Climate Change and Underserved Communities

Carol Ziegler, DNP, APRN, NP-C, RD[a,b], Vincent Morelli, MD[c,*], Omotayo Fawibe, MD[b]

KEYWORDS

• Climate change • Global warming • Greenhouse gases • Greenhouse gas emissions
• Patient education

KEY POINTS

- Climate change is a threat to the basic necessities of life, especially for the most vulnerable. These necessities include health, shelter, food, and water.
- Climate change will have direct health impact on populations seen in primary care.
- The effects of climate change must be dampened with adaptation and mitigation strategies.

A GLOBAL PERSPECTIVE ON CLIMATE CHANGE

The Intergovernmental Panel on Climate Change defines climate change as a change in the state of the climate that persists for an extended period, typically decades, and can be identified by the variability of its properties. It is also any change in climate over time, whether due to natural variability or as a result of human activity.[1] Climate change is not currently widely accepted as a health hazard by health care professionals in the United States; yet it is the single greatest global health threat of the twenty-first century.[2] The effects of climate change on global health are so enormous that in the next few decades billions of lives will be affected.[2] The concept of climate change, despite skepticism and political opposition, is valid. Available science concludes with 90% certainty that the earth's climate has warmed over the past few decades as a result of greenhouse gas emissions from human activities.[1,3] Moreover, no credible body of climate scientists have found an alternate explanation for the rising global temperature.

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[a] Vanderbilt University School of Nursing, Nashville, 461 21st Ave South, Nashville, TN 37240, USA; [b] Department of Family & Community Medicine, Meharry Medical College, 1005 Dr D. B. Todd Boulevard, Nashville, TN 37208, USA; [c] Sports Medicine Fellowship, Department of Family and Community Medicine, Meharry Medical College, 1005 Dr D. B. Todd Boulevard, Nashville, TN 37208, USA
* Corresponding author.
E-mail address: vmorelli@mmc.edu

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Climate change occurs due to an imbalance between incoming and outgoing radiation in the atmosphere.[4] When solar radiation from sunlight enters the atmosphere, some of the radiation is absorbed by the earth's surface and emitted as infrared radiation. Greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), absorb the infrared radiation, heating up the lower atmosphere.[5,6] These greenhouse gases can occur naturally or from human activities. Fluctuations in the temperature of the lower atmosphere have occurred in the past due to variations in concentrations of naturally occurring greenhouse gases. The significant rise in global temperatures now experienced, however, is due to a rise in the concentration of global greenhouse gases in the atmosphere due to various human activities. CO_2 accounts for 76% of greenhouse gas emissions and is a product of petroleum product combustion, natural gas, and coal. CH_4 is a product of landfills, coal mines, and oil and gas operations and accounts for 16% of emissions, whereas N_2O accounts for 5% of emissions and is a product of nitrogen fertilizers, burning biomass, and waste management processes. Finally, fluorinated gases account for 2% of emissions and are a product of industrial processes like refrigeration (**Fig. 1**).[7]

Since the industrial revolution, atmospheric concentration of CO_2 has increased from 280 parts per million to approximately 395 parts per million today.[3,5] This has led to record-high global temperatures. The planet's average temperature has increased by 0.8°C since 1880 and if the current trend of CO_2 emission levels remains stable, it is predicted that the planet's average temperature will increase by an additional 1.8°C to 5.8°C by the end of the twenty-first century.[5] This is expected to have an impact on basic human needs like food, water, shelter, and health. Increased global temperature will disrupt the water cycle because warmer air retains more moisture, causing flooding in some areas and drought in others; this will affect crop yield from farming and even livestock productivity. Increased temperature can also lead to heat waves increasing the incidence of heat-related illnesses. Heat waves can also increase the ambient level of some air pollutants, which can increase morbidity and mortality related to cardiorespiratory conditions. Also, flooding or drought can affect the geographic distribution of vector-borne diseases, such as malaria and dengue fever. Increased global temperature will also increase ocean

