REVIEW ARTICLE

THE IMPACT OF CLIMATE CHANGE ON OUR PATIENTS' HEALTH AND THE FAMILY PHYSICIAN'S ROLE

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KEYWORD:

Climate change

Abstract:

Climate change continues to have a detrimental effect on the overall health of people globally. The average yearly temperature has continually risen since the late 19th century and is projected to continue rising for decades ahead. Increased temperature has been linked to decreased sleep quality and increased heat strokes and pregnancy complications.

Adverse effects on cardiopulmonary health have been linked to climate change. Air pollution is correlated to an increased risk of myocardial infarctions and aggravation of symptoms pertaining to asthma and chronic obstructive pulmonary disorder. Lengthening of the pollination season because of warmer weather due to climate change has led to an increase in allergy-related rhinitis and asthma.

Temperature increases have caused a lengthening of the transmission season of infectious disease, especially vector and water-borne diseases. Infectious disease has begun to spread to new areas globally due to increased temperatures, rainfall and flooding attributed to climate change.

The mental health impacts attributed to climate change, including depression and anxiety, are escalating. With increased floods and hurricanes, people of certain geographic areas can experience an increase in acute stress, which may lead to chronic post-traumatic stress disorder.

Family physicians are at the forefront of advising patients on how to handle the health effects of climate change. In addition to climate change's impact on health, patients of lower socioeconomic status are more at risk because of lack of adequate resources and financial stability. Through detailed histories, family physicians have an opportunity to identify affected patients and intervene earlier.

INTRODUCTION

Scientific researchers have tried for many years to explain why the Earth's overall temperature is rising, a critical component of climate change. Since the middle of the 19th century, an overall increase of greenhouse gas emissions into the Earth's atmosphere has caused a consistent rise in the average yearly temperature of the Earth.[1] Warming of the Earth caused by climate change has led to both acute and chronic changes to the Earth's ecosystem. Acute changes include increased natural disasters, flooding, and heat waves while chronic changes include increased pollution and creation of environments more suitable for pathogens.[1] These chronic and acute changes to the Earth can cause drastic direct and indirect effects on the health of humans.[2]

Every American's health is at risk of being impacted by climate change. However, there seems to be external factors not directly related to climate change that can contribute to the increased risk of health consequences. People with lower socioeconomic statuses were shown to have a higher likelihood of having their health impacted by climate change. More specifically, in urban populations, there is a higher risk of health issues from climate change in lower socioeconomic areas due to less green space, fewer community resources, and inability to attain adequate help to address their health problems.[3] In addition, a study based in the southeast United States showed the presence of a higher number of people living below the poverty line in rural populations. These communities may have a lower ability to respond to the health burdens imposed by climate change, like increased heat and weather variations.[4]

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Even though researchers have started to uncover the effects that climate change has had on human health, it is still difficult to formally attribute health outcomes solely due to climate change. Many health-related burdens due to climate change can be classified as climate-sensitive or climate-induced. Climate-sensitive illnesses can be exacerbated by the consequences of climate change and include cardiovascular, pulmonary, and renal diseases. Climate-induced illnesses can be linked directly to the consequences created by climate change and include heat stroke, malnutrition, and mental illness.[5] This is significant for healthcare providers, especially family medicine physicians who are the first-line defense as they see a vast array of clinical cases. With increased mortality and morbidity now being associated with climate change, new research and data can help family medicine physicians with the diagnosis, management, and treatment of future patients with climate-change provoked diseases.[6]

HEAT

On average, temperatures in the United States have risen 1.3–1.9°F (0.72–1.06°C) since 1895 and are estimated to continue to increase 2–4 degrees over the next few decades. These increasing temperatures lead to extreme heat-related events, such as heat strokes, which is the most prominent cause of weather-related deaths.[7] Deaths from heat strokes are often associated with agricultural workers because they continue to work despite feeling ill. The southeast and southwest portions of the United States are the areas at most risk of these increasing temperatures, where hot and humid work conditions increase health risk.8 Studies in the central valley of California show migrant farm workers have been developing acute and chronic kidney disease at higher rates due to increased prevalence of heat waves in this area.[9] This increase in renal disease could potentially be caused by chronic dehydration due to heat stress, because these workers spend the majority of time outside.[9]

