affected by a VBD infection. This can be influenced by age, genetics, health status or community health disparities. **Adaptive Capacity:** The ability of an individual or community to respond to and protect against VBDs. Capacity may include access to informational, social, financial, and institutional supports.	• **Older adults,** 60 years of age and older • Infants and young **children** • **Pregnant** individuals • **Indigenous** Peoples • People with a **weakened immune system** • People who **work or spend time outdoors** ** Those who experience all three factors of VBD vulnerability are at greatest risk of negative health outcomes from VBDs.*

Climate-related VBDs can lead to mental, emotional, and spiritual health impacts, that are often underexplored by health systems. The relational approaches of Indigenous knowledge systems can help to guide methods for understanding, preventing, and addressing the broader health consequences of climate change.

VBD surveillance mainly focuses on vector surveillance, case counts and physical health impacts. The Mississaugas of Scugog Island remind us that it is essential to also explore and respond to how increased risks of VBD affects the emotional, spiritual, mental, and cultural wellbeing of Indigenous and non-Indigenous Peoples. VBDs may limit safe access to natural systems crucial for food, water, refuge, physical activity, stress reduction, cultural celebrations, relationship building, community connection, knowledge sharing, collective wellbeing, and more. Indigenous knowledge and perspectives are uniquely suited to guide and inform approaches for understanding the broader health impacts of VBDs, and can be applied through a municipal planning lens, ensuring that land use, public health, and climate adaptation policies address the spectrum of health impacts. For example, zoning for climate adaption such as identifying high-risk areas for VBD expansion, and preventive actions. Indigenous knowledge systems, in general, offer direct, extensive, multi-generational and long-term insight into the biological, physical, cultural, and spiritual impacts of climate change, including VBD.[5]

Integrating Indigenous Knowledge and relational approaches into climate-health assessments can create more effective and culturally appropriate solutions. For example, traditional land management techniques, such as controlled burns, can help manage tick populations and reduce disease risk.

DRHD recognizes the need and strongly advocates for the inclusion of MSIFN's voice and participation in climate action strategies, health planning, and land use policies in Durham Region to create more effective and culturally appropriate solutions to mitigate the health impacts of VBDs on Indigenous Peoples.

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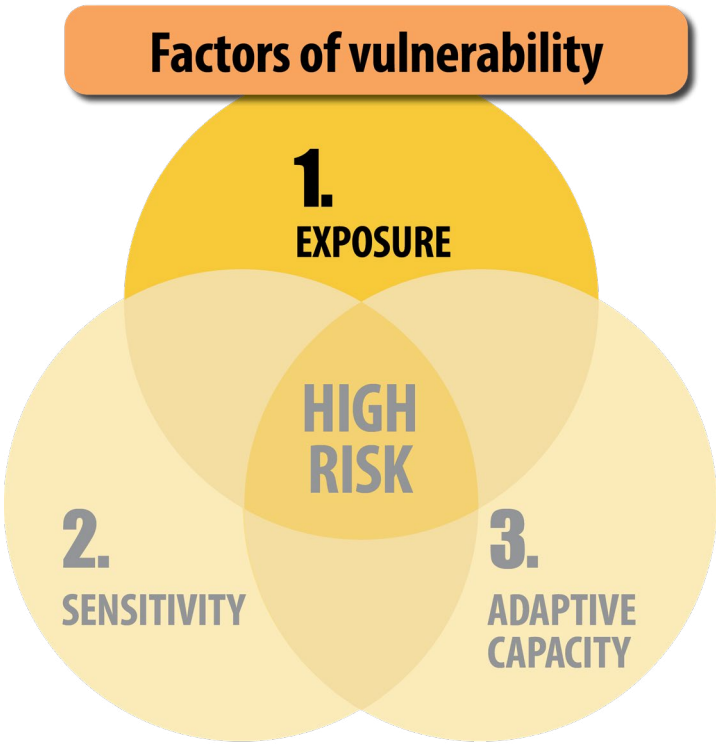
5 To learn more see: Climate Change and Indigenous Peoples' Health in Canada, available at: https://nccih.ca/Publications/Lists/Publications/Attachments/10367/Climate_Change_and_Indigenous_Peoples_Health_EN_Web_2022-03-22.pdf

5. Understanding vector-borne disease vulnerability in Durham Region

VBDs are preventable by addressing factors of vulnerability.

It is possible to prevent VBD in Durham Region by reducing exposure to disease carrying vectors; prioritizing the needs of those at greatest risk of severe health outcomes; and supporting local residents' capacity to take preventive measures.



5.1 VBD exposure in Durham Region

All Durham Region residents can expect greater future exposure to VBDs due to warmer seasons.

Based on future projections of warmer seasonal temperatures in Durham Region, the number of disease-carrying vectors and the periods of exposure to these vectors are expected to increase. Warmer temperatures, moisture, standing water and mild winters can increase the survival, speed of development, and geographic range of vectors such as ticks and mosquitoes, and the diseases they transmit. Warmer and longer summer seasons due to climate change are also associated with more outdoor activities, which increases the overall likelihood of a VBD exposure. [20]

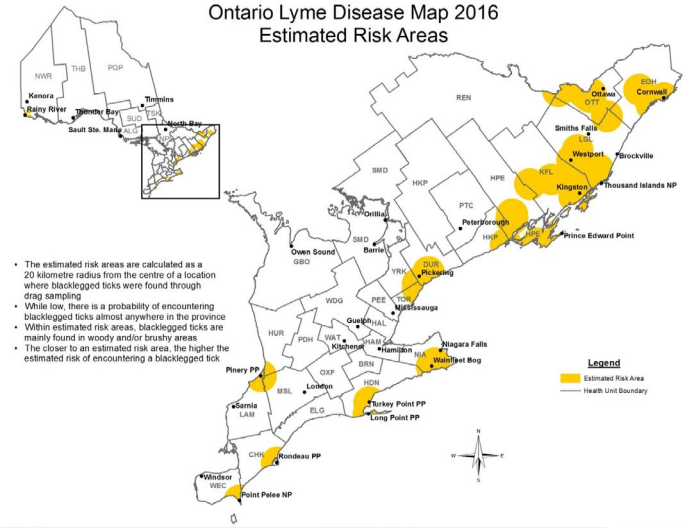
Exposure to LD

The areas of Durham Region with ticks that carry LD has rapidly expanded, and they are now established in all municipalities.

The Ontario Blacklegged Tick Established Risk Areas map (formerly the Ontario Lyme disease Map: Estimated Risk Areas) is updated annually by Public Health Ontario. Estimated risk areas are locations where blacklegged ticks are known to occur and where people have the potential to encounter infective ticks. [21] **Figure 5.1.1** shows that since 2016 the estimated LD Risk Areas in Durham Region has rapidly expanded west, east and north. All municipalities are now established LD risk areas[6] . [22, 21]

6 It is important to note that white areas of the map do not indicate that they free of LD risk. There is a risk of encountering an infective blacklegged tick almost anywhere in Ontario because they can be transported by migratory birds.

LD Risk Area, Southern Ontario



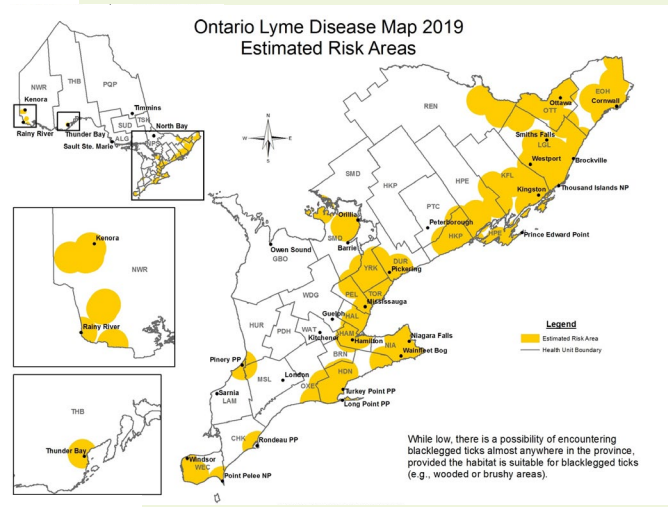
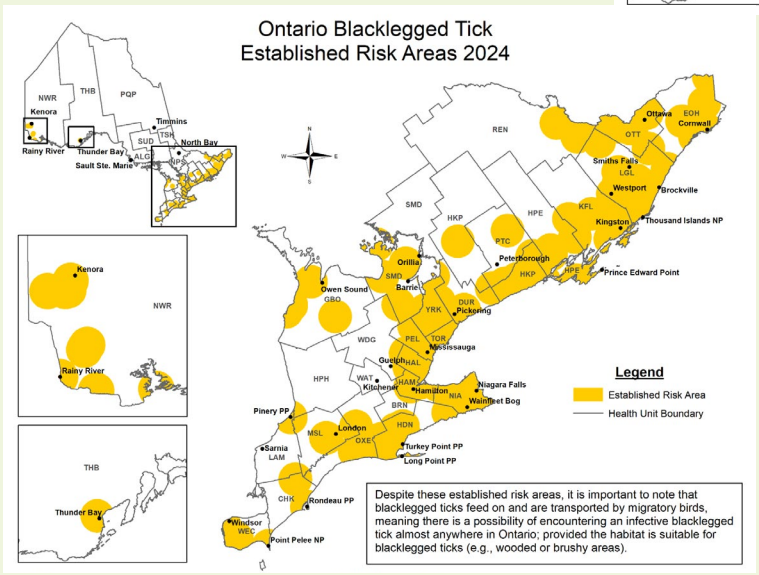


Figure 5.1.1 | Changes in estimated LD risk area from 2016 to 2024

Figure Source: Reproduced with permission from Public Health Ontario Lyme disease Risk Area Map 2016, 2019, 2023 [22, 21]



The establishment of infective blacklegged ticks in Durham Region has occurred faster than historically reported trends.

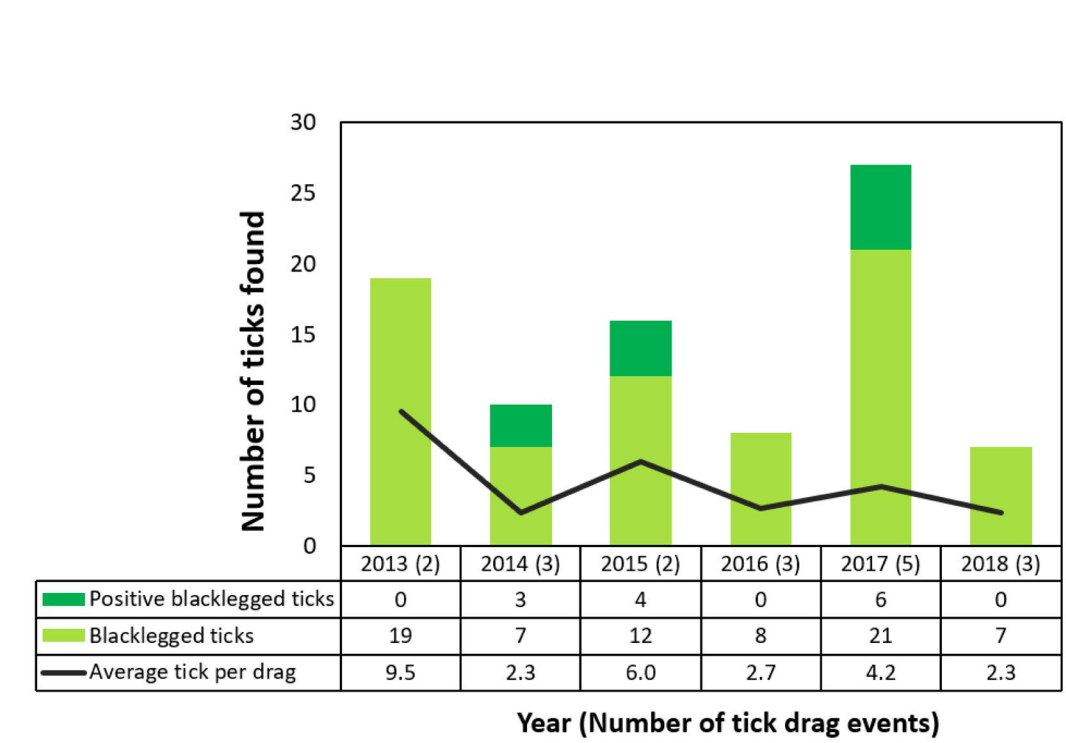
Finding at least one blacklegged tick during active surveillance in both the spring and fall indicates a risk area for LD. [21] Blacklegged ticks in Durham Region were found positive with *Borrelia burgdorferi* (the bacteria that causes LD) only one year after the population was first established in 2013. The first confirmed locally acquired case of LD occurred one year later, in 2015. The establishment of LD risk areas in Durham Region is faster than the historically reported trend which is between 3 to 5 years. [23] **Figure 5.1.2** shows active LD surveillance in Durham Region from 2013 to 2018, showing an increase in the number of infective blacklegged ticks over time. [24]

Blacklegged tick exposures among Durham Region residents is increasing.

Passive tick surveillance is conducted when ticks found on a resident are submitted to DRHD for species identification and testing for *Borrelia burgdorferi* infection.[7] **Figure 5.1.3** shows the ticks submitted to DRHD from 2009 to 2019, showing that the number of locally acquired blacklegged ticks and ticks positive for *Borrelia burgdorferi* has continued to increase.

7 DRHD no longer conducts passive tick surveillance and testing of submitted ticks by the Field Studies section at the National Microbiology Laboratory (NML), as part of the passive surveillance program, which ended on January 1, 2020.

