The impact of physical risks from climate change on future mortality in Canada

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Executive Summary

Projecting future mortality due to physical risks from climate change is not easy, as multiple factors influence global temperature increases, including greenhouse gas (GHG) emissions. Mortality trends are also influenced by pre-existing disease in a population, population growth, and population aging. People aged 65 years and older, particularly those with low socioeconomic status and/or with a pre-existing medical condition, are at greater risk of climate change impacts, specifically sustained temperature changes.

In Canada, climate change's impact on heat-related mortality is of particular concern. Extreme heat can substantially contribute to the cause of death due to heatstroke or hyperthermia and an increase in vector-borne diseases, particularly Lyme disease and West Nile virus (WNV). Research shows that the rate of warming in Canada overall is twice that of the global mean, and the rate of warming in Canada north of 60°N is approximately three times that of the global mean. Over the past three decades, Northeastern Canada has seen an increase of 0.75°C – 1.2°C per decade, compared to the global mean temperature increase of 0.18°C per decade. However, while heat-related mortality is projected to increase, milder winters will reduce cold-related mortality, leading to a possible reduction in temperature-related deaths.

Physical risks such as fires, droughts, floods, vector-borne disease, and sea-level rise are of further concern. Climate change models show a greater-than-average increase in temperatures, with greater and faster warming over the Arctic and sub-Arctic regions, impacting northeastern Canada, in part due to the melting of the cryosphere (permafrost, glaciers, sea ice, snow cover). Coastal sea flooding may increase because of melting sea ice in the Arctic, in Eastern Quebec, and along the Atlantic coast. Storm surges are also likely to impact coastal flooding.

Climate change in Canada could also increase food insecurity. Crop yield and food production could be affected by droughts, floods, and changes in precipitation patterns. Outdoor labor hours may be reduced by extreme temperatures, affecting agricultural output and harvesting. Currently, figures for Canada show that under a SSP2-4.5 "middle-of-the-road" GHG emissions scenario to 2050 (see Appendix), a slight change in mortality from the above-mentioned climate hazards is likely.

These climate hazards could put millions of lives at risk globally, particularly under a more severe GHG emissions scenario. It is important to understand these physical risks and their likely impacts in Canada by 2050 and beyond.

Introduction

Recent estimates from the World Economic Forum (WEF), made in collaboration with Oliver Wyman, suggest that climate change could lead to an extra 14.5 million deaths worldwide by 2050 under a "middle-of-the-road" SSP2-6.0 GHG scenario, driven by physical risks such as floods, droughts, heat waves, and tropical storms. To a first-order approximation, the WEF/Oliver Wyman estimates imply that annual average global mortality rates could increase by around 1% by 2050.[1] Vulnerability to these climate change physical risks varies by region, and so it is expected that if the average impact is 1%, some regions may see a significantly higher increase in mortality rates, while other countries, specifically those in the northern hemisphere, may see a decrease in mortality rates from climate-related physical hazards.

Canada has an estimated population of 41,575,585, of whom 19.5% are aged 65 and older. Its population is expected to increase to 59.3 million by 2074. The current life expectancy is 81.65 years, and the mortality rate is 7.9 per 1,000 population.[2] Of its 10 provinces, Ontario and Quebec are the most populous. Almost half the country – primarily northern, eastern, and central Canada – is semi-barren and sparsely populated,[3] as permafrost (frozen soil, rock, and sediment) covers nearly 40% of the country's land mass and extends under the Arctic Ocean. Up to 20% of this permafrost in northern areas is expected to thaw by 2090.[4]

Canada is the world's second-largest country by land mass, covering more than 3.8 million square miles. It is bordered by the Atlantic Ocean, the Arctic Ocean, and the Pacific Ocean, with 125,500 miles of coastline and covered by 344,000 square miles of water. The country's terrain and climate vary dramatically, but it is considered to be in the cool temperate zone and at lower risk of the impacts of climate change. Current environmental issues include air pollution and acid rain, resulting from industrial coal-burning and vehicle emissions, which impact agriculture, forestry, rivers, lakes, and ocean waters.[3]

The World Meteorological Organization reports that from 1970 to 2019, disasters due to water, weather, and climate-related events increased fivefold and caused approximately 2 million deaths globally. It is estimated that from 2030 to 2050, climate change will be responsible for about 250,000 deaths each year due to climate-driven diseases alone.[5]

Global warming has accelerated since the 1990s, with 19 of the 20 hottest years recorded since 2000, as well as increased intensity and duration of extreme temperatures.[6] As part of the Paris Agreement, Canada committed to reduce its GHG emissions by 40% – 45% by 2030 from 2005 levels. The interim objective is to reduce GHG emissions by 20% below 2005 levels by the end of 2026. In 2023, Canada emitted 694 megatons of carbon dioxide equivalent, decreasing its GHG emissions by 8.5% from 2005.[7]

Acute physical risks due to climate change refer to risks driven by events such as extremely high or exceptionally low temperatures, storms, hurricanes, floods, droughts, or forest fires. Chronic physical risks refer to those brought about by longer-term climate shifts, such as rising sea levels, sustained higher temperatures, or changes in precipitation patterns. Climate risks can result in increased air pollution, greater prevalence of vector-borne diseases, food insecurity, and destruction of property.

Transition risks are associated with the transition to a sustainable and low-carbon economy that impacts physical risks through adoption of new technologies or infrastructure. Mitigation measures, such as installing air conditioning in every home, may impact heat-related mortality, while building flood defenses in areas at risk of future flooding may reduce deaths from drowning. Yet the consequences of transitional risks on mortality are not known and may change over time. This report does not assess the impact of transitional risks on mortality.

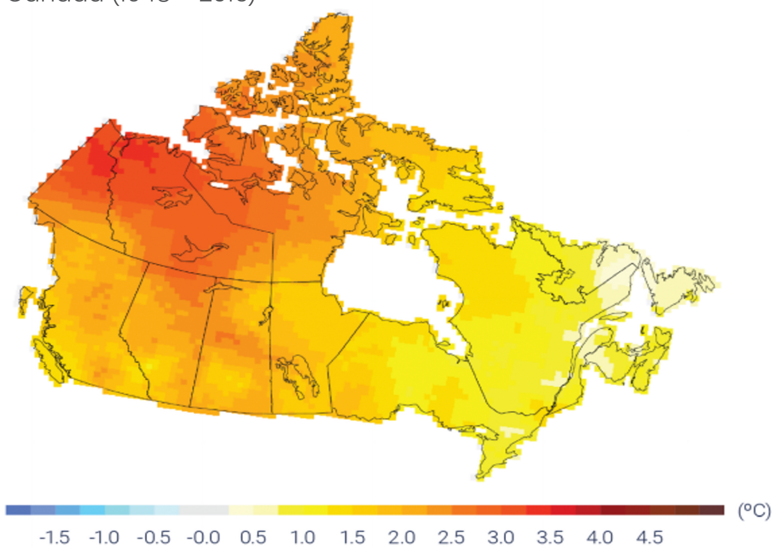
This paper reviews the academic literature on climate change from physical risks and future mortality in Canada by 2050, under a "middle-of-the-road" SSP2-4.5 emissions scenario. This scenario assumes a 2.7°C global warming by 2100, similar to RCP4.5, where GHG emissions stabilize after 2100.

Key Physical Risks

Average temperatures

Temperatures vary significantly across Canada due to its diverse topography, with average temperatures affected by the extremes in different regions. Average daytime temperatures in summer are approximately 20°C in coastal regions, while inland and central regions can frequently record daytime temperatures of more than 30°C.[8] Since 1948, surface temperatures have risen by 1.7°C, twice the global mean rate.[9] Under a low-emissions scenario, annual mean temperatures in Canada could increase by 1.8°C by 2050.[10]

Figure 1: Observed changes °C in annual temperatures in Canada (1948 – 2016)[10]



Over the past three decades, northeastern Canada has seen an increase of 0.75°C – 1.2°C per decade, compared to the global mean temperature increase of 0.18°C per decade. By 2070, the majority of Canada is projected to be 5°C warmer than in the period between 1971 and 2000.[11]

Heat stress can cause physical effects, such as profuse sweating, dehydration, exhaustion, rashes, loss of consciousness, arrhythmia, and heatstroke. The impact of extreme heat elevates the risk of mortality, particularly for those aged 65 and older. High temperatures can exacerbate medical conditions, such as cardiovascular and respiratory diseases, and promote the formation of air pollutants associated with early mortality.[12]

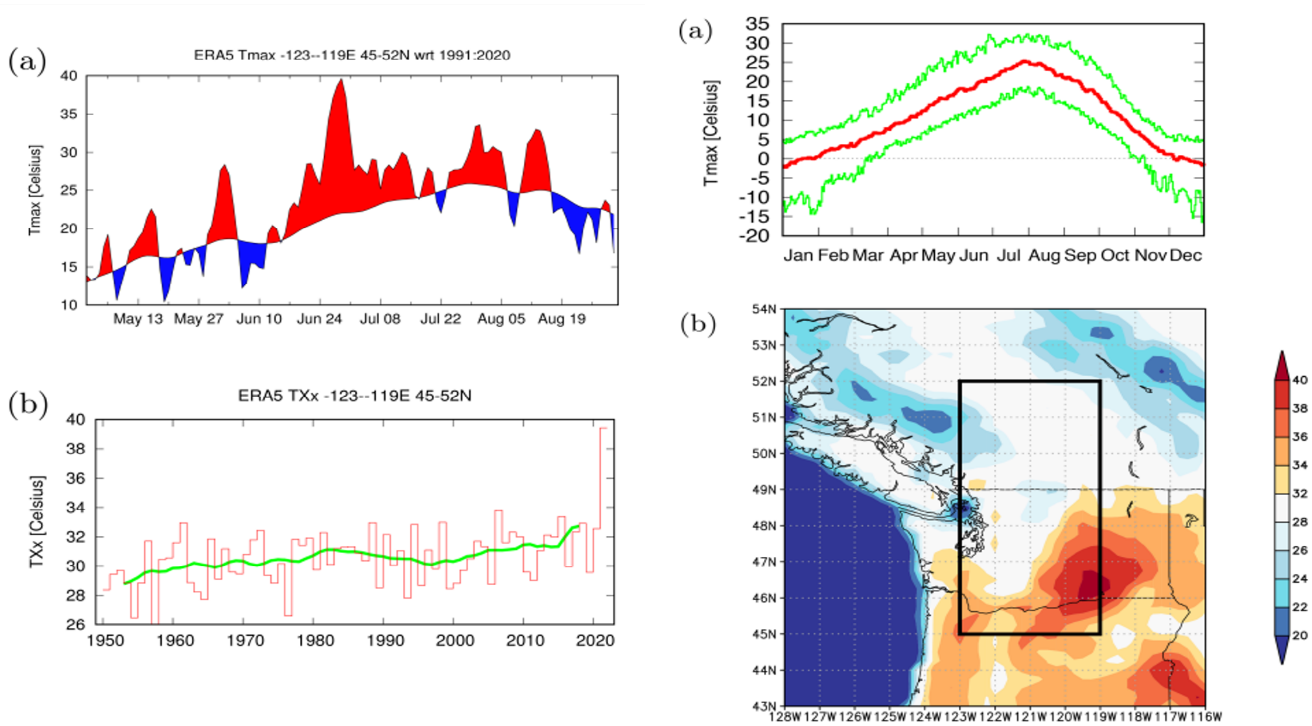
Heat waves, characterized by elevated temperatures and high humidity usually over several days, can also be referred to as "extreme heat events" or "heat domes." Extreme heat events are growing in frequency and intensity across Canada. In 2010, extreme heat events caused 106 deaths in Quebec, which increased daily mortality by 33% in greater Montreal.[4, 5] British Columbia (B.C.) also experienced a damaging heatwave in 2009, resulting in 114 deaths due to heat exposure.[13]