Heat itself has also been tied to decreased sleep quality, duration of sleep, and increased rates of obstructive sleep apnea.[7] Negative effects of increased temperature have also begun to impede on city areas due to increased amounts of black pavement which absorb and trap heat. This phenomenon, called the "heat-island effect," coupled with a decrease in the amounts of trees in cities, further contribute to increases in temperature.[10]

Multiple studies have also investigated heat-related increases in preterm births. Increases in temperature due to climate change were correlated with decreased birth weights, decreased gestational length, increased risk of stillbirth, and an increase in neonatal stress and mortality.[11]

NUTRITION

Of the many implications of climate change, its effect on food resources is a topic gaining immense traction. Due to climate change's correlation with increased temperatures, rainfall and CO2 levels, this poses problems with agriculture, potentially impacting nutrition. Many effects of climate change can alter crop yield, nutrient value, protein content and even livestock. Furthermore, climate change is attributed to a decreased amount of animal pollination, which can potentially impact patients. Growing research shows possible contributions to altered levels of micronutrients in crops, such as folic acid, which could lead to birth defects.[12] The increases in CO2 concentrations can also potentially change nutritional value by decreasing protein content in crops by 7%–15%. This can cause patients susceptible to malnutrition to not meet their daily intake of protein. Additionally, decreases in zinc and iron levels in cereals and legumes, as well as a decrease in phosphorus and potassium, can cause individuals to have a deficiency in these minerals.[12]

Studies based on models accounting for CO2 levels, water nitrogen, and temperature also project how climate change would affect the wheat grain protein concentration, which is amongst the three main sources of human nutrition. It was found that areas with low and mid-latitude locations, such as Texas, Florida and North Carolina, show a negative correlation to grain yield and protein concentration. In contrast, high-latitude locations, such as states along the northern border of the United States, show a more positive yield, once again interplaying with proper nutritional value.[13]

CARDIOPULMONARY

Cardiopulmonary systems are affected by climate change through air pollution, extreme temperatures, sand dust storms, and wildfires. Air pollution is assessed using fine particulate matter (PM2.5) and ground level ozone (O3). $PM_{2.5}$ comes from ambient air pollution and causes the greatest threat to public health.[14,15] Particles with a diameter less than 2.5 μm can travel into bronchioles and alveoli and cause systemic oxidative stress and inflammation.[16,17] O_3, likewise, is a harmful oxidizing agent and the primary constituent of smog.[18,19] Measurements of $PM_{2.5}$ and O3 show that air quality worsens as areas become more urban.[19] Air pollution is associated with increased emergency department visits, asthma and chronic obstructive pulmonary disease (COPD) exacerbations, and higher risks of myocardial infarctions.[14,15,18–21] Inhaled pollutants can increase the risk of myocardial infarctions by causing atherothrombosis through systemic inflammatory responses, sympathetic nervous system activation, and the direct result of pollutants in systemic circulation.[20]

Exposure to extreme temperatures, sand dust storms and wildfires are becoming more frequent and are affecting more individuals. Severe heat waves and cold spells lead to dehydration and force the human body to activate the sympathetic nervous system and renin-angiotensin system. During a heat stroke, a systemic inflammatory response may result as the body attempts to reduce its core temperature. These adaptations can explain the association between extreme temperatures and increased morbidity and mortality of cardiovascular disease.[20] Both temperature extremes, as well as transitions and variability in temperature, may trigger acute myocardial infarctions and are associated with increases in morbidity and mortality in individuals with COPD.[16,18]

During the spring and summer months, sand dust storms are a rising threat in states like Arizona, California, Washington and Nevada. Dust storms are hazardous to cardiopulmonary health

because they increase $PM_{2.5}$. The inhaled particles damage bronchial epithelial cells and attract immune cells leading to increased hospitalizations in asthma and COPD patients and an increased risk for myocardial infarctions.[14,17] The dust also increases the risk for infectious diseases such as influenza, coccidioidomycosis, bacterial pneumonia and meningococcal meningitis.[17]

Finally, wildfire activity has increased over the past decades, affecting multiple western states. While the rest of the country is decreasing in $PM_{2.5}$, wildfires are believed to be the cause of $PM_{2.5}$ increases in the Northwest.[22] There has been consistent evidence that wildfire air pollution leads to exacerbation of asthma. Associations between increased exacerbation of COPD or respiratory infections and wildfire pollution have been neither clear nor consistent within recent literature.[23]