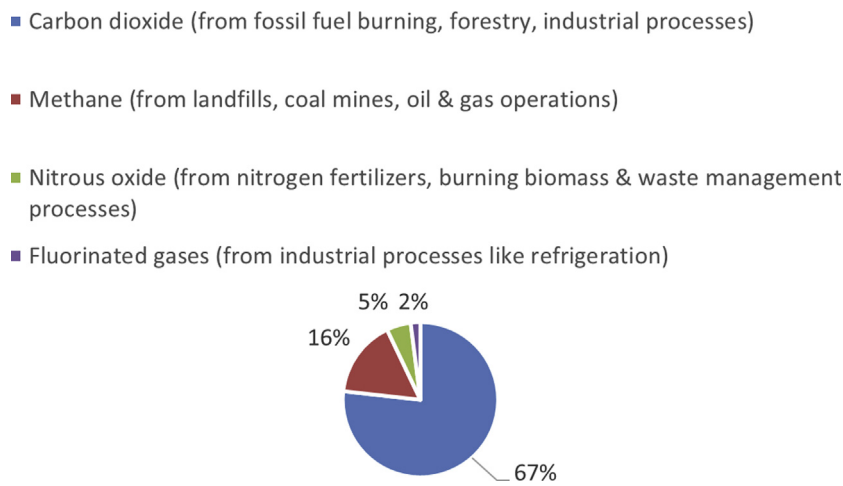

Fig. 1. Global greenhouse gas emissions.

temperatures, potentially disrupting the aquatic ecosystem and affecting industries like fishing. The increased global temperature will also cause sea levels to rise as a result of melting sea ice, forcing migration of coastal dwellers and leading to a host of other challenges (Fig. 2).[3,5,7]