In June 2021, B.C. experienced another deadly heatwave. Between June 25 and June 30, record temperatures included a new record high of 49.6°C set in Lytton, B.C. Daytime temperatures of 29°C to 35°C were associated with a 5% increase in mortality.[12] The heatwave caused the death of 619 people, of whom 67% were aged 70 years or older. Many of those who died were at home indoors without working air conditioning units or fans.[8, 13]

2025 was the 11th warmest summer on record since 1948. Canada's Rapid Extreme Weather Event Attribution System identified 12 heat waves in 2025. In mid-August, Southern Quebec recorded the highest peak daily temperature in Canada of 29.3°C, while B.C. recorded the longest heat event from August 23 to September 9. Temperature anomalies were highest in Atlantic Canada, where they exceeded 10°C above normal in many areas.[63]

The Philip et al. study investigated the extent to which climate change influences the probability and intensity of further deadly heat waves in this region of Canada. Defining the probability of this heatwave as one in 1,000 years under current climate conditions, they estimated that the event would have been 150 times less likely without climate change and that, if global warming continued at a 2°C increase above pre-industrial levels, such a heatwave would occur every 5 – 10 years.[14]

Figure 2: Time series of temperatures in Canada (May – August 2021)[14]



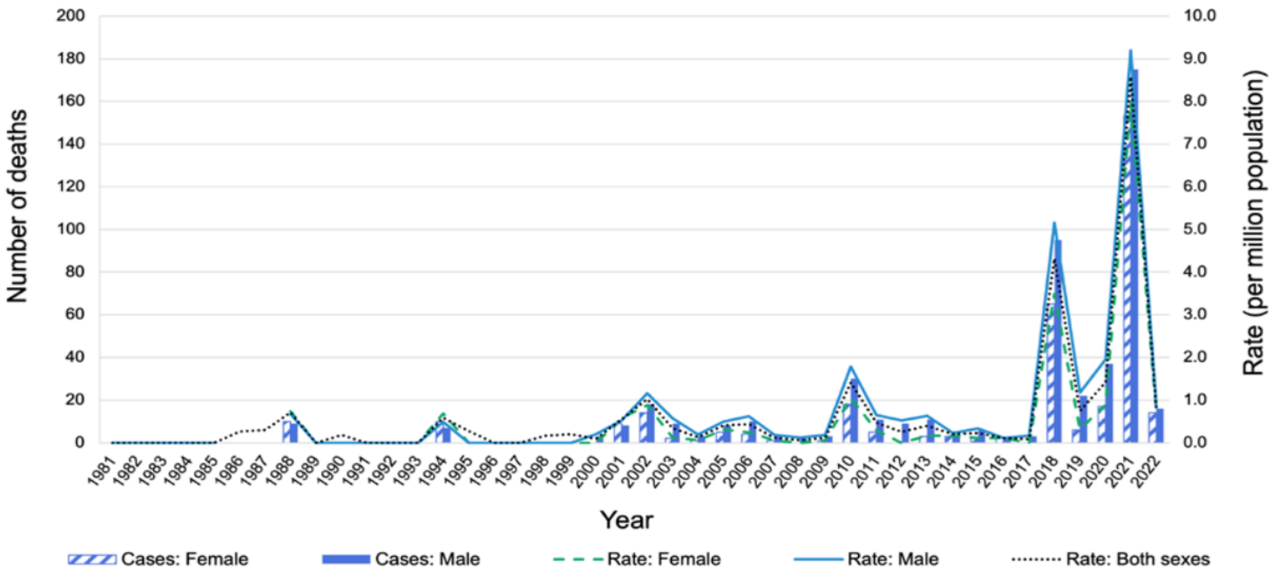
Left column (a) Time series for May – August 2021 of the maximum daily temperature averaged over the study area based on ERA5, with positive and negative departures from the 1991 – 2020 climatological mean of daily maximum temperature shaded red and blue, respectively. (b) Annual maximum of the index series with a 10-year running mean (green line)

Right column (a) Seasonal cycle of Tmax averaged over the land points of 45 – 52°N and 119 – 123°N, showing the 1950 – 2021 mean (red) and 2.5% and 97.5% percentiles of the distribution (green). (b) Spatial pattern of the 1950 – 2021 mean of the annual maximum of Tmax (multi-year mean TXx) at each grid point

Health Canada's 2025 publication on morbidity and mortality in Canada noted 916 deaths caused by extreme heat between 1981 and 2022, with two-thirds of these deaths occurring since 2016, and 85% occurring in individuals aged

45 years and over. In 2021, the rate of deaths due to extreme heat per million population was 8.6, a 1,333.3% increase over the annual average rate for the reporting period.[66]

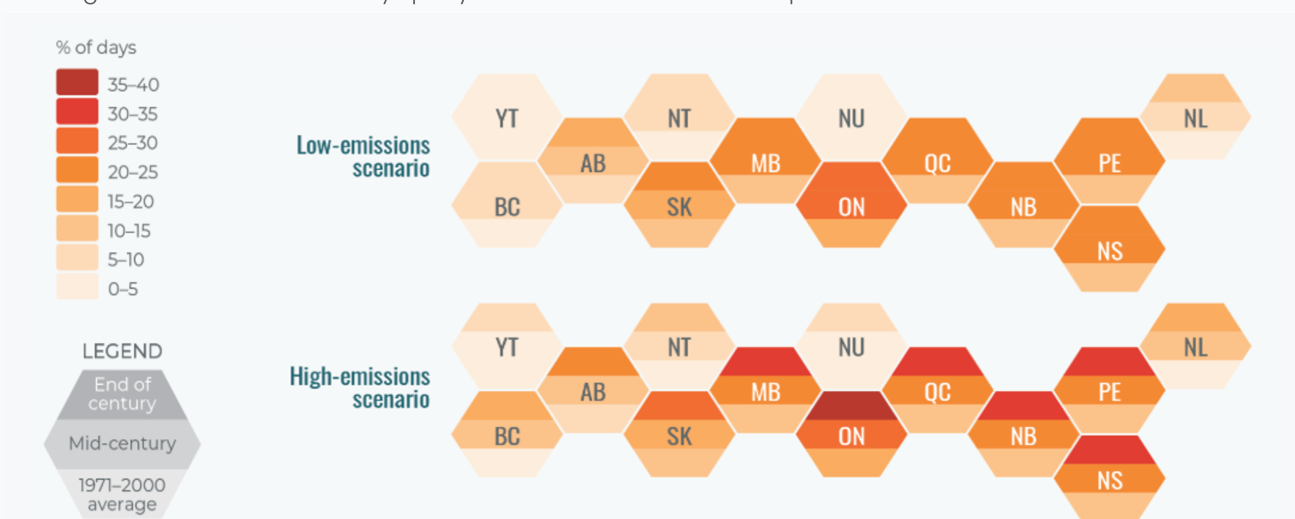
Figure 3: Counts and rates of heat-related deaths (per million population), overall and by sex, Canada, 1982 to 2021



Research indicates a 10% chance of a similar heatwave occurring in B.C. in the next two decades and that a similar heatwave could occur an average of three out of every 10 years by 2050, should emissions not be substantially reduced.[8]

Each 5°C increase in summertime temperature from 1996 to 2010 in Ontario was associated with a 2.5% increase in mortality.[4] Under a medium-warming scenario, it is estimated that by 2050, southern Ontario will experience nearly twice as many days with temperatures above 30°C per annum.[8]

Figure 4: The number of days per year where heat can cause premature death[64]



An analysis of 12 Canadian cities from 2000 to 2020 showed a 9% higher mortality risk in Montreal on extreme heat event days. For cardiovascular mortality, daily mortality risks increased by approximately 18%, while for respiratory mortality, the risk increased by 30%. Using population weighted averages, daily mortality risks during extreme heat events increased by 4.2% for non-accidental causes, 3.8% for cardiovascular causes, and 11.7% for respiratory causes.[13]

The Gasparrini et al. 2015 study showed that mortality attributable to high and low temperatures in Canada (1985 – 2012) was 4.46% for cold-related and 0.54% for heat-related deaths.[15]

Heat-related mortality may be offset by a reduction in cold-related mortality, although older-age lives are likely to be most impacted by future temperature increases.[9] Projections in the Gasparrini et al. 2017 study of temperature-related excess mortality under climate change scenarios show a +0.1% change under RCP 4.5 from 2010 – 2019 to 2050 – 2059.[16]

Increased temperatures are predicted to increase heat-related deaths but reduce cold-related deaths. However, it should be noted that increased air conditioning may offset excess deaths in Canada due to heat by as much as 16.7%, as was noted in the Sera et al. 2020 study. Potential population adaptation to future increased temperatures could further offset that excess.[9]

