

Climate change and human health

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Introduction

Climate change poses a serious threat to human health, with recent simulations predicting an increase in mean global temperature by 1.5-5.8°C, as well as a 5-15% increase in mean global precipitation by the end of the century.¹ These environmental changes impact several social determinants of health by affecting air quality, food chains, forced migration, and the incidence of various infectious diseases.²⁻⁴ Within the global community, specific populations will be more vulnerable to these consequences than others.^{2,5-7} It is the role of healthcare professionals, through education, leadership, and advocacy, to recognize and account for these changes and adapt current practices. Healthcare professionals must not only be able to provide appropriate care to populations that are most vulnerable to climate change, but also minimize the environmental burden of the healthcare system. This will help mitigate the negative health effects of climate change, which are expected to surge in the coming years.

Infectious Diseases

Many infectious agents can be impacted by climate changes.⁸ The explanations as to how these affect vector-borne disease communication are varied. Considerations include lengthy transmission periods due to changing seasonality, increasing temperatures leading to increased reproduction rates, and climate-induced migration of vectors and human hosts.⁹ With varying climates globally, it is understood that the distribution of infectious diseases will be impacted, leading to some regions being unsuitable for certain diseases, while others becoming vulnerable. The lack of acquired immunity in these newly infected regions is concerning.¹⁰

Malaria and dengue fever are two vector-borne diseases that have been influenced by temperature changes.¹¹ An increase in temperatures since the 1970s in Africa has been correlated with increased malaria distribution at higher altitudes in the southern and eastern regions of the continent.¹¹ Increasing temperatures are believed to shorten the time it takes for mosquitoes to become infected with dengue fever, thus increasing transmission.⁸ Additionally, water-borne diseases are expected to be influenced as well. Specifically, the rate of cholera infection in developing countries is anticipated to increase with rising temperatures.¹² Challenges in food and water security will also force individuals to rely on unsafe food sources, therefore increasing susceptibility to food- and water-borne illness.² Of particular concern is the vicious cycle that involves food-borne illness compounding existing hunger, which increases an individual's vulnerability to acquiring other infectious diseases.²

Food Chains and Water Security

Food security is achieved when “all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs.”¹³ Almost all qualitative assessments predict that climate change is going to have a negative impact on food security, particularly in developing countries.²

While climate change is predicted to lead to detrimental effects on crop yields, agriculture also accounts for 25% of greenhouse gas emissions.¹⁴ The impacts of climate change on agriculture are expected to be seen after 2020, especially with the demand for agricultural products increasing by about 50% by 2030.¹⁵⁻¹⁷ Temperature increases and changes in precipitation are expected to impact crop yields, specifically for crops grown at the extremes of temperature.¹⁸ The changes in crop yields will not only exacerbate existing hunger through direct means, but also through decreasing the net income of farmers.¹⁹ Increased CO₂ is actually predicted to positively impact crop yields, leading to a mixed picture when accounting for CO₂ changes that are expected with climate change.^{15,17,20} However, foods grown at increased CO₂ environments have also been shown to have decreased iron, zinc, and protein content.^{5,21} Rising CO₂ emissions are expected to make 150–200 million people zinc deficient, and a similar number deficient in protein.⁵ The decrease of insect pollinators due to pollution and climate changes may lead to reduced intake of vitamin A and folate, as well as fruits, vegetables, seeds, and nuts.⁵ It is expected that the negative impacts on agriculture will be most pronounced in developing countries and coastal regions, with developed countries actually benefiting from climate changes.^{2,13,17,22}

The availability of freshwater has been threatened due to decreasing glaciers, ultimately leading to deprivation, displacement, and conflict.^{5,14} Additionally, various regions are turning to methods to extract water which require increased energy, ultimately resulting in increased CO₂ emissions.¹³ Ocean warming, acidification, deoxygenation, and overfishing have led to a decline in seafood availability, particularly in low-income countries.¹⁴ Approximately one billion people obtain over 20% of their daily intake from fish, making them particularly vulnerable to the decline in wild fish harvests.^{5,23} Furthermore, 22 of the 33 countries that are most vulnerable to climate change impacts on fisheries are classified as “Least Developed Countries.”²⁷ It is, therefore, individuals from many of the world's lowest-income countries that are most vulnerable to these changes, as they are over twice as reliant on fish than those from less vulnerable countries.⁷

Migration

Climate change also threatens human security through forced migration, which can lead to political conflict, physical and emotional trauma, and death.²⁴⁻²⁶ Forced displacement is known to have severe impacts on human health, and is associated with higher rates of malnutrition, infectious disease, and mental illness.^{5,27} It is often those living in low-resource settings that are subjected to forced migration, therefore compounding pre-existing vulnerability.^{5,6,26,28} It is estimated that up to 700 million individuals may become displaced due to climate change by 2050.³ The causes of climate-based displacement are often

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categorized into two groups: sudden-onset and slow-onset events.²⁴ Sudden-onset events, such as hurricanes, floods, and wildfires, can occur rapidly.²⁴ Slow-onset events happen over time, such as land degradation and decreasing crop yields.^{24,29,30}

