EDITORIAL

Climate change and infectious diseases: What can we expect?

NH Ogden[1,2]*, P Gachon[3]

Abstract

Global climate change, driven by anthropogenic greenhouse gas emissions, is being particularly felt in Canada, with warming generally greater than in the rest of the world. Continued warming will be accompanied by changes in precipitation, which will vary across the country and seasons, and by increasing climate variability and extreme weather events. Climate change will likely drive the emergence of infectious diseases in Canada by northward spread from the United States and introduction from elsewhere in the world via air and sea transport. Diseases endemic to Canada are also likely to re-emerge.

This special issue describes key infectious disease risks associated with climate change. These include emergence of tick-borne diseases in addition to Lyme disease, the possible introduction of exotic mosquito-borne diseases such as malaria and dengue, more epidemics of Canada-endemic vector-borne diseases such as West Nile virus, and increased incidence of foodborne illnesses. Risk is likely to be compounded by an aging population affected by chronic diseases, which results in greater sensitivity to infectious diseases. Identifying emerging disease risks is essential to assess our vulnerability, and a starting point to identify where public health effort is required to reduce the vulnerability and exposure of the Canadian population.

Suggested citation: Ogden NH, Gachon P. Climate change and infectious diseases: What can we expect? Can Commun Dis Rep 2019;45(4):76–80. https://doi.org/10.14745/ccdr.v45i04a01

Keywords: climate change, vector-borne disease, foodborne, temperature, precipitation, chronic disease, Lyme disease, mosquito-borne diseases

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Introduction

The articles in this edition of the Canada Communicable Disease Report provide insight into how climate change may increase the number and extent of vector-borne diseases and increase the incidence of foodborne infections in Canada (1–4). In this editorial, we summarize recent and projected future climate change in Canada; how climate change may affect infectious disease emergence and re-emergence; and how, in light of the changing demographics and health of Canadians, these changes may impact risks from infectious diseases.

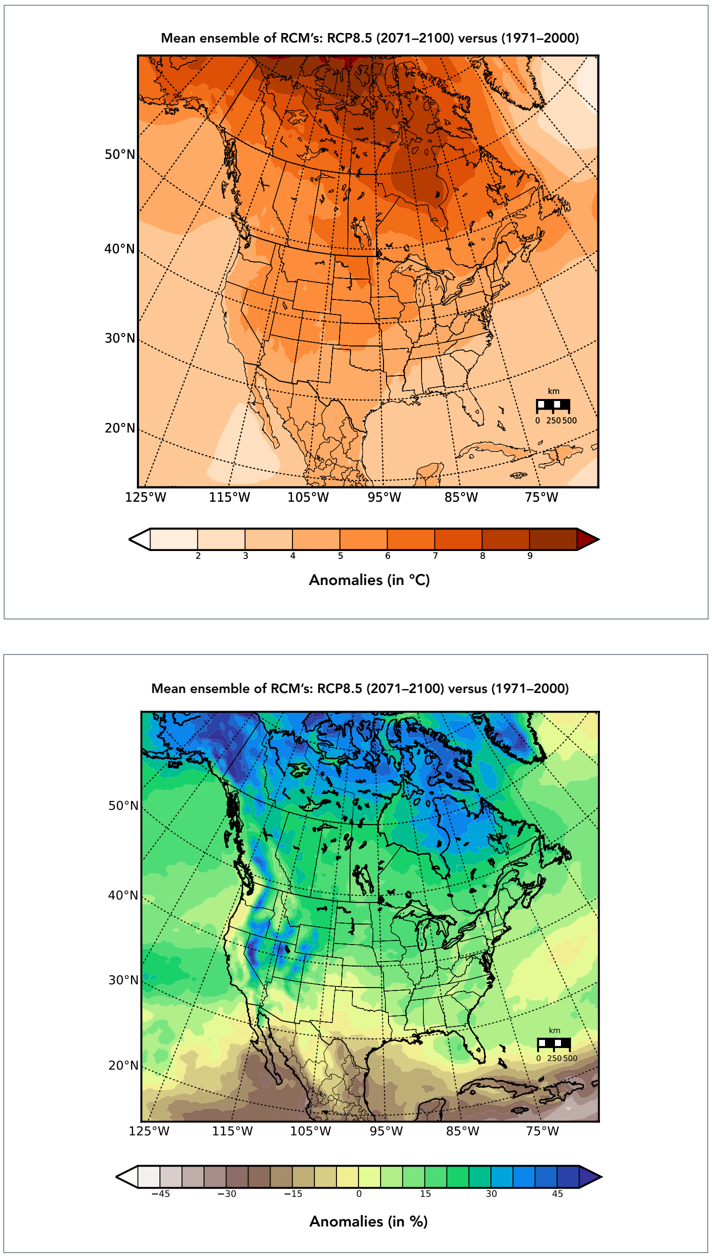
Recent and future climate change in Canada