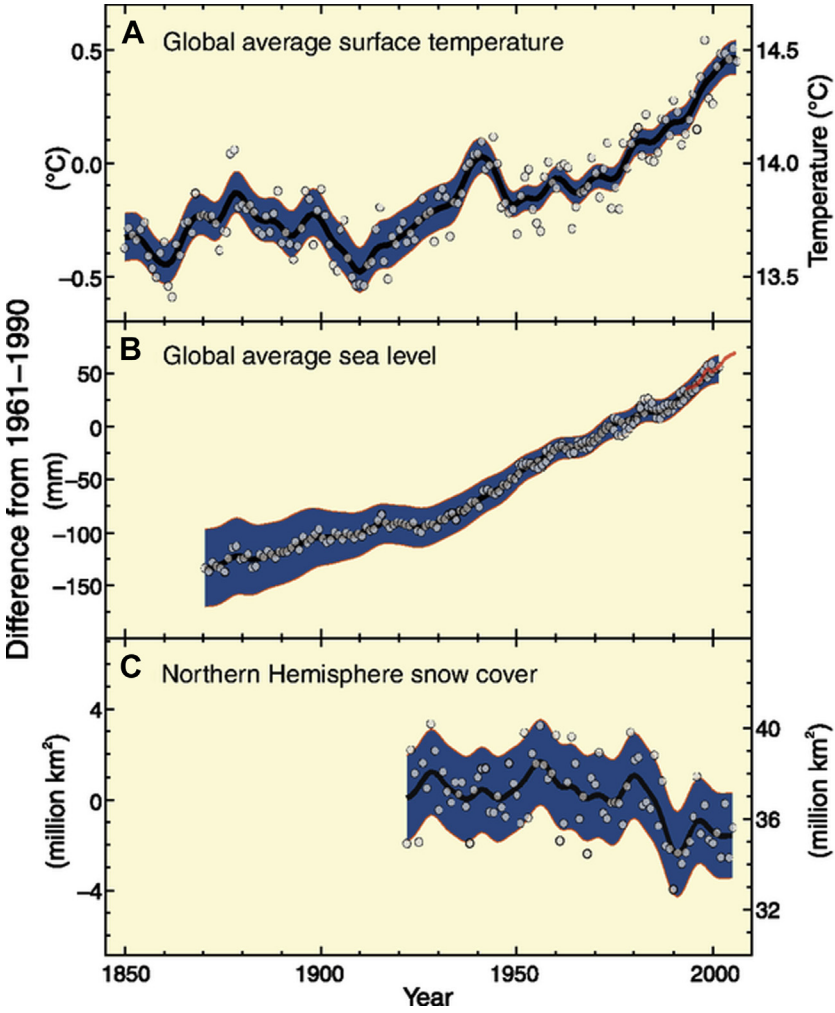

Fig. 2. Changes in temperature, sea level, and Northern Hemisphere snow cover.[1] Observed changes in (a) global average surface temperature, (b) global average sea level from tide gauge (*blue*) and satellite (*red*) data, and (c) Northern Hemisphere snow cover for March–April. All differences are relative to corresponding averages for the period 1961 to 1990. Smoothed curves represent decadal averaged values whereas circles show yearly values. The shaded areas are the uncertainty intervals estimated (a and b) from a comprehensive analysis of known uncertainties and (c) from the time series. (*From* IPCC. Climate change 2007: Synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change. 2007. Available at: http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html. Accessed March 6, 2016; with permission.)

CLIMATE CHANGE IN THE PRIMARY CARE SETTING

Climate change is a phenomenon that is real but is still approached with skepticism. It is the duty of health care practitioners to learn about the various impacts of climate change and serve as an informant for their patients as well as serving as sentinels for the public health sector when health crises erupt due to climate change. Although the impact of climate change will be seen across the globe, low-income and middle-income countries (LMICs) with minimal resources along with the susceptible groups in wealthy countries are going to be the most negatively impacted by climate change. In the United States, health and socioeconomic disparities as well as geographic location leave the most marginalized citizens vulnerable to climate change. Policies promoting adaptation and mitigation strategies must be implemented to both dampen some of the adverse effects and decelerate or possibly halt the trend of the change. Primary care providers play a vital role in promoting climate change mitigation and activism through their unique perspective and ability to make it personally relevant to health.

Although primary care providers may be aware of the impact of climate change on global health, most are not aware of its acute and sustained impacts in their local practice setting. Beyond being prepared to respond to extreme weather events through disaster preparedness and emergency response training, frontline providers should be attentive to the local impacts on patient health associated with climate change. The process of climate change and a discussion of specific health issues related to climate change and environmental justice that are relevant to primary care providers in the United States are briefly explained.

Climate Events and Natural Disasters

Increases in extreme climate and weather events and natural disasters, including hurricanes, tornadoes, coastal and inland flooding, droughts, and extreme temperature fluctuations, will have an impact on the health and movement of populations in the United States. In underserved communities, lack of adequate resources for evacuation and relocation place persons at increased risk from natural disasters. Case studies of communities after the occurrence of natural disasters suggest that lower socioeconomic status has a negative impact on a community's ability to prepare for, respond to, and recover from natural disasters.[8–11] Natural disasters often result in mass casualties with a spectrum of injuries and, unfortunately, significant mortality. The role of primary care providers in these events is centered around emergency preparedness and disaster response as well as advocating for climate mitigation and adaptation. Ensuring that primary care providers are aware of and promoting interventions that improve individual resilience, such as immunizing against vaccine-preventable illnesses, such as pneumonia, influenza, and tetanus; maintaining infection control in health care settings; and educating patients about nutrition and exercise as well as optimally managing chronic illnesses, is imperative to maximizing patient resilience.[12] Mitigation and adaptation are discussed later; however, emergency preparedness and disaster response are outside of the scope of this article. Primary care providers should avail themselves of training and information related to specific disaster risk and response relevant to their respective regions. Mental health impacts associated with such events are discussed later.