Active LD surveillance in Durham Region

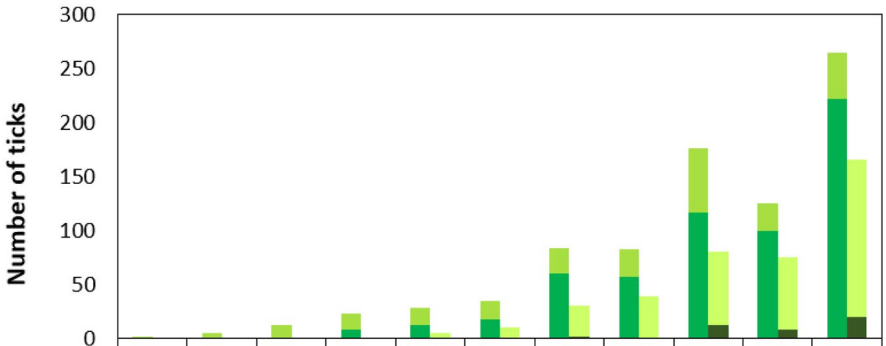


	2013 (2)	2014 (3)	2015 (2)	2016 (3)	2017 (5)	2018 (3)
Positive blacklegged ticks	0	3	4	0	6	0
Blacklegged ticks	19	7	12	8	21	7
Average tick per drag	9.5	2.3	6.0	2.7	4.2	2.3

Figure 5.1.2. | Ticks found from active tick surveillance from 2013 to 2018 in Durham Region

Data source: VBD Reports, Durham Region, 2013-2018. [24]

Passive LD surveillance in Durham Region



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Ticks submitted	2	5	12	23	28	35	84	83	176	125	264
Locally aquired blacklegged ticks					5	10	30	39	80	75	165
Blacklegged ticks submitted	1	0		8	12	18	60	57	117	100	222
Locally acquired positive blacklegged ticks					0	0	2	1	12	8	20

Year

Figure 5.1.3. | Ticks submitted to Durham Region for testing 2009 to 2019

Data Source: VBD Reports, Durham Region, 2010-2019. [24]

Rising exposure to tick-borne illness, including LD, is expected to continue in Durham Region due to increased temperatures and precipitation.

Warmer temperatures increase the development rate of ticks. Ticks can generally survive to -10°C and are active when the temperature is 4°C or higher. [23, 25] This means that larval ticks can develop, and adult ticks can bite during the warmer winter months. Overall warmer winters under future climate change projections will accelerate the tick development cycle and increase the chance of exposure to an infected tick. [23, 25]

Figure 5.1.4. shows the risk maps for range expansion of LD infective blacklegged ticks from 1971 through to the 2080s, showing a steady and rapid geographic expansion based on future temperature projections under RCP8.5 greenhouse gas concentration trajectory. [26][8] [9] Increased precipitation can also help ticks to thrive and increase their geographic range. Blacklegged ticks prefer a very humid environment, with packed leaf litter which is augmented by precipitation. [25]

8 Other factors were not taken into consideration such as changes in evolutionary pressures and changes in human activities that alter the frequency that humans are exposed to blacklegged ticks. [26]

9 RCP8.5 or representative concentration pathway 8.5 is one of the greenhouse gas concentration trajectories used in climate modeling and represents a high-emission scenario that assumes continued increases in greenhouse gas emissions throughout the 21st century.

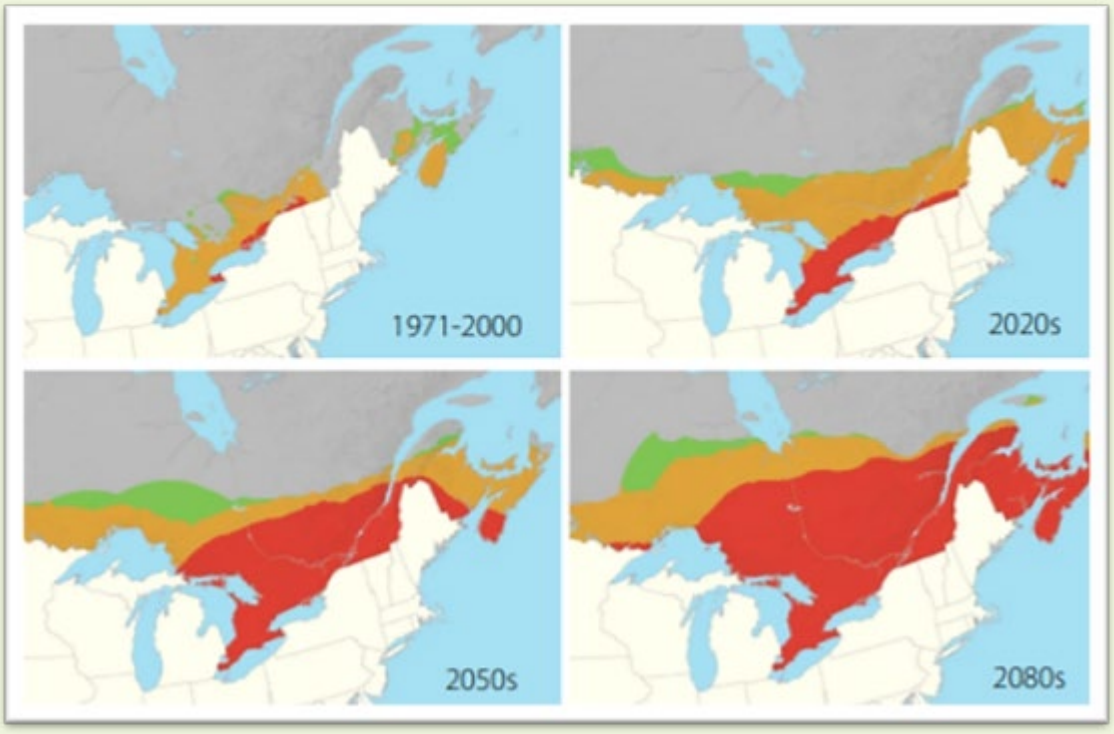


Figure 5.1.4 | Predicted LD zone based on RCP8.5.

Red is endemic area, orange is potential, and green is host (Birds) zone that isolated ticks may be found.

Data Source: [26]

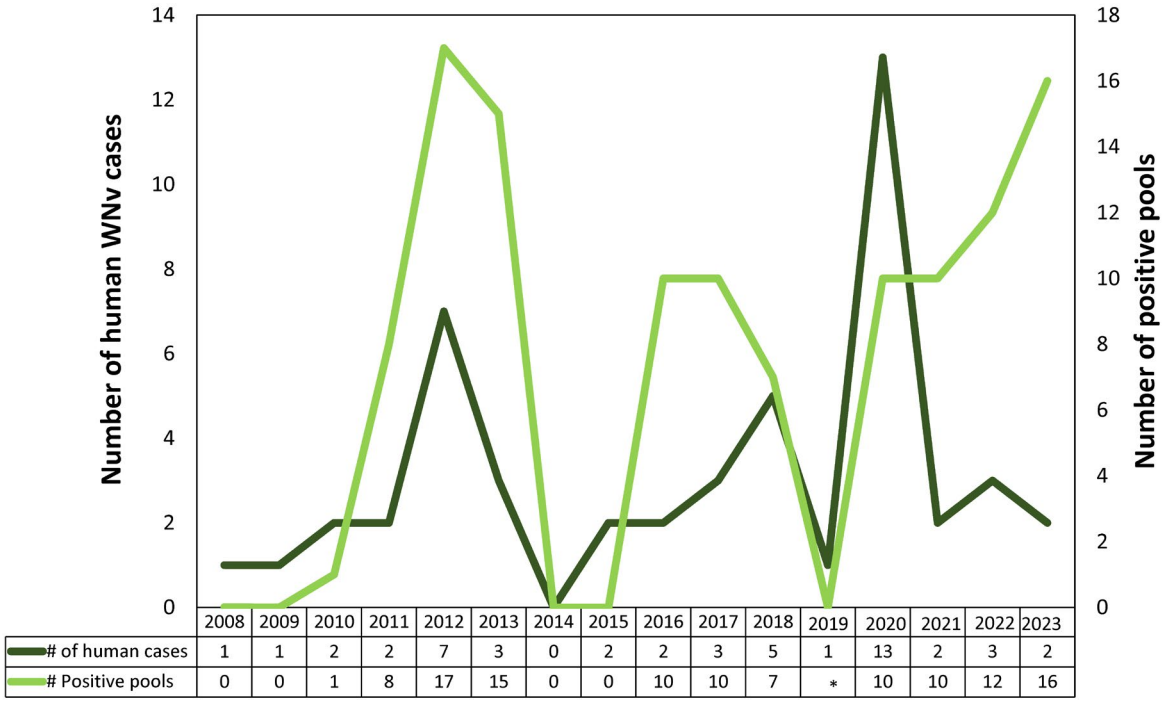
Exposure to LD is greatest from May to July and from September to November but these windows of time may be expanding due to warmer seasons.

The risk of tick exposure is greatest when nymph ticks are active (May to July) and again in the fall when adult ticks become active (September to November). [27] With warmer seasons and increasing winter days above 4 degrees Celsius, the periods of time when nymph ticks and adult ticks are active are expected to increase.

Exposure to WNv

Mosquito surveillance indicates that human cases of WNv disease are increasing in Durham Region.

DRHD conducts mosquito surveillance and reports on mosquito species and WNv positive pools. As seen in **Figure 5.1.5**, positive pools of WNv can serve as an indicator of WNv disease risk. [28] There are similarities between positive pools and human WNv disease cases in the Durham Region, with peaks occurring in 2012, followed by a decrease to zero in 2014, followed by an overall incline. Although positive pools of WNv can serve as an indicator of WNv disease risk, it does not always translate directly to the number of reported human WNv disease cases in an area, as there are factors that influence the number of human cases outside of the number of positive mosquito vectors. This can be seen in the graph in years where the number of human WNv disease cases do not correlate well with the number of WNv positive mosquito pools. Notably, 2024 marked the earliest recorded WNv-positive pool of mosquitoes trapped in Durham Region. [24]



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
# of human cases	1	1	2	2	7	3	0	2	2	3	5	1	13	2	3	2
# Positive pools	0	0	1	8	17	15	0	0	10	10	7	*	10	10	12	16

* Data for the number of positive mosquito pools is not available for 2019.

Figure 5.1.5 | Cases of human WNv disease in Durham Region and positive WNv pools of mosquitoes

Data Source: VBD Reports, Durham Region, 2010-2023 [24]

Exposure to WNv is expected to increase in Durham Region due to warmer temperatures.

Mosquitoes require a minimum temperature of 14°C to a maximum of 35°C to develop. [29] The mosquito lifecycle (the time a mosquito requires to develop into a reproductive organism) decreases as the temperature warms. [30] For example, at 19.3°C the mosquito lifecycle is 7 days and at 25.3°C the life cycle is only one day. [30] A warm spring can allow mosquito population to rise quickly and repopulate often. [30]

Warmer seasons with average temperatures greater than 19.3°C leads to WNv vectors earlier in the year, increasing the abundance of mosquitoes and the chances of infection. [30] WNv cases generally occur between June and September with most cases in Durham Region occurring in August and September. Warmer winters can allow mosquitoes to survive over winter and start the infection cycle in early spring. [30]

The maps of southern Ontario in **Figure 5.1.6** depict the predicted future climate conditions using degree days for 2050 and 2080. The degree days shows a measure of accumulated heat throughout the year, by calculating the average temperatures above 15°C. Higher degree days are expected to create more mosquitoes with faster development cycles. The projected increase in temperature across Ontario over the next 50 years due to climate change is projected to increase the incidence of WNv across the province.

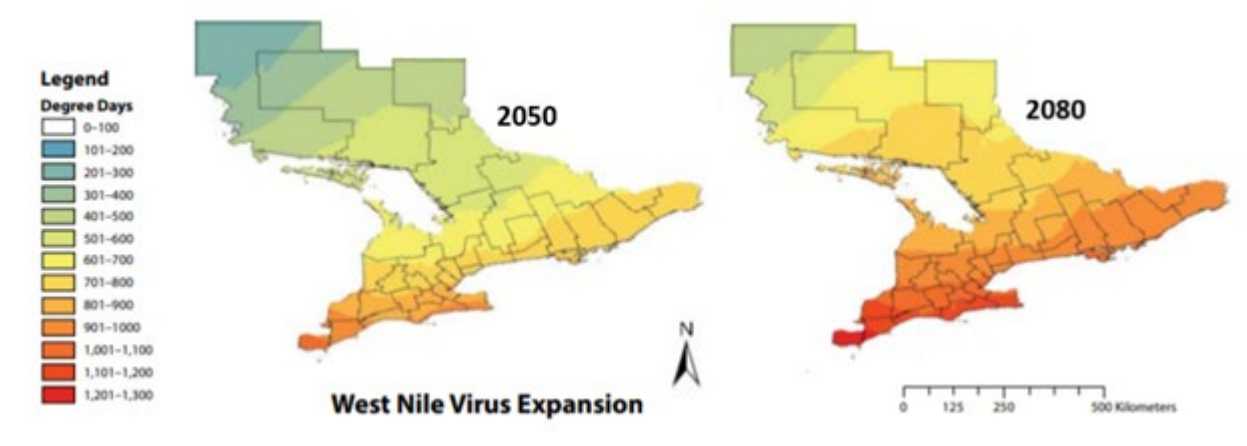


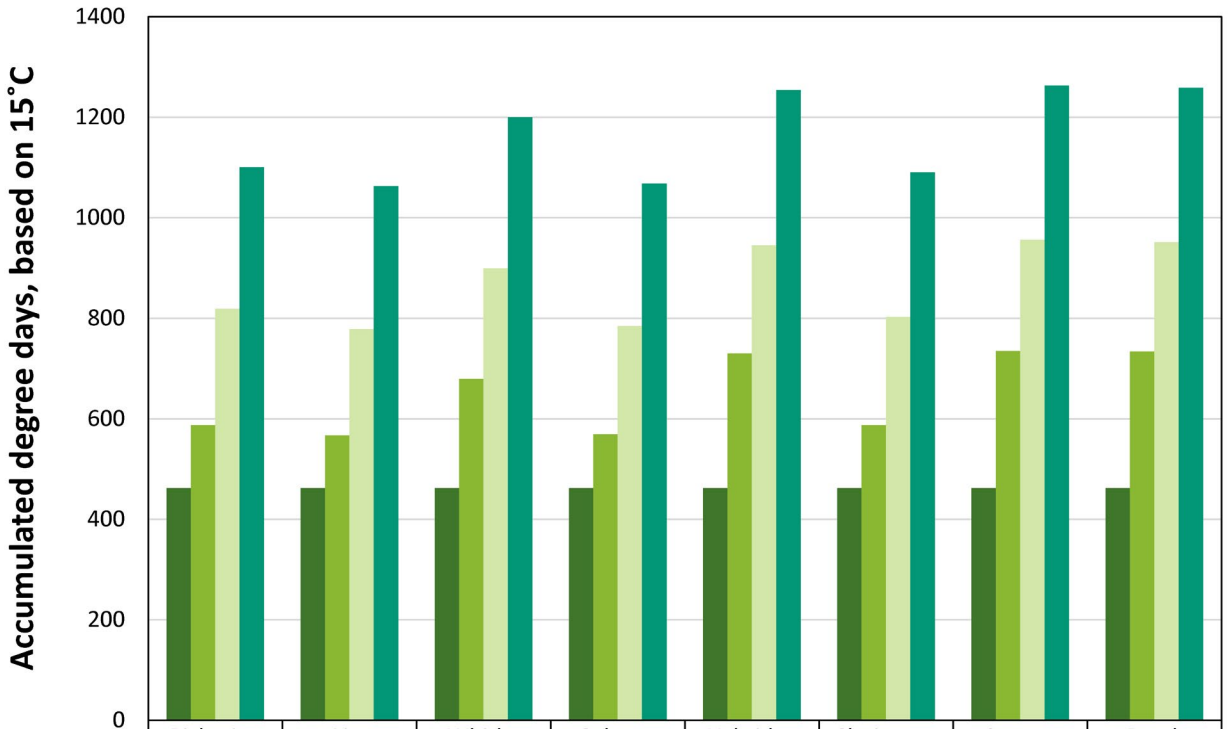
Figure 5.1.6 | Predicted WNv expansion for 2050 and 2080

Data Source: Reproduced with permission from the Ontario Climate Change and Health Modelling Study, 2016 [55]

The future burden of WNv disease is expected to increase in all Durham Region municipalities but may be highest in Brock, Scugog, and Whitby.