Warming trends have accelerated globally, with overall annual air temperature increases of nearly 1 °C during the period 1880–2017 (5). The years 2015 to 2017 were clearly warmer than any previous years (6), and the last three decades were warmer than any decade since 1850 (7). This trend varies geographically, with greater and faster warming over the Arctic and sub-Arctic basins, particularly in northeastern Canada, due to the rapid decrease of sea-ice and snow cover (8,9).

Since 1948, the rate of warming in Canada as a whole has been more than two times that of the global mean, and the rate of warming in northern Canada (north of 60°N) has been roughly three times or more the global mean (10). Over northeastern Canada (north of 60°N and east of 110°W), the annual mean temperature has increased by 0.75–1.2 °C per decade over the last three decades compared with around 0.18 °C per decade globally (5). Mean air temperature will continue to increase as greenhouse gas concentrations in the atmosphere continue to rise due to human activities.

By the 2070s, most of Canada is projected to be 5 °C warmer than in the period 1971–2000. Predicted changes in annual total precipitation include slight increases in precipitation in the Prairie provinces and greater precipitation (mostly rain) in northern and eastern Canada. However, projections for precipitation are associated with less robust estimates than those for temperature (**Figure 1**).

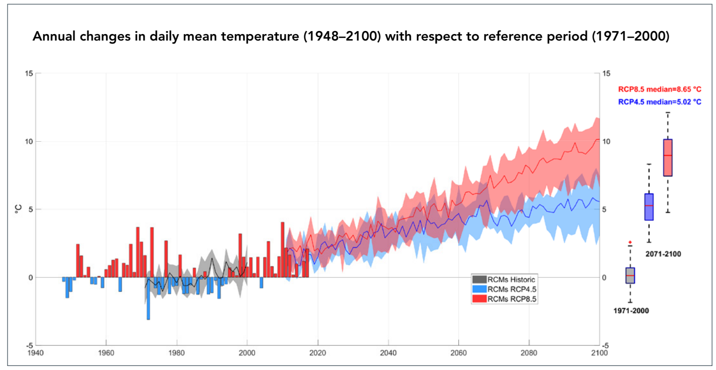
Figure 1: Projected increases in a) mean annual temperature (in °C) and b) annual total precipitation amount (in %) 2071–2100 compared with 1971–2000



Abbreviations: RCM, regional climate model; RCP, regional concentration pathway
Note: Simulated by nine regional climate models (RCMs) and the available datasets from the North America CORDEX (COordinated Regional climate Downscaling EXperiment) project (11). All simulations use the representative concentration pathway (RCP) 8.5 greenhouse gas emission scenario (12) with a spatial resolution of 0.44 ° around 50 km. Shaded areas correspond to regions where 60% of the models are in agreement in the direction of change and have a magnitude of change higher than the standard deviation of data from the reference period (1971–2000)

In the future, warming is expected to be greater in northeastern Canada (up to 8.65 °C warmer by the 2070s) (**Figure 2**), linked with large declines in sea-ice and snow cover by the end of the 21st century (13).

Figure 2: Observed and projected annual changes in daily mean temperature over northeastern Canada[a]: 1948–2100 compared with 1971–2000



Abbreviations: RCM, regional climate model; RCP, representative concentration pathway
[a] Northeastern Canada is defined as land areas north of 60°N and east of 110°W
Note: Annual changes in daily mean temperature are noted in bar graphs for reference data and line graphs for projected changes. Projected changes were obtained from the same model simulations as used in Figure 1, and using two emissions scenarios of RCP4.5 (blue line) and RCP8.5 (red line), the latter being more realistic at the current time. Shading around the blue and red lines (median of all simulations) illustrates the range of increases in temperatures projected by the different regional climate models. The box-and-whisker plots to the right show the median and ranges of increases in temperatures for the reference period (i.e. observed data), and for the period 2071–2100 (i.e. model projections) under the two different RCPs (12)

Long-term changes in temperature and precipitation are expected to be accompanied by increased variability in temperatures and rainfall from one year to the next, as well as extreme weather events, including heat waves and heavy rainfall events that increases the risks of flooding (13). A significant increase in mean annual precipitation intensity per wet day (up to 15% by the 2070s), but fewer wet days per year, is anticipated in northeastern Canada where warming will be more pronounced over the course of the 21st century. Precipitation intensity is projected to increase substantially over time corresponding with the rate of warming, also affecting southern and eastern areas of Canada.