Extreme Temperatures

The American Meteorological Society declared 2014 the hottest year on record.[13] Extreme fluctuations in temperature, both increases in intensity of heat and duration

of heat waves, rapid shifts in hot and cold temperatures, and altered patterns of extreme cold are occurring globally and across the United States. Several studies have demonstrated that cold (for normal) and hot (for normal) ambient temperatures are associated with increased risk of mortality in regions across the globe.[14] Although both hot and cold temperatures seem associated with increased risk of mortality across regions, the impact associated with heat, termed *thermal injury*, is observed more rapidly and is typically shorter in duration (the isolated impact of heat on mortality), whereas cold temperatures seem to have a more delayed but longer-lasting impacts.[14]

In addition to impacts from hyperthermia and hypothermia, both of which are emergent conditions not managed in primary care, temperature extremes increase morbidity and mortality with respect to respiratory and cardiovascular systems. Extreme or unseasonably cold temperatures place persons at increased risk of death from cardiovascular disease and respiratory illnesses. Persons with chronic respiratory illnesses, such as asthma and chronic obstructive pulmonary disease (COPD), as well as cardiovascular and cerebrovascular diseases are observed to experience increased mortality in colder temperatures.[15–18] Extreme temperature fluctuations have been observed to increase cardiovascular mortality and morbidity and these impacts disproportionately affect the elderly, small children, people with low socioeconomic status, and those with comorbidities, such as diabetes, hypertension, and kidney disease.[19]

Outside of the direct impact of heat and cold stress on the body's thermoregulatory system, heat waves have been associated with increased exacerbations in cardiovascular disease, asthma, and COPD, and these increases seem related to the temperature itself as well as outdoor and indoor air pollution and humidity.[20] Primary care providers should be aware of the potential impacts of extreme temperature on patients with cardiovascular and respiratory illnesses so that they are able to rapidly optimize management strategies and assist patients in adapting to temperature changes. Educating patients about safety in extreme temperatures, air quality information, and warnings and how to react to them and communicating with local agencies to assist patients in obtaining housing or climate control devices are critical aspects of providing care for those at risk to climate and temperature-related stress.

Vector-Borne Illnesses

Changes in temperature, humidity, and seasonal weather and flooding patterns have broadened the geographic range and seasonal survivability of many vectors of disease. This increase in seasonal and geographic range of common vectors, combined with increased human population density in urban centers and increased human mobility, will broaden the distribution and increase the prevalence of vector-borne and waterborne illnesses. Human mobility and migration patterns due to extreme and insidious changes in climate, as well as conflict, will likely exacerbate this problem.

Warmer winters and changes in seasonal weather patterns will likely broaden the geographic range and encourage expansion of common vectors (in the United States, notably, rodents, ticks, and mosquitoes) to wider latitudes. Globally, malaria, dengue fever, diarrheal diseases, and cholera are on the rise and this increase is directly attributable to climate change.[5] Barriers to vaccinations and other primary care services as well as increased exposures due to inadequate housing and poor vector control in impoverished communities leave persons living in distressed regions of poverty in the United States, such as in communities of color in the Mississippi Delta, impoverished communities in Appalachia, and the urban poor, at increased risk from infections known as neglected infections of poverty.[21]

In the United States, primary care providers must be aware of the signs, symptoms, and most up-to-date transmission patterns and treatment guidelines for illnesses like leptospirosis, Lyme disease, mosquito-borne encephalitis, and hantavirus as the transmission patterns of these illnesses have been noted to increase with respect to the changing climate.[22] Data on the direct impact of climate change on tick and mosquito-related illness in the United States are limited, but modeling suggests that climate change may shift the onset of tick-related illnesses in the United States, expanding the season for tick-borne infections.[23] It is also expected that emerging and re-emerging infections, such as Zika virus, avian flu, malaria, West Nile virus, and others, will likely increase in prevalence and range, appearing in areas where primary care providers may not be familiar with presenting symptoms. In addition, primary care providers must respond rapidly to apparent changes in seasonal patterns of vector-borne illnesses and new cases of vector-borne illnesses by communicating with their local health departments as well as providing patients with education about prevention of these illnesses and the most up-to-date and evidence-based care and management of the illness once a patient is sick. Ensuring that patients are up to date with regular vaccination schedules will prevent the resurgence of vaccine-preventable illnesses.