The predicted degree days, based on 15°C, for each municipality of Durham Region are shown in **Figure 5.1.7**. This graph shows Brock, Scugog, and Whitby have the highest predicted degree days, indicating that the burden of WNv may be higher in those municipalities. However, it is important to note that although temperature has a major impact on mosquito development, the burden of WNv disease among local municipalities may vary depending on the local built and natural environment, including management of standing water where mosquitoes breed.

Predicted Degree Days, based on 15°C in Durham Region



	Pickering	Ajax	Whitby	Oshawa	Uxbridge	Clarington	Scugog	Brock
1971-2000	463	463	463	463	463	463	463	463
2001-2040	588	567	680	570	730	588	735	734
2041-2070	819	779	899	785	945	803	956	952
2071-2100	1101	1063	1200	1068	1254	1091	1263	1258

Figure 5.1.7 | Accumulated degree days at 15°C, RCP 8.5 for each municipality in Durham Region

Data Source: Guide to Conducting a Climate Change Analysis at the Local Scale: Lessons Learned from Durham Region, (Ontario Climate Consortium). [61]

Increased precipitation under future climate projections has a variable effect on mosquito populations, but in general is expected to promote mosquito development.

Precipitation patterns can affect the growth and development of mosquitoes. Extended rain events can promote standing water pools, increasing larval development. [7, 9] In general, greater precipitation is expected to result in larger mosquito populations, however in some cases, large and intense rain events can flush out and dilute nutrients needed for larval development in standing water and catch basins, disturbing the larval development process and decreasing mosquito populations. [7]

WNv exposure is highest from June to September with a peak usually in August.

WNv cases generally occur between June and September with most cases in Durham Region occurring in August and September. In Ontario, the number of positive pools generally peaks in mid to late August. The peak can shift by about 2 weeks earlier or later, depending on environmental factors (e.g., temperature).

The majority of Durham Region residents are exposed to VBDs by spending time in outdoor vector-prone areas. Outdoor workers may be more exposed than others.

People who spend time outdoors are more likely to be exposed to VBDs. For example, it is estimated that people who spend 12 or more hours outside in a day were 10.5 per cent more likely to be infected with WNv than those who spend 6 or fewer hours outside in a day. [11]

Outdoor workers may be more exposed to VBDs than other residents of Durham Region. Based on data from the 2021 Census, almost 10 per cent of Durham Region residents work outdoors (**Table 5.1.1**). [31] The proportion of outdoor workers is underestimated and does not include seasonal recreational workers such as lifeguards, camp counsellors, and landscapers.

Table 5.1.1 | Percentage of Durham Region residents that are outdoor workers

Industry classification	Per cent (%)
Natural resources, agriculture, and related production occupations	1.6
Construction	8.1
Total	9.7

Data source: Statistics Canada. 2021. Durham Region Census Profile. 2021 Census. [28]

Most Durham residents spend time outside in VBD risk areas with greater possible exposure among males, adults aged 44 and younger, those with moderate to high incomes, and residents of rural areas.

DRHD collects information about LD awareness and protective behaviours to prevent tick bites among Durham Region adults (18+) through the Rapid Risk Factor Surveillance System (RRFSS) telephone survey. During the 2023 survey, respondents were asked if they spent any time in grassy areas in the spring or summer. This is used to estimate the proportion of the population who are potentially at risk of contracting LD through tick bites. Survey results showed that approximately 64 per cent of Durham adults spent time in grassy areas during the spring or summer.

Figure 5.1.8 shows that time spent outdoors in grassy areas varied substantially across various demographic metrics including gender, age group, estimated income level, and municipality. Significantly more males reported spending time outdoors in grassy areas than females.

There was a decreasing trend observed with age. About three quarters of residents between the ages of 18 to 44 reported spending time in grassy areas. This proportion then decreased with increasing age. Individuals living with lower incomes were less likely to report spending time in grassy areas than individuals living with moderate to high incomes.

There was a geographic trend evident. Individuals living in the more rural communities of Clarington and North Durham (i.e., Brock, Scugog, Uxbridge) spend more time in grassy areas than those in the urban municipalities in the south. The two municipalities closest to Toronto (Pickering and Ajax) had the lowest proportion of residents spending time outdoors in grassy areas.

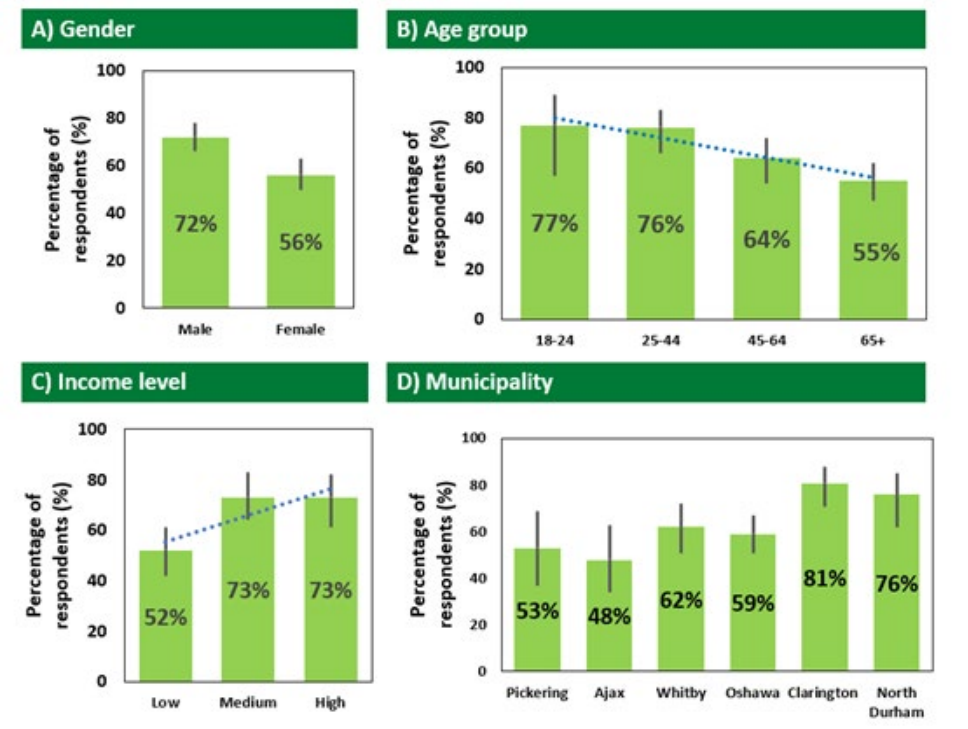


Figure.5.1.8 | Durham Region adults (18+) who spent time in grassy areas during the spring or summer, 2023

I = 95% confidence interval

Data source: Rapid Risk Factors Surveillance System (RRFSS), Durham Region Health Department and Institute for Social Research, York University, Summer 2023.

5.2 VBD sensitivity in Durham Region

A commitment to health equity means prioritizing the needs and barriers of those who are at greater risk of severe illness and complications from VBD.

Some people are more susceptible to severe illness from VBDs than others.

Sensitivity to VBDs can be influenced by age, genetics, health status or other health inequalities. Our understanding of VBD sensitivity is incomplete and evolving. This section provides an overview of five broad VBD-sensitive populations in Durham Region: older adults; infants and young children; pregnant individuals; Indigenous Peoples, and people with a weakened immune system.

Consideration of intersectionality and compounding risk factors are essential to assessing vulnerability and appropriate interventions.

VBD-related health risks are not evenly distributed across sensitive populations and are often more prevalent among those experiencing multiple health barriers. For example, an older adult with a chronic illness who is insecurely housed has a greater risk of poor health outcomes from infection than a healthy older adult with safe housing. [32] Understanding the interaction of VBD sensitivity with other vulnerability factors is important for identifying and prioritizing those with the greatest risk of severe illness, and for developing appropriate interventions.

5.2.1. VBD-sensitive populations in Durham Region

5.2.1.1 Older adults, age ~65+ [3, 11, 33]

Table 5.2.1 | Factors of VBD vulnerability and potential health outcomes among older adults

Factors of VBD vulnerability	Examples of health outcomes
Sensitivity • In 2019, the incidence of Lyme disease in Canada was highest among adults aged 55–79 (over 40 per cent of cases). This pattern is consistent with previous years. • The specific age range associated with increased sensitivity to WNv is unclear, but in general, older adults, around 65 years and older are at greater risk for severe disease. [3, 11, 33] • Older age combined with chronic health conditions, such as cancer, diabetes, and heart disease can increase the risk of severe disease from WNv. [34] • Aging is associated with reduced function of the immune system which increases the likelihood of severe symptoms when infected. [11] **Interactions with other vulnerability factors:** **Exposure** • There is greater potential exposure for older adults who experience homelessness, live in rural areas, engage in outdoor activities, or live in substandard housing (e.g., lacking window screens or adequate protections from insects). **Adaptive capacity** • Illnesses or disabilities often associated with older age may reduce some people's ability to protect themselves (e.g., scan for ticks) or access time sensitive treatment (e.g., antibiotic treatment immediately after a tick bite). [35] • Some older adults may be dependant on the awareness and actions of caregivers to prevent VBD exposure. • Older adults experiencing low income or homelessness may face barriers to accessing necessary protection such as insect repellent and adequate shelter.	• Adults over 65 may have slower resolution of the rash associated with LD and higher odds for an unfavorable outcome of treatment for LD. [36] • Those aged 65 and over have a 1 in 50 chance of neuroinvasive disease from WNv. [33] • People over the age of 55 are at higher risk of developing meningoencephalitis if they become infected with WNv. [37]

Similar to national trends, a large proportion of LD cases in Durham Region are among older adults over the age of 55, with the majority of cases among those 40 and older.

Over a five-year period, between 2018 and 2022, there were 361 newly diagnosed cases of LD in Durham Region. An age trend is noticeable in the graph shown in **Figure 5.2.1**, where the number of new cases sharply increases with increasing age, until it hits the peak at the 50-59 age group and then slowly declines with increasing age. More than 50 percent of all LD cases during this time were between the ages of 40 and 69.

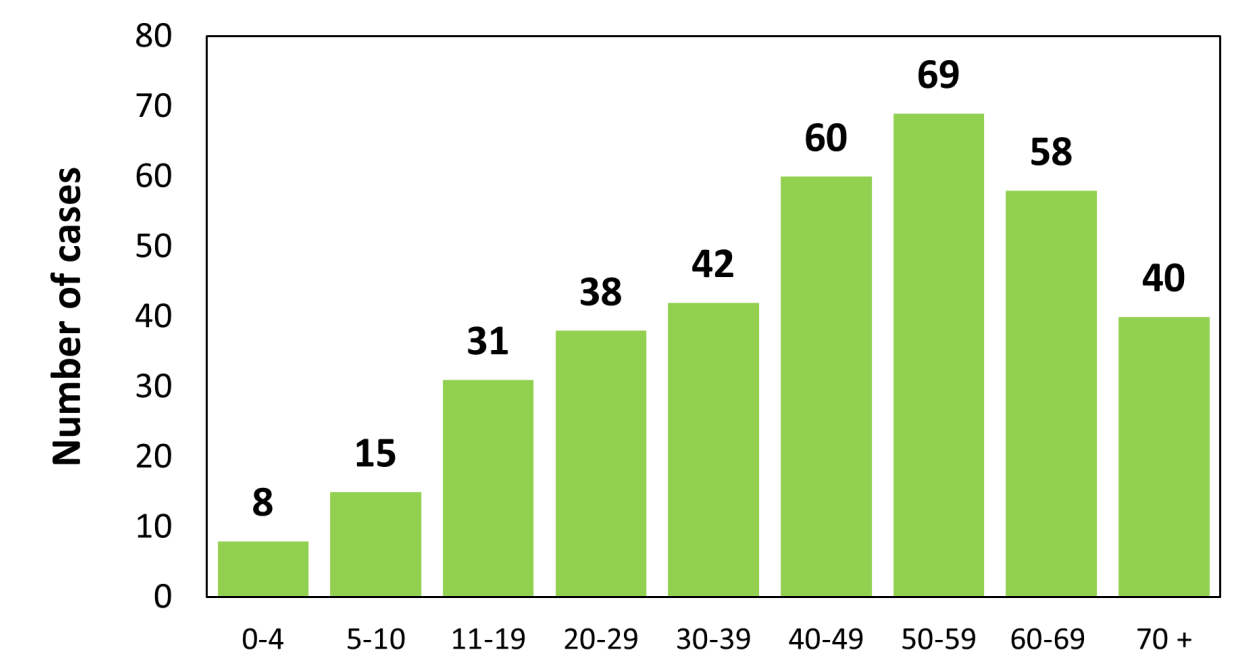


Figure 5.2.1. | Lyme disease cases in Durham Region from 2018-2022 by age group*

*Interpret 2020 and 2021 data with caution due to changes in the availability of health care and health care seeking behaviour during the COVID-19 pandemic.