Climate change also exacerbates sociopolitical conflict. For example, millions were displaced due to the civil war in Syria, which was the result of political conflict and exacerbated by the region's worst known three-year drought.^{5,28} Additionally, changes in land fertility have caused increased conflict over land possession.³ The unreliability of harvests, in combination with the increasing incidence of natural disasters, has led to displacement.³ Migration often occurs disproportionately from rural to urban settings, which can pose a serious problem, as many urban cities lack the capacity and infrastructure to host large waves of migrants.^{3,25,29}

It is also important to recognize that in precarious situations, it is often the young male of the family that is forced to relocate to find work, increasing the vulnerability of family members left behind.^{24,31} Children are also often sent to live with extended family to relieve resource demand within families.²⁴ Studies indicate that individuals that migrate due to climate-based reasons prefer to stay in their place of origin; therefore, it is crucial that the mental health implications of these forced displacements are also explored and treated.²⁴

Air Quality

Climate and weather have significant influences on air quality, thus resulting in its sensitivity to climate changes. Air pollution results from a combination of emissions and untimely weather patterns.³² While there are various air pollutants, the two key players that influence health are particulate matter and surface ozone.³² Both of these pollutants have been associated with higher temperatures, however, the exact relationship between temperature and particulate matter is not clear in the literature.^{33,34} Ozone causes respiratory inflammation when inhaled, and studies have shown an increase in asthma-related hospital visits in regions with higher levels of these air pollutants.³⁵

Climate change is also influencing health through its impact on aeroallergens such as outdoor pollens. Several studies in Europe have shown that the pollen seasonal onset is advancing in alignment with warming trends.³⁵ Further research has suggested that increases in CO₂ concentrations alone lead to greater pollen levels, through increased production and efficacy as an allergen.³⁶

Additional consequences of air quality on health include the effects of wildfires, with elevated temperatures along with extended droughts potentially leading to an increase in fires.³⁷ The consequent smoke in surrounding communities has been shown to lead to an increase in hospital visits due to respiratory complaints.³⁸ This was evident in a study looking at three weeks of wildfires in Kelowna, where physician billings for respiratory illnesses were largely increased from the same three-week period over each of the ten years prior.³⁹

Discussion

The connection between climate change and health is well established in the literature. Although many are susceptible to these effects, it is clear that certain populations are more vulnerable to the impacts on food chains, migration, infection transmission, and air quality. On a large scale, the infrastructure and robust healthcare systems of many industrialized countries can be expected to support their populations through these challenges. Unfortunately, this may not be feasible for many other regions globally, for example in coastal areas where infrastructure to combat rising sea levels is not affordable.⁴⁰ For any

region, government-level support is critical. For example, an enhanced infectious disease program could help relieve some of the sequelae of increased disease distribution and transmission. This would include public education, increased vaccination, and food and water safety measures.⁴¹

Further populations at particular risk include the elderly, as they have a higher vulnerability in heat waves as well as in cold-related events.⁴² In regions with wildfires, individuals suffering from respiratory diseases, such as chronic obstructive pulmonary disease and asthma, have experienced additional exacerbations.³⁹ Within Canada, Indigenous communities would be expected to have increased sensitivity to climate-related health outcomes, as well as a decreased adaptive capacity to climate changes, due to the lasting intergenerational trauma, lack of healthcare access, and poverty that has been disproportionality experienced.⁴³ When considering the many consequences of climate change on health, it is inevitable that climate change will impact mental health. This could be through more severe adverse weather events, displacement, and added stress related to resource deficiencies, which can lead to anxiety-related responses and trauma, as well as the implications on physical health that are so closely related to an individual's mental well-being.⁴⁴

To mitigate some of the challenges of climate change, it is essential that action is taken by the physician community. Recently, the global non-profit World Organization of Family Doctors (WONCA) issued a declaration calling on physicians to advocate and take action to prevent climate change.⁴⁵ WONCA recognized the influence that physicians could have on making immediate and constructive change in local communities. The healthcare sector is a significant contributor to carbon emissions. In 2016, Eckelman *et al.* reported that the United States healthcare sector reached nearly 10% of the national output of emissions in the United States in 2013.⁴⁶ The same study showed yearly increases over a recent ten-year period, with a total increase of healthcare emissions of over 28% during that timeframe. Unfortunately, this is a trend in the wrong direction. The WONCA statement suggested that physicians can promote a sustainable workplace by reducing medical waste, encouraging active transit and plant-based diets, and educating themselves and their patients on climate and health. Evidently, this theme is important for medical students and physicians. One possible way to build understanding around this issue is by creating workshops for future physicians on the topic of climate change. To this end, the University of British Columbia's Global Health Initiative, a student-led initiative, has recently introduced an annual climate health workshop. The session encourages thoughtful discussion on how climate can influence the health outcomes of varying communities. This also spurred ideas on how medical students felt action could be taken in their future careers. Furthermore, the UBC Faculty of Medicine plans to lead a teaching session on climate health as part of their new "Emerging Topics" initiative. The formal introduction of this issue to the curricula, as well as continued advocacy and efforts toward promoting sustainability within healthcare, is likely to create progress towards positive change.

Conclusion

Climate change is expected to have detrimental effects on several aspects of human health, specifically by affecting food chains, migration patterns, infectious disease distribution, and air quality. With recognition of the complex interplay of climate and health, it is imperative that the medical community takes action to mitigate the

negative effects that climate change has on the health of patients.

Conflict of interest

The authors have declared no conflict of interest.

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