CME MOC

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How does climate change impact our patients?

Physicians are increasingly aware of the health harms associated with climate change.[1–3] Both climate change and air pollution are driven by emission of greenhouse gases, including carbon dioxide, which trap heat in the atmosphere (**Figure 1**).[4,5] Although the resultant harms affect nearly every organ system,[6] gaps exist between the evidence of harm and clinical practices that address it. Patients may lack knowledge about the specific health impacts and risks of climate change, but they are receptive to learning more.[2] Indeed, government agencies and nonprofit health organizations make climate change and health information readily available to the public and encourage patients to ask their doctors about their own risks and how to avoid harm.[7]

One need not be a climate and health expert to empower patients to learn more and to work with them to protect their health. Clinicians at all levels of experience can integrate climate-related health information and counseling into their practices.[8] In this Commentary, we address 3 disease areas where climate influence on health is relevant to the clinical practice setting—cardiovascular, respiratory, and infectious disease—and offer important resources to share with patients (**Tables 1 and 2**).

CARDIOVASCULAR HEALTH AND CLIMATE

Heat is the leading weather-related killer in the United States and is implicated in deaths caused by cardiovascular disease,[9,10] and more than one-third of deaths worldwide are attributable to climate change.[11] With the increasing frequency and duration of heat waves,[12] more patients will experience cardiovascular morbidity. Further, despite physiologic adaptations intended to dissipate heat,[13] heat exposure places acute demands on the cardiovascular system that can lead to ischemia and heart failure, especially in patients with pre-existing cardiac conditions.[14]

Medication adjustments

Many common medications have the side effect of temperature dysregulation, and some medications contribute to dehydration during heat exposure (see sidebar, "**Climate change and patient care**"). For example, diuretics cause blood volume loss, antihypertensives lower blood pressure, and antidepressants can increase perspiration.[15] Other medications may reduce sweating and dysregulate thermoregulation, contributing to heat-related illness.[16]

Medication storage may be a concern. Exposure to heat and humidity decreases the effectiveness of some prescription and over-the-counter drugs.[17] Such concerns should be shared with the patient and a joint decision made regarding whether alternative medications are appropriate.

Avoiding and responding to heat-related illness

Any patient, including those with pre-existing cardiovascular disease, who exercises or works outdoors should be educated to recognize an impaired physiologic response to heat.[18,19] Heat-related illness presents on a spectrum that may range from muscle cramps to seizure, with muscle cramps being an early warning sign. Heat exhaustion is characterized by heavy sweating that progresses to headache, nausea, weakness, and dizziness. Heat stroke presents with altered mental status, loss of consciousness, and seizure.

Treatment of heat-related illness includes applying cold water or ice to the skin. Heat stroke, where there is a risk of multiorgan failure and death, requires cold water immersion and emergency medical care.[20]

Outdoor activity should be avoided during midday and early afternoon. The "urban heat-island effect" is a factor in locations where pavement and vehicular traffic are abundant, and outdoor activity should be avoided in