In a 2023 study by Hebbern et al., examining projected temperature-related excess mortality across 111 health regions in Canada, a net increase of 4.35% compared to the baseline decade of 2010 – 2019 is expected under a SSP2 – 4.5 GHG scenario for Canada by 2050 – 2059.[9]

Figure 5: Trends in heat-related and cold-related excess mortality by RCP scenario[16]

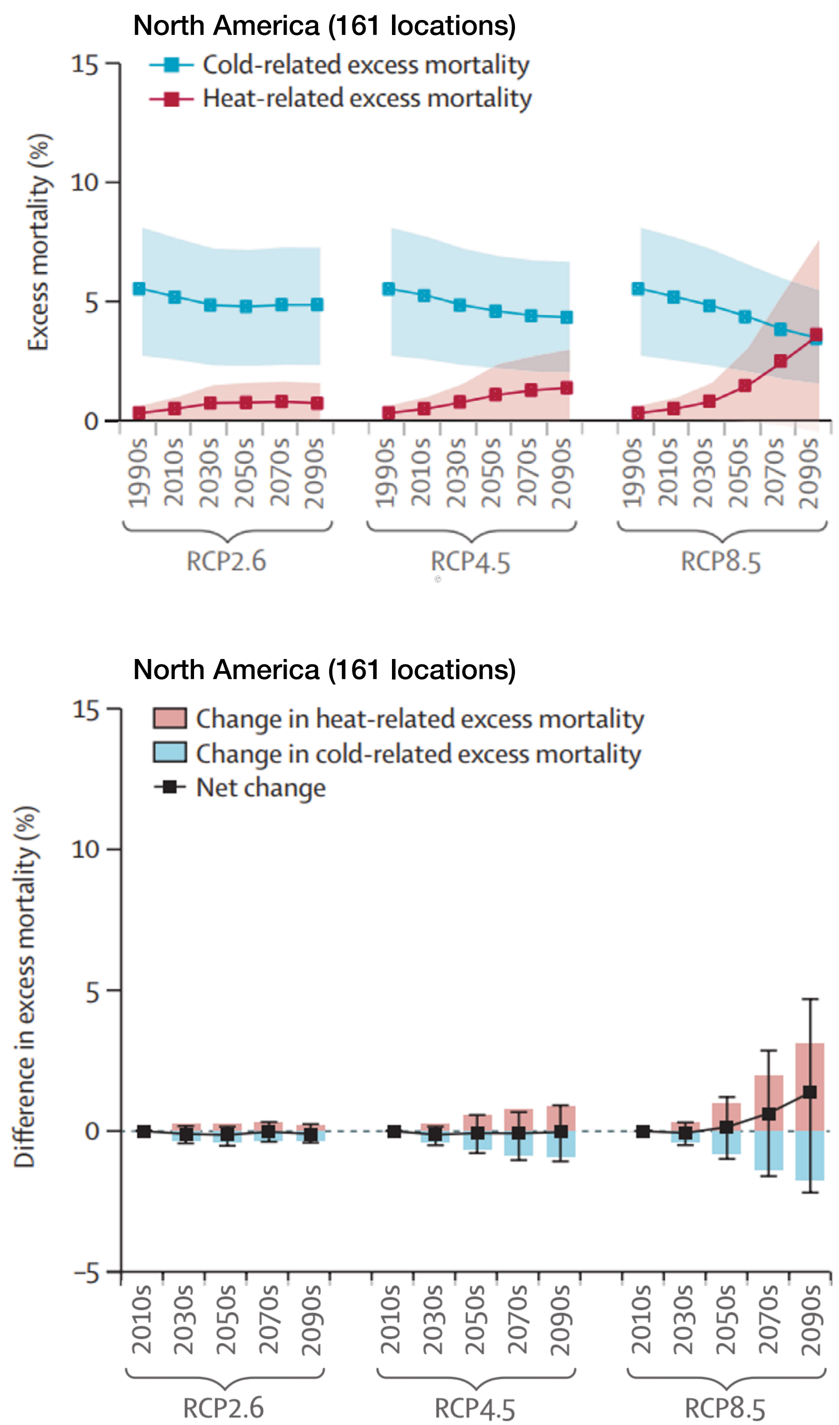


Table 1: Heat- and cold-related excess non-accidental mortality (%) (midpoints), by period, under SSP2-4.5 population aging and climate change scenarios in Canada[9]

Age	Effect	2010 – 2019	2050 – 2059	2090 – 2099
All	Heat	1.25	0.94	1.67
	Cold	5.93	5.92	7.21
	Net	–	4.35	5.41
Age ≥65	Heat	2.52	2.28	2.14
	Cold	-6.1	11.07	3.94
	Net	–	10.89	5.47
Age <65	Heat	0.02	-0.33	-0.18
	Cold	-9.24	-12.72	-8.74
	Net	–	-7.24	-2.46

95% empirical confidence interval (eCI) by period

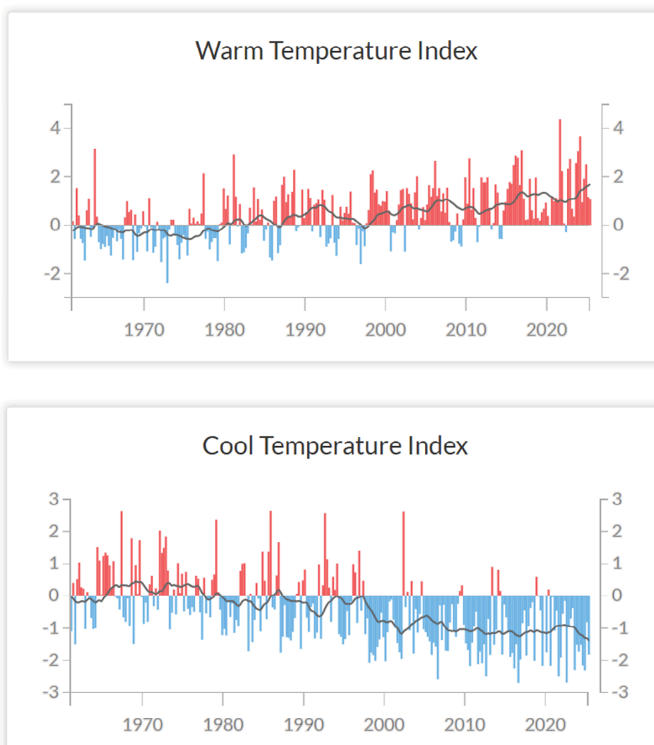
A study by Martin et al. (2012) found that 1981 – 2000 base-period temperatures were predicted to increase by an average 1.7°C by 2031 – 2050 across 15 Canadian cities and that winter temperatures were predicted to increase faster than summer temperatures.[17] The daily and yearly crude mortality rates per 100,000 individuals for the 1981 – 2000 period was 1.68 and 614.5, respectively.

- On average, predicted change to 2031 – 2050 in annual cold-related mortality rate per 100,000 population from the 1981 – 2000 base period was -5.0%. Predicted change to 2031 – 2050 in annual heat-related mortality rate per 100,000 population from the 1981 – 2000 base period was +1.97%.[17]
- These predicted changes were based on a 2.2°C winter (December, January, and February) temperature anomaly and a 1.7°C summer (June, July, and August) temperature anomaly compared to base period (1981 – 2000).[17]

In the Lee et al. study, excess mortality attributed to diurnal temperature range in the period 2010 – 2019 was 2.4% but rose to approximately 3% by 2050 – 2059 under an RCP 2.6 climate change scenario.[58]

A 2024 study by Chen et al. looked at the impact of population aging on future temperature-related mortality at global warming levels of 1.5°C, 2°C, and 3°C. Projected changes in cold-related, heat-related, and net excess mortality (%) at a 2°C

Figure 6: Actuaries Climate Index seasonal standardized anomalies*, 1961 – 2025, Warm and Cool Temperature Index[20]



*Standardized anomalies measure what level of change in the average readings is significant relative to the underlying level of variability for each quantity at the region level.

Source: Actuaries Climate Index (http://actuariesclimateindex.org), sponsored by the American Academy of Actuaries, Canadian Institute of Actuaries, Casualty Actuarial Society and Society of Actuaries warming level under SSP5-8.5 Canada under the “climate only” scenario to 2037 – 2056 were -0.6%, +0.8%, and +0.2%, respectively.[18]

Canada’s population aged 65 and older is projected to increase from 18.9% in 2024 to between 21.6% and 31.7% under slow- and fast-aging scenarios by 2074.[19] This population aging would substantially increase the population at risk of heat- and cold-related mortality. Although cold-related mortality is projected to decrease, population aging could attenuate this decrease.

Many studies do not account for the impact of air conditioning on heat-related deaths, nor consider populations adapting to increasing temperatures, so it is possible to overestimate the impact of climate change on heat-related deaths. Hence, study findings vary in their projected mortality rates and potential changes by 2050 and beyond. A summary of the study findings is shown in the table below.