Data source: Ontario Agency for Health Protection and Promotion (Public Health Ontario). Lyme disease [Internet]. Toronto, ON: King's Printer for Ontario; 2023 [Cited 2024 Jul 04]. Available from: Infectious Disease Trends in Ontario | Public Health Ontario.

Similar to LD, cases of WNv disease in Durham Region appear to be most common in residents who are 40 and older.

Figure 5.2.2. shows that between 2018 and 2022, there were 24 new cases of WNv disease reported in Durham Region, with just over half of those cases (n=13) reported in 2020. Of these cases, the majority were among residents between the ages of 40 and 69, and only one third of cases (n=7) were among those 39 years and younger.

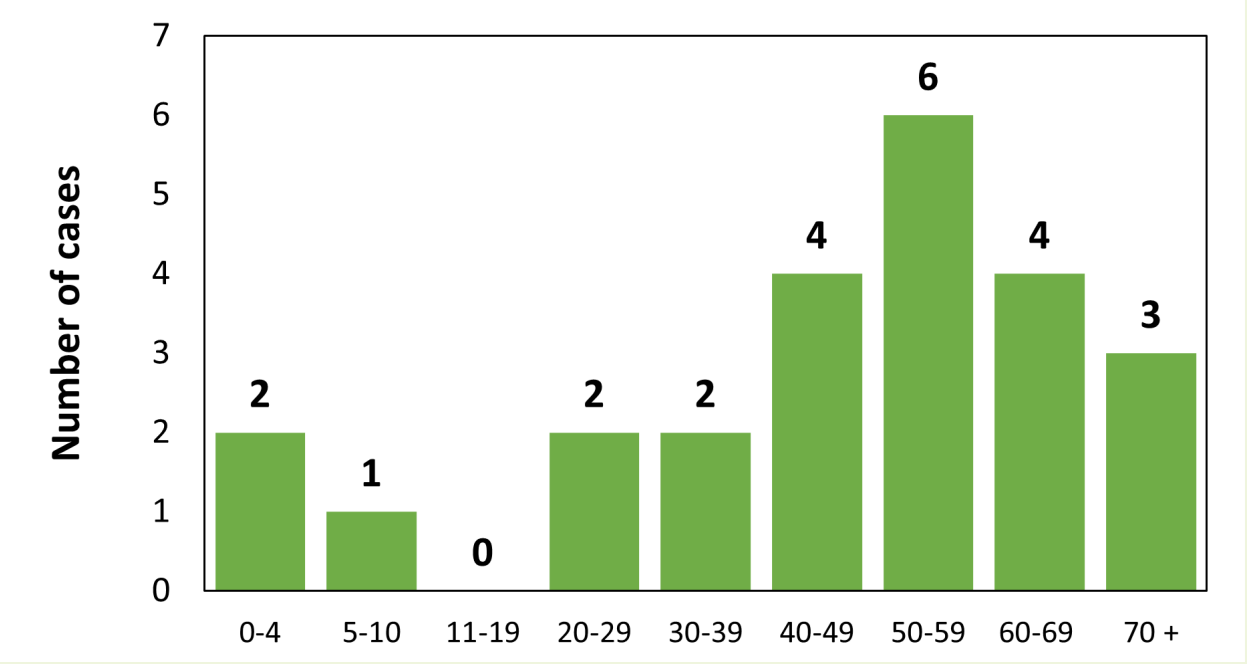


Figure 5.2.2 | Number of WNv disease cases reported in Durham Region from 2018 to 2022, by age group

*Interpret 2020 and 2021 data with caution due to changes in the availability of health care and health care seeking behaviour during the COVID-19 pandemic.

Data source: Ontario Agency for Health Protection and Promotion (Public Health Ontario). West Nile virus illness [Internet]. Toronto, ON: King's Printer for Ontario; 2023 [Cited 2024 Jul 04]. Available from: Infectious Disease Trends in Ontario | Public Health Ontario.

Durham Region has a rapidly growing older adult population who are generally more susceptible to the growing risks of LD, WNv disease and other VBDs.

By the year 2036, the age category of 65 years and older is projected to represent 24 per cent of the Region's population. [38, 31] This was the only group with noticeable growth from 2011 to 2021; approximately four times more than the Region's general population (**Figure 5.2.3**). [31]

Older adults experiencing low income may face greater health risks due to compounding health inequalities such as inadequate shelter, chronic illness, or a lack of access to protections such as insect repellant.

Over 8 per cent of Durham Region older adults live with a low income. Oshawa and Brock have the highest proportion of older adults with low incomes. [31] Oshawa is also home to five of Durham Region's Priority Neighbourhoods where there is an overall higher prevalence of chronic diseases and low incomes than other Durham Region Neighbourhoods. It is difficult to characterize the rate of homelessness in Durham Region, but data suggest a significant increase since 2019. Based on recent homelessness counts (October 20 to 21, 2021), 33 per cent of Durham residents experiencing homelessness were older adults aged 50 and older. [39]

A more fulsome demographic profile of Durham Region's older adult population can be found in chapter five of the DRHD background primer: Climate Change and Health in Durham Region, available at **durham.ca/ClimateAndHealth**

Older adults, 65+

POPULATION GROWTH FROM 2016 TO 2021

Durham Region average	65 years and older
7.9%	25.9%

OLDER ADULT POPULATION, 65+

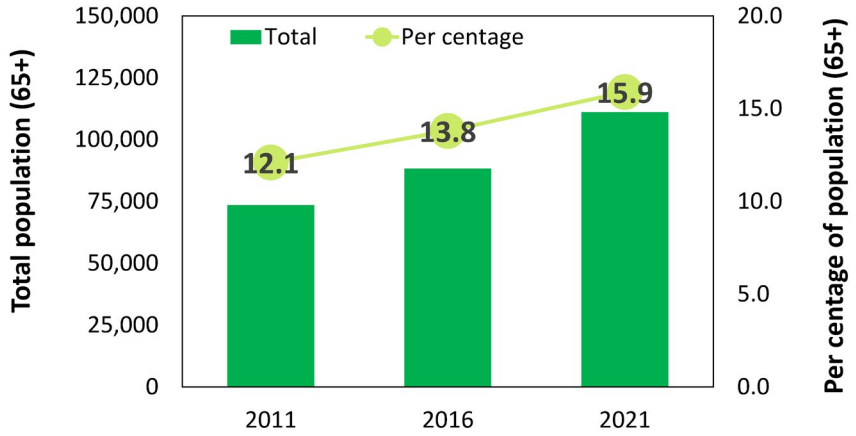


Figure 5.2.3 | Total and per cent population aged 65 years and older (2011 to 2021) and population growth (2016 to 2021) in Durham Region

Data source: Statistics Canada, 2021, 2016 & 2011 Census of Population.

5.2.1.2 Infants and young children

Table 5.2.2 | Factors of VBD vulnerability and potential health outcomes among infants and young children

Factors of VBD vulnerability	Examples of health outcomes
Sensitivity • In Ontario, children ages 5 to14 have a higher risk of acquiring LD compared to most other age groups (except for the 55 -79 age group). [40] • Children who are immunocompromised or have a chronic health condition may be at greater risk of severe health outcomes. [3] **Interactions with other vulnerability factors:** **Exposure** • There is greater potential exposure for children who experience homelessness, live in rural areas, engage in outdoor activities, or live in substandard housing (e.g., lacking window screens or adequate protections from insects). **Adaptive capacity** • Infants and children have a limited ability to recognize or protect against VBD exposure and generally depend on caregiver knowledge and ability to prevent exposure and infection.	• Most children treated for all stages of LD report full resolution of symptoms within 6 months, however some (~22%) report one or more symptom persisting >6 months. [41]

Some children in Durham Region face a disproportionate risk of poor health outcomes from VBD due to health and socioeconomic disparities.

The proportion and distribution of immunocompromised children in Durham Region is not known, however chronic health conditions combined with socioeconomic risk factors including low-income can increase the risk of poor health outcomes from VBD infections. For example, children and youth who experience hunger are more likely to suffer from chronic health conditions including lowered immunity. [42] In 2021, almost 9 per cent of Durham Region's children ages 5 and under were living with low income with the highest proportion living in Oshawa (almost 15 per cent). [31] Health promotion strategies, with an emphasis on equity-deserving children, may help prevent VBD in children and help promote protective behaviour and prevention over their lifetime.

5.2.1.3 Pregnant individuals

Table 5.2.3 | Factors of VBD vulnerability and potential health outcomes among pregnant individuals

Factors of VBD vulnerability	Examples of health outcomes
Sensitivity • Changes to the immune system during pregnancy may increase health risks associated with some infections. [43] • Current evidence related to LD and pregnancy is limited. Most pregnant people with LD, can be treated with antibiotics and early treatment reduces the risk of potential placenta infection and complications. [44] • Treatment options for tick-borne illnesses may in some cases, be limited for pregnant or nursing individuals which increases the risk of health impacts [27]. **Interactions with other vulnerability factors:** **Exposure** • There is greater potential exposure for pregnant people who experience homelessness, live in rural areas, engage in outdoor activities, or live in substandard housing (e.g., lacking window screens or adequate protections from insects). **Adaptive capacity** • Pregnant people experiencing low income or homelessness may face barriers to accessing necessary protection such as insect repellent, adequate shelter, and time sensitive health care.	• Tick -borne infections during pregnancy have been associated with perinatal outcomes ranging from minor self-limiting illnesses to pregnancy loss, fetal infection, and in some cases birth defects. [45]

Targeted prenatal health promotion to reduce VBD exposure may help reduce health risks and support life-long protective practices.

A better understanding of local VBD risks for pregnant individuals is needed. Including VBD risk and prevention information in prenatal health promotion planning, may help to reduce the risk of pregnancy complications associated with VBD, as well as promote prenatal and early childhood prevention.

5.2.1.4 Indigenous Peoples

Table 5.2.4 | Factors of VBD vulnerability and potential health outcomes among Indigenous Peoples

Factors of VBD vulnerability	Examples of health outcomes
Sensitivity • Indigenous Peoples are uniquely sensitive to the health impacts of climate change including VBD. [46] • Processes of colonization have led to a warming climate, ecosystem destruction and entrenched health inequities for Indigenous Peoples. This includes increased VBD within the lands that many First Nations depend on for their livelihood, culture, identity, health, and well-being. [46] • Ongoing processes of colonization, including socio-economic and political marginalization have resulted in systemic health inequalities that may result in an increased risks of health complications associated with VBDs. [46] **Interactions with other vulnerability factors:** **Exposure** • In general, many Indigenous Peoples are engaged in land-based activities that require substantial time outdoors (e.g., hunting, fishing, trapping), leading to disproportionate risks of exposure to VBDs. • Williams Treaties First Nations have constitutionally protected Rights in Durham Region; therefore, exposure is greater when they are asserting their harvesting, gathering, and fishing Rights. • Exposure among Indigenous Peoples is difficult to estimate because there are no publicly available data from surveillance programs that identify the prevalence of vector-borne illnesses among specific populations, including Indigenous populations.	• Increased risk of health complications due to **health and socio-economic inequities**. [46] • Higher exposure risk due to land-based practices can lead to **chronic illness, mobility issues, and reduced participation in cultural activities, disrupting traditional knowledge transfer**. • Disconnection from the land and avoiding traditional use areas due to increased disease risk can lead to a **loss of cultural identity, spiritual connection, and overall well-being**. • Losing access to traditional lands and witnessing environmental changes that threaten health can contribute to **grief, eco-anxiety, historical trauma, and intergenerational stress**. • Changes in disease-carrying species impact the health of wildlife relied upon for food and cultural practices, **threatening food, and medicine security**.

Factors of VBD vulnerability	Examples of health outcomes
Adaptive capacity • Processes associated with colonization have had a significant role in limiting the adaptive capacity of Indigenous Peoples, including the member citizens of the Mississaugas of Scugog Island First Nation. Examples include deforestation, the filling of wetlands, and the conversion of grasslands, prairies, and savannahs into agricultural land for crops and grazing. These activities have contributed to a significant release of greenhouse gases into the atmosphere and the related spread of VBDs. • The forced removal of Indigenous Peoples from their lands and territories, and the genocidal practices of residential schools and the 60's Scoop has resulted in the intentional removal of traditional Anishnaabeg land management practices across much of Southern Ontario, decreasing resiliency to VBDs. • MSIFN emphasizes that processes of reconciliation, such as the co-management of ecosystems that re-capture carbon, not only enhance adaptive capacity and resilience to VBDs but also restore cultural relationships with the land, water, and all beings. Moreover, embedding Indigenous language into climate action strategies – such as naming landscapes in Anishinaabemowin and revitalizing place-based teachings – strengthens cultural identity, deepens intergenerational Knowledge transfer, and fosters holistic resilience to the health impacts of climate change and VBD.	• Indigenous communities often face barriers to timely diagnosis and treatment, leading to **delayed diagnoses, limited healthcare access and worsened health outcomes**. • **Loss of land-based language transmission**. Anishinaabemowin is deeply tied to the land and contain detailed ecological vocabularies that describe the behaviours of animals, plants, and seasonal changes. If VBDs limit access to traditional territories, current and future generations lose opportunities to learn the language with fluent speakers through land-based practices like harvesting, hunting, and medicine gathering.