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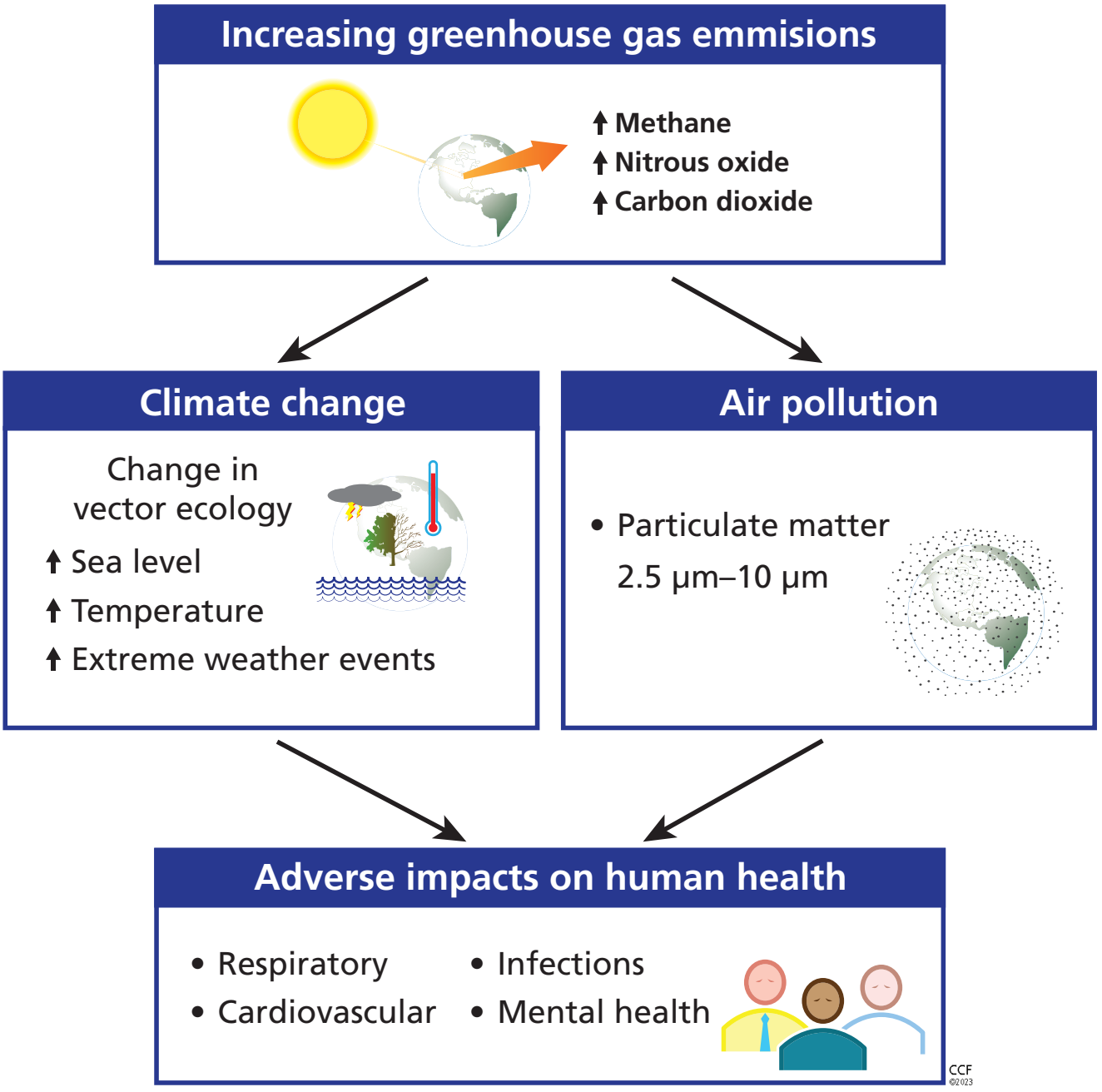

Figure 1. Greenhouse gas emissions are increasing, leading to climate change and air pollution, which both adversely impact human health.

those locations. Patients who must engage in outdoor activity on high-heat days should be encouraged to drink plenty of water before and during activity.

RESPIRATORY DISEASE AND AIR QUALITY

Asthma, chronic obstructive pulmonary disease, and allergies comprise a large proportion of primary care.[21] These can be exacerbated by heat, extreme weather events such as wildfires and flood, air pollution, and allergens—all of which are increasing due to climate change.[22]

Air quality basics

Polluted air consists of hundreds of interrelated substances that form mostly in association with indus-

TABLE 1
Climate influence on health: What patients can do

Disease area	Climate change consequences	Patient actions
Cardiovascular	Increased risk of heart attack, stroke, ischemic heart disease, heart failure	Avoid going out during midday heat
		Exercise early in the morning and in the shade
	Increased risk of heat-related illness during exercise	Be aware of signs of heat-related illness: eg, heart racing, nausea, headache, muscle cramping
Respiratory	Increased potency of allergic inflammatory response	Check air quality index on a weather app or bookmarked website
	Increased asthma and chronic obstructive pulmonary disease symptoms and exacerbations	Follow simple measures to improve indoor air quality, such as removing shoes and dusting
Infectious	Changing distribution of infectious disease-bearing vectors	Wear appropriate clothing to reduce skin and hair exposure
	Increased survival and breeding of disease-bearing vectors	Be aware of possible disease-bearing ticks and mosquitos in the area, use insect repellent, and check for ticks after being outdoors