Impacts on Mental Health

The impact of climate change on mental health is more difficult to assess and more insidious than the direct impact on physical health. The devastating effects of drought, flooding, and other natural disasters coupled with increased migration from conflicts and food shortages will likely have disturbing impacts on populations. Posttraumatic stress disorder, depression, and acculturation stress may result from the devastating impacts that climate change will have on individuals, families, communities, and even entire countries in cases of conflict, drought, or famine.[24] Survivors of floods and hurricanes have increased rates of stress-associated psychiatric disorders.[25–27] In the United states, unusually warm temperatures are associated with increases in mental health disorders, and exacerbations, such as mood and anxiety-related disorders, as well as dementia are increased in heat waves.[28] Heat waves are also associated with higher levels of community violence in low-income neighborhoods.[29] There is a strong association between climate change and collective violence. Increases in social instability and political unrest are associated with elevated temperatures and extreme precipitation.[30,31] It is highly likely that armed conflict will continue to increase with the destabilization of the global climate system.[32]

In addition to effects directly related to extreme weather events and heat, the economic and social consequences of climate change to individuals and entire industries (like agriculture) as well as the impact of increased social conflict have the potential for deleterious effects on the mental health of individuals and populations.[33–35] Climate change will likely have long-term impacts on seasonality, temperatures, and rainfall, thus having an impact on food security and the health of the agricultural industry.[36] The downstream impact of destabilization of broad-based food security systems globally will disproportionately have an impact on the poor and likely lead to malnutrition as well as increases in metabolic diseases from diminished nutrient density of food and food quality.[37] Additionally, economic distress diminishes patient access to primary care services, limiting their ability to manage chronic illnesses and placing them at increased risk for poor health outcomes. Primary care providers practicing in regions experiencing extreme heat and weather events, conflict, and/or community violence or practicing in regions where industries, such as agriculture, are significant sources of employment and income must be cognizant of the pressures felt by the

populations they serve. Conducting mental health evaluations and providing trauma-informed counseling for patients experiencing stress from climate-related events and assessing families for food security are critical roles for the primary care provider practicing in the age of climate change.

ADDRESSING HEALTH DISPARITIES RELATED TO CLIMATE CHANGE

The health effects of climate change will not be uniform across the globe. LMICs that already lack the basic infrastructure to meet the essential health care needs of its citizens, are likely to suffer to a greater extent from the impact of climate change than developed countries. These LMICs have little capacity to prevent and/or treat illnesses due to climate change. Ironically, LMICs are the least responsible for climate change, producing less than 10% of global greenhouse gas emissions.[38]

Certain groups in both LMICs and wealthier countries are more susceptible to adverse health effects from climate change. These susceptible groups include the poor, elderly, children, and patients with underlying chronic diseases. The poor have limited access to quality health care, are more likely to be malnourished, and are more likely to live in residences with poor indoor air quality, all factors that contribute to the greater burden of disease experienced by the poor in relation to climate change. The elderly are also at a greater risk of disease from climate change due to frail health and limited mobility, making them less likely to be able to evacuate in the case of a storm or any extreme weather event related to climate change.[39] Children often have developing immune, respiratory, and neurologic systems, making them more sensitive to the adverse health effects of climate change like extreme weather events, heat, and vector-borne diseases.[40,41] In addition to physiologic immaturity, which makes children living in poor countries vulnerable to the health-related consequences of climate change, their poor living conditions often compound health risks.[42] Children accounted for 88% of yearly deaths attributed to climate change in the early 2000s[43] and 99% of the children lived in LMICs.[44,45] In addition, climate change is thought to worsen the top causes of under–5-year-old child mortality, such as acute respiratory infection, diarrhea, malaria, malnutrition, and neonatal deaths.[38] Patients with underlying chronic diseases, such as COPD or asthma, often have impaired lung function that becomes even further impaired by the effects of climate change.[3] It is known that patients with asthma are particularly sensitive to changes in weather, with hot humid days increasing airway resistance of asthmatics.[3] Rapid rises in temperature and humidity have been associated with increased emergency department visits for asthma.[46] Also, exposure to ground-level ozone, production of which is catalyzed by warmer temperatures, has been found associated with increased emergency department visits and hospitalization due to asthma,[47–49] worse asthma control,[50] and reduced lung function.[51,52] Patients with COPD have been found to have more exacerbations, hospitalizations, and even increased all-cause mortality with exposure to heat.[53,54]

