Impacts of Climate Change on Human Health

DISCUSSION PAPER C3 – 08

Prepared by:
Cailen Henry
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EXECUTIVE SUMMARY

Human health and the environment are intimately connected\textsuperscript{13}, and a disruption in the stability of climatic variables and parameters are expected to have a broad range of health impacts\textsuperscript{42,10}. The Intergovernmental Panel on Climate Change (IPCC) and the World Health Organization (WHO) state, “The sustained health of human populations requires the continued integrity of the Earth’s natural systems”\textsuperscript{13,23}. Human health ultimately depends on society’s capacity to manage the interaction between human activities and the physical and biological environments in ways that safeguard and promote health, but do not threaten the integrity of the natural systems upon which the physical and biological environment depends. This includes maintaining a stable climate\textsuperscript{13,54}.

This paper was commissioned by Climate Change Central to investigate the potential impacts of climate change on human health. More specifically, to outline these impacts, how climate change may impact population health in Alberta, and to make recommendations for action in this area.

The research presented in this paper is organized into four broad categories. The first - key issues - outlines the health impacts associated with thermal extremes, air pollution, extreme weather events, drought, water- and food-borne disease, and vector-borne disease. The second category discusses the health impacts associated with climate change that are of particular importance to Albertans. The third category outlines knowledge gaps and uncertainties, followed by implications for public policy. The last section concludes, with recommendations to Climate Change Central.

In conclusion, global warming has the potential to pose a serious threat to Alberta’s population health in the long run. The gaps in the literature, and knowledge outlining the impacts to human health with a doubling of atmospheric carbon dioxide in Alberta are significant. How climate change will impact various indicators of public health is unknown. But whatever the potential risk, the impact of climate change on human health can be mitigated through adaptation strategies, though it is not clear to what extent these strategies will be successful.
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INTRODUCTION

Human health and the environment are intimately connected, and a disruption in the stability of climatic variables and parameters are expected to have a broad range of health impacts. The Intergovernmental Panel on Climate Change (IPCC) and the World Health Organization (WHO) state, “The sustained health of human populations requires the continued integrity of the Earth’s natural systems.” Human health ultimately depends on society’s capacity to manage the interaction between human activities and the physical and biological environments in ways that safeguard and promote health, but do not threaten the integrity of the natural systems upon which the physical and biological environment depends. This includes maintaining a stable climate.

The rate of change in key climatic variables and parameters from greenhouse gas emissions is expected to be rapid on the evolutionary time scale. The IPCC predicts that continental regions and higher latitudes will warm more than coastal and tropical regions. Nighttime minimum temperatures will increase more than daytime maximum temperatures, and winter temperatures are expected to increase more than summertime temperatures. If warming trends continue, climate variables that have direct effects on human health, such as floods, heat waves, droughts and extreme weather events may become more frequent and severe.

The disruption of ecosystems, water and food supplies, and changes in the concentration of air pollutants and air-borne allergens, have the potential to impact the incidence of infectious disease, nutritional status, cardiovascular, cerebrovascular, and respiratory conditions.

This paper addresses the broad area of climate change and human health and much of the research presented in this paper was pulled together in a University of Alberta Master’s Thesis, by Justine Klaver, in 2002. Key issues define both the direct and indirect effects of changes in climate variables and parameters on human health, followed by a discussion of uncertainties and knowledge gaps in the conventional literature. Implications for public policy are discussed, followed by conclusions and recommendations for study or action by Climate Change Central.

Key Issues

Global warming will impact climatic variables and climate-related parameters, and these impacts are expected to have a deleterious impact on human health. The impacts on human health can be divided into direct and indirect effects. The former encompasses the direct impact on human biology, while the latter impacts human biology via another climate variable or parameter.

There are five possible pathways through which climate change can impact human health: 1) temperature-related morbidity and mortality, 2) health effects associated with air...
pollution, 3) effects of extreme weather events (and drought) on population health, 4) water and food borne disease, and 5) vector borne disease.

Health Outcomes Associated with Thermal Extremes

Climate change will be accompanied by an increase in the occurrence of extreme temperatures that have both direct and indirect effects on human health. The direct effects include thermal related and induced morbidity and mortality, while the indirect effects are via the impact of heat on air pollution.

Warm temperatures are expected to occur more frequently, while cold temperatures will occur less frequently in Canada. Heat waves, characterized by extreme and prolonged heat, are associated with an increase in mortality rates. An increase in the duration, intensity, and frequency of heat waves is expected to have an impact on all causes of death, and is also associated with heat cramps, heat syncope (fainting), heat exhaustion, heat stroke and dehydration.