Table 2: Summary of research findings by study

Research	Net change in mortality	Scenario
Gasparrini et al. 2017	+0.1%	RCP4.5
Martin et al. 2012	-3.03%	+2.2°C winter/+1.7°C summer
Lee et al. 2020	+0.6%	RCP2.6
Chen et al. 2024	+0.2%	SSP5-8.5
Hebbern et al. 2023	+4.35%	SSP2-4.5

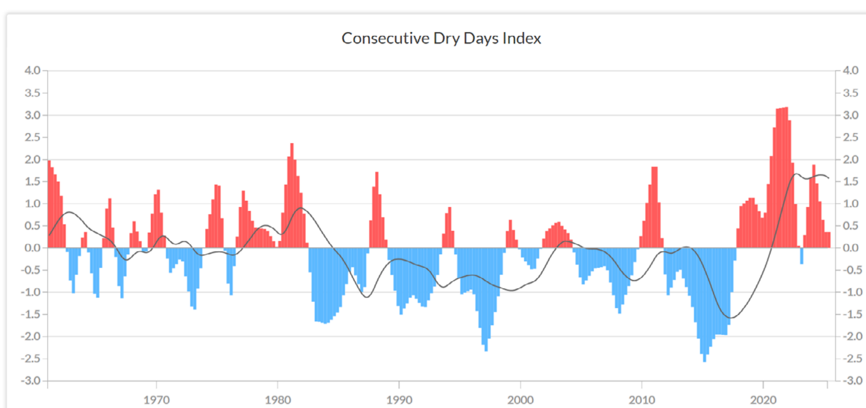
Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change in Population Impact by 2050 in 1°C Warming Scenario** Increase/(reduction) in annual deaths estimated to be attributable to risk
Average temperatures • Cold-related • Heat-related	 6.2% [16] 0.7% [16]	 Net change 0.1% [16]

Droughts

Increased temperatures and decreased precipitation can lead to drought conditions, impacting drinking water supply, crop yield, and food security. Under an intermediate emissions scenario, approximately 3 billion people globally are expected to be affected by future drier and wetter conditions. As global temperatures increase, the probability of drought also increases by up to 36% to 2050. Under the “middle-of-the-road” scenario, 3.2 million deaths globally are projected to occur because of droughts by 2050, the second-highest number of deaths due to weather-related events after flood events.[1]

Parts of Canada are expected to see an increase in drought conditions by the end of the century, but no increasing trend

Figure 7: Consecutive Dry Days Index seasonal standardized anomalies, 1961-2025 [20]



Source: Actuaries Climate Index (http://actuariesclimateindex.org), sponsored by the American Academy of Actuaries, Canadian Institute of Actuaries, Casualty Actuarial Society and Society of Actuaries has been observed to date. In Canada, precipitation is projected to increase during the winter months, while summer rainfall may somewhat decrease, impacting crop growth, particularly in Prairie Provinces. Regions that rely on melting snow and ice for water supply during summer months may see an increase in droughts due to reduced winter snowfall and earlier snow melt. However, it is estimated that Canada is not likely to be significantly impacted by drought conditions by 2050 or 2100.[4, 21]

The Actuaries Climate Index shows no increasing trend in consecutive dry days in Canada since 1962.

Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change in Population Impact by 2050 in 1°C Warming Scenario** Increase/(reduction) in annual deaths estimated to be attributable to risk
Drought	0%	Net change 0%

Air pollution and wildfires

Air pollution is caused by the burning of fossil fuels, vehicle emissions, and forest fires. In 2016, the Fort McMurray fire in Alberta, Canada, burned 1.5 million acres of forestry and caused billions of dollars in damage. It is estimated that climate change exacerbated the fire-risk hazard by 1.5 – 6 times.[23] Large fires (burning around 500 acres) currently account for only 3% of all fires but are responsible for 97% of the area burned. Under future climate projections, Canada is expected to see an increase in wildfires and a subsequent increase in particulate matter (PM2.5). Fire season will be longer, with an increased number of days with spread potential.[23]

With no official definition of fire season, the Canadian Forest Fire Weather Index (FWI) system is used to calculate fire danger and risk, based on measurements such as temperature, humidity, wind speed, and 24-hour precipitation. Warmer temperatures result in longer fire seasons and higher risk of thunderstorms, increasing the risk of lightning strikes.[24] It is estimated that pollution from wildfires could double across Canada by 2100.[4]

In May 2023, wildfire smoke significantly impacted western Canada, with cities as far away as Denver, Colorado, recording hazardous levels of air pollution. Monitoring stations in Denver recorded an air quality index (AQI) of 155, the second-worst in the world on the morning of May 17. This is roughly equivalent to a PM2.5 concentration of more than 50 micrograms per cubic meter (μg/m^3).[25] Canada was the most polluted country in North America, with the continent's 13 most polluted cities located in its borders. The table below compares the AQI in four Canadian cities on July 14, 2025: PM2.5 concentration in Toronto was 13.6 times the World Health Organization annual PM2.5 guideline value.[26]

Table 3: Air quality index (AQI) in four Canadian cities, 14 July 2025

City	AQI 14/07/25	PM2.5 μg/m^3
Edmonton, Alberta (12 p.m.)	61	14.6
Montreal, Quebec (2 p.m.)	89	29.7
Toronto, Ontario (2 p.m.)	160	68
Vancouver, B.C.	12	2.2

Extreme heat and smoke from forest fires over northern Ontario are responsible for driving the increase in poor air quality and PM2.5. Exposure to PM2.5 increases the risk of adverse health outcomes, such as respiratory disorders, and early mortality. The Canadian Community Health Survey compared long-term PM2.5 exposure estimates to mortality incidence from 1981 – 2016. For each 10μg/m^3 increase in a three-year moving average of PM2.5 exposure, there was an 11% (HR 1.11) increase in non-accidental mortality. Other studies have shown comparable results.[27]

The Chen et al. study researched the relationship between mortality and short-term exposure to wildfire-related PM2.5 pollution. In the analysis of global mortality during 2000 – 2016, 0.62% of all-cause deaths were attributable to wildfire-related PM2.5 per annum, with each 10μg/m^3 increase in the three-day moving average of PM2.5 associated with a 1.019% increased risk of all-cause mortality. For Canada, the population attributable fraction of yearly deaths due to short-term exposure was 0.33% for all-cause and cardiovascular mortality, and 0.32% for respiratory mortality.[28]

Health Canada estimated 54 – 240 premature deaths (0.09%) due to short-term exposure, and 570 – 2,500 premature deaths (0.96%) due to long-term exposure to PM2.5 from wildfire smoke between 2013 and 2018, excluding 2016, each year. Health Canada also estimated 17,400 deaths due to above-background air pollution in 2018 from PM2.5, ozone, and NO_2.

- 12,500 from chronic PM2.5
- 1,300 from acute NO2
- 2,400 from acute ozone
- 1,200 from chronic summer ozone

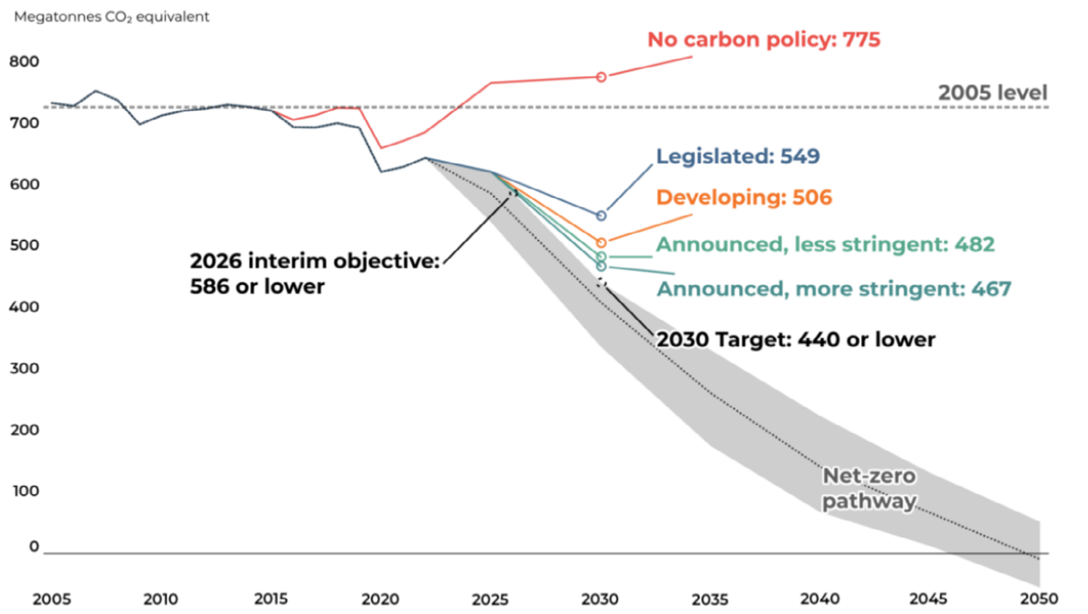
Total deaths in 2018 were 283,700, which means air pollution accounted for 6.1% of total deaths.[60]

Under RCP4.5 and RCP8.5, premature mortality in the U.S. due to wildfire PM2.5 is estimated to double by the end of the century.[4] This report assumes the same estimate for Canada in relation to deaths from wildfire-related PM2.5.

Figure 8: Estimated death rates from air pollution (per 100,000 population), Canada, 1990 – 2021 [29]

In 2022, Canada introduced its 2030 Emissions Reduction Plan to reduce emissions by 40% – 45% and to achieve net zero emissions by 2050, along with the interim target of 20% by 2026 from 2005 levels. Canada also plans to reduce emissions from the oil and gas industry by 31%.[55]

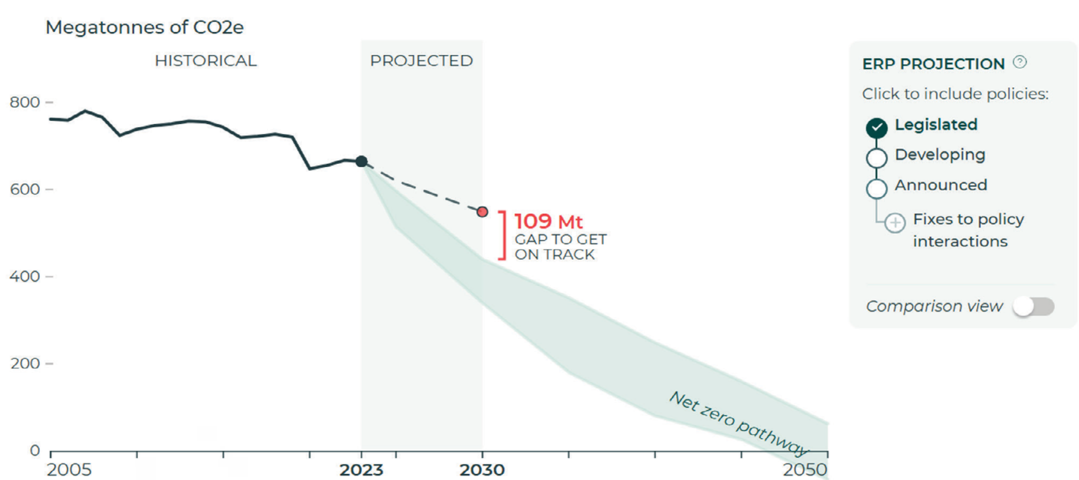
Figure 9: Canada's emissions pathway according to the Institute's independent modeling of the 2023 Progress Report [54]