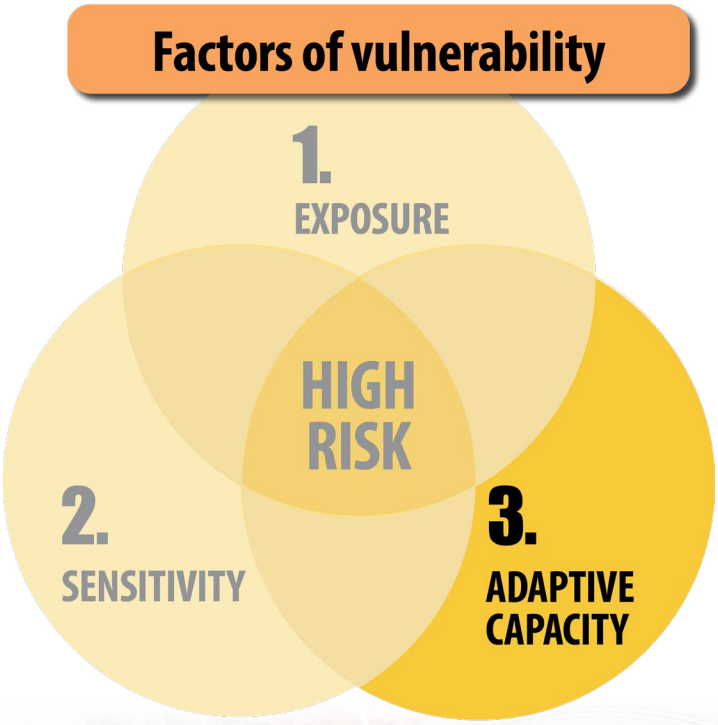
5.2.1.5 People with a weakened immune system

Table 5.2.5 | Factors of VBD vulnerability and potential health outcomes among people with a weakened immune system

Factors of VBD vulnerability	Examples of health outcomes
Sensitivity • People who have a weakened immune system are at greater risk of serious illness and complications from VBD infections. [3, 7] **Interactions with other vulnerability factors:** **Exposure** • There is greater potential exposure for people who experience homelessness, live in rural areas, engage in outdoor activities, or live in substandard housing (e.g., lacking window screens or adequate protections from insects). **Adaptive capacity** • Co-morbidities associated with a weakened immune system may reduce capacity of some people to take preventive action (e.g., use insect repellant, scan for ticks, shower after outdoor time) as well as access time-sensitive treatment (e.g., antibiotic post-exposure prophylaxis (PEP) treatment in the case of a tick bite). [35] • Individuals may be dependent on caregiver awareness and use of preventive measures. • People experiencing low income or homelessness may face barriers to accessing necessary protection such as insect repellent and adequate shelter.	• People with a compromised immune system are at higher risk of developing meningoencephalitis if they become infected with WNV. [37] • Complications associated with LD include neurological and cardiac symptoms such as myocarditis, pericarditis, and heart failure. [10, 47]

Some people in Durham Region may face a disproportionate risk of poor health outcomes from VBD due to health and socioeconomic disparities.

The proportion and distribution of immunocompromised people in Durham Region is not known, however a weakened immune system is associated with many chronic health conditions, as well as socioeconomic risk factors such as low-income and insecure housing. For example, not eating enough is associated with greater risks for chronic disease, infection, and lowered immunity. [48, 49, 50] DRHD's climate and health primer report, Understanding the Local Health Impact of Climate Change provides a more in-depth summary of Durham Region residents living with chronic disease, low income and insecure housing. [18] For example, the proportion of individuals experiencing chronic homelessness substantially increased from 38 per cent in 2018, to 57 per cent in 2021. Health promotion strategies, with a focus on equity-deserving, priority populations may help to prevent severe health impacts from VBDs.



5.3 Adaptive capacity to VBD in Durham Region

VBDs are preventable and all Durham Region residents should have equal ability to protect themselves.

Serious health outcomes from VBDs can be prevented if a person has the knowledge and ability to avoid disease carrying vectors, as well as access to timely treatment, when needed. Unfortunately, not everyone has the same ability to adequately protect themselves because exposure is influenced by many factors such as neighbourhood conditions, income, housing quality, access to information, and healthcare. In Canada, overall adoption of VBD protective behaviours is low and there is an urgent need for innovative approaches to increasing awareness and prevention. [35]

5.3.1 Improving adaptive capacity to vector-borne disease in Durham Region

The following section identifies some local needs to increase awareness and prevention of VBDs. More comprehensive community engagement is required to understand the full range of needs and opportunities, particularly among priority populations and the organizations that serve them.

A. Prevention strategies and health promotion to protect outdoor workers.

Due to climate change, a wide range of workers in Durham Region may face increased occupational exposure to VBDs. It is estimated that at least 10 per cent of workers in Durham Region work outdoors (**Table 5.1.1**) . Examples include utility workers, roads and works crews, waste collection crews, agricultural workers, construction workers, emergency workers, conservation authority field staff, and summer camp, recreation, and outdoor sports staff. [31]

Given that these workers are required to spend more time in high-risk areas than the general population, it is important to prioritize and promote strategies that protect their health and ensure safe working environments. Examples include tailored training on prevention and treatment, administrative controls, personal protective equipment, as well as methods for tracking and reporting workplace exposure and cases.

B. Targeted health promotion strategies to address the overall low awareness and poor uptake of Lyme disease prevention measures, particularly for young adults.

The following section summarizes key data showing that knowledge and action by Durham Region residents to prevent LD can be improved.

Data suggests that some LD cases in Durham Region may have been avoided if preventive measures were taken.

Figure 5.3.1 shows LD cases in Durham Region over a five-year period, from 2019 to 2023. Of these cases, 80 per cent of people reported that they spent time in a tick prone location such as a wooded area or tall grass, yet most did not check for ticks, wear protective clothing, or use insect repellant. Checking for ticks and removing them before 36 hours of attachment usually prevents infection. [51]

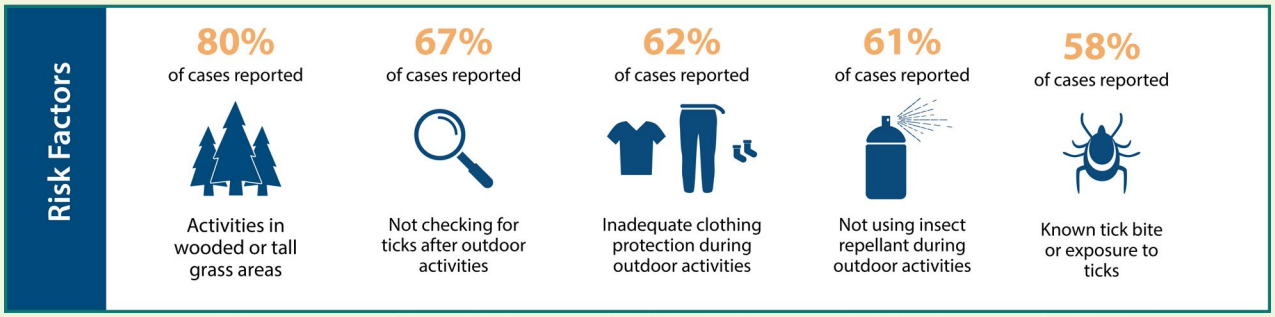


Figure 5.3.1 | LD cases in Durham Region, 2019-2023

Most residents do not protect themselves from tick bites.

Low uptake of measures to prevent LD was documented through the 2023 RRFSS telephone survey, which DRHD uses to collect health data of Durham Region adults (ages 18+). Survey results showed that fewer than half of residents reported that they "almost always" take measures to protect themselves from tick bites after visiting a tick-prone area, and 40 per cent reported that they rarely or never check themselves for ticks after an activity in a tick-prone setting. [52]

Adults ages 18 to 44 appear to be least likely to protect themselves from tick bites.

The RRFSS survey results showed that Durham Region residents 25-to 44 years of age are significantly less likely to take protective measures against tick bites compared to the 45- to 64-year-olds (**Figure 5.3.2**). Targeted health promotion to children and young adults may improve life-long protection from LD. [52]

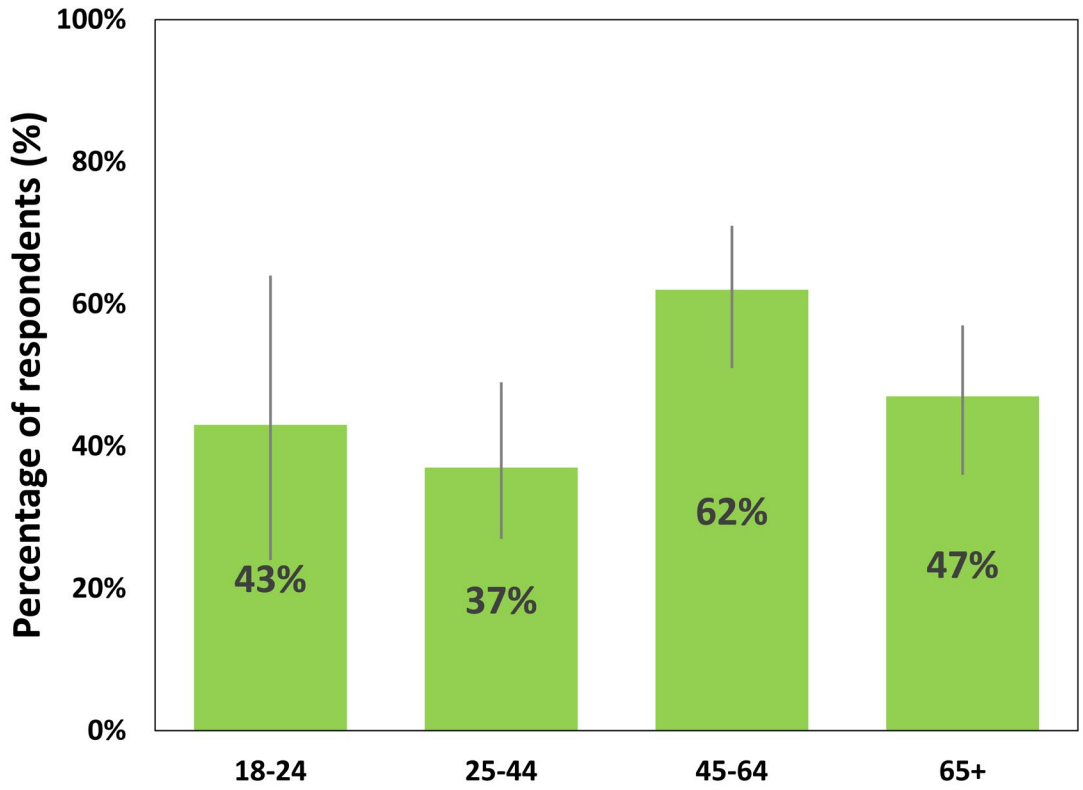


Figure. 5.3.2 | Percentage of Durham Region adults who protect themselves against tick bites, by age group (Spring-Summer 2023)

I= 95% confidence interval

"Yes" refers to practicing the behaviour 'all of the time' or 'most of the time'.

Data source: Rapid Risk Factors Surveillance System (RRFSS), Durham Region Health Department and Institute for Social Research, York University, Summer 2023.

Lack of awareness of LD and associated symptoms may prevent Durham Region residents from seeking timely healthcare and treatment.

The ability to recognize LD symptoms and seek timely treatment is essential for preventing serious health outcomes from infection. While most respondents (89%) indicated they had heard about LD, only 30 per cent were able to name more than one symptom. Rash and fatigue were the most named symptoms. A large proportion of residents (41%) were unable to name any LD symptoms and almost none of the respondents were aware that LD symptoms could include muscle or joint pain, swollen lymph nodes and headache. [52]

Knowledge and awareness of LD symptoms among younger adults is very low. Although awareness appears to increase with age, overall awareness among residents is low.

Figure 5.3.3 shows that awareness of LD symptoms is lowest among the youngest age group (18-24) and highest among the oldest age group (65+). However, even among the highest age group, only 36 per cent could name more than one symptom and another 36 per cent were unable to name any symptoms.

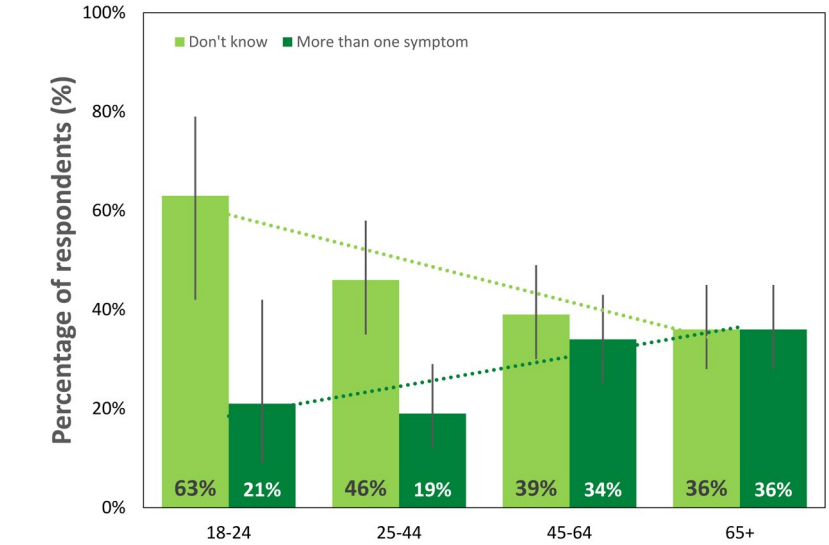


Figure. 5.3.3 | Awareness of Lyme disease symptoms among Durham Region adults, by age category (2023)

Don't know = Respondents were unable to list any Lyme disease symptom.

More than one symptom = Respondents were able to list 2 or more correct Lyme disease symptoms.

I = 95% confidence interval

Data source: Rapid Risk Factors Surveillance System (RRFSS), Durham Region Health Department and Institute for Social Research, York University, Summer 2023.

C. Targeted health promotion strategies to address the overall low awareness and poor uptake of West Nile virus prevention measures.

The following section summarizes key data showing that knowledge and action by Durham Region residents to prevent WNv disease can be improved.

Most Durham Region residents do not protect themselves from mosquito bites.

Figure 5.3.4 shows WNv disease cases in Durham Region over a ten-year period, from 2014 to 2023. Of these cases, most were involved in activities that exposed them to mosquitoes, yet most did not wear protective clothing or insect repellant.