The deleterious health effects of heat waves are expected to be more pronounced in urban areas, and in heat sensitive locations. The Heat Island Effect occurs when natural vegetation is replaced by surfaces that absorb heat, such as building roofs, walls, and pavement, and is prevalent in urban and suburban areas. Heat sensitive locations are defined as areas where high temperatures occur infrequently or irregularly.

Populations that are vulnerable to the adverse health effects of heat waves are those groups with pre-existing illness, the young, elderly, and frail populations. A disproportionate amount of heat related mortality is the result of the union of heat and cardiovascular, cerebrovascular, and respiratory co-morbidities. Age, alcohol and illicit drug use, prescription drug therapy, and the existence of a cognitive impairment is associated with an increase in heat related morbidity and mortality. Socio-economic status is inversely related to heat related morbidity and mortality. However, increased heat related morbidity and mortality may be offset by acclimatization to warmer temperatures and lower cold related morbidity and mortality. Acclimatization of populations may reduce predicted health related morbidity and mortality. Acclimatization occurs gradually and may be slower than the rate of ambient temperature change. It is less likely to occur during cooler summers where heat waves are less frequent, relative to warmer summers where heat waves occur more frequently. Milder winters are expected to decrease winter related morbidity and mortality rates.

There is evidence that Albertans may have a lower risk of suffering from heat-related morbidity and mortality as dry hot air masses, characteristic of parts of the prairie region, are not significantly related to adverse health outcomes.
Health Outcomes Associated with Air Pollution

A warmer climate and thermal extremes may increase exposure to urban air pollution and will affect regional and local air pollution concentrations.

More specifically, warmer temperatures are expected to be accompanied by an increase in primary and secondary pollutants. For example, heat and sunlight are significant climatic variables in the production of smog, and smog has the potential to aggravate pre-existing respiratory and cardiovascular conditions. This has the potential to increase the number of hospitalizations (and medical visits) in response to respiratory distress and may contribute to the development of asthma in children.

Health Impacts of Extreme Weather Events

Extreme weather events have both direct and indirect effects on public health. In a warmer climate, floods, convective storms (thunderstorms producing lightning, hail, tornados, heavy rains and strong winds), and droughts are expected to become more frequent and severe.

The possible health impacts of extreme weather conditions include an increase in the incidence of death, physical injury, infectious disease, and stress-related disorders and may have an impact on nutritional status (especially in children), increases in respiratory and diarrheal disease; increased risk of exposure to water-borne diseases; and may contribute to the release of dangerous chemicals from storage sites and waste disposal sites into flood waters. Extreme weather events are expected to be accompanied by social disruption, environmentally forced migration, and settlement in urban slums.

However, the extent of the realization of these health outcomes is, in part, determined by the vulnerabilities, and the ability of the environment and the local population to recover from extreme weather events. More specifically, the level of preparedness in any community will, in part, determine the severity of the health effects.

Health Outcomes associated with Drought

Warmer global temperatures are expected to increase and prolong episodes of drought in the prairies. The health outcomes associated with drought are expected to disproportionally impact rural areas, and pose direct and indirect risks to human health.

Farmers are at the highest risk of experiencing symptoms of mental and emotional distress in response to drought conditions. Financial pressures due to decreased crop yields are the primary mechanism here.

Drought is associated with an increase in air-borne particulate matter. Respirable air-borne particulate matter can be an initiator for respiratory disorders, or can exacerbate existing respiratory co-morbidities, become chronic, and present as rhinitis, bronchitis, and asthma.
Drought is also expected to have a detrimental effect on fire danger in forest areas, by increasing fire vulnerable areas, and lengthening the fire season. This is likely to result in an increase in the frequency and severity of forest fires. There are both direct and indirect health effects associated with forest fires. The direct effects include evacuation and loss of property and lives, while the indirect effects are smoke inhalation and haze. Smoke inhalation and haze may induce or aggravate respiratory distress.

**Water- and Food-Borne Disease**

Temperature and precipitation are key climate, or weather variables in the risk of exposure and transmission of water- and food-borne disease. Extreme weather events and warmer temperatures change the risk of exposure and are an indirect health effect of global warming.

There are three mechanisms in which humans can be exposed to water- and food-borne disease: 1) through ingestion of food contaminated with food-borne pathogens, 2) ingestion of water contaminated with water-borne pathogens, and 3) ingestion of food contaminated by water-borne pathogens or water contaminated with food-borne pathogens.