How climate change may affect infectious disease emergence and re-emergence

Over the past 10 years, we have seen the emergence and re-emergence of infectious diseases globally, including Ebola virus disease in Africa, Middle East respiratory syndrome coronavirus (MERS-CoV) in the Middle East and Zika virus disease, chikungunya, yellow fever and dengue in the Americas. These have posed great challenges for public health.

Infectious diseases emerge due to changes in their geographic ranges and by "adaptive emergence," a genetic change in the microorganisms infecting animals (usually wildlife) that results in these microorganisms becoming capable of infecting humans, and perhaps being transmitted from human to human (14) – in other words a genetic adaptation that leads to a new zoonotic disease.

There are multiple drivers of disease emergence, including those associated with environmental (including climatic) changes; social and demographic changes including globalization; and changes in public health systems and policies (15). Endemic diseases can re-emerge (i.e. increase in incidence or resurge as epidemics) associated with the same drivers. Climate and climate change may directly impact infectious disease emergence and re-emergence via effects on pathogen survival, arthropod vector survival and reproduction, contamination of water and, in the case of zoonoses, abundance of reservoir hosts (the animals that harbour the microbes). Such direct effects of climate change on the ecology, and transmission to humans, of infectious agents have been the focus of previous national (16,17) and international assessments (18–20). However, climate change may have indirect impacts on disease emergence and re-emergence, by affecting other environmental and social changes, and by impacting public health systems.

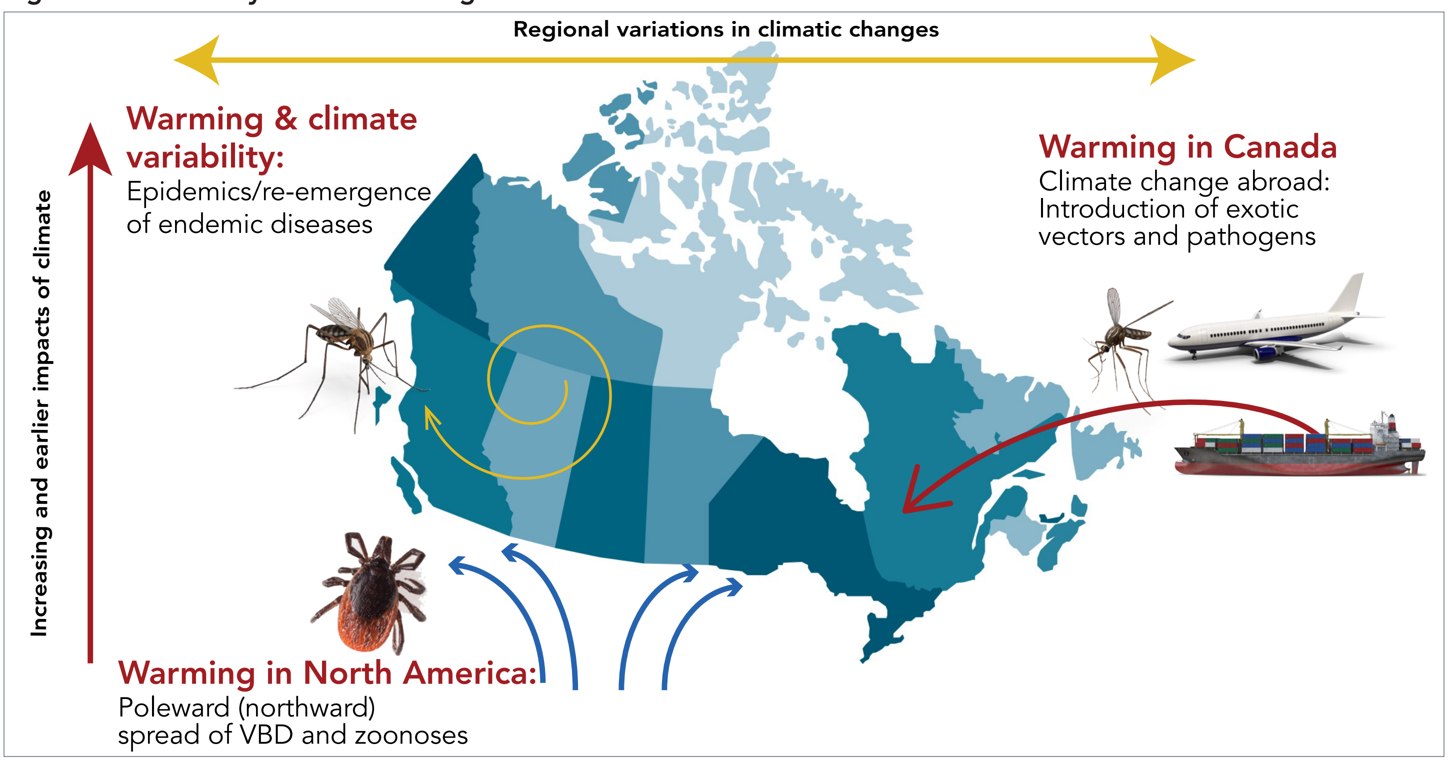
Effects of climate change on ecosystems, including effects on biodiversity, may alter the risk of a new zoonoses originating from wildlife (21,22). In addition, climate change may negatively impact economies globally, particularly those of low and middle income countries. This may directly, or via increased frequency of conflicts, reduce infectious disease control and contribute to increasing densities of infectious agents in countries outside North America. Negative impacts on low- and middle-income economies may drive increased economic or refugee migration, increasing importation of infectious diseases into Canada (23).