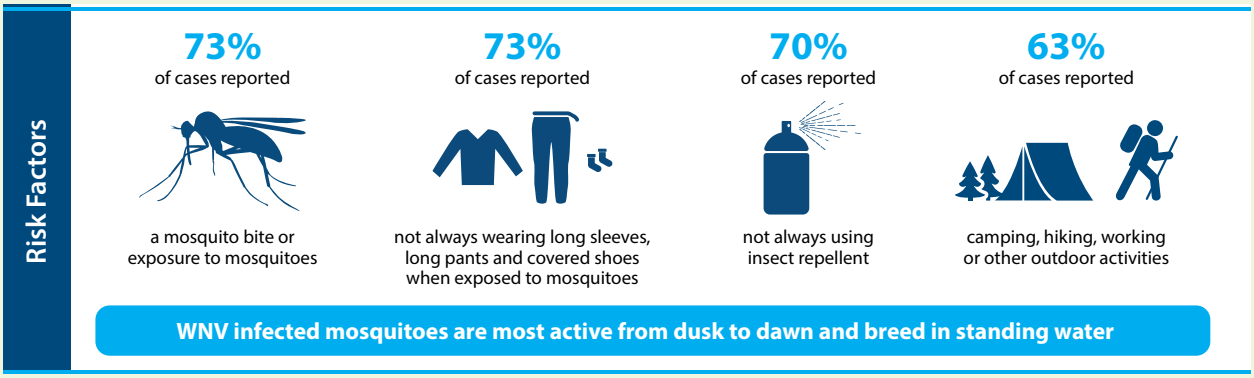


Figure 5.3.4 | WNv disease cases in Durham Region, 2014 - 2023 [17]

Over 90 per cent of Durham Region residents surveyed reported they do not use any type of insect repellant.

Low uptake of measures to prevent WNv disease was also documented through the 2022 RRFSS telephone survey which found that almost all (90%) of Durham Region residents reported they do not use any type of insect repellant and only 30 per cent wore protective clothing (**Figure 5.3.5**).

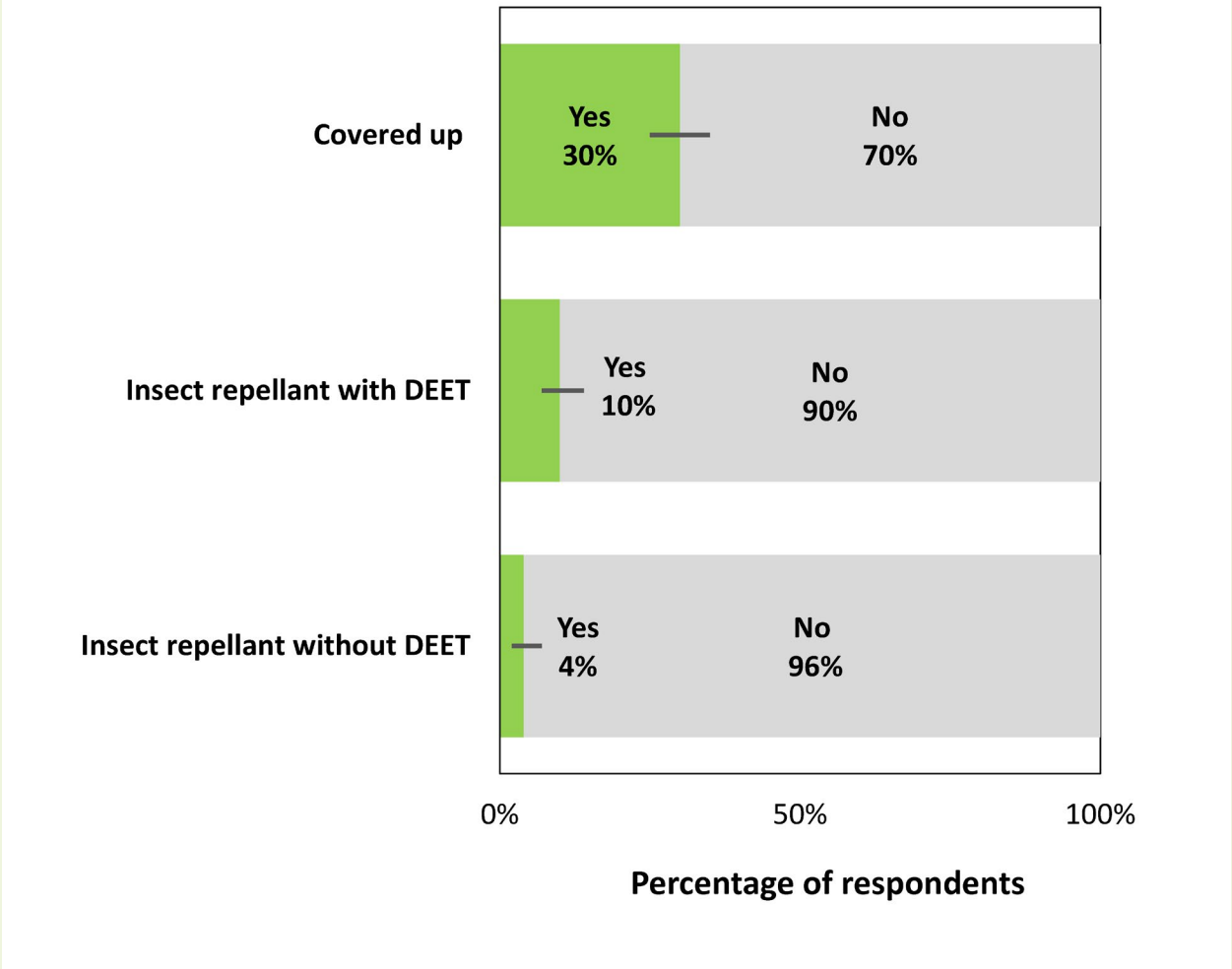


Figure 5.3.5 | Behaviours used to prevent mosquito bites (Summer 2022)

I = 95% confidence interval

"Yes" refers to practicing the behaviour 'all of the time' or 'most of the time'.

Data source: Rapid Risk Factors Surveillance System (RRFSS), Durham Region Health Department and Institute for Social Research, York University, Summer 2022.

D. Improved understanding of barriers to VBD prevention among equity deserving priority populations who are more susceptible to severe health outcomes.

Some people in Durham Region may face a disproportionate risk of poor health outcomes from VBD due to health and socioeconomic disparities. Education alone may not be sufficient in preventing VBDs because there may be other reasons that prevent people from protecting themselves from exposure to infective vectors or accessing health care when needed. Targeted outreach and engagement with priority populations and the organizations that serve them would help to develop appropriate interventions and prevention strategies. Priority populations include older adults, infants and young children, pregnant people, Indigenous Peoples, and people with weakened immune systems who are experiencing health inequities.

E. Increased awareness among residents of the links between VBD risk and climate change.

Data from DRHD's climate and health primer report, Understanding the Local Health Impact of Climate Change, showed that awareness of the current and near future health risks of climate change is not well established in Durham Region. [18] Although most residents are worried about climate change, particularly for future generations, many think they will not be personally affected.

During the 2023 RRFSS survey, respondents were asked about potential health risks from climate change in Durham Region, including questions about resident's perception of climate-related health risks from mosquitoes and ticks carrying diseases.

Figure 5.3.6A shows that overall, most Durham Region adults (67%) think that mosquitoes and ticks carrying diseases pose a moderate to major risk to health. Females were significantly more likely to perceive the health risks posed by mosquitoes and ticks as moderate or major compared to males (**Figure 5.3.6B**).

The perception of risk also increased with age; a little more than half of younger adults (ages 18-44) perceived health risks from mosquitoes and ticks as moderate to major compared to three quarters of older adults (65+)(**Figure 5.3.6C**).

Establishing strong links between climate change and the increasing risk of VBDs in Durham Region is essential for supporting action to mitigate climate change and its health impacts.

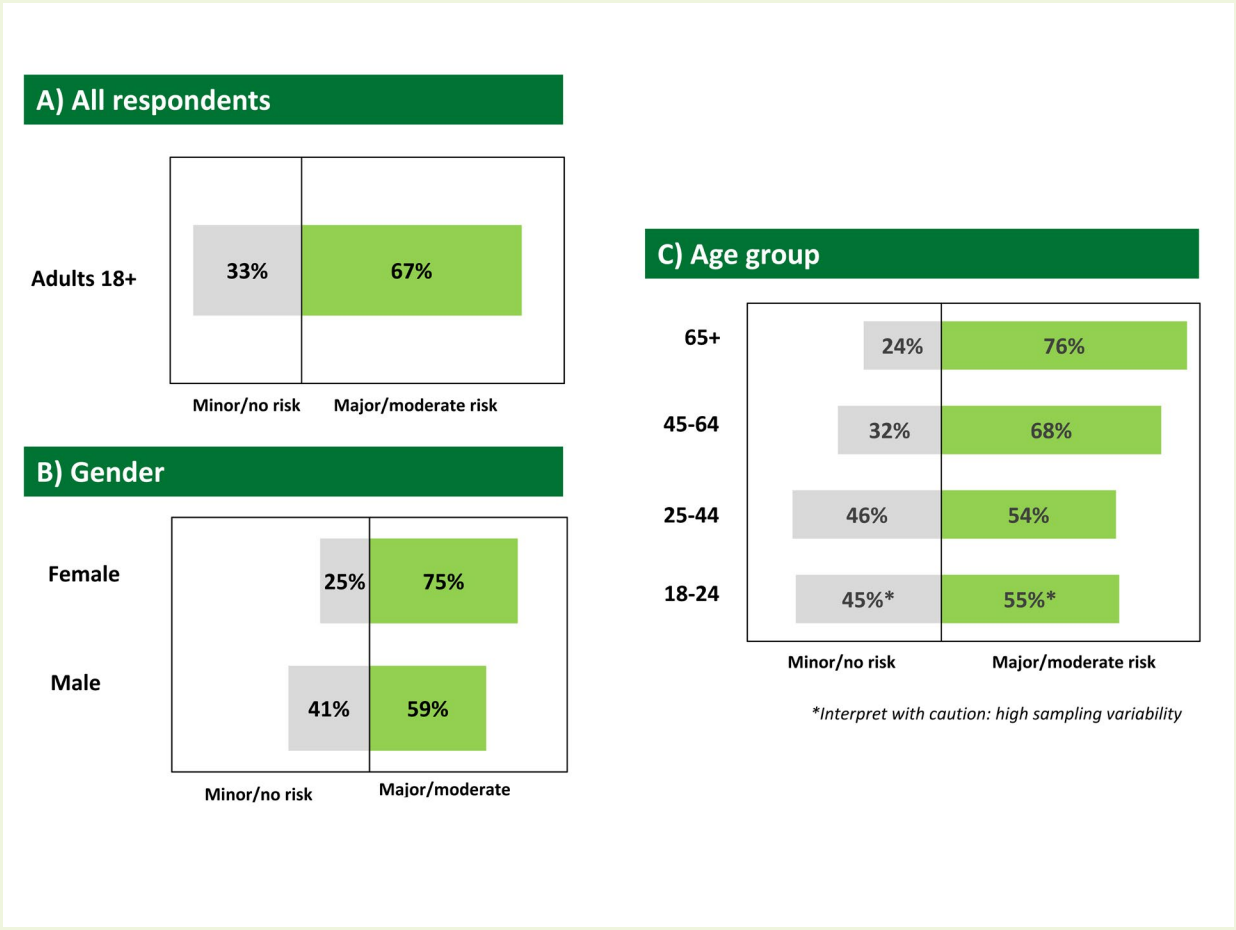


Figure 5.3.6 | Demographic differences in the percentage of Durham Region adults (18+) who think that risk posed by mosquitoes and ticks is major or moderate risk compared to minor or no risk at all, 2023

Data source: Rapid Risk Factors Surveillance System (RRFSS), Durham Region Health Department and Institute for Social Research, York University, Fall 2023.

5.3.2 Local strengths and opportunities for VBD prevention

Durham Region's VDB Prevention and Response Plan is established to provide surveillance and programming to prevent WNv disease , LD, and other emerging VBDs.

In alignment with provincial public health legislation, standards, protocols, and guidelines, DRHD has an active VBD plan that provides an ongoing program to monitor and prevent WNv disease, LD, and other emerging VBDs within Ontario. [53] The plan includes an active Durham Region Vector-borne Disease Response Committee (DRVBDRC) comprised of regional, municipal, conservation authorities, and public representatives. DRHD leads surveillance, case investigation, abatement measures, health communications, health promotion, education and training, and risk assessment. The Durham Region Works Department (DRWD), school boards, and municipalities also participate in abatement and education activities.

Key activities of the plan include:

- **Mosquito surveillance and population reduction**
  From mid-May to mid-September, DRHD conducts routine surveillance of long-term standing surface water sites as well as catch basins. Larval and adult mosquitoes are monitored to determine mosquito populations associated with WNv and EEEv. [24] If a standing water site is found to contain moderate numbers of mosquito larvae, the site will be treated with an environmentally friendly biological pesticide within 24 hours. Durham Region does not currently have an insecticide program to control adult mosquitoes.
- **Site inspections in response to Durham Region resident complaints**
  Public health inspectors collaborate with municipal by-law and DRWD to investigate stagnant water concerns which are possible breeding sites for mosquito larvae on both private and public property to remediate any existing health hazard.
- **Active tick surveillance**
  Active surveillance is used to monitor local tick populations associated with LD (now endemic to Durham Region), anaplasmosis, Powassan virus, and babesiosis.
- **Health promotion to prevent infections**
  Health promotion includes tick-borne disease education provided to local agencies and organizations upon request (outdoor employees in risk areas, school boards, etc.), signage posted at public entrances of all municipal and privately owned risk areas (walking trails, Durham Forest, Rouge Valley Urban Park, etc.), a media campaign to promote LD awareness including LD Awareness Month in May, and an educational webpage with updated summary reports on local VBD trends.