In a warmer climate, exposure and infection to food-borne pathogens, commonly known as food poisoning, is more likely, as these infections exhibit seasonal patterns. Some of the pathogens that may cause additional risk to human health in a warmer climate are Salmonella, Clostridium perfringens, Staphylococcus aurus, Baccillus spp., Escherichia coli, vibrio parahaemolyticus, Campylobacter jejuni, Listeria monocytogenes, Cryptosporidium parvum, and Giardia lamblia. Exposure to food-borne pathogens is also a function of food imports. As the integrity of agricultural operations is compromised abroad via a variety of mechanisms, one being climate change, there is expected to be an increase in illness from viral, parasitic and bacterial diseases.

The risk of infection from water-borne pathogens increases with the realization of extreme hydrological events, for example, flash floods, and is an indirect health consequence of climate change. The impact of climate change on water quality and human health is a function of the location of the extreme hydrological event. For example, in urban areas, intense precipitation may overwhelm sewage treatment plants. Consequently, storm water and raw sewage may combine and be released into drinking water resources. In rural areas, especially those that are home to industrial agricultural operations, intense precipitation carries with it the risk of contaminating drinking water reserves.

Exposure and infection from food-borne pathogens are the most ambiguous adverse health effect associated with global warming. The impact of temperature on food-borne disease can occur at many points along the food processing cycle, from livestock operations to domestic...
preparation and consumption \(^3\). Thus, the responsibility of controlling food-borne disease outbreaks lies in industry and at home.

The prevalence of water-borne pathogens in a warmer climate can be controlled through management and disposal of sewage, bio-solids, animal wastes, and the protection of water sheds and fresh water flows \(^2\).

**The Health Impact Associated with Vector-borne Disease**

Global warming is expected to impact the ecology of insect, tick and rodent vectors \(^3\), and poses an indirect risk to human health.

Generally, the most significant determinant in the transmission of vector-borne pathogens to humans is the survival rate of the vector under consideration \(^1\). However, the rate of transmission to humans is complex, and varies with each disease and vector. Therefore, the impact of climate change on vector-borne disease is not uniform across vectors and disease. In general, warmer temperatures have an ambiguous impact on the survival rate of a vector, and therefore, the probability of transmission to humans \(^4\).

Most vector-borne diseases exhibit a seasonal pattern indicating disease transmission is sensitive to weather patterns, such as precipitation, heat, and humidity \(^5\). For example, warmer temperatures increase mosquito and tick reproduction, pathogen development \(^6\), and biting despite shortening survival \(^7\).

The impact of vector-borne disease on human health in an increasingly warmer climate is a complicated and complex issue. In the Canadian prairie region, Lyme Disease, Rocky Mountain Spotted Fever, Hantavirus Pulmonary Syndrome (HVP), and Western equine encephalitis (WEE) are vector-borne diseases that pose a threat to population health. Lyme Disease and Rocky Mountain Spotted Fever are tick-borne diseases \(^8\). Under conditions of climate change, the tick species responsible for harboring Lyme disease could eventually extend their range into the Canadian Prairies \(^9\). The incidence of HVP and WEE, rodent and mosquito-borne diseases respectively, are expected to change because of increased temperatures and amplified climate variability expected to occur in response to global warming \(^4\).

Populations that are at the highest risk for contracting vector-borne disease are those with the greatest exposure to the vector \(^9\). However, vector-borne disease outbreaks are likely to be relatively small in developed nations \(^4\). Moreover, warmer temperatures are expected to be accompanied by indoor living and increased use of air-conditioners, which may offset an increase in the risk of transmission of vector-borne pathogens.
Climate–Related Health Outcomes that are of Particular Importance to Albertans

Drought is the most likely climatic outcome for the prairie region. Most climate change scenarios for the prairies indicate rising temperatures accompanied by reductions in soil moisture in response to a doubling of atmospheric carbon dioxide \(^{22}\). Therefore the health impacts from climate change that are of particular importance to Albertans are those arising from an increase in respirable air-borne particulate matter and forest fires. An increase in respirable air-borne particulate matter, which is linked to a decrease in soil moisture, has the potential to initiate respiratory disorders and exacerbate pre-existing respiratory illness. Forest fires are associated with an increase in respiratory distress from smoke inhalation and haze, as well as an increase in loss of life and property. Drought has also been linked to mental distress in the farming community.

Knowledge Gaps and Uncertainties

Uncertainties and knowledge gaps in the climate change and human health area arise from several areas. First, there is limited data for use in analysis \(^{19}\). It has also proven difficult to model environment and health relationships \(^{10}\) for a variety of reasons, for example, the presence of population specific sensitivities and vulnerabilities of the health outcome to a change in climate and environment \(^{19}\). Furthermore, the impact of climate change on health can be mitigated by adaptation strategies, and it is not clear to what extent these strategies will be successful.

In general, the majority of original research linking climate change and public health status is not specific to Alberta \(^{31}\), therefore, the realization of health outcomes for Albertans is difficult to predict.