In 2023, Canada released 664 megatons* (Mt) of carbon emissions, down from 762Mt in 2005, and has a goal to reduce emissions by a further 109 Mt by 2030 to get back on track for its 2050 target.[56]

*1 megaton = 1 million metric tons

Figure 10: Total greenhouse gas emissions for Canada, 2005 – 2050 [56]

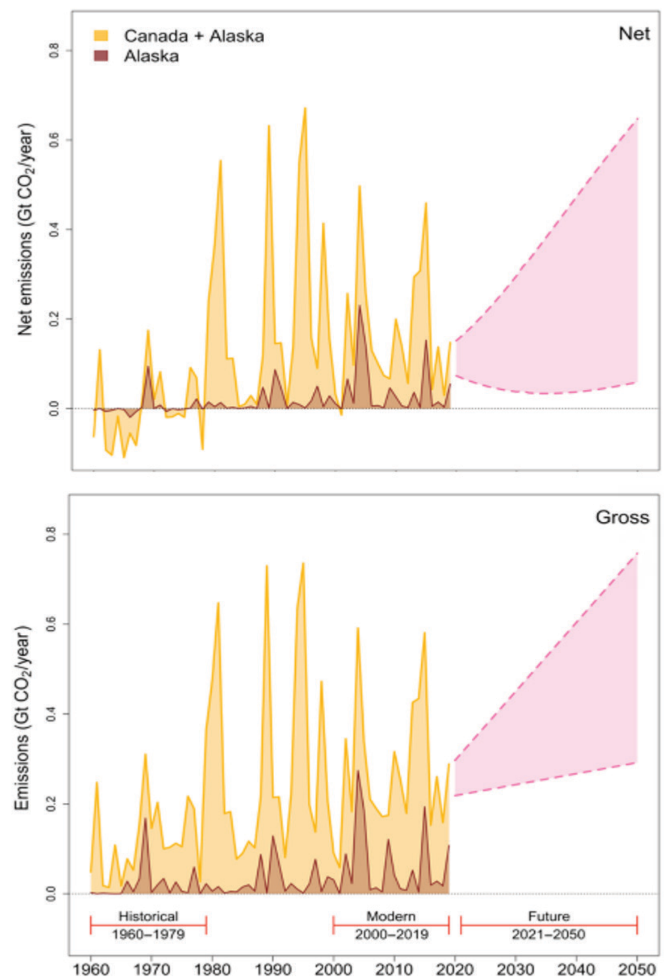


Sources: Statistics Canada, Navius Research, Canadian Climate Instutute

However, in 2023 it is estimated that Canadian wildfires burned more than seven times the average annual area compared to the previous four decades. The fires were responsible for 647 (570-727) Mt of carbon emissions. 2025 was the second-worst wildfire season in Canada on record, affecting over 8.3 million hectares of land. More than 85,000 people were forced to evacuate.[65] It is likely that increased temperatures will continue to drive forest fires and consequently reduce the carbon uptake by Canadian forests.[57]

Based on Matz et al. (2020), total population deaths in 2018 were 283,706,62 of which 0.5% were from wildfire-related PM2.5.[53]

Figure 11: Observed (1960 – 2019) and projected (2020 – 2050) gross and net CO_2 emissions [59]



The IQAir 2023 World Air Quality Report estimates that the population-weighted PM2.5 level in Canada was 10.3 μg/m³ in 2023. Relative to the average over 2018 – 19 and 2021 – 22, which is 7.9 μg/m³, wildfires in 2023 contributed an additional 2.4 μg/m³ on top of the average annual wildfire-related PM2.5 level.[61] This suggests that 2023 saw 3.0 μg/m³ wildfire-related PM2.5, around five times that in 2018. If deaths were also assumed to be five times that in 2018, this would be 2.5% of population deaths, an increase of 2%. Could 2023 be the "new normal" by 2050 for wildfire-related PM2.5?

The Phillips et al. paper on escalating carbon emissions from North American boreal forest wildfires notes that the burned area is projected to increase by 24% – 169% in Alaskan boreal forests and 36% – 150% in Canadian boreal forests. This indicates that wildfires in these locations are projected to cumulatively release net emissions between 1.33 and 11.93 billion Mt of CO_2, assuming current levels of fire suppression are maintained to 2050.[59]

Although wildfires and resulting PM2.5 are projected to increase in Canada, it is hard to predict the health impacts of air pollution on the population to 2050, since exposure to PM2.5 will depend on the location of forest fires and their proximity to large populations, while health impacts will also be impacted by planned carbon emission reductions. Although Ford et al. reported that fire-related PM2.5 is projected to increase by 2050 under RCP4.5 but overall PM2.5 are expected to reduce in the U.S. , the "Health of Canadians in a Changing Climate" report notes that the relative contributions of fire-related PM2.5 are projected to increase from about 25% in 2000 to roughly 50% in 2050, which may outweigh any benefits from reductions in carbon emissions.[4]

Pulling all this information together reveals the following:

Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change in Population Impact by 2050 in 1°C Warming Scenario** Increase/(reduction) in annual deaths estimated to be attributable to risk
Wildfire PM2.5	0.5%	2.0%
Other air pollution	5.6%	-0.8%
Total air pollution deaths	6.1%	1.2%

Food insecurity

Current figures show the number of food-insecure households has increased significantly from 2006 – 2007, when 11.3% of households experienced food insecurity.[30] The percentage of individuals by household for both marginal and moderate or severe food insecurity has increased year on year from 2019. Combined, 15.9% experienced food insecurity in 2019, rising to 25.5% by 2023; a larger proportion experienced moderate or severe food insecurity (19.1%) than marginal (6.4%) in 2023.[31]

Food insecurity is the "inability to acquire or consume an adequate diet quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so." Food insecurity is associated with disease development and infections, as well as mental health problems.

Household food insecurity is associated with increased mortality in the Canadian population. In a study by Men et al., all-cause premature mortality for marginal, moderate, and severe food insecurity was HR 1.10, 1.11, and 1.37, respectively. There was a strong correlation between severe food insecurity and cause-specific mortality from infectious parasitic disease (HR 2.24), unintentional injuries (HR 2.69), and suicides (HR 2.21). The study noted that severe food-insecure adults died nine years earlier than their food-secure counterparts.[30]

Extreme heat can impact the quality and quantity of agricultural food production. Increasing volatility in global crop production is likely, with an increased annual probability of a greater than 10% reduction in yield, rising from 6% in 2020 to 11% by 2030, and to 20% by 2050. However, this trend is reversed in Canada. By 2050, Canada is predicted to see a 50% increase in crop yields relative to 1998 – 2017, and the annual probability of a greater than 10% reduction in yield is predicted to decrease from 16% in 2020 to 0% by 2050. This is despite an increased risk of drought in parts of Canada, such as the Southern Prairies and Prince Edward Island.[22] Overall, precipitation patterns are expected to change, with increasing rainfall during the winter and reduced rainfall during the summer, but this is not expected to significantly affect crop yield, at least for the moment.

Between 2005 and 2017, a total of 2,075 adults aged 52 – 64 died from food insecurity in Canada. Figures show that the prevalence of food insecurity is less than half of that in adults approaching age 65 compared to adults aged 65 and older, likely due to the benefit of the Canadian public pension. For marginal, moderate, and severe food insecurity, adjusted HR was 1.38, 1.41, and 1.79, respectively, for adults younger than 65.[32]

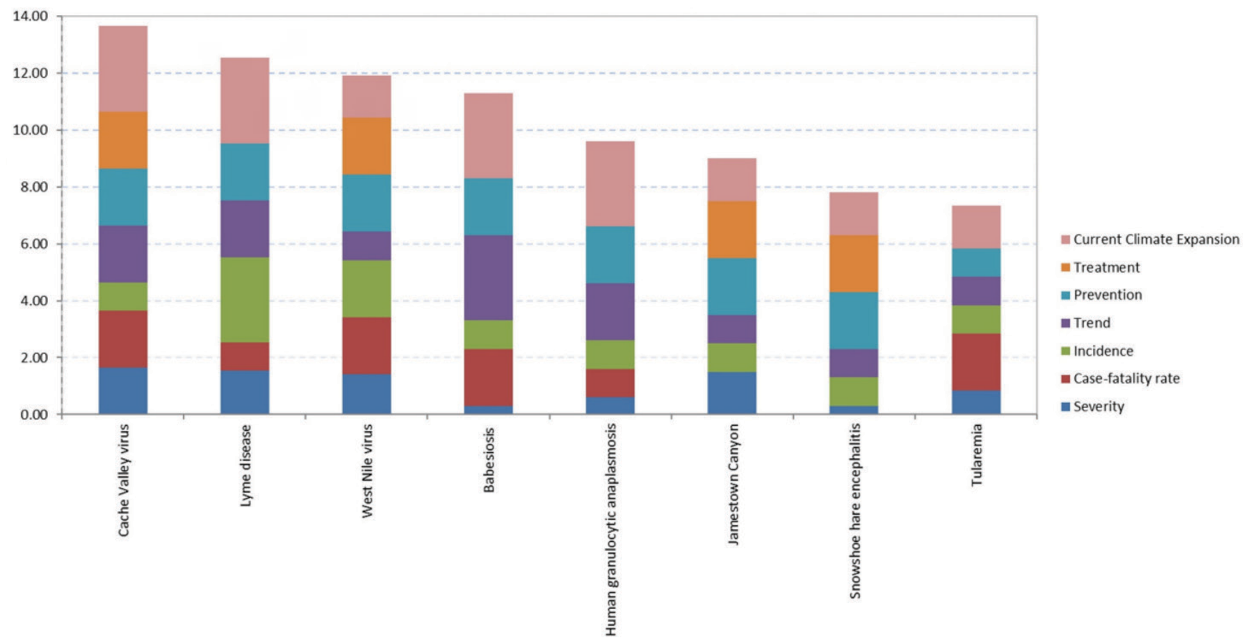
Canadian data sources do not publish direct national mortality counts attributable specifically to food insecurity, as mortality is classified by medical cause of death, and not by socioeconomic factors. However, some academic sources document health risks and increased mortality associations linked to food insecurity.

Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change in Population Impact by 2050 in 1°C Warming Scenario** Increase/(reduction) in annual deaths estimated to be attributable to risk
Food insecurity	Unknown	Unknown

Vector-borne diseases

Vector-borne diseases are expected to spread in Canada due to climate change. For example, higher temperatures increase the geographic spread of mosquitoes and their rate of development, and the subsequent spread of diseases such as malaria and West Nile virus (WNV). Other vector-borne diseases in Canada include babesiosis, Cache Valley virus (CVV), chikungunya virus, Lyme disease, Rocky Mountain spotted fever (RMSF), and Zika virus. Although Zika and chikungunya are not endemic to Canada, both WNV and Lyme disease are now established diseases in Canada.[33]

Figure 12: Endemic vector-borne disease baseline ranking under current climate [33]



The first human case of WNV in Canada was identified in 2002, and it has been a nationally notifiable disease since 2003.[34] Between 2002 and 2022, there were 6,683 cases of WNV, an average annual incidence of 318 cases. Its activity has varied significantly from year to year, from a high of 2,401 cases in 2007 to a low of five cases in 2010.[35] Recent figures from Public Health Ontario show 87 recorded cases in 2024 in the province, a rate of 5.6 per million population, but this rose to 178 cases to October 2025, a rate of 10.9 per million population.[36] Government statistics show five WNV-associated deaths in 2022 from a total of 47 reported infections in Canada, a disease-specific mortality rate of 10.6%.[37]

Given that cases of WNV vary significantly from year to year, there is no clearly established trend in annual incidence and mortality. It is possible that rising temperatures will increase annual incidences and therefore cause more people to die from the disease, although current annual population deaths are minimal.

Lyme disease is a bacterial disease spread by the bite of blacklegged ticks, as is babesiosis. Its prevalence has increased in recent years, particularly during the summer months. In 2024, there were 2,337 recorded cases of Lyme disease in Ontario, a rate of 149.8 per million population, but this rose to 2,761 to October 2025, a rate of 168.9 per million population. It is expected that blacklegged tick habitat will widen, increasing the spread of Lyme disease into new areas. However, antibiotics are an effective treatment option, reducing the risk of severe disease or death.[36, 39]

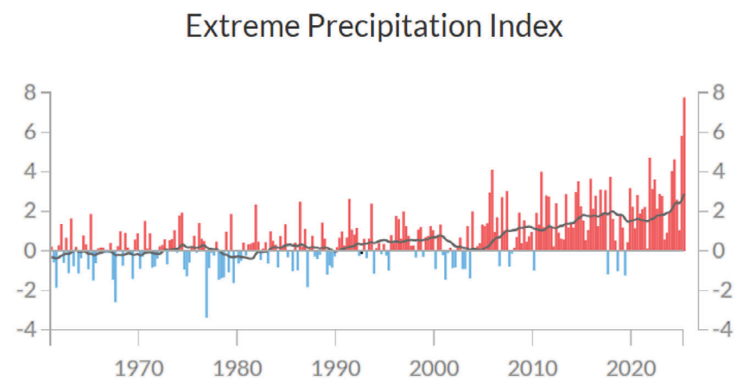
In a study examining prioritization of vector-borne diseases in Canada under current and projected climate change (RCP 8.5), the current top 10 non-endemic diseases remain in the same order. For endemic diseases, while CVV and WNV infection remain top priorities, babesiosis and Lyme disease have moved into the top four ranked diseases. Although only 2 cases were reported in Ontario last year to October 2025, babesiosis is considered to have a high potential to expand regionally, while Lyme disease already has significant geographic distribution and potential for increased incidence. Babesiosis has a case fatality rate of approximately 1.6%, while death from Lyme disease is extremely rare. Only 11 fatal cases of Lyme carditis occurred globally between 1985 and 2019.[38, 39]

Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change in Population Impact by 2050 in 1°C Warming Scenario** Increase/(reduction) in annual deaths estimated to be attributable to risk
Vector-borne diseases	0%	0%

Floods/storms

Floods are the most frequent natural disasters globally, with flood events predicted to increase in severity, frequency, and duration due to climate change. However, future estimates of precipitation are hard to predict.[40] There is significant agreement that Canada will experience wetter conditions, particularly in northern Canada, with a cumulative change of +35% by the end of the 21st century.[41] In southern Canada, summer precipitation is projected to decrease under a high-emission scenario but remain relatively constant under a low-emission scenario. Annual and winter precipitation is projected to increase in all parts of Canada, with larger percentage changes in northern Canada.

Figure 13: Extreme precipitation index seasonal standardized anomalies, 1961 – 2025 [20]



Source: Actuaries Climate Index (http://actuariesclimateindex.org) , sponsored by the American Academy of Actuaries, Canadian Institute of Actuaries, Casualty Actuarial Society and Society of Actuaries

Under a low-emissions scenario, precipitation may increase by 7%, but under a high-emissions scenario, this increase may be up to 24% by the end of this century.[10] Assuming a "middle-of-the-road" scenario, increased precipitation may fall somewhere around 15% – 16%.

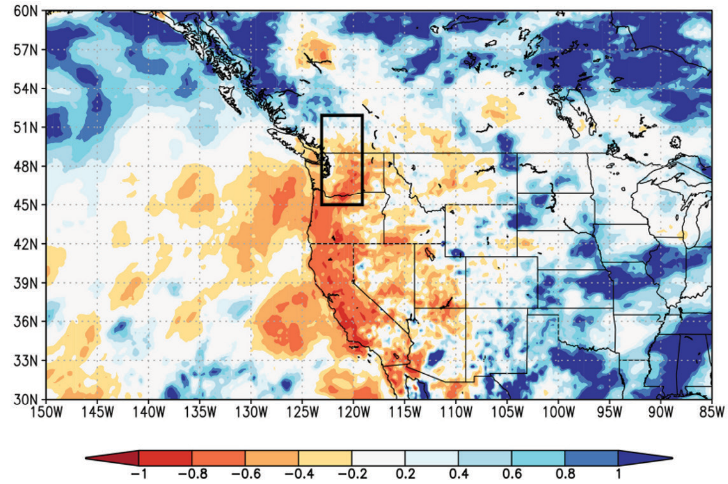
Between 1948 and 2012, annual average precipitation (AAP) increased by 20% across Canada, with projections indicating that AAP and extreme precipitation events will increase by 2100 under all RCP scenarios, although to a lesser degree under less-severe scenarios.[4]

The 2021 Canadian heatwave may have been impacted by precipitation anomalies noted prior to the event. Only 20% – 40% of the average precipitation fell in northwestern U.S. states, while in the coastal mountains north of Vancouver Island, large positive precipitation anomalies occurred in March – June 2021.[14]

Figure 14: Annual number of heavy precipitation days projected for 2021 – 2050 (RCP 8.5) [4]

In a study examining mortality risk with floods in 35 countries, in regions impacted by floods, up to 0.10% of all-cause deaths, 0.18% of cardiovascular deaths, and 0.41% of respiratory deaths were attributed to floods. Floods were associated with a relative risk (RR) of all-cause mortality and cardiovascular mortality of 1.021, and 1.049 for respiratory mortality. For Canada, the relative risk for all-cause mortality was 1.16, cardiovascular mortality was 1.43, and respiratory mortality was 1.67.[42]

Figure 15: Precipitation anomalies in March – June 2021, North America [14]

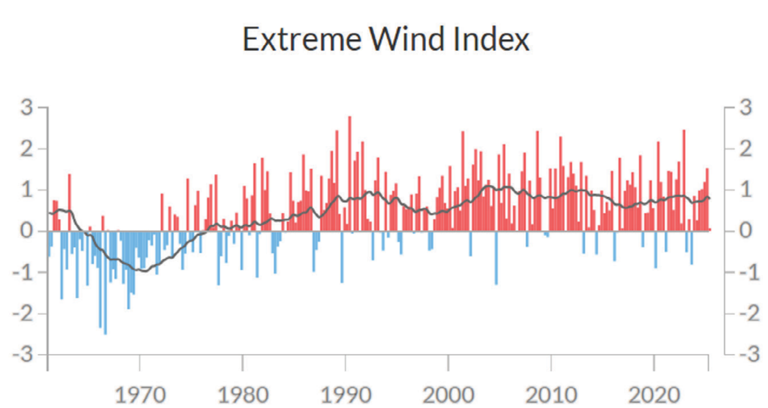


The Hu et al. 2018 study of flood-induced mortality across the globe found that 46.1% of flood events occurred in regions at least 100 km from the coast, causing 80% of total flood-induced deaths, while areas with elevations of only 0 – 10 meters accounted for 4.9% of total floods, but 17.7% of total flood-induced deaths. For the period 1975 – 2016, flood-induced mortality for Canada was <0.3%. River-related floods accounted for 0.1% – 0.3%, while flash floods account for 0% of deaths. Tropical cyclone-induced floods had strong impacts on global flood-related mortality, which Canada is not subject to.[43]

There is medium confidence that average annual mean precipitation has increased, with larger percentage increases in northern Canada. More rain is expected to fall in more frequent rainfall events, increasing the likelihood of flash flooding. Currently, extreme rainfall happens about once every 20 years, but climate models suggest that by the end of the century this could increase to every five years with 24-hour extreme precipitation increasing by 12%.[44]

Storms are becoming more common across Canada, but projecting the future trajectory for storms is complicated, as there are many variables influencing their formation. Research to date would indicate that outside of storm-induced flood events, deaths due to extreme wind and storms are negligible. Storm hazards include intense winds, hail, and lightning, posing risks to both humans and physical property. Hurricanes are likely to become more frequent, particularly in the Atlantic region of Canada, as rising ocean temperatures evaporate surface water, creating an environment for hurricanes to develop and intensify rapidly. Every 1°C of global warming brings a 5% – 20% increased likelihood of severe storm development. It is now twice as likely that a Category 1 hurricane will become a Category 3 or higher hurricane within a 24-hour period, compared to 50 years ago.[45]

Figure 16: Extreme Wind Index seasonal standardized anomalies, 1961 – 2025 [20]



Source: Actuaries Climate Index (http://actuariesclimateindex.org), sponsored by the American Academy of Actuaries, Canadian Institute of Actuaries, Casualty Actuarial Society, and Society of Actuaries