ALLERGIES

Due to industrialization, increasing fossil fuel consumption has led to high levels of CO_2.[24] High CO_2, coupled with warmer temperatures, contributes to the promotion of plant growth and elongation of the pollen season. This is due to plants flowering earlier in the spring with warmer weather and surviving longer into fall with a delayed first frost.[24,25] Not only has the pollen season been prolonged, but the pollen load in certain plants has increased as well. There is also a suspected increase in the allergenicity of the pollen being produced. These effects are contributing to more and worsening allergic diseases, such as asthma.[25]

Pollen is not the only factor of climate change that can affect allergies. Heat stress and ground level ozone both promote inflammation and, therefore, are associated with increased allergic responses.[24] Additionally, as areas of the country experience more precipitation, humidity, flooding, and subsequently, an increase in indoor moisture, fungal growth and inhalation of fungal components can increase. These inhaled fungal components activate the immune system and can lead to allergic rhinitis and asthma exacerbations.[24,26]

INFECTIOUS DISEASE

Vector-borne infectious diseases are anticipated to continue globally spreading as the zone of optimal temperature for vector survival and pathogen transmission moves away from the equator and toward the hemispheres.[27,28] Transmission seasons, which occur from spring through fall, and geographical ranges of diseases will continue to change as temperate regions experience warmer temperatures, milder winters, and more rainfall.[28–30] It is important to analyze vector response to climate change separately. For example, malaria, West Nile, Zika, dengue, chikungunya and yellow fever viruses are all spread through mosquitoes, while Lyme disease is spread through different regional ticks. Because of their life cycles and feeding patterns, mosquito populations can respond rapidly to acute climate variability, like temperature fluctuations, and can cause both short-term and long-term epidemics. In contrast, increased tick populations result from chronic climate changes, like progressive increases in temperature and humidity in a region.[27] As vector-borne diseases spread to new areas or when individuals travel to areas endemic with disease without acquired immunity, they are more likely to experience more severe symptoms if they contract the disease.[30] Fortunately, socioeconomic factors like public health services, education, housing infrastructure and drug availability will likely deter disease spread in the United States. However, extreme weather like flooding can hinder adequate vector control.[29,30]

Warmer temperatures, as well as an increase in rainfall and flooding, are believed to increase the incidence of waterborne diseases because they increase pathogen survival and replication and can increase expression of virulence genes in bacterial pathogens.[31,32] Increased temperatures also affect human behavior, as individuals consume more water during warmer temperatures, thus causing an increase in the probability of pathogen ingestion.[31] Increased rainfall and flooding can transport pathogens, contaminate groundwater and overwhelm water treatment infrastructure.[31,32] The increased incidence of waterborne diseases after a heavy rain can be intensified when there is a significant dry period preceding it, allowing for an increased concentration of pathogens. When there is heavy rainfall, these pathogens can be spread by the increased flow of water.[32] Heavy rainfall can also carry protozoan pathogens from manure and can contaminate fresh produce.[31] Finally, flooding can cause the displacement of affected people to temporary communities with inadequate sanitation and water treatment systems.[31]

MENTAL HEALTH

An often-overlooked impact of climate change is its effects on mental health. These climate related events can lead to displacement of individuals from their homes, stress and mental health problems, such as depression, anxiety and post-traumatic stress disorder (PTSD). Extreme weather is estimated to produce negative mental health outcomes in about 25%–50% of individuals within the first year after the event.[33]

Amongst patients who experience a flood, 30%–40% are diagnosed with PTSD. Initial trauma from the climate change event may cause an acute stress disorder, which can ultimately lead to PTSD.[33] Patients affected by flooding are said to experience PTSD at an eight times higher rate than those from homes that were not affected.[34] A study done after Hurricane Katrina in New Orleans showed 20%–35% survivors had mental health disorders afterwards. Amongst these survivors, half of them with PTSD came from marginalized communities, mainly low-income African American women.[35]

Increasing temperatures alone can take a substantial toll on an individual's mental health. Extreme heat and humidity have increased the amount of hospital admissions for patients with mood and behavioral disorders, such as schizophrenia, mania, and neuroticism. Thermoregulation can be affected in patients with pre-existing mental illnesses, chronic medication use, or substance abuse, thus further contributing to the susceptibility to heat-related morbidity.[35]

more than twenty-five days of precipitation. This data suggests that the southern United States during the spring and summer months will be more susceptible.[36]