TABLE 2
Climate change and health: Resources for patients

Cardiovascular disease
- US Department of Labor. Occupational Safety and Health Administration. Heat. https://www.osha.gov/heat-exposure
- Centers for Disease Control and Prevention. Natural Disasters and Severe Weather. Extreme heat. https://www.cdc.gov/disasters/extremeheat/index.html

Respiratory disease
- US Air Quality Index. AirNow. https://www.airnow.gov/
- American Lung Association. Clean Air. https://www.lung.org/clean-air

Infectious disease
- US Centers for Disease Control and Prevention. Climate effects on health: Diseases carried by vectors. https://www.cdc.gov/climateandhealth/effects/vectors.htm

trial and traffic-related emissions from burning fossil fuels. Ozone, derived from sunlight interacting with other air pollutants, is one of 6 common or "criteria" air pollutants,[23] while others are particulate matter, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide. Known as "smog" when present at ground level, ozone can potentiate oxidative stress, particularly when airways are inflamed, as in asthma and chronic obstructive pulmonary disease.[24] For individuals with allergies, exposure to ozone pollution can increase the potency of the allergic inflammatory response.[25]

Climate change aggravates these factors by altering the seasons so that allergen-producing plants have longer growth and flowering periods and therefore higher allergenicity.[26] Enhanced ozone formation is associated with high-heat days, and longer ozone seasons are associated with more prominent asthma symptoms[27,28] and a higher incidence of asthma in children who play outdoor sports.[29] The environmental impact may have direct effects on the bronchial epithelium, or the effects may be mediated by epigenetic mechanisms, interactions that set the stage for disease occurrence and increased severity of disease.[30]

Managing the response to air quality

Patients who have chronic respiratory disease can be reminded to check local outdoor air-quality conditions, including smog levels, and to limit outdoor activities (see sidebar, "**Climate change and patient care**").

Indoor air quality should not be overlooked when counseling patients, given the vast amount of time that many people spend indoors. Indoor air pollution levels may be 2 to 5 times greater than outdoor levels.[31,32] Exposure to indoor gas stoves is associated with increased risk of asthma and asthma symptoms in children, and gas stoves produce nitrogen dioxide, a criteria pollutant.[33]

Outdoor air pollution also influences indoor air quality. Infiltration occurs when the home "envelope" is not airtight, such as with suboptimal insulation. Natural ventilation occurs when windows and doors are open, and mechanical ventilation occurs when rooms or appliances are connected to the outdoors through ductwork.[31] To improve indoor air quality[34] and reduce respiratory disease exacerbations,[35] patients can be advised to do the following:

- Use an air purifier
- Close windows that face roadways
- Remove shoes at entryways
- Properly ventilate a gas stove or switch to an electric stove
- Evaluate chemicals used in home cleaning.

Medication adjustments

Alternative choices might be appropriate for patients who need prescription inhalers. Inhaled corticosteroids and dry-powder inhalers are better options than metered-dose inhalers. The propellants in metered-dose inhalers are themselves greenhouse gases.[36]

INFECTIOUS DISEASE

Global warming is expected to significantly impact the distribution of infectious diseases because of its effects on vectors (usually arthropods such as ticks and mosquitoes) or habitats and behaviors of animal hosts. The likely result will be unfamiliar vector-borne illnesses in previously unaffected locations.

In addition to climate change, factors that affect vectors and host animals include discontinuation of the use of dichloro-diphenyl-trichloroethane (DDT) in the 1960s, deforestation, and increasing travel and global trade.[37] It can be difficult to isolate the specific effects of climate change, but there is evidence that it will increase the spread of vector-borne illness.[38] For example, arthropods are cold-blooded creatures that survive better in warmer climates, and increased rain and water collection will increase their breeding sites.

Evolution of infection spread

Changes in ecosystems and sea level may drive migration of humans and animal hosts, introducing diseases into new areas.[39] The following are several examples:

- **Mosquito migration.** *Anopheles aegypti*, a mosquito, is the primary vector that spreads dengue virus, Zika virus, yellow fever, and Chikungunya. This mosquito prefers warm climates and is spreading from its traditional tropical habitat. *Anopheles albopictus* (tiger mosquito), also a vector for these diseases, can survive in colder climates and is found in North America and Europe.[40] A visitor infected with one of these diseases can introduce it into a nonendemic area, where it can then be spread by *A albopictus*, and a local outbreak can result.[41]
- **Changing Canadian weather.** The *Ixodes* tick in its nymphal stage is the vector for Lyme disease. Meteorologic variables such as heat and humidity affect tick activity, accounting for their spread into southern Canada.[42] The white-footed mouse, the primary reservoir host for *Borrelia burgdorferi*, is migrating into Canada in response to shorter, milder winters.[43]
- **Mosquito- and tick-borne spread.** West Nile virus infection was first reported in the United States in 1999 in the New York City area. Spread primarily by the *Culex* mosquito, it has now been reported in every US state.[44] Eastern equine encephalitis (mosquito-borne) and Powassan virus infection (tick-borne) are rare arthropod-transmitted infections. They are present in limited areas in North America but could spread over time, similar to West Nile virus.[45,46]

Similar presentations

Common to these infections are fever, rash, headache, joint pain, and neurologic symptoms. When encountering patients with these signs and symptoms, the differential diagnosis should include emerging infectious diseases (see sidebar, **"Climate change and patient care"**). Limited exposure to these diseases during clinical training and day-to-day practice underscores the need for vigilance and consideration when the clinical context is appropriate.

INCREASING PATIENT AWARENESS OF CLIMATE'S EFFECTS ON HEALTH

The increasing frequency and intensity of extremely hot weather, worsening air pollution, and changing

CLIMATE CHANGE AND PATIENT CARE

Scenario 1: Chronic lung disease and cardiac risk

An 86-year-old patient presents with worsening shortness of breath. An ex-smoker with a history of hypertension and hypothyroidism, the patient is afebrile and has new lower-extremity swelling. A chest radiograph shows findings consistent with emphysema, and thyroid-stimulating hormone and B-type natriuretic peptide levels are both mildly elevated. The management plan includes prescriptions for an inhaler and diuretic, and an adjusted thyroid medication dose.

Climate implications. You note that the outdoor temperature is 89°F with high humidity and poor air quality and, upon questioning, you learn that the patient has no air conditioning at home. The high temperature is a risk for a patient with pulmonary and cardiovascular disease. Further, certain medications can contribute to temperature dysregulation and be damaged by high temperature and humidity. Accordingly, you prescribe a dry-powder inhaler instead of a metered-dose inhaler and advise the patient regarding:

- Access to cooling centers
- Medication storage (eg, thyroid medication) in a space protected from heat
- The need to check the air quality index and ambient temperature before going outside
- Awareness of signs of heat stress.

Scenario 2: A young patient with possible infection

A 14-year-old presents with fever, headache, joint pain, and fatigue. A maculopapular "sunburn" type of rash is noted on the extremities. A COVID-19 test is negative. Being in a midwestern US state, you initially consider a limited differential diagnosis of influenza, Lyme disease, and West Nile virus. The patient's guardian mentions that no one else at home has been sick.

Climate implications. You ask whether the family has been affected by recent flooding in the area, and learn that they have been forced to spend more time outdoors while mold-mitigation was under way in the home due to flood damage. With this information, you consider the likelihood of an increase in the local mosquito population due to standing water and extend the differential diagnosis to include emerging mosquito-borne illnesses in the Midwest, such as eastern equine encephalitis, dengue virus, and Chikungunya. You advise the patient and their family regarding:

- Use of mosquito repellents
- Wearing clothing that covers the arms and legs when outdoors
- Removing sources of standing water outdoors.

vector habitats are some of the effects of climate change that will change the scope of cardiovascular, respiratory, and infectious disease. Awareness of risk factors associated with climate change will enhance our ability to provide effective care for patients with existing chronic illness and those with new onset of disease. Knowledge about the health effects of climate change will enhance our ability to consider the consequences of climate change in our differential diagnoses and gain confidence in counseling patients on mitigation of these harmful effects. Comprehensive patient health and well-being will benefit from our understanding of the effects of climate change on health.

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