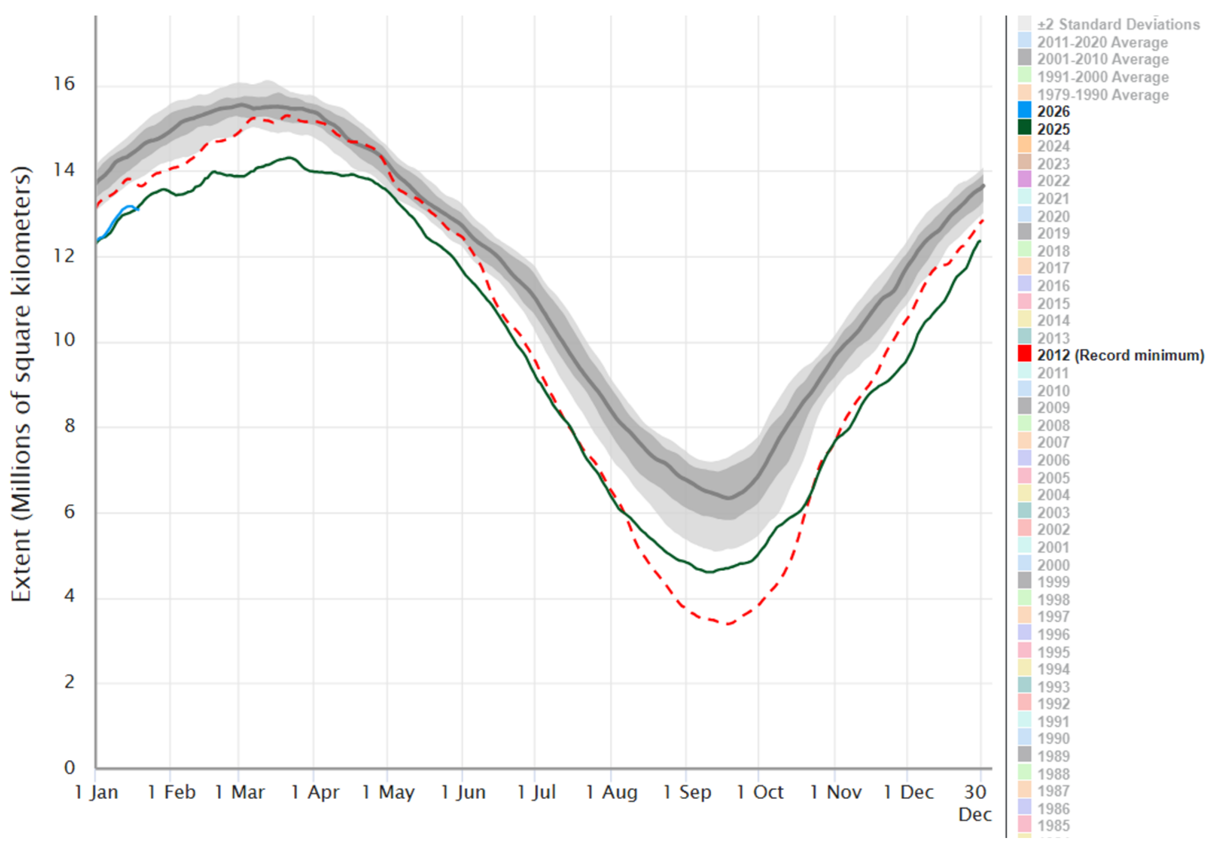
Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change in Population Impact by 2050 in 1°C Warming Scenario** Increase/(reduction) in annual deaths estimated to be attributable to risk
Floods	0.3%[43]	0.06%[44]

Glacial melting/sea-level rise

Under a 1°C warming scenario, Canada will experience a change in its cryosphere and see increased levels of glacial melting. Climate change models show a greater-than-average increase in temperatures, with greater and faster warming over the Arctic and sub-Arctic regions, impacting northeastern Canada, in part due to the melting of the cryosphere. Coastal sea flooding may increase because of melting sea ice in the Arctic, eastern Quebec, and along the Atlantic coast.[4]

It is projected that warming of permafrost in Canada, which has increased in temperature by 0.1°C – 1°C per decade, will reduce the area covered by permafrost from 40% to 20% by the end of the century under low-to-moderate GHG emissions scenarios. Annual mean temperatures across northern parts of Canada have increased at more than double the global rate. Summer Canadian Arctic sea ice area has declined at a rate of 5% – 20% per decade, while winter sea ice area in eastern Canada has decreased by approximately 8% per decade since 1968.[40] Compared with the median on January 1 (1981 – 2010), when there was 13.703 million square kilometers (km^2) of sea ice (yellow line), by January 1 2026 there was only 12.376 million km^2 of sea ice (blue line) in the Arctic ocean.[46]

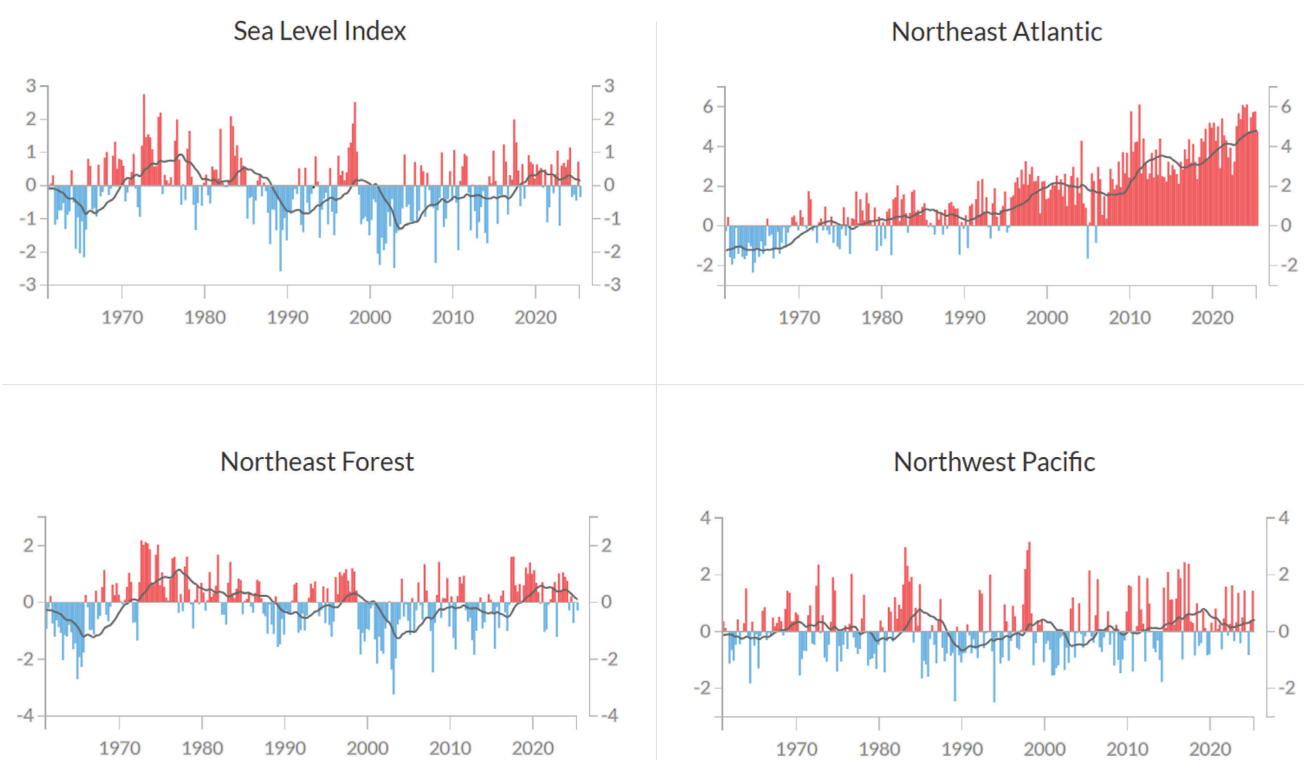
Figure 17: Arctic sea ice extent (area of ocean with at least 15% sea ice), as at 21 January 2026 [46]



Coastal sea flooding may increase due to sea-level rise, caused by the melting sea ice in the Arctic, eastern Quebec, and along the Atlantic coast. This will increase the risk of land subsidence and risk of greater wave activity in the Atlantic and Arctic seas due to increased duration of the ice-free period. Avalanches may become more frequent, as massive snow accumulations are released due to warming temperatures. From 2009 to 2018, 123 people died from avalanches in Canada, which carry a mortality rate of 23%. Storm surges are likely to impact coastal flooding.[4] Glaciers in western Canada have experienced a fourfold increase in mass loss during 2009 – 2018 compared to 2000 – 2009. However, climate model projections suggest that under low-GHG-emissions scenarios, snow and sea ice loss will stabilize in the future as global surface temperature stabilizes, although these changes will be smaller under a 1°C warming scenario.[40]

The Actuarial Climate Index shows Canada did not see a rise in average sea levels from 1961 to 2024. Sea-level rise, however, varies by region and is of most significance in the northeast Atlantic region.[20]

Figure 18: Sea level index seasonal standardized anomalies, Canada 1961 – 2025 [20]



Source: Actuaries Climate Index (http://actuariesclimateindex.org), sponsored by the American Academy of Actuaries, Canadian Institute of Actuaries, Casualty Actuarial Society, and Society of Actuaries

Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change in Population Impact by 2050 in 1°C Warming Scenario** Increase/(reduction) in annual deaths estimated to be attributable to risk
Sea-level rise	0%	0%

The following table provides a summary of how the mortality impact of physical risks related to climate change might change by 2050 in Canada.

Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change in Population Impact by 2050 in 1°C Warming Scenario** Increase/(reduction) in annual deaths estimated to be attributable to risk
Average temperatures	Cold-related 6.2% Heat-related 0.7%	0.1%
Drought	0%	0%
Air pollution	0.33%	0.33%
Food insecurity	Unknown	Unknown
Vector-borne diseases	0%	0%
Floods	0.3%	0.06%
Sea-level rise	0%	0%

Caveats and limitations

Climate science has improved significantly in recent decades, but significant uncertainty remains. That said, even doubling the impacts of each risk to account for uncertainty would still lead to a relatively modest overall physical impact. A 0.8% increase in annual population mortality in 2050 is equivalent to a three-basis-point reduction in annual mortality improvements over a 25-year period. Most research on the impact of climate change on mortality does not allow for the adaptation we will likely see as society works to lessen the impacts of these negative risks. An example of this would be the rollout of new malaria vaccines that, if successful, could mitigate the impact of climate change on the spread of vector-borne malaria.