The Mississaugas of Scugog Island First Nation recommend expanding the plan to include:

- Inclusion of Rights-holders Knowledge in Durham Region's VBD response decision-making, ensuring it aligns with Mino-Bimaadiziwin (Living a Good Life/ The Way of a Good Life).
- Incorporation of Anishinaabemowin into climate-health policies, such as the use of traditional place names and ecological terms in climate adaptation policies, public health campaigns, and municipal planning documents.
- Climate-health policies to fund Indigenous language programs and/or education programs tied to climate resilience, such as seasonal land-based learning focused on ecological changes and disease risk.
- Incorporation of collaborative approaches that combine scientific monitoring with Indigenous Knowledge (e.g., controlled burns) to guide VBD prevention.

6. Next steps and priorities

This assessment characterized VBD exposure, priority populations, and adaptive capacity in Durham Region. Due to climate change, residents will experience increasing exposure to VBDs. Health promotion interventions are needed to increase all resident's ability to protect themselves and others. Due to unequal burdens of VBD, tailored strategies are also needed to meet the unique needs of priority populations.

Durham Region can improve adaptive capacity to VBD through data and knowledge gathering, health promotion strategies and local services, program, and policies.

1. **Local knowledge and data** such as monitoring and reporting on vector prevalence, VBD cases and associated health burdens on residents and health systems.
2. **Health promotion and education** to support the ability of Durham Region residents to assess their risk and take action.
3. **Policies, programs, and services** to help residents avoid VBD exposures.

A list of potential activities is provided in **Table 6.1**. These are illustrative examples only and have yet to be assessed for feasibility or priority.

Table 6.1 | Examples of adaptation initiatives to prevent VBD

Local Knowledge and Data	• Surveillance and reporting of mosquito and tick populations. • Surveillance and reporting of local VBD cases and associated healthcare burden. • RRFSS data to monitor and report on VBD awareness and protective behavior among residents. • Survey on barriers and facilitators to VBD prevention among priority populations. • Changes in the incidence and geographic range of climate-sensitive infectious diseases.

Health Promotion and Education	• Tailored communications to raise awareness about risk factors and low-cost methods for preventing VBDs. This may include:
	  ○ Educational materials for schools, seniors and community centres, parks, garden centres, outdoor recreation centres, conservation areas, etc.
	  ○ Social media campaigns
	  ○ Media interviews
	  ○ Posted signage
	• Train the trainer programs for community partners on preventing infections and when to seek medical attention (e.g., in the case of a tick bite or symptoms).

Programs, Policies or Services	• Integrated vector management programs to control mosquito populations and other vectors, where possible. • Environmental management such as mowing paths and removing standing water to reduce exposure to and breeding of disease-causing vectors. • Enhancing capacity of health systems to diagnose, treat, and manage VBDs, including training community workers who serve residents at higher risk of exposure or severe disease from infection. • Promote regulations and planning that minimizes vector breeding sites, including proper drainage systems.

7. Assessment methods and limitations

Durham Region Health Department's CCHVA approach is adapted from of the Ministry of Health's Guidelines for Ontario [54, 55, 56] and Health Canada's adaptation workbook [57]. Assessment of VBD risk is examined through the three factors of vulnerability: exposure, sensitivity and adaptive capacity and draws on empirical studies, social theory, and local data on health, socioeconomic disparities, the built environment, and climate trends. [58] For a complete description of the assessment process, scope, and limitations, please see **Appendix 3.1** of the primer report: Climate Change and Health in Durham Region (durham.ca/ClimateAndHealth).

Additional limitations of this assessment include:

- Limited understanding of spatial risk patterns within Durham Region due to difficulty in determining where an individual was bitten by an infected mosquito or tick.
- Emerging VBDs and other emerging climate sensitive diseases are underexplored in this assessment. Future vulnerability assessments may be required for other "climate-sensitive" diseases such as those directly transmitted from animals (these include zoonoses such as rabies and hantavirus pulmonary syndrome), those transmitted directly from human-to-human (such as influenza, and enterovirus infections), and those that can be acquired by inhalation from environmental sources (such as Cryptococcus infection and Legionnaires' disease). [3]
- Although some patterns of risk associated with age, gender and income were identified, data to support analysis of sociodemographic risk factors were generally very limited.
- Some estimates of local exposure to VBD-prone areas were based on self-reported data. For example, while most residents report that they spend time in "grassy fields", it is unclear if they mean tall grass and meadows (higher risk of tick exposure) or a mowed field (lower risk of tick exposure).

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Appendix A: Acronyms, terms and definitions

Acronyms & abbreviations

°C	Degrees Celsius
CCHVA	Climate change and health vulnerability assessment
COPD	Chronic obstructive pulmonary disease
EEEv	Eastern equine encephalitis virus
DCCAP	Durham Region Climate Change Adaptation Plan
DOPHS	Disease of public health significance
DRHD	Durham Region Health Department
DRVBDRC	Durham Region Vector-borne Disease Response Committee
DRWD	Durham Region Works Department
LD	Lyme Disease
MSIFN	Mississaugas of Scugog Island First Nation
PEP	Post exposure prophylaxis
RRFSS	Rapid Risk Factor Surveillance System
VBD	Vector-borne disease
WNv	West Nile virus

Terms and Definitions

A more complete list of terms and definitions related to climate change and health can be found in our primer report: Climate Change and Health in Durham Region: Understanding the local health impacts of climate change, available at: durham.ca/ClimateAndHealth.

ACTIVE TICK SURVEILLANCE

Conducted by tick dragging; when a person goes into a wooded or trailed area and drags a $1m^3$ cloth along the ground, close to plants. This is continued for three hours per site, counting the ticks collected on the person and cloth frequently.

ADAPTIVE CAPACITY

The ability of an individual or community to respond to and protect against climate hazards such as VBD. Capacity may include access to informational, social, financial, and institutional supports.

ANAPLASMOSIS

A tick-borne disease caused by the bacterium *Anaplasma phagocytophilum*, with non-specific symptoms (e.g., fever, headache, and muscle aches) and a case-fatality rate less than one per cent. Human or animal cases have been identified in most Canadian provinces where the ticks occur. [1]

BABESIOSIS

A disease caused by the protozoan parasite *Babesia microti*, causes a Lyme-like disease, with a case-fatality rate of 2%–5%. The pathogen has been detected in *Ixodes scapularis* ticks in Manitoba, Ontario, Quebec, and New Brunswick, although human cases have been identified only in Manitoba. [1]

BORRELIA MIYAMOTOI

A disease first identified in 2013 in Canada, and this pathogen has been found in I. scapularis and *Ixodes pacificus* ticks. *Borrelia miyamotoi* is more closely related to the Borrelia species that cause relapsing fever, which are transmitted by soft-bodied ticks. The disease has generally non-specific symptoms of fever, fatigue, headache, muscle pain, chills, nausea, and joint pain, which may relapse, as do other relapsing fever infections. [1]

CHIKUNGUNYA

A viral disease transmitted to humans by infected mosquitoes primarily the, *Aedes aegypti* and the *Aedes albopictus*, which also transmit other diseases like dengue fever and Zika. There is an emerging population of A. *albopictus* in a very limited area of Southern Ontario [1] However, the current risk of a chikungunya infection in Canada is extremely low because A. *aegypti* and A. *albopictus* mosquitoes do not survive in the current Canadian climate. These species require an average temperature above 20°C and 10°C , respectively, including the coldest month of the year. [1] Based on these temperature ranges they may become a threat to south Ontario and British Columbia by 2100. [2]

CLIMATE VULNERABILITY

The predisposition for health to be adversely affected by climate change. Climate vulnerability is determined by differential exposure, sensitivity, and capacity to adapt to climate hazards. In public health, the concept of vulnerability can be highly stigmatizing, so it is important to emphasize that vulnerability is not a label for communities or populations. [3, 4, 5]

DENGUE FEVER

A viral infection transmitted to humans by mosquitoes primarily the *Aedes aegypti* and *Aedes albopictus* species. There is an emerging population of A. *albopictus* in a very limited area of Southern Ontario. [1] However, the current risk of a dengue infection in Canada is extremely low because A. aegypti and A. *albopictus* mosquitoes do not survive in the current Canadian climate. [2] These species require an average temperature above 20°C and 10°C , respectively, including the coldest month of the year. [2] Based on these temperature ranges they may become a threat to south Ontario and British Columbia by 2100. [2]

EASTERN EQUINE ENCEPHALITIS

A viral disease that is transmitted to humans through the bite of an infected mosquito (*Culiseta melanura*) which has fed on an infected bird. EEEV is one of the most severe mosquito-transmitted diseases in the United States, with approximately 33% mortality in those developing neurological illness and significant brain damage in most survivors who developed symptomatic disease.[1]

EQUITY DESERVING GROUPS

Populations or communities that experience significant collective barriers to participating in society often due to historical and structural disadvantages, inequities, and underrepresentation.

EXPOSURE

The degree to which an individual or community encounters climate hazards. It is influenced by underlying social and economic conditions that result in some individuals or communities experiencing more exposure to climate hazards than others.

HEALTH EQUITY

Health equity means that everyone has a fair opportunity to enjoy their full health potential and are not disadvantaged by unfair social, economic, and environmental conditions. Many factors outside the health care system influence health. Health equity is achieved when health inequalities between groups that are due to unfair social and structural factors are eliminated. [6, 7]

HEALTH INEQUITY

Differences in health outcomes that are unfair, unjust, and avoidable. Health differences result from social, economic, demographic, geographic, or environmental disadvantages.

HEALTH NEIGHBOURHOODS

Durham Region has 50 Health Neighbourhoods and presents health and demographic information at the neighbourhood level to better understand the demographics and health of Durham Region communities.

LYME DISEASE

A bacterial infection transmitted to people through the bite of a blacklegged tick (*Ixodes* spp.) infected with the bacterium *Borrelia burgdorferi*. [1, 8] If caught early, it can be treated to prevent neurological symptoms and serious health impacts. Untreated cases can cause neurological and cardiac symptoms such as myocarditis, pericarditis, and heart failure. Lyme disease one of the most rapidly emerging infectious diseases in Canada, the most commonly reported vector-borne disease in North America, and incidence has increased more than 17-fold between 2009 and 2019. [9]

MALARIA

Malaria is a life-threatening disease spread to humans by some types of mosquitoes, that is mostly preventable and curable. It is caused by parasites in the Plasmodium group that are transmitted to humans through the bite of infected female *Anopheles* spp. mosquitoes, the primary vectors of malaria. [10] Malaria is not endemic to Canada, most cases are related to travel to endemic areas such as Sub-Sahara Africa, New Guinea, South Asia, Oceania, Haiti, Central and South America, Mexico, Dominican, Republic, Northern Africa, and the Middle East. [11] It is possible, although rare, for it to be transmitted by transfusion, shared needles, or mother to an unborn child. [11] In Durham Region, all cases with risk factor details included travel to an endemic country. Symptoms are flu-like, headache, nausea, vomiting, muscle pain, chills, and malaise. [12] Severe malaria can lead to kidney and liver failure. It can cause enlargement of the spleen and a sore liver. Malaria was taken off the "Diseases of Public Health Significance" list in 2018. [13]

MENINGOENCEPHALITIS

A condition which occurs when you have inflammation and/or infection of your brain and meninges (the three layers of membranes that cover and protect the brain and spinal cord) at the same time. It is a life-threatening condition that requires early treatment. Symptoms can include fever, stiff neck, and neurological issues such as light sensitivity, behavioural changes, and seizures.

MYOCARDITIS

A term to describe inflammation of the heart muscle. Symptoms can include shortness of breath, chest pain, decreased ability to exercise, and an irregular heartbeat.

NEUROINVASIVE DISEASE

A term used to describe illnesses caused by arboviruses that infect the nervous system. A virus is said to be neuroinvasive if it is capable of entering the nervous system and neurovirulent if it is capable of causing disease within the nervous system. Symptoms of neuroinvasive illnesses usually include fever, headache, muscle pain, stiff neck, altered mental status, seizures, limb weakness or increased concentration of white blood cells in the cerebrospinal fluid.

PERICARDITIS

A term used to describe inflammation of the pericardium, the sac that covers the heart. It can cause chest pain, trouble breathing and other symptoms.

POWASSAN VIRUS DISEASE

A disease which first detected in Powassan, Ontario, is transmitted by a number of different tick species. Presentation can vary greatly, from asymptomatic infections to fatal encephalitis cases, and the case-fatality rate is 10 per cent. [1]

RAPID RISK FACTOR SURVEILLANCE SYSTEM

RRFSS is an online and telephone survey that collects health-related behaviour data among Ontario adults 18-years and older. These data provide important information that helps support public health units in planning and evaluating local programs and services, and informing education, awareness and advocacy efforts related to health behaviours.

SENSITIVITY

How much individuals or a population are affected by the health impacts of climate change. It is influenced by biologic and social factors within the population such as age, sex, chronic illness, or socioeconomic status.

VECTOR-BORNE DISEASE

Illness caused by pathogens and parasites in human populations, which are transmitted by vectors. Vectors are living organisms, typically blood feeding arthropods like mosquitoes, ticks, and fleas, that can carry and transmit pathogens such as viruses, bacteria, or parasites from one host to another. Examples include West Nile virus, Lyme disease, malaria and Zika virus.