The combined effects of all these factors lead to three expected, broad impacts of climate change:

- Increased risks of introduction, and endemic transmission, of "exotic" infectious diseases (both directly transmitted and vector-borne) from around the world (e.g. Severe Acute Respiratory Syndrome [SARS])
- South-to-north spread of diseases currently endemic to the United States (e.g. Anaplasmosis)
- Re-emergence (i.e. more epidemic behaviour and range change) of Canada-endemic infectious diseases (e.g. West Nile virus outbreaks) (**Figure 3**).

The long-term changes in temperature and precipitation, increased climate variability and increased frequency of extreme weather events described above will affect the different infectious disease risks idiosyncratically (24). Modelling studies are increasingly being developed to assist with the prediction of effects of climate change on infectious diseases to allow us to be better prepared for these changing risks.

Figure 3: A summary of climate change effects on infectious disease risks for Canada[a]



[a] Modified (23)

Other factors to consider

Changing patterns of infectious diseases in Canada due to climate change also need to be considered in the context of other disease trends associated with the changing demography and health of Canadians.

The Canadian population is aging and increasingly affected by chronic illnesses. This means that both infectious and chronic disease risks will need to be considered together (25). The risk from infectious diseases comprises two aspects: the likelihood of exposure and sensitivity (i.e. severity of infection outcome). Exposure likelihood depends on the number of infective organisms (the "hazard"), that is, infective humans, microorganisms, arthropod vectors and animal reservoir hosts, in our environment and the rate of contact of humans with infectious organisms. These will likely increase with climate change. At the same time, the severity of infectious disease outcomes will likely be greater in populations that are increasingly elderly and affected by chronic diseases. This seems to be the case for vector-borne viruses such as West Nile virus (26).

Conclusion

Canada's climate is changing. With increased temperatures and spatial and temporal variability in precipitation patterns, this will likely increase the risk of acquiring Lyme disease and West Nile virus, already well-established in Canada, as well as other tick-borne, mosquito-borne and foodborne diseases. More detailed overviews of current and projected from climate change–mediated infectious disease risks are presented in the articles in this issue. Risk is likely to be compounded by the fact that in Canada we have an aging population increasingly affected by chronic diseases who may develop more severe infections than the young and healthy. Identifying these risks is a key activity to assessing our vulnerability as a nation, and a starting point to identifying where public health effort is required to reduce the vulnerability and exposure of the Canadian population.

Authors' statement

NHO and PG conceptualized and co-wrote the article, NHO provided the public health and infectious diseases components and PG provided the information on climate change.

Nicholas Ogden was the Guest Editor of this issue of CCDR, but recused himself from taking any editorial decisions on this manuscript. Decisions were taken by the Editor-in-Chief, Dr. Patricia Huston.

Conflict of interest

None.

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