Additional Vulnerable Populations in the United States

Vulnerability to climate change may be increased by marginalized mental and/or physical health status, geographic location, or access to adaptation resources (resources that decrease vulnerability to the impacts of climate change). Although climate change will likely have an impact on persons living in low-resource settings globally, in the United States, several populations have been identified who are at increased risk for morbidity and mortality due to climate change and associated stress (in addition to those described previously): older adults (over age 65), children under age 5,

pregnant women, persons living with chronic physical and mental illness and/or addiction, the homeless, and people employed in industries requiring exposure to the outdoors. Additionally, specific geographic regions are at increased risk based on proximity to shorelines, coastal and inland waterways, weather patterns, and availability of natural resources, such as water.[55,56] Specific climate-associated risks related to these vulnerable groups are discussed later.

Regional risk depends on availability of resources, proximity to waterways and flood zones, and regional weather patterns. Climate change will have a disproportionate impact on vulnerable populations, but what traits make a community more vulnerable in the United States? Communities of color, indigenous peoples, those who are isolated geographically, and the poor are least able to respond and adapt to climate change. Currently in the Unites States, the southeastern region is at greatest risk from collective impacts of climate change.[57] The southeastern United States is susceptible to climate-related events, such as hurricanes and extreme weather, tornadoes, and also sea level rise along the coastal states. Heat waves and drought also disproportionately have an impact on the southeastern United States[58]; southern cities, such as Atlanta, Miami, New Orleans, and Tampa, reported increased deaths from extreme heat from 1975 to 2004 relative to an increase in days with temperatures at 95°F or greater.[59] Climate change in the southeastern region will have long-term impacts on water availability and associated stresses from water shortages.[60] Additionally, the southern United States has more people living in rural areas and more people working outdoors in agriculture, both at increased risk for health problems from climate change.[61]

Persons employed in industries, such as utilities, transportation, emergency response, health care, environmental remediation, construction or demolition, landscaping and agriculture, forestry and wildlife management, heavy manufacturing, and warehouse work, are at increased risk from extreme weather and temperature events due to the nature of their work and being exposed regularly to the outdoors.[62,63] Workers in these fields may have increased exposure to temperature variations and precipitation, injury due to extreme weather, and exposure to vector-borne illnesses and outdoor pollutants, including from forest fires and industries.

The homeless and the poor will be disproportionately impacted by climate change. Homeless persons typically have increased severity of chronic disease, specifically cardiovascular disease and respiratory illnesses, due to stress, lifestyle factors, and difficulties accessing health care and other resources. Additionally, the homeless disproportionately suffer from substance use and mental health disorders, giving them multiple risk factors for climate change vulnerabilities.[64–67] Homeless persons tend to congregate in urban areas and, due to their lack of shelter, are at increased risk from extreme temperatures and weather events, outdoor air pollution, and vector-borne illnesses, such as West Nile virus.[68]

ADAPTATION STRATEGIES

Considering that LMICs and susceptible groups are more vulnerable to the adverse health effects of climate change, policies promoting adaptation and mitigation strategies should be implemented. Adaptation refers to actions taken by individuals, communities, and governments to lessen or protect against the impacts of climate change. On the other hand, mitigation refers to actions taken by individuals, communities, and governments to reduce or eliminate greenhouse gas emission, thereby limiting the damage from future climate change. Adaptation strategies for adverse health effects of climate change include improving access to quality health care for vulnerable populations, improving disease surveillance, improving weather forecasting, advancing

emergency management, ensuring that health facilities are equipped to handle disasters, educating the public about climate change health impacts, development and dissemination of appropriate vaccines, ensuring food and water safety, and having a good vector control program.[38] Mitigation strategies for adverse health effects of climate change include using energy-efficient and renewable energy sources, reducing deforestation, reforestation, and development of greenhouse gas capture and greenhouse gas sequestration technologies.[33,69]