WEST NILE VIRUS

A mosquito-borne viral disease that is spread to humans by infected mosquitoes. The virus is maintained within an avian (bird) and mosquito enzootic cycle. The main vectors of WNv in Ontario are *Culex pipiens* and *Culex restuans* mosquitoes. The virus spills over into the human population as a result of "bridge vectors", which consist of mosquito species that feed on both birds and mammals, including humans. [14]

ZIKA

A virus transmitted through the Aedes aegypti and Aedes albopictus mosquitoes, which are the same mosquitoes that transmit dengue and chikungunya viruses. [15] These mosquitos are endemic in South America and Europe. [15] Currently, the primary means of transmission of the Zika virus is sexual, from one partner to another, or from a mother to their fetus during pregnancy or at the time of birth. [12] It can potentially be transmitted via blood transfusion or health care settings. The mosquito vectors for the Zika virus were first found in Canada in 2016. [2] There is an emerging population of A. albopictus in a very limited area of Southern Ontario [1] However, the current risk of a Zika virus infection in Canada is extremely low because *A. aegypti* and *A. albopictus* mosquitoes do not survive in the current Canadian climate. [2] These species require an average temperature above 20°C and 10°C , respectively, including the coldest month of the year. [2] Based on these temperature ranges they may become a threat to south Ontario and British Columbia by 2100. [2]

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Appendix B: Detailed overview of Lyme Disease and West Nile virus in Durham Region

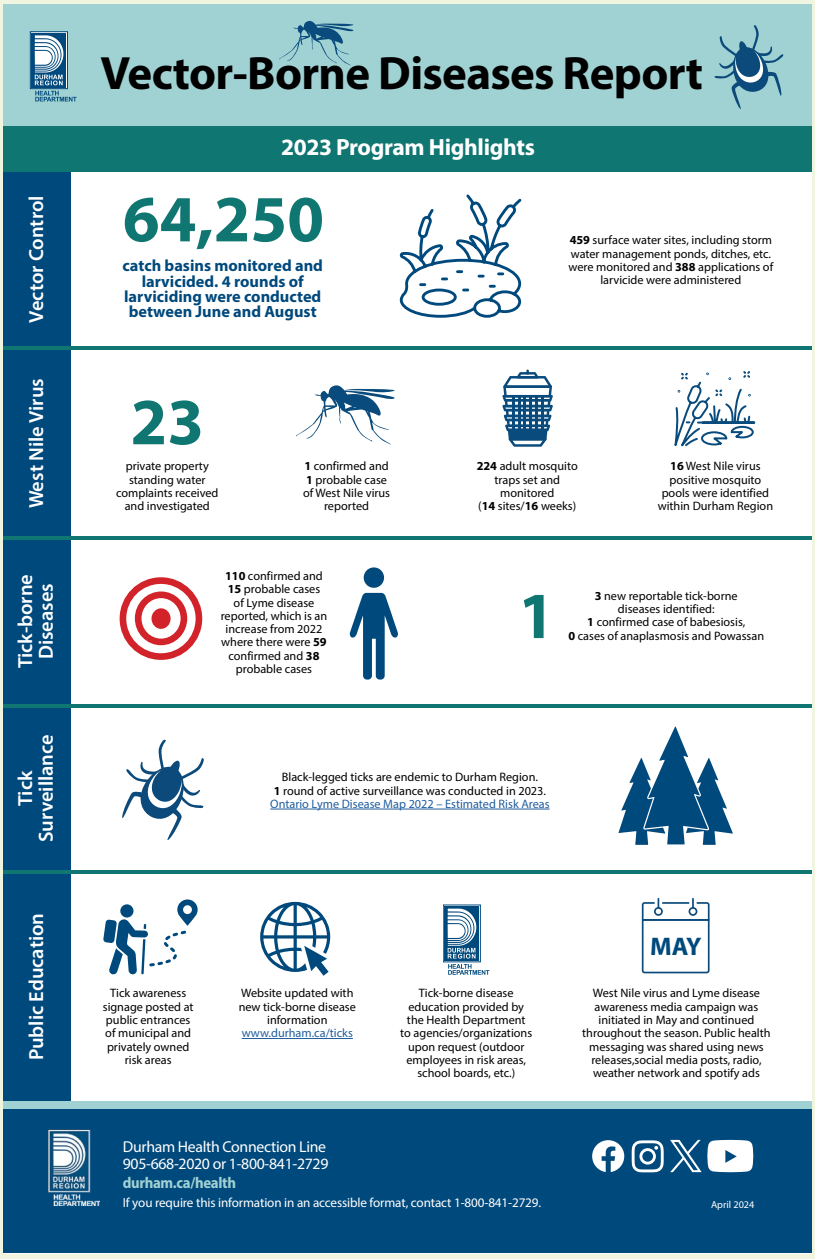

Figure B.1 | Durham Region VBD Report, 2023 Program Highlights [1]

Table B.1 | Lyme disease cases and incidence rate in Durham Region and Ontario from 2013 to 2022

Year	Number of new cases	Incidence rate Durham Region (cases per 100,000)	Incidence rate Ontario (cases per 100,000)
2103	12	1.9	2.3
2014	15	2.3	1.9
2015	19	2.9	3.3
2016	24	3.6	2.9
2017	53	7.9	7.4
2018	34	5	4.5
2019	66	9.5	8.2
2020*	53	7.4	5.9
2021*	108	14.8	11
2022	94	12.6	9.9
Total	**478**		

*Interpret 2020 and 2021 data with caution due to changes in the availability of health care and health care seeking behaviour during the COVID-19 pandemic.

Data source: Ontario Agency for Health Protection and Promotion (Public Health Ontario). Lyme disease [Internet]. Toronto, ON: King's Printer for Ontario; 2023 [Cited 2024 Jul 04]. Available from: Infectious Disease Trends in Ontario | Public Health Ontario.

Table B.2 | West Nile virus disease incidence in Durham Region and Ontario from 2013 to 2022

Year	Number of new cases	Incidence rate Durham Region (cases per 100,000)	Incidence rate Ontario (cases per 100,000)
2013	3	0.5	0.4
2014	0	0	0.1
2015	2	0.3	0.3
2016	2	0.3	0.4
2017	3	0.4	1.1
2018	5	0.7	1
2019	1	0.1	0.2
2020*	13	1.8	0.7
2021*	2	0.3	0.2
2022	3	0.4	0.2
Total	**34**		

*Interpret 2020 and 2021 data with caution due to changes in the availability of health care and health care seeking behaviour during the COVID-19 pandemic.

Data source: Ontario Agency for Health Protection and Promotion (Public Health Ontario). West Nile virus illness [Internet]. Toronto, ON: King's Printer for Ontario; 2023 [Cited 2024 Jul 04]. Available from: Infectious Disease Trends in Ontario | Public Health Ontario

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Appendix C: Tick-borne illnesses reported in Ontario

Table C.2 provides a list of tick-borne illnesses that have been reported in humans in Ontario, which may increase as climate change intensifies.

Table C.2 | Tick-borne illnesses reported in humans in Ontario

Disease	Infectious organism (bacteria, virus, parasite)	Tick species
Human anaplasmosis	*Anaplasma phagocytophilum**	*Ixodes scapularis, Ixodes pacificus*
Human babesiosis	*Babesia microti**	*Ixodes scapularis*
Lyme disease	*Borrelia burgdorferi**	*Ixodes scapularis, Ixodes pacificus*
Lyme disease- like illness	*Borrelia mayonii*	*Ixodes scapularis, Ixodes angustus*
Lyme disease- like illness	*Borrelia miyamotoi*	*Ixodes scapularis, Ixodes pacificus*
Tularemia	*Francisella tularensis*	*Dermacentor variabilis, Dermacentor andersoni, Amblyomma americanum*
Powassan virus*	*Powassan virus*	*Ixodes cookei, Ixodes marxi, Ixodes spinipalpis*
Rocky Mountain Spotted Fever	*Rickettsia rickettsii*	*Dermacentor variabilis, Dermacentor andersoni, Rhipicephalus sanguineus*

Data source: [1] *A disease of public health significance (DOPHS) in Ontario and reportable to Public Health to enable effective public health management and disease surveillance. [2, 3, 4]

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Appendix D: Protecting against VBD

The following behaviours can be effective in protecting yourself against VBD.

A. Protect skin from vectors when outdoors

Wear light colour long sleeve clothing, with pants tucked into your socks to prevent a bite.Completely covering your skin can help protect against vectors bites. Cover your skin with light-colored, long-sleeved shirts and pants. Tuck your pants into your socks and used closed-toe shoes. Hats with netting can be used to protect your head and neck from mosquitos.

B. Check and remove ticks

Checking for ticks, on yourself, your clothes, your family, and your pets, is the best way to prevent a tick-borne illness.

A full body check should be completed within two hours of outside activities to remove ticks before they attach to the body. Activities outside could be a walk, gardening, piling wood, or playing in the yard. Ticks found attached can be removed with tweezers. [1] Ticks removed before 36 hours of attachment usually prevent infection. [1] **Figure D1** shows a tick's top ten tick hiding spots on the human body. [1]

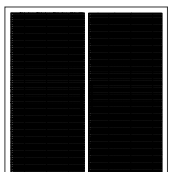
Remove clothes and put them into the dryer on high heat for 10 mins to kill any ticks on them.

C. Use insect repellant

The use of personal repellants, not area repellants, helps to protect individuals against insect bites.

There is strong evidence showing the use of personal repellents prevents mosquito bites, thus preventing WNv disease. [2] There are many options for personal insect repellents, including sprays, lotions, clip-on products, and clothing treated with insecticide. [1] There is also a combination of insect repellent ingredients available such as DEET, permethrin, oil of lemon eucalyptus, and mixtures of essential oils including lemon, pine needle, camphor, geranium, and eucalyptus. Each option has its limitations and safety guidelines that should be followed. [1] Area repellants, such as citrosa houseplants, traps, bug zappers, and candles may help to repel mosquitos from an area but do not protect individuals against insect bites.

D. Prevent insects from coming indoors



Screens in windows and doors prevent mosquitos from entering a building. Having complete screens, without rips or tears, that cover the entire open surface is required to prevent the insect from entering the building. Other items such as air curtains can be effective in passageways such as service windows or receiving doors, in preventing flying insects from entering the area.

E. Limit standing water

Reducing the locations that mosquitos can develop, such as birdbaths, rain barrels, empty flowerpots or unused fish ponds can reduce the number of mosquitos.

The mosquito lifecycle occurs in still water. Items around your house can collect water and become a breeding ground for mosquitos. It takes seven days or less for the mosquito to transition from egg to adult, thus emptying water features weekly or more frequently can reduce the number of mosquitos in your area. [3]

Limit standing water around your home, such as bird or pet baths, cans, tires, non-circulating ponds, children's toys like wagons, clogged eavestroughs, unused pools, or standing puddles from poor water drainage. Rain barrels should be tightly sealed to prevent mosquitos from entering. Eavestroughs and land should be sloped away from the house to prevent standing water close to windows and discourage host animals from coming near the house.

Water attracts animals that carry ticks to new locations. Limit standing water to prevent the spread of ticks.

Standing water can attract host species such as birds, white-footed mice, and other rodents. [4]

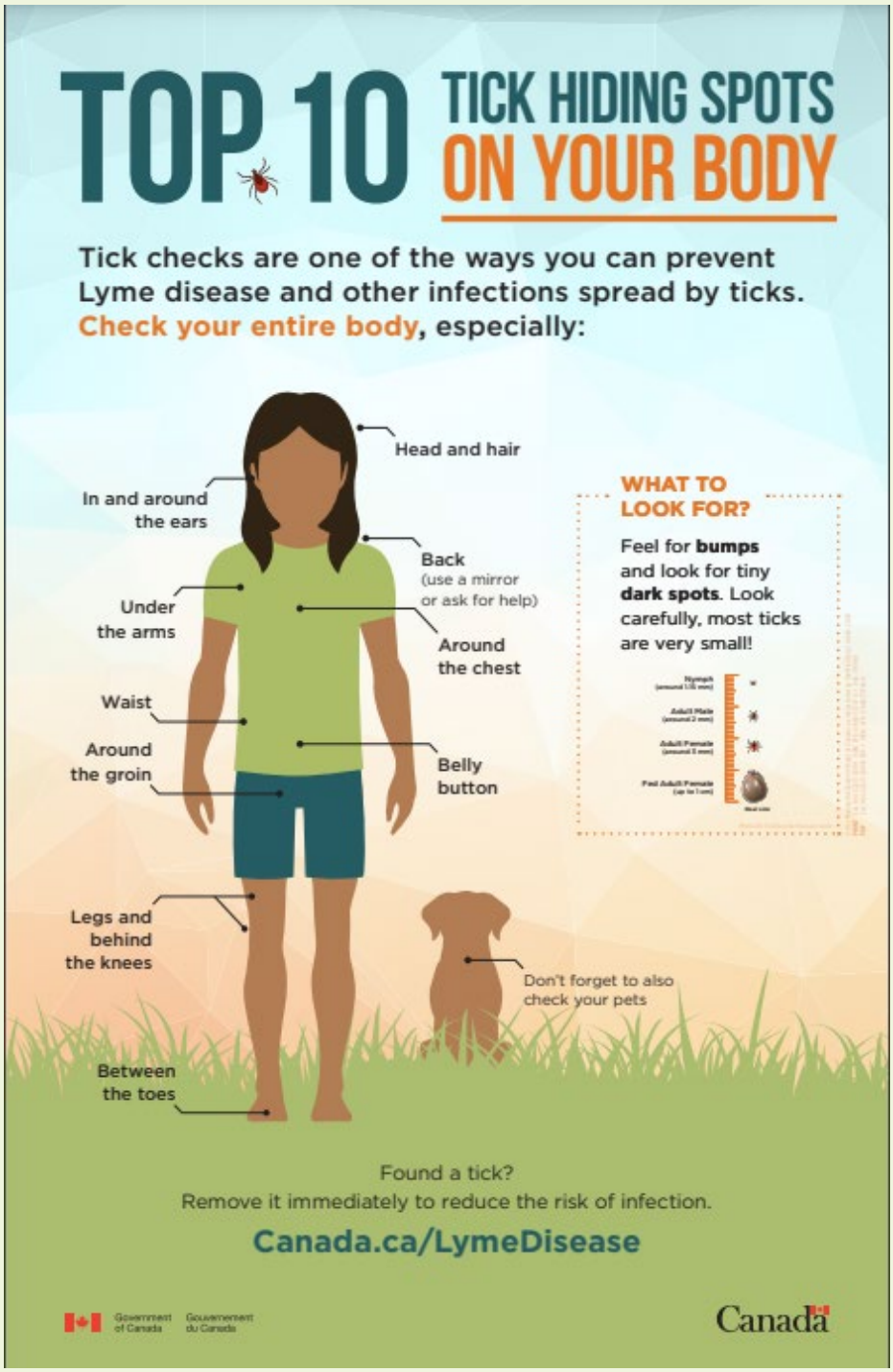


Figure D.1 | Top ten tick hiding spots on people

Source: Public Health Agency of Canada [5]

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DURHAM REGION

HEALTH DEPARTMENT

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