Note that scope for adaptation against climate-related physical risks is greatest for higher socioeconomic groups. We have concentrated on the direct mortality impacts of physical risks in this paper, but these physical risks could cause new-onset morbidity, and there could be negative mortality impacts from this further into the future. An example of this would be the negative mental health consequences of extreme weather events, such as flooding for those who lose their homes or livelihoods and are displaced.

Severe-weather events that do not have a significant direct mortality impact can still have significant negative economic impacts and severely damage infrastructure, both of which could lead to negative health consequences and, ultimately, higher mortality. The data analyzed for this report suggests a small impact of climate change on future mortality by 2050 for Canada. However, other countries closer to the equator will likely see a greater impact.

We have considered a "middle-of-the-road" emissions scenario over the period to 2050. Over longer periods and in higher emissions scenarios, the mortality impact could be greater. We have considered each physical risk in isolation, but reality is more complex if considering transitional risks, and interactions between risks increase uncertainty. There is also the risk of reaching climate tipping points, which could lead to a self-reinforcing cycle of increased GHG emissions and warming.

Some of the actions that have led to climate change, such as deforestation, bring humans and animals closer into contact, which increases the risk of zoonotic disease transmission and increases the risk of future pandemics.

The information provided in this paper is intended for general discussion and education purposes only and should not be relied upon for making specific decisions. The potential change in annual population deaths in 2050 under a 1°C warming scenario is based on the assumptions specified, and different assumptions would give rise to different results.

Conclusions

As Canada lies in the Northern Hemisphere, it is probable that it will be less impacted by global warming than countries on or near the equator. Heat-related mortality is projected to increase, but the projected decrease in cold-related mortality is expected to offset any overall increase due to sub-optimal temperatures. No increasing trend in drought conditions has been observed in Canada to date, and it is likely that most of Canada will avoid drought conditions in the summer, except for the Prairie Provinces.

However, Canada is expected to see an increase in forest fires and a subsequent increase in PM2.5. This will likely double the current mortality rate from PM2.5 exposure by 2050. There is a great degree of uncertainty associated with this, since an increase in wildfire-related PM2.5 could more than offset any reduction from air quality improvements, resulting in an overall increase in deaths related to air pollution.

While incidence of West Nile virus and Lyme disease is expected to increase, deaths are extremely rare, and projected future deaths by 2050 are unlikely to increase much beyond current mortality. Canada is likely to be less impacted by food insecurity because of climate change than other parts of the world. While precipitation patterns are changing, these changes are expected to be more favorable for crop yield in Canada by 2050.

Reports show that northern Canada is warming at a rate twice that of the global average, increasing the rate of glacial melting and reduction in permafrost. Warmer winters will lead to earlier snowmelt in spring, increasing the risk of early flooding, while precipitation falling as rain rather than snow is projected to increase during the winter months, with rainfall decreasing during the summer months. Although floods can cause drownings and hypothermia, mortality due to flooding accounts for only an exceedingly small portion of the Canadian health burden.

These changes are expected to continue under a "middle-of-the-road" global warming scenario, impacting sea-level rise, particularly along the northeast Atlantic region. As global temperatures stabilize, it is expected that the loss of the cryosphere will also stabilize. Although Canada clearly will be impacted by global warming and climate change, future mortality is projected to be less affected than for many countries. Except for heat-related deaths, the data currently available on known risks does not indicate an increase in mortality due to climate change by 2050.

Climate change will impact everyone, whether through transitional risks, such as loss of employment due to the closure of fossil fuel production plants, or through physical risks, such as population migration, ecological changes, loss of life due to heat waves, forest fires and floods, or the spread of disease. The magnitude of these impacts depends on several factors, including proactive mitigation.

The modest positive mortality impact from (where possible) quantifiable physical risks in Canada outlined in this paper does not absolve society from taking action to limit GHG emissions and future climate change impacts. Climate change remains a significant risk factor to mortality and morbidity and a priority issue that must be addressed through collective action at the governmental, corporate, and individual levels. The insurance industry has an opportunity to play a leadership role in combating the climate crisis by promoting awareness, providing education, and inspiring, motivating, and incentivizing populations to modify behaviors in ways that will benefit their health as well as the planet's.

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Appendix

The **Intergovernmental Panel on Climate Change SSP-RCP scenarios sixth Assessment Report** (AR6)[67] explores five emissions scenarios that project socioeconomic global changes up to 2100. These are (SSP1), middle-of-the-road development (SSP2), regional rivalry (SSP3), inequality (SSP4) and fossil-fueled development (SSP5) and their five SSP families:

- SSP1-1.9 (below 2°C, with a target of 1.5°C scenario by 2050)
- SSP1-2.6 (a 1.8°C scenario by 2100, similar to RCP2.6)
- SSP2-4.5 (2.7°C scenario by 2100, similar to RCP4.5)
- SSP3-7.0 (3.6°C by 2100, a medium-high scenario)
- SSP5-8.5 (4.4°C by 2100, a high scenario, similar to RCP8.5)

The previously used **Representative Concentration Pathways (RCPs)** are scenarios used to project future climate change to 2100 based on various levels of greenhouse gas concentrations:

- RCP 2.6 – low emissions due to mitigation strategies/GHG peak before 2100 and decline
- RCP 4.5 – moderate emissions/intermediate scenario/GHG stabilize after 2100
- RCP 6 – moderate emissions/intermediate scenario/GHG stabilize after 2100
- RCP 8.5 – high emission scenario due to rising GHG

Radiative forcing (2/4.5/6/8.5) is the extra heat the lower atmosphere will retain because of additional greenhouse gases, measured in Watts per square meter (W/m^2)

The 2020 McKinsey report[68] on climate risk and response divided countries into six main groups (based on RCP 8.5):

- Significantly hotter and more humid countries (countries near the equator)
- Hotter and more humid countries (between the equator and 30-degree north and south lines of latitude)
- Hotter countries (near the equator)
- Increased water-stress countries (locations of the world's deserts, e.g., Egypt, Iran, Mexico, and Turkey)
- Lower-risk increase countries (outside the 30-degree north and south latitude, e.g., Canada)
- Diverse climate countries (span broad range of latitudes, e.g., U.S., China)

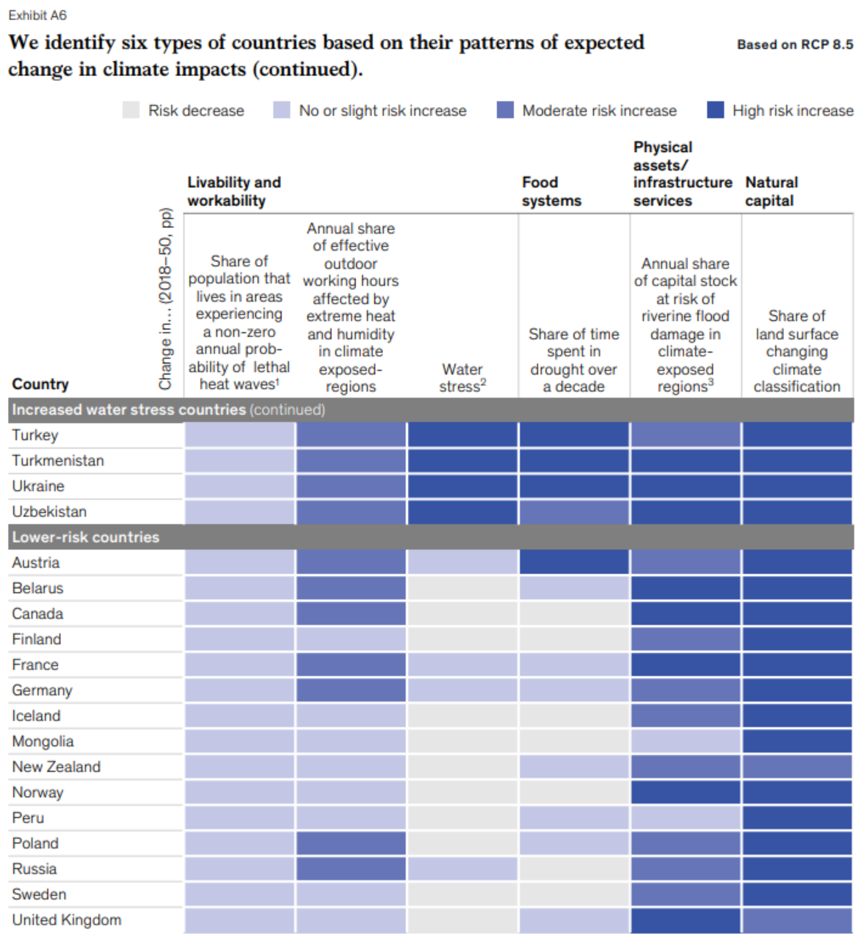

Exhibit from "Climate risk and response: Physical hazards and socioeconomic impacts", 2020, McKinsey Global Institute, www.mckinsey.com/mgi. Copyright (c) 2025 McKinsey & Company. All rights reserved. Reprinted by permission.

Statistics Canada, 2020-2024 [69, 70]

Leading causes of death, total population, by age group, Canada: 2020-2024

Leading causes of death (ICD-10)[15, 16, 17]	Characteristics	2020	2021	2022	2023	2024
		Number				
Total, all causes of death [A00-Y89]	Rank of leading causes of death[18]	..	..	..	..	..
	Number of deaths	308,824	313,268	338,217	327,546	326,779
Malaria [B50-B54]	Rank of leading causes of death[18]	45	47	45	47	48
	Number of deaths	0	0	1	0	1

Deaths and age-specific mortality rates, by selected group causes, Canada: 2020-2024

Characteristics [15, 16]	Number of deaths					Age-specific mortality rate per 100,000 population				
Cause of death (ICD-10)[17, 18, 19]	2020	2021	2022	2023	2024	2020	2021	2022	2023	2024
Malaria [B50-B54]	0	0	1	0	1	0.0	0.0	0.0	0.0	0.0
Other and unspecified infectious and parasitic diseases and their sequelae[20]	925	1,003	1,402	1,692	1,806	2.4	2.6	3.6	4.2	4.4