Klaver et al (2001), through a research project entitled ‘A Feasibility Assessment to Study Societal Adaptation and Human Health Impact under Various Future Climate Scenarios Anticipated in the Canadian Prairies: Report on Prairie Round Table Discussions’, identified areas of concern and future research in the prairie region.

The areas that emerged from the Prairie Round Table Discussions are: how changes in climatic variables and parameters will manifest in changing weather patterns in the Canadian prairies and how climate will impact water quality and quantity, air quality, the reconstitution of infectious disease, emerging infectious disease, agriculture, and rural health status indicators. The project also addressed how changes in weather patterns will impact population health status, the quality of health care and health care infrastructure. The participants of the Prairie Round Table Discussions indicated the need for coupling of health and physical sciences, effective dissemination of climate-change risks to public health, investigation of the prairie region’s current ability to adapt to warmer temperatures, and what resources or mechanisms should be constituted in the future.
There are two research programs the author (of this paper) is aware of at the time of writing. The Climate Change and Health Research Program (CHRP), Department of Earth and Atmospheric Sciences at the University of Alberta, is examining the effects of heat stress, air pollution, and weather on human health, as well as linking ENSO events, weather and mosquito-transmitted disease. The second project, Climate Change, Extreme Weather Events and Health-Effects in Alberta, at the University of Alberta, is examining the link between extreme weather events and the health and well-being of Albertans. The data is derived primarily from print media, in an effort to help the public and policy makers better prepare for climate change in Alberta.

**Implications for Public Policy**

Global warming has the potential to pose a serious threat to Alberta’s population health in the long run. The gaps in the literature and knowledge outlining the impacts to health with a doubling of atmospheric carbon dioxide in Alberta are significant. Climate change in Alberta has the potential to devastate rural and farming communities both financially and through indicators of health and well-being, as well as groups that are predisposed to respiratory illness. Alberta Health and Wellness, together with the provincial health regions, has the potential to address climate change and health issues by determining the vulnerabilities of the Alberta population, educating health professionals and the public about the risk to their health arising from climate change. Public health policy must pay special attention to vulnerable groups when addressing climate change and health issues. This is a starting point to inserting human health into climate change discussions in a tangible and concrete way.

Adaptation to climate change action within the public health infrastructure can take place in five areas:

1. disease surveillance, early detection and treatment,
2. immunization campaigns for existing and emerging health risks that target vulnerable populations,
3. health promotion campaigns that link energies use to behavior,
4. identification and assessment of risks rising from mitigation strategies,
5. adoption of adaptation strategies, for example, emergency preparedness programs, weather/health early warming systems, and acclimatization assistance.

The Canadian Public Health Association (CPHA) suggests public policy that would promote joint actions on health and climate change at the national level. The first is establishing a health and climate change research program. Ideally, their vision encompasses a collaboration between the meteorological and health research communities in determining the links between atmosphere, weather and health (Dr. I Butron). The CPHA also advocates for:
• educating health professionals on the health impacts of climate change, and encouraging them to monitor these impacts on the population,
• implementation of policy that emphasizes and encourages health promotion and protection, rather than concentrating on remediation,
• quantifying the economic benefits of GHG emissions reductions, from a societal perspective, and inserting this information into policy discussions on climate change.

Conclusion

There are five mechanisms in which climate change can affect population health: through thermal extremes, extreme weather events, pollution, and exposure to water, food, and vector-borne pathogens. However, there is a limited amount of research on how climate change will impact the health status of Canadian prairie residents, and even less literature that models these health outcomes in Alberta.

Drought is the most likely climatic response to global warming. The majority of climate change scenarios for the prairies indicate warmer temperatures accompanied by a decrease in soil moisture in response to a doubling of atmospheric carbon dioxide.

The gaps in the literature linking health outcomes to key climatic variables and parameters in Alberta, and the Prairie region are significant. However, there are two research programs the author is aware of at the time of writing this paper that are attempting to address issues and uncertainties with respect to climate change and its associated health impacts in the prairie region.

Recommendations to Climate Change Central

1) Encourage the collection of data that links key health status indicators (for example, mortality and cardiovascular, cerebrovascular, and respiratory co-morbidities) to key climate variables (for example, maximum and minimum temperature, maximum and minimum dew points, cloud cover and wind speed)

2) Encourage research that models the health effects of climate change and incorporate into the model a change in human behavior to the perceived risk of an adverse health event.

3) Encourage research that estimates the economic impact of climate-related morbidity and mortality.

4) Advocate for the inclusion of perceived health effects into Alberta’s action on climate change.

5) Monitor key areas.
REFERENCE LIST