Newer terminology has been developed to further define some of the possible mental health outcomes from climate change. These mental health issues can stem from what is known as psychoterratic syndromes. These syndromes include ecoanxiety, defined as the anxiety brought on by climate change, and ecoparalysis, which is defined as one's non-effectiveness in having control over climate change. Extreme weather events associated with climate change may cause another syndrome known as solastalgia, which is described as the stress from the progressive loss of solace from one's surroundings.[35]

Similar to adults, children are susceptible to the mental health effects of climate change. Children are a lot more aware of the world around them and have an increased expression of fear and worry towards their future due to climate change.[37]

ROLE OF THE FAMILY PHYSICIAN

The family physician's priority is their patients' health, so it is important to be well informed on everyday aspects of living that can affect their patient's quality of life. Family physicians can directly impact these changes by implementing green practices, such as telemedicine into their practice. This is noteworthy since healthcare delivery can be attributed to 10% of the greenhouse emissions.[38] The effects of climate change can offer a unique opportunity for family physicians to play a significant role in healthcare.

A study performed in Wisconsin surveyed family physicians about the effects of climate change in their community. The results showed that 64% of physicians reported that climate change affected their patient's health. However, only 33% of physicians reported feeling very well or well informed on the health impacts of climate change. Moreover, 17% of physicians felt extremely or somewhat comfortable counseling patients on climate change and health.[39] Family physicians felt that continued medical education courses regarding the health effects of climate change would benefit their patient care.[40]

There are many ways that family physicians can evaluate patients affected by climate change and even prevent potential adverse outcomes. Thorough histories, especially regarding mental health in relation to climate change, can aid in early intervention and counseling. If mental health issues are identified, it is important to offer early and prompt treatment or refer these patients for additional care if needed, such as counseling.[41] Table 1 outlines the various interventions and educational opportunities that can be implemented by family physicians.

TABLE 1:[7,9,11,12,14-21,23-33,41-42]

The Physician's Response to Climate Change Health Outcomes

CLIMATE CHANGE CONCERN	CLINICAL IMPACTS	PHYSICIAN'S ROLE
Heat	Heat stroke, AKD, CKD, altered sleep quality, pre-term births	Advise patients of the signs and symptoms of heat stroke and emphasize the importance of adequate hydration Inquire about previous geographic locations in agricultural workers Counsel outdoor workers in the importance of breaks and avoidance of outdoor activity at peak temperatures During heat waves, advise patients to seek cooler places, such as those with air conditioning Educate pregnant patients on potential pregnancy risks associated with extensive heat exposure
Nutrition	Malnutrition, mineral deficiencies in zinc, iron, potassium, and phosphorus	Educate the patient on potential nutritional effects of climate change Encourage the consumption of foods rich in minerals
Cardiopulmonary	Asthma and COPD exacerbations, increased risk of myocardial infarction	Encourage monitoring of local air quality and temperatures Promote indoor activities when conditions are suboptimal N95 masks may be useful when air quality is poor such as during wildfires
Allergies	Allergic responses, asthma exacerbations	Encourage the patient to monitor pollen counts and maximize treatment options for symptom control Following heavy pre-cipitation and flooding, discussions regarding mold growth in homes may be warranted

TABLE 1 CONT'D

Infectious diseases	Vector-borne and water-borne diseases	Proper clothing and repellents should be advised for outdoor activities Education on signs and symptoms may lead to early detection and treatment of diseases Caution patients that local produce may become contaminated after heavy rainfall
Mental health	Depression, anxiety, post-traumatic stress disorder	Especially following natural disasters, screening and proper referrals are essential

CONCLUSION

Climate change is a global issue that will continue to take a toll on human lives. The World Health Organization has predicted that between the years 2030 and 2050, up to 250,000 additional deaths per year will be attributable to climate change.[39] These statistics bring awareness to the impact of climate change and its consequences. For example, companies who have employees working in high heat conditions should take into account that their workers are at a higher risk of getting heat stroke. Therefore, employers should have resources available on job sites to prevent symptoms of heat stroke.

It is important for physicians to become aware of the toll climate change is having on their patients. This especially pertains to family medicine physicians, who see a wide array of clinical presentations throughout their practice. With the majority of their clinical cases involving mental health, cardiopulmonary, allergies, and infectious disease topics, it would be advantageous for family medicine physicians to understand the impacts that climate change can have on patients.

Climate change can affect many aspects of health. Increasing public and physician awareness is fundamental to offset these potential health issues. Continued research and analysis are needed to uncover more information regarding climate change, and more importantly, ways to improve and protect the comprehensive health of all.

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