Aside from individual and community adaptation strategies for dealing with the effects of climate change, primary care providers and primary health systems must be prepared to respond to climate-related shifts in both the short term and long term. Great variability exists in the response and adaptation abilities of primary care systems across the globe.[70] Communities in the United States and abroad need functional adaptation assessments prior to climactic events to determine readiness to respond and react to climate change.[70,71] Knowing the significant impact of climate-associated changes on the health of individual patients and the larger impacts on community and population health, frontline care providers have a responsibility to advocate for climate mitigation policies to reduce greenhouse gas emissions and adaptation strategies aimed at preparing for anticipated impacts on the most vulnerable.[72] Several organizations, such as the International Society of Doctors for the Environment (http://www.isde.org/) and the Climate and Health Council (http://www.climateandhealth.org/), are currently engaged in linking primary care providers with climate change policy activism.

Educating Patients About Impact of Climate Change and Ways to Make a Difference

Because patient with underlying chronic diseases like COPD and asthma are more likely to be impacted by climate change, primary care providers have a vital role to

Table 1
Impact of climate change

Type	Effect
Health	1. Increasing burden of disease from malnutrition (as a result of drought and flooding)[41] 2. Increasing burden of disease from diarrheal diseases (as a result of drought and flooding)[41] 3. Increase mortality and morbidity from cardiovascular diseases and respiratory diseases (as a result of heat waves, fluctuations in weather, and air pollution) 4. Increasing burden of disease from vector-borne diseases (as a result of drought, flooding, and increased or decreased precipitation causing change in distribution of some disease vectors)
Shelter	1. Loss of coastal wetlands (as a result of flooding and storms),[41] which means people who live in coastal communities are less protected from adverse events, such as storms 2. Forced migration (as a result of flooding, drought, and hurricanes)
Food	1. Decline in crop yields and livestock productivity (as a result of drought and flooding) 2. Reduction in fish supply (as a result of warming of ocean bodies)
Water	1. Increased water stress, especially in arid and semiarid areas (as a result of drought)[44] 2. Decrease in availability of safe water (as a result of flooding, rise in sea level, and increase in water temperature, which can cause alga blooms and increase bacteria population in water)[44]

play in informing patients about the impact of climate change on their health. **Table 1** lists and discusses the direct health impacts of climate change.

People can make a difference in slowing climate change by adopting environmental-friendly practices. These include improving home energy efficiency by properly insulating homes; using energy-efficient appliances and recycling; using renewable energy sources when feasible, such as photovoltaic solar panels for electricity and compressed natural gas for automobiles; where possible, walking, cycling, using mass transit, or using energy-efficient cars; using a carbon footprint calculator, which is an online tool found on Web sites, such as the Environmental Protection Agency (https://www3.epa.gov/carbon-footprint-calculator/EPA), to estimate household carbon print to identify areas of improvement; and joining an advocacy group, such as Sierra Club, Greenpeace, or Citizens Climate Lobby, to provide opportunity to learn more about the impact of climate change and also be able to advocate for a change.[5,6,38]

SUMMARY

Primary care providers can act as critical advocates for the populations they serve by promoting climate change mitigation and adaptation strategies to optimize the health spans of patients. As frontline providers, primary care providers are critical informants for policymakers, public health researchers, and patients on the emerging health impacts of climate change. In addition to emergency preparedness in the face of increasing climate-related events, primary care providers must be aware of increased risks to marginalized patients related to both extreme weather and vector-borne illnesses and of mental health and environmental impacts on chronic disease management. By educating emerging health care providers as well as patients about this great threat to public health, primary care providers can increase the resilience of the patients they care for in the face of increasing pressure from climate-related changes.

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