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***Notes**: ACP President Dr. Wayne Riley is available for live interviews via satellite on Tuesday morning, April 19, from the National Press Club in Washington, DC. To book Dr. Riley for an interview, contact Sue Higgins (shiggins@dssimon.com or 212-736-2727) at DS Simon Media. The URL for the paper will be live when the embargo lifts. For an interview with Dr. Riley before April 19, contact Steve Majewski at smajewski@acponline.org or 215-351-2514. Earth Day is April 22.*

American College of Physicians issues urgent call to action on climate change to avert major threat to public health

Internists say climate change will have devastating health effects across the world

Philadelphia, April 19, 2016 -- Climate change will have devastating consequences for public and individual health unless aggressive, global action is taken now to curb greenhouse gas emissions, the American College of Physicians (ACP) says in a new policy paper published today in *Annals of Internal Medicine*.

"The American College of Physicians urges physicians to help combat climate change by advocating for effective climate change adaptation and mitigation policies, helping to advance a low-carbon health care sector, and by educating communities about potential health dangers posed by climate change," said ACP President Wayne J. Riley, MD, MPH, MBA, MACP. "We need to take action now to protect the health of our community's most vulnerable members -- including our children, our seniors, people with chronic illnesses, and the poor -- because our climate is already changing and people are already being harmed."

ACP cites higher rates of respiratory and heat-related illnesses, increased prevalence of diseases passed by insects, water-borne diseases, food and water insecurity and malnutrition, and behavioral health problems as potential health effects of climate change. The elderly, the sick, and the poor are especially vulnerable.

As clinicians, physicians have a role in combating climate change, especially as it relates to human health, ACP says. ACP calls on the health care sector to implement environmentally sustainable and energy efficient practices and prepare for the impacts of climate change to

ensure continued operations during periods of elevated patient demand. The health care sector is ranked second-highest in energy use, after the food industry, spending about $9 billion annually on energy costs.

Health care system mitigation focus areas include transportation, energy conservation/efficiency, alternative energy generation, green building design, waste disposal and management, reducing food waste, and water conservation.

“Office-based physicians and their staffs can also play a role by taking action to achieve energy and water efficiency, using renewable energy, expanding recycling programs, and using low-carbon or zero-carbon transportation,” Dr. Riley said.

ACP encourages physicians to become educated about climate change, its effect on human health, and how to respond to future challenges. ACP recommends that medical schools and continuing medical education providers incorporate climate change-related coursework into curricula.

“ACP has 18 international chapters that span the globe,” said Dr. Riley. “This paper was written not only to support advocacy for changes by the U.S. government to mitigate climate change, but to provide our international chapters and internal medicine colleagues with policies and analysis that they can use to advocate with their own governments, colleagues, and the public, and for them to advocate for changes to reduce their own health systems impact.”

The paper was developed by ACP’s Health and Public Policy Committee, which is charged with addressing issues that affect the health care of the U.S. The committee reviewed available studies, reports, and surveys on climate change and its relation to human health. The recommendations are based on reviewed literature and input from ACP's Board of Governors, Board of Regents, additional ACP councils, and nonmember experts in the field.

About the American College of Physicians

The American College of Physicians is the largest medical specialty organization and the second-largest physician group in the United States. ACP members include 143,000 internal medicine physicians (internists), related subspecialists, and medical students. Internal medicine physicians are specialists who apply scientific knowledge and clinical expertise to the diagnosis, treatment, and compassionate care of adults across the spectrum from health to complex illness. Follow ACP on Twitter and Facebook.

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Annals of Internal Medicine

POSITION PAPER

Climate Change and Health: A Position Paper of the American College of Physicians

Ryan A. Crowley, BSJ, for the Health and Public Policy Committee of the American College of Physicians

Climate change could have a devastating effect on human and environmental health. Potential effects of climate change on human health include higher rates of respiratory and heat-related illness, increased prevalence of vector-borne and waterborne diseases, food and water insecurity, and malnutrition. Persons who are elderly, sick, or poor are especially vulnerable to these potential consequences. Addressing climate change could have substantial benefits to human health. In this position paper, the American College of Physicians (ACP) recommends that physicians and the broader health care community throughout the world engage in environmentally sustainable practices that reduce carbon emissions; support efforts to mitigate and adapt to the effects of climate change; and educate the public, their colleagues, their community, and lawmakers about the health risks posed by climate change. Tackling climate change is an opportunity to dramatically improve human health and avert dire environmental outcomes, and ACP believes that physicians can play a role in achieving this goal.

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For author affiliation, see end of text.
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Climate change could pose a "catastrophic risk" to human health and undermine the global health gains achieved during the past half century (1, 2). The reality of climate change and our warming planet is unequivocal, and although there continues to be debate and dissenting views on whether climate change is largely the result of human activity, the American College of Physicians (ACP), on the basis of its review of the evidence as described in this paper, strongly concurs with the finding of the Intergovernmental Panel on Climate Change (IPCC), which has stated that "human influence on the climate system is clear" (2). The burning of fossil fuels, deforestation, other land-use changes, agriculture and food production, and power plant emissions all release carbon dioxide and other greenhouse gases into the atmosphere, trapping heat which then elevates global temperatures and causes other changes to the climate system (3). Possible direct and indirect health effects include higher rates of respiratory and heat-related illness, elevated prevalence of vector-borne diseases, increased food insecurity and malnutrition, and behavioral health problems. Although all nations will face the negative health effects of climate change, developing countries as well as vulnerable populations throughout the world—such as elderly persons, children, and persons with chronic illnesses—will be disproportionately affected.

Climate change is happening now, and its effects are expected to worsen over the next century. Anthropogenic (human-caused) greenhouse gas emissions must be substantially curbed to hold the global average temperature increase to "well below" 2 °C (3.6 °F) (and the more ambitious target of 1.5 °C [2.7 °F]) above preindustrial levels, as established in the Paris Agreement under the United Nations Framework Convention on Climate Change, which was adopted by the representatives of 195 nations in December 2015 (4). Efforts to adapt to a changing planet and mitigate future harmful emissions could bring about major health and environmental cobenefits.

A sense of urgency is warranted. Under one scenario, cumulative carbon dioxide emissions could cause the global average temperature to reach the threshold of 2 °C (3.6 °F) above preindustrial levels by 2045 (5). Although cautiously optimistic, the Lancet Commission on Health and Climate Change warns that "the effects of climate change are being felt today, and future projections represent an unacceptably high and potentially catastrophic risk to human health" (1). The ACP is concerned about the effect that climate change could have on individual persons and populations in the United States and throughout the world.

Although climate change poses a potentially major threat to human and environmental health, taking action to reduce greenhouse gas emissions could have major benefits to human health. For example, reducing motor vehicle use in favor of walking or cycling could yield carbon emission reductions and health improvements (6–8), and carbon pollution standards for power plants could have a positive effect on cardiovascular and respiratory health (9). Physicians and the wider

See also:

Editorial comment 1

* This position paper, written by Ryan A. Crowley, BSJ, was developed for the Health and Public Policy Committee of the American College of Physicians. Individuals who served on the Health and Public Policy Committee from initiation of the project until its approval and authored this position paper are Darilyn V. Moyer, MD (*Chair*); Douglas M. DeLong, MD (*Vice Chair*); Sue S. Bornstein, MD; James F. Bush, MD; Gregory A. Hood, MD; Carrie A. Horwitch, MD; Gregory C. Kane, MD; Robert M. Lohr, MD; Kenneth E. Olive, MD; Shakaib U. Rehman, MD; Micah Beachy, DO; Mitch Biermann, BS; and Fatima Syed, MD. Approved by the ACP Board of Regents on 16 February 2016.

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health care community have a major stake in addressing climate change, not only by treating patients experiencing its health effects but also by advocating for effective climate change adaptation and mitigation policies, educating the public about potential health dangers posed by climate change, pushing for a low-carbon health care sector, researching and implementing public health strategies, and adopting lifestyle changes that limit carbon emissions and may achieve better health. The issue of climate change is often positioned as a purely environmental, economic, or political one; however, climate change could have severe consequences for human health and physicians can play an important role in raising awareness.

In this position paper, the ACP explores the evidence on the health effects of climate change and offers recommendations on how physicians and the broader health care sector can take action to slow global warming and reduce the effects of climate change on patients and the planet. The **Appendix** (available at www.annals.org) contains the full position paper, including the expanded background and policy rationale.

METHODS

This policy paper was developed by the Health and Public Policy Committee of the ACP, which is charged with addressing issues that affect the health care of the U.S. public and the practice of internal medicine and its subspecialties. The committee reviewed available studies, reports, and surveys on climate change and its relation to human health from PubMed, Google Scholar, relevant news articles, policy documents, Web sites, and other sources. Recommendations were based on reviewed literature and input from the ACP's Board of Governors, Board of Regents, Council of Early Career Physicians, Council of Resident/Fellow Members, Council of Student Members, and Council of Subspecialty Societies, as well as nonmember experts in the field. The policy paper and related recommendations were reviewed and approved by the ACP Board of Regents in February 2016.

POLICY RECOMMENDATIONS

1. A global effort is required to reduce anthropogenic greenhouse emissions and address the health impact of climate change. The United States must commit to taking both a leadership and collaborative role in developing, implementing, and ensuring the success of such a global effort and in reducing its own contributions to greenhouse emissions. Climate change adaptation strategies must be established, and mitigation measures must be adopted.

2. The health care sector, within the United States and globally, must implement environmentally sustainable and energy-efficient practices and prepare for the impacts of climate change to ensure continued operations during periods of elevated patient demand.

3. Physicians, both individually and collectively, are encouraged to advocate for climate change adaptation and mitigation policies and communicate about the health cobenefits of addressing climate change in objective, simple language to their community and policymakers. For its part, the American College of Physicians is committed to working with its international chapters and with other professional membership and public health organizations within the United States and globally to pursue the policies recommended in this paper.

4. Physicians are encouraged to become educated about climate change, its effect on human health, and how to respond to future challenges. Medical schools and continuing medical education providers should incorporate climate change–related coursework into curricula.

5. Governments should commit to providing substantial and sufficient climate change research funding to understand, adapt to, and mitigate the human health effects of climate change.

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References

1. **Watts N, Adger WN, Agnolucci P, Blackstock J, Byass P, Cai W, et al.** Health and climate change: policy responses to protect public health. Lancet. 2015;386:1861-914. [PMID: 26111439] doi:10.1016/S0140-6736(15)60854-6

2. **Pachauri RK, Meyer LA; Core Writing Team, eds.** Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva: Intergovernmental Panel on Climate Change; 2015.

3. **U.S. National Academy of Sciences; Royal Society.** Climate Change: Evidence and Causes. Washington, DC: National Academies Pr; 2014. Accessed at http://nas-sites.org/americasclimatechoices/events/a-discussion-on-climate-change-evidence-and-causes on 3 September 2015.

4. **United Nations.** Adoption of the Paris Agreement. 12 December 2015. Accessed at http://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf on 11 January 2016.

5. **Levin K.** World's carbon budget to be spent in three decades. World Resources Institute. 27 September 2013. Accessed at www.wri.org/blog/2013/09/world%E2%80%99s-carbon-budget-be-spent-three-decades on 8 October 2015.

6. **Woodcock J, Edwards P, Tonne C, Armstrong BG, Ashiru O, Banister D, et al.** Public health benefits of strategies to reduce

rich4/zai-aim/zai-aim/zai00816/zai5806d16z | xppws | S=1 | 3/23/16 | 12:16 | Art: M15-2766

greenhouse-gas emissions: urban land transport. Lancet. 2009;374: 1930-43. [PMID: 19942277] doi:10.1016/S0140-6736(09)61714-1

7. **Frumkin H, Hess J, Luber G, Malilay J, McGeehin M.** Climate change: the public health response. Am J Public Health. 2008;98: 435-45. [PMID: 18235058] doi:10.2105/AJPH.2007.119362

8. **Maizlish N, Woodcock J, Co S, Ostro B, Fanai A, Fairley D.** Health cobenefits and transportation-related reductions in greenhouse gas emissions in the San Francisco Bay area. Am J Public Health. 2013;103:703-9. [PMID: 23409903] doi:10.2105/AJPH.2012.300939

9. **Schwartz J, Buonocore J, Levy J, Driscoll C, Lambert KF, Reid S.** Health Co-benefits of Carbon Standards for Existing Power Plants: Part 2 of the Co-Benefits of Carbon Standards Study. Boston: Harvard School of Public Health; 2014. Accessed at www.chgeharvard.org/sites/default/files/userfiles2/Health%20Co-Benefits%20of%20Carbon%20Standards.pdf on 7 January 2016.

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Appendix: Expanded Background and Rationale

The Reality of Climate Change

The U.S. Environmental Protection Agency (EPA) defines *climate change* as "any substantial change in measures of climate (such as temperatures or precipitation) lasting for an extended period (decades or longer). Climate change may result from natural factors and processes or from human activities" (10). An important driver of climate change is the increased accumulation of carbon dioxide and other greenhouse gases that trap heat in Earth's atmosphere, causing warming of the troposphere (the layer of the atmosphere closest to Earth).

There is broad consensus among climate scientists that Earth's climate is changing mainly as a result of human activity (11, 12). Ninety-seven percent of climate scientists agree that humans are largely causing global warming (13). Many respected scientific organizations have issued statements in support of the evidence on anthropogenic climate change, including the American Association for the Advancement of Science (14), the National Academy of Sciences (3, 15) and other international science academies (16), the American Chemical Society (17), and the American Meteorological Society (18). Many medical societies, including the American Academy of Pediatrics (19) and the American Medical Association (20), have expressed concern about climate change and called for swift and aggressive action. Religious leaders, including Pope Francis (21) and members of the International Islamic Climate Change Symposium (22), have cast addressing climate change as a moral issue.

Although the vast majority of scientists affirm that global warming is occurring, some question the degree to which greenhouse gases are responsible for climate change or whether mitigation policies would be effective or economically feasible (23). Climate change projections are based on observations and climate system modeling. Precise prediction of how much carbon will be emitted in the coming decades or how natural climate variations may affect temperature trends is difficult; however, the National Research Council states that "there are still some uncertainties, and there always will be in understanding a complex system like Earth's climate. Nevertheless, there is a strong, credible body of evidence, based on multiple lines of research, documenting that climate is changing and that these changes are in large part caused by human activities" (24).

Climate Change Indicators

The average surface air temperature of Earth has increased by 0.8 °C (1.4 °F) since 1880 (25). In the Northern Hemisphere, the period from 1983 to 2012 was likely the warmest 30-year period of the past 1400 years (2), and 2015 was Earth's hottest year on record (26). The current atmospheric carbon level is unprecedented in the past million years (3). Atmospheric concentrations of carbon dioxide hovered in the range of 170 to 300 parts per million for the past 800 000 years before the 20th century. In 2015, the global carbon dioxide concentration passed the 400–parts per million threshold for the first time in recorded history (27). Greenhouse gas emissions continue to increase: 2011 emissions exceeded 2005 rates by 43% (28). Under current global carbon emission trends (that is, without additional efforts to constrain emissions), the IPCC predicts that global average temperatures could increase by up to an additional 2.6 to 4.8 °C (4.7 to 8.6 °F) by the end of the 21st century (2, 3). However, if coordinated, aggressive mitigation efforts are made to reduce carbon emissions, the planet could warm by 0.3 to 1.7 °C (0.5 to 3.1 °F).

Climate change indicators are not limited to surface temperatures; several other indicators have been observed. First, Arctic and Antarctic sea ice and glacier mass have dwindled. The minimum extent of Arctic sea ice was at its smallest on record in September 2012 (10). According to the National Aeronautics and Space Administration, satellite data show that land ice sheets in Antarctica and Greenland have lost an estimated 420 billion metric tons of ice per year since 2002, totaling about 5 trillion metric tons in 13 years (29). Second, global sea levels increased by about 17 cm (6.7 in) over the past century (30), and according to the IPCC, "the rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia" (2). Sea level rise is the result of melting land ice and expansion of water as it absorbs radiant heat. Finally, oceans have warmed and become more acidic (28) due to absorption of carbon dioxide. Ocean heat affects surface temperature, sea levels, and currents.

The United States has experienced a higher number of extreme weather events. According to the EPA,

trends include increased frequency of abnormally high annual precipitation totals, higher occurrence of extreme temperature conditions, an increase in tropical cyclone activity in the past 20 years, and lower total snowfall and decreasing snowpack (10).

Climate change may affect different areas of the United States in different ways. The Third National Climate Assessment Report (31) outlines the following regional climate change effects:

- *Northeast*: From 1895 to 2011, temperatures in the region increased by nearly 1.1 °C (2 °F) and precipitation increased by more than 10%. The sea level in the Northeast has risen by more than 30.5 cm (12 in) since 1900, exceeding the global average of about 20.3 cm (8 in). The region has also seen a disproportionately high number of extreme precipitation events. Projected continued heat waves, heavy precipitation, and sea level rises may compromise the region's ecosystem, infrastructure, agriculture, and fisheries.
- *Southeast and the Caribbean*: The region has experienced an increased number of high-temperature days and fewer freezing events and a higher number of hurricanes and heavy precipitation events in recent decades. Projected outcomes include continued sea level rise, increasing temperatures, and reduced water availability. Such effects may compromise the region's seafood and energy industries and endanger such coastal cities as Miami, Florida; Charleston, South Carolina; and Virginia Beach, Virginia.
- *Midwest*: Projected effects of climate change in the region include more frequent and extreme heat waves, poorer water and air quality, and extreme rainfall events and flooding. The report notes that according to one study, Chicago, Illinois, is projected to see between 166 and 2217 excess deaths from heat wave–related mortality per year by 2081 to 2100.
- *Great Plains*: Temperatures in the region are projected to increase, causing an increased demand for water and energy. The number of days with high temperatures over 37.8 °C (100 °F) is forecasted to double in the northern part of the region and quadruple in the southern part. Potential effects include drought, heat stress, and heightened demand for air conditioning (and, with it, energy use).
- *Northwest*: The average regional temperature has increased by about 0.7 °C (1.3 °F) from 1895 to 2011. The average annual temperature is projected to increase by 1.8 to 5.4 °C (3.2 to 9.7 °F) by 2070 to 2099, with the largest increases expected in the summer. Increased snowmelt could alter the timing of streamflow and affect water supply and demand. Reduced snowmelt and higher temperatures may also enhance the risk for wildfires, leading to respiratory problems, stress from displacement, and other issues.
- *Alaska*: Alaska (and the surrounding Arctic region) is experiencing some of the most dramatic effects of climate change. Over the past 60 years, the state has "warmed more than twice as rapidly as the rest of the U.S., with average annual temperature increasing by 3 degrees F and average winter temperature by 6 degrees F, with substantial year-to-year and regional variability." Wildfires are more frequent as a result of thawing permafrost. Arctic summer sea ice and glaciers are receding. Residents of coastal villages have sought to relocate inland as a result of sea level rise and erosion.

The estimated climate change risks vary in different regions of the world. Representative key risks around the world, according to IPCC projections (2), are as follows:

Polar Regions (Arctic and Antarctica): Risks for ecosystems, human health and well-being, unprecedented challenges especially from rate of change.
Europe: Increased damage from river and coastal floods, increased water restrictions, increased damages from extreme heat events and wildfires.
Asia: Increased flood damage to infrastructure, livelihoods, and settlements; heat-related human mortality; increased drought-related water and food shortage.
Australasia: Increased flood damage to infrastructure and settlements, increased risks to coastal infrastructure and low-lying ecosystems.
Small Islands: Loss of livelihoods, settlements, infrastructure, ecosystems, services, and economic instability; risks for low-lying coastal areas.
Africa: Compounded stress on water resources, reduced crop productivity, vector- and water-borne diseases.
Central and South America: Reduced water availability and increased flooding and landslides; reduced food production and quality, spread of vector-borne diseases.

Effect of Climate Change on Human Health

In 2009, the Lancet and University College London Institute for Global Health Commission called climate change "the biggest global health threat of the 21st century" (32). The World Health Organization estimates that "climate change will cause an additional 250,000 deaths per year from 2030 to 2050," likely the result of malnourishment, malaria, diarrhea, and heat exposure related to climate change effects (33). All populations will be affected by climate change, but children, elderly persons, and those living in economically poor and developing nations will be disproportionately impacted. Patz and colleagues (34) outline the health effects of

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climate change, including heat-related disorders, respiratory disorders, infectious diseases, food security, and mental health. Of note, limitations exist in determining the relationship between climate change and health, which may require laboratory studies, observational data, and modeling studies rather than traditional experimental designs. Despite this, Patz and colleagues state, "given that evidence over the past 20 years suggests that climate change can be associated with adverse health outcomes, strategies to reduce climate change and avert the related adverse effects are necessary" (34). Such limitations underscore the need for additional research to better determine the relationship between climate change and health, which is discussed further in recommendation 5.

Heat-Related Disorders, Including Heat Stress

As the climate warms, more people could be susceptible to heat-related illness. Some sources predict that extreme heat events that currently happen every 20 years in the United States will occur about every other year by the end of the 21st century under a higher-emissions scenario (35). Residents of urban areas with impermeable, dry, paved surfaces are especially at risk due to the heat island effect that causes temperatures to be considerably higher than in outlying areas (36). Extreme heat is among the deadliest weather-related phenomena in the United States (37). Excessive heat exposure caused more than 7400 deaths in the United States from 1999 to 2010. In France, 6 heat waves occurring from 1971 to 2003 were associated with significant excess mortality, contributing to 13 700 deaths in 2003 alone (38). Across Europe, about 70 000 premature deaths were attributed to the 2003 heat wave (39). Heat-related health effects include rashes, cramps, heat exhaustion, and heat stroke. Heat exposure can exacerbate existing health problems as well. Cardiovascular and respiratory-related deaths also increase during heat waves (40). Elderly persons and children are especially prone to illness due to heat (41). Heat-related illness has economic consequences, decreasing the productivity of those who work outdoors.

Respiratory Disorders, Such as Asthma and Allergies

Climate change may already be having a troubling effect on respiratory health. In 2012, 7 million deaths were connected to the joint effects of outdoor ambient air pollution and household indoor air pollution, according to the World Health Organization (42). The pollen season has lengthened in central North America as temperatures have increased and the frost-free period has lengthened (43, 44). Elevated pollen production may be more prevalent in large cities and other densely populated areas, and increasing temperatures and shifting weather patterns may disperse pollen and spore-containing dust into new areas, thus introducing aeroallergens to new populations (45). Further, elevated carbon dioxide concentrations may facilitate the increased growth of allergen-producing weeds, grasses, trees, and fungi (46, 47). Experimental studies have shown that ragweed production increases as carbon dioxide concentrations and temperatures increase (48, 49). Heavy rainfall and flooding can cause dampness in homes, potentially leading to indoor mold and fungal growth, which is associated with such problems as nasal and throat symptoms, coughing, wheezing, and asthma exacerbation (50, 51). After Hurricanes Katrina and Rita, a report from the Centers for Disease Control and Prevention (CDC) and the Louisiana Department of Health and Hospitals found that 46% of inspected homes in the New Orleans, Louisiana, area had visible mold growth (52).

Ozone gas irritates and inflames the respiratory system and may be associated with increased mortality (53, 54). Evidence suggests that higher ozone concentrations can temporarily decrease lung function, are linked to respiratory-related emergency department and hospital visits and school absenteeism, and could increase the risk for premature death (55, 56). Because heat and light together cause a reaction that transforms carbon-based gases to ozone, asthma and breathing problems could be exacerbated as hotter days lead to increased ozone levels (57). It is estimated that by 2030, more areas could have background ozone concentrations of 60 parts per billion, the level at which symptoms are triggered in children with asthma and young healthy adults experience reduced lung function and airway inflammation (57, 58). Particulate matter exposure may also increase as a result of changing weather patterns induced by climate change. The threat of inhalation of smoke and related fine particulate matter may also increase as climate change leads to more frequent and intense wildfires. Smoke from forest fires and other landscape fires causes about 339 000 premature deaths globally per year (59). Particulate matter exposure may also increase due to drought, sandstorms, and desertification as well as coal-derived electricity needed to power air cooling systems (60).

Vector-borne and Waterborne Infectious Diseases

A warmer climate and changing rainfall patterns may also create hospitable environments for mosquitos, ticks, and other climate-sensitive vectors that spread such diseases as malaria, chikungunya (61, 62), and dengue fever. Although climate change is only one factor that may contribute to the spread of malaria, it has made some areas of Africa more suitable and others less suitable for transmission of the disease (63);

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however, malaria transmission may intensify in certain areas, including highland regions of Africa, due in part to climate and land-use changes (64, 65). Some models predict that climate change could be a factor in spreading Lyme disease into Canada (34, 66), and existing evidence shows that 5 vector-borne diseases (including dengue fever, malaria, and lymphatic filariasis) are now found in previously nonendemic hill and mountain regions of Nepal (67). The West Nile virus may be transmitted in drought areas when birds and other vectors seek water supplies used by humans. Waterborne diseases may also thrive in flooded regions as well as those where water is scarce. Cholera may develop and spread in drought-stricken areas where lack of water leads to poor sanitation (68). Water contamination may occur during floods as overwhelmed sewage systems and livestock waste enter the human water supply. In the United States, downscaled climate modeling projects a 50% to 120% increase in combined sewer overflow in the Great Lakes region by 2100 (69).

Food Security Problems and Water Scarcity

As the population grows and food demand increases, "climate change could result in an increase of 20% of people at risk of chronic hunger" (70). Changing precipitation patterns, variable carbon dioxide and ozone levels, and temperature extremes resulting from climate change may cause decreased food production and food quality in various parts of the world (71). Aquatic life could be endangered by warming oceans and higher carbon concentrations, and marine biodiversity may be compromised. Under some forecasts, rice, maize, and wheat crop yields may suffer in areas that do not implement adaptation plans; in high-elevation areas, yields may increase with the temperature (2). Higher temperatures and delayed fall frost could increase crop yields as land becomes more suitable for multiple-crop planting; however, these yield increases may be surpassed by climate change–connected crop losses by 2100 (72, 73).

Massive aquifers, such as the Ogallala in the midwestern United States, are drying up, and groundwater supplies are decreasing in southern Asia as farmers have irrigated their cropland (74, 75). Water scarcity may be accelerated as the climate changes and more regions experience drought. Climate and land-use change may also increase water shortages in some urban areas. One study estimated that about 100 million additional urban dwellers will experience perennial water shortages under climate change conditions (76). Climate change may also affect potable water access in coastal regions. Freshwater aquifers are vulnerable to encroaching saltwater as sea levels rise in places like the southeastern coast of the United States (77). Drought connected to climate change could lead to agricultural collapse and subsequent migration and strife; one study cites human interference with the climate system as a factor that exacerbated the Syrian drought in 2007 to 2010, which contributed to civil unrest in the country (78). Climate change may also limit access to groundwater sources in dry subtropical regions, potentially increasing competition for potable water.

Mental Health Disorders, Including Posttraumatic Stress Disorder and Depression Connected to Natural Disasters

Climate change may also exacerbate conflict and political instability and lead to displacement and other problems. Disasters caused by climate change may negatively affect mental health. Extreme weather events can cause stress that may result in a decline in mental health, and prolonged heat or cold events may cause chronic stress that exacerbates health issues (79). Reactions to traumatic events can range from insomnia and worry to posttraumatic stress disorder and depression (80). Mental health problems can occur due to displacement, relocation, and loss of property and personal finances in the aftermath of a disaster (81). Nearly half of surveyed New Orleans residents affected by Hurricane Katrina reported anxiety mood disorder, and a substantial number reported posttraumatic stress disorder (82). Drought periods in Australia led to increased distress among rural residents (83). The United Nations has identified prolonged drought, desertification, flash floods, and other climate change–intensified events as factors that caused displacement among refugees in the East and Horn of Africa (84). The U.S. military considers climate change to be a "threat multiplier," a factor that exacerbates existing problems, such as food insecurity, disease pandemics, and conflict over resources (85). The risk analysis firm Verisk Maplecroft states that climate change and food insecurity could "amplify" conflict and civil unrest in developing countries and predicts that Bangladesh, Haiti, Nigeria, India, Myanmar, and the Philippines are among the most vulnerable to risks associated with climate change (86).

Knowlton and colleagues estimated the lost lives and health costs associated with 6 climate change–related events in the United States: nationwide ozone air pollution from 2000 to 2002, the 2006 California heat wave, the 2004 Florida hurricane season, the West Nile virus outbreak in Louisiana in 2002, flooding of the Red River in North Dakota in 2009, and wildfires in southern California in 2003 (87). The events resulted in 1689 premature deaths, 8992 hospitalizations, 21 113 emergency department visits, and 734 398 outpatient visits. Estimated associated health costs totaled $14 billion.

According to surveys, many physicians believe they are already treating patients for illnesses that may be

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connected to climate change. A survey of American Thoracic Society members found that 77% of respondents believed that increases in the severity of chronic illness resulted from increased air pollution caused by climate change (88). In a survey of allergists in the American Academy of Allergy, Asthma, and Immunology, 63% indicated that their patients had increased allergic symptoms associated with climate change (89). A survey of members of the National Medical Association found that 61% of respondents indicated that their patients were already being harmed by climate change "a great deal" or "moderately" (90).

Recommendations

1. A global effort is required to reduce anthropogenic greenhouse emissions and address the health impact of climate change. The United States must commit to taking both a leadership and collaborative role in developing, implementing, and ensuring the success of such a global effort and in reducing its own contributions to greenhouse emissions. Climate change adaptation strategies must be established, and mitigation measures must be adopted.

The IPCC states that surface temperatures are projected to increase under all assessed emissions scenarios over the 21st century and that it is very likely that heat waves will be more frequent, extreme precipitation episodes will occur more often in certain areas, sea levels will rise, and oceans will warm and acidify. However, with a concerted effort to reduce greenhouse gas emissions, the likelihood of drastic consequences can be reduced. Adaptation in this context is "adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects" (91). Adaptation to climate change can reduce existing and near-term risks. The CDC has developed a public health–focused framework for climate change adaptation called Building Resilience Against Climate Effects (BRACE). The 5 steps of BRACE are 1) forecasting climate impacts and assessing vulnerabilities, 2) projecting the disease burden, 3) assessing public health interventions, 4) developing and implementing a climate and health adaptation plan, and 5) evaluating impact and improving quality of activities (92). For example, as the risk for Lyme disease grows, public health departments are working with health care professionals on how to respond to and report disease incidence. In Maine, public health officials are monitoring the threat of vector-borne disease as ticks and other pests find the warmer climate more hospitable (92). After the devastating 2003 heat wave, many European countries devised and implemented heat health warning systems that use meteorological forecasts to launch public health interventions to minimize heat-related health problems in a region or population. When extreme heat is forecasted, media announcements, telephone hotlines, cooling centers, alerts to hospital emergency departments, and other activities are initiated (93). In addition, although climate change may contribute to malaria transmission in some areas, public health and other interventions, such as poverty reduction, distribution of bed nets, and investment in the health care sector, can help to curb its spread (63, 94). Existing programs, such as the U.S. National Flood Insurance Program; federal, state, and professional engineering standards; and the U.S. Coastal Zone Management program, can be amended to consider and implement future climate change adaptation needs (91).

Unless greenhouse gas emissions are curbed, the effects of climate change may reach a threshold where adaptation will be ineffective. Many Arctic Alaskans are being forced to relocate inland as the rising sea encroaches on coastal villages and frequent storms erode the land (91). Long-term efforts must also be made to prevent further climate change–related harm. Climate change mitigation is the goal of "implementing policies to reduce greenhouse gas emissions and enhance sinks" (95). Mitigation strategies include more efficient use of energy and expanded use of carbon-neutral or low-carbon energy, improved carbon sinks (including reductions in deforestation and increases in reforestation), and lifestyle and behavioral changes (such as energy conservation and reduced energy demand). A carbon sink is anything that removes carbon dioxide or other greenhouse gases from the atmosphere. This includes natural sinks, such as trees, or artificial sinks, such as carbon sequestration technology that permanently diverts gas to underground stores. Policy experts have proposed a range of mitigation options, including increasing fuel-efficiency standards for automobiles and trucks, creating energy-efficiency standards for the built environment, establishing cap-and-trade approaches, and creating financial incentives or regulations related to land management (2, 31, 96). The health benefits resulting from climate change mitigation policies may at least partially offset the cost of such interventions in developed countries. According to the Organisation for Economic Co-operation and Development, collateral benefits from reducing local air pollution could range from "0.7% of [gross domestic product] in the European Union to 4.5% in China in 2050 under a 50% [greenhouse gas] emissions cut scenario" (97). The EPA estimates that the economic benefits to the United States of avoiding premature deaths related to air quality are estimated to be $160 billion in 2050 and $930 billion in 2100 (98).

Climate change mitigation policies will benefit public health as well as the environment. Cobenefits arising from greenhouse gas emission reduction policies include improved respiratory health from better air quality and reduced heart disease from walking and

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using other environmentally friendly active transportation (99). The Lancet Commission on Health and Climate Change recommends an accelerated phaseout of coal from the global energy mix over the next 5 years as a way to mitigate climate change and protect human respiratory and cardiovascular health (1). Promoting active transportation, such as walking and cycling, as well as urban green spaces and energy-efficient building strategies could also have substantial cobenefits to health and the environment (100). One study estimated that increasing safe active transport and use of lower-emission vehicles in London, England, could reduce heart disease burden by 10% to 19%, cerebrovascular disease burden by 10% to 18%, dementia by 7% to 8%, and depression by 4% to 6% (6). The benefits were even more pronounced for Delhi, India, including reduction of total ischemic heart disease burden by 11% to 25%. In developing countries, transitioning from inefficient cookstoves or open fires to low-emission, clean-burning cookstoves could reduce illness related to indoor air pollution exposure (99). The agricultural sector is a major source of global greenhouse gas emissions, such as methane from livestock (101). By reducing demand for greenhouse gas–intensive meat in high-income countries and shifting to healthier diets rich in legumes, fruits, and vegetables, environmental and health cobenefits could be realized (102, 103). Of note, climate change mitigation policies may carry their own health risks. For example, increased active transportation could increase the risk for accidents (99), and replacing food crops to grow biofuels could reduce the food supply or result in the clear-cutting of native ecosystems (104). Therefore, to ensure that climate change mitigation policies have a net health benefit, health impact assessments should be conducted.

Health cobenefits should be a prominent part of the climate change discussion. A 2009 statement released by the InterAcademy Medical Panel and signed by representatives of 34 of the world's academies of sciences, including the National Academy of Sciences, recommended that "Health Ministers and ministries should actively engage in promoting mitigation strategies that result in health co-benefits in their own country and should make the case for such strategies to their national climate change negotiators in advance of international meetings" (105).

In December 2015, the 195 nations of the United Nations Framework Convention on Climate Change adopted the Paris Agreement of the Conference of the Parties, in which they committed to taking the necessary actions to keep the global temperature increase to well below 2 °C (3.6 °F) above preindustrial levels and advocated for efforts to limit the temperature increase to 1.5 °C (2.7 °F). The agreement states that parties should promote and consider their respective obligations on "the right to health" when taking action to address climate change. In addition to the overall global temperature goal, the agreement includes a global emissions target, outlines climate financing obligations, and mandates a review of participating countries' plans every 5 years (4). The agreement will "enter into force after 55 countries that account for at least 55% of global emissions have deposited their instruments of ratification" (106). In 2013, the Obama administration released the Climate Action Plan, which established goals to reduce domestic carbon pollution, prepare the country for the effects of climate change, and position the United States to lead international efforts to combat climate change and prepare for its effects (107). As part of this effort, President Obama, EPA Administrator Gina McCarthy, and U.S. Surgeon General Vivek Murthy convened a summit with medical and public health professionals to discuss the effects of and potential solutions to problems arising from the health effects of climate change (108). Other related activities include a CDC guide to help public health departments assess local climate change risks (109) and the development of a National Integrated Heat Health Information System (110). In 2015, the federal government finalized the Clean Power Plan, which seeks to reduce power plant carbon emissions by 32% below 2005 levels by 2030. The EPA has touted the environmental and public health cobenefits of adopting the plan's standards, estimating the prevention of up to 3600 premature deaths, 90 000 asthma attacks, and 300 000 missed work and school days (111). Although these steps are important, addressing climate change will require a concerted effort by government; the business community; public health professionals; the health care, agricultural, and energy sectors; environmental stakeholders; and others throughout the global community.

Although outside the scope of this article, issues such as trade, financing, and job displacement will also need to be addressed as the world responds to climate change. Attention should be given to climate financing to provide financial resources necessary to assist developing countries in their efforts to adapt to and mitigate climate change. Developed nations have committed to providing funding to help developing countries transition from fossil fuel–dependent development and growth to a low-emission future. In 2014, the United States announced it would join 33 governments, including Germany, France, Denmark, Mexico, and Korea, to contribute to the United Nations Green Climate Fund, committing to providing $3 billion (112). However, as of June 2015, the United States and many other countries had yet to allocate money to the fund. Of the $10.2 billion pledged, only $6.8 billion in contributions had been signed (113). According to the Paris Agreement, "Governments decided that they will work to define a clear roadmap on ratcheting up climate finance to [$]100 billion by 2020 while also before 2025

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setting a new goal on the provision of finance from the [$]100 billion floor" (106). Beyond funding acquisition, questions remain about how best to use financing and how to effectively track and monitor climate finance, among many others (114).

Global trade issues are intertwined with climate change policies. Given the potential economic havoc that climate change could cause throughout the world, the World Trade Organization has identified agriculture, tourism, and trade infrastructure and routes as areas at the greatest risk for the effects of climate change. Although economic expansion resulting from liberalized trade could increase carbon emissions, it could also facilitate the distribution of carbon mitigation technologies (115). Other important considerations include the direct and indirect effect of mitigation policies on the labor market, such as mining in the coal-rich Appalachian region of the United States. Metrics to better understand the effect of mitigation policies on the labor market, efforts to track "green" job growth, and policies to alleviate job losses in industries affected by mitigation policies should be investigated (116).

2. The health care sector, within the United States and globally, must implement environmentally sustainable and energy-efficient practices and prepare for the impacts of climate change to ensure continued operations during periods of elevated patient demand.

The health care sector is ranked second in energy use after the food industry (117); it spends about $9 billion annually on energy costs (118, 119). Hospitals in the United States produce a massive amount of waste (>2.3 million tons per year) (120). The health care system (particularly hospitals) must adopt policies to reduce greenhouse gas emissions and prepare for the inevitable effects of climate change. By increasing energy efficiency and using renewable energy sources, the EPA estimates that 30% of the health care sector's energy use could be reduced without compromising care quality (121). Areas of focus for mitigation efforts in the health care system include transportation, energy conservation and efficiency, alternative energy generation, green building design, waste disposal and management, food service, and water conservation (122). The report *Addressing Climate Change in the Health Care Setting: Opportunities for Action*, published by Health Care Without Harm and Practice Greenhealth, recommends ways that the health care sector can reduce its carbon emissions in various areas (117). Recommendations include the following:

- Transportation: reduce fleet emissions, help commuters reduce emissions, choose suppliers with efficiency or alternate-fuel standards, prefer local suppliers, purchase energy-efficient shipping.
- Energy operations: make building operations more energy-efficient, install on-site renewable energy capability, purchase energy-efficient products, buy green power.
- Energy in the built environment: incorporate green building principles, consider overall transportation impacts of facility siting, use native vegetation and plant trees on site, use local and regional building materials, offset emissions from building construction, purchase only lumber products certified by the Forest Stewardship Council.
- Waste: recycle and buy recycled products, collect and recycle nitrous oxide anesthetic gases, dispose of waste locally, prevent waste, divert at least 90% of constructed waste.
- Food service: reduce the amount of meat protein on menus, buy local and seasonal food, procure organic food when possible, prevent waste in food services, compost food waste, eliminate bottled water.

Under the direction of its Sustainability Action Plan, the University of California San Francisco Medical Center has established an aggressive recycling and composting program, reduced its medical waste yield, and incorporated an energy-efficient and water conservation–focused design at its Mission Bay campus (123). Kaiser Permanente has reduced its purchasing and overall waste disposal costs by recycling and reusing single-use devices in accordance with federal regulations (124). Gundersen Health System has established a goal of complete energy independence (125). The system improved energy efficiency and decreased energy demand, leading to a 25% improvement in energy efficiency and more than $1 million in cost savings in 2009. Sustainability is improving in the global health care sector. The U.K. National Health Service has set a goal to decrease carbon dioxide equivalent emissions across building energy use, travel, and procurement by 34% by 2020, and in Germany, hospitals participating in the BUND energy-saving hospital project have saved 54 000 tons of carbon dioxide and reduced energy costs by €8.2 million per year (126).

Environmentally friendly activities are not limited to the hospital setting. The My Green Doctor Web site, a project supported by the Florida Medical Association, provides resources to physicians and their staffs on how to adopt environmentally sustainable policies in the physician practice. Project resources offer guidance on energy and water efficiency, use of renewable energy, recycling programs, proper disposal of medications and chemicals, transportation and commuting, and healthy foods (127). As employers, physicians may also be able to influence their staff to help limit greenhouse gas emissions. For example, physician offices may establish energy conservation and recycling programs and encourage colleagues to commute by walking, cycling, or public transit.

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The health care sector must also prepare for the inevitable consequences of climate change to ensure continued operations during extreme weather events and elevated patient demand. As climate change poses new challenges to health care sector infrastructure and continuity, strategies must be developed to monitor and react. The U.S. Department of Health and Human Services has released "Primary Protection: Enhancing Health Care Resilience for a Changing Climate," a best practices tool kit for health care facilities to assist them in developing climate resilience plans to maintain essential health care services (128).

3. Physicians, both individually and collectively, are encouraged to advocate for climate change adaptation and mitigation policies and communicate about the health cobenefits of addressing climate change in objective, simple language to their community and policymakers. For its part, the American College of Physicians is committed to working with its international chapters and with other professional membership and public health organizations within the United States and globally to pursue the policies recommended in this paper.

As trusted members of the community, physicians should advocate for policies to address climate change and its effects on human health. According to a 2014 Gallup poll, 56% of Americans believe that reports on the seriousness of global warming are either generally correct (23%) or generally underestimated (33%). Four in ten believe that global warming is greatly exaggerated, a substantial increase since 2008 (129). The Pew Research Center found that a majority of people in the United States believe global warming is a threat but do not consider it one of the top threats facing the country (130). In the United States, disagreement over the cause of climate change has become a political issue, stalling movement toward a climate change action plan. Elsewhere in the world, the idea that humans are largely the cause of climate change is widely accepted, with 93% in China, 84% in Argentina and Italy, and 80% in Turkey agreeing that "the climate change we are currently seeing is largely the result of human activity" (131). The same poll found that the United States had the lowest percentage responding affirmatively to the question, with 54% saying they agreed.

As clinicians, physicians have a role in combatting climate change, especially as it relates to human health. Physicians and other health care professionals are often viewed as trusted sources of information, including on environmental issues (88). The aforementioned survey of American Thoracic Society members found that 72% believed that physicians should inform the public about climate change, and 75% of physicians believe that medical societies should play an advocacy role (132). The survey of National Medical Association members found that 86% of respondents expressed that climate change was relevant to direct patient care, 88% stated that the United States should invest in efforts to protect people from the health effects of climate change, and 93% indicated support for efforts to reduce the potential effects of climate change (90). A strong majority agreed that "physicians have a responsibility to bring the health effects of climate change to the attention of their patients" and the public and believed that their medical societies should advocate for policies to address climate change and health.

On a broad policy level, U.S. physicians can work at the community, state, and federal level to advocate for efforts to reduce greenhouse gas emissions in the energy and transportation sectors and educate their legislators and policymakers about the health consequences of climate change. The health risks associated with climate change provide an opportunity for the global health community to band together and advocate for aggressive action. In 2011, health professional organizations, including the World Medical Association, convened in Durban, South Africa, and released the Durban Declaration on Climate and Health. The declaration calls on climate negotiators to create a binding agreement that, among other things, makes the protection of human health a primary objective, establishes a fair framework to reduce global emissions, fosters energy efficiency and clean renewable energy, and provides necessary resources to initiate the United Nations Green Climate Fund as well as long-term funding to provide for adaptation and mitigation measures necessary to address the health effects of climate change (133, 134).

A later document, signed by the World Medical Association, the Royal College of Physicians, and other groups, called for policies to ensure that the health effects of climate change are taken into account domestically and globally, investment in climate change mitigation and adaptation are significantly increased on a rapid time scale, and the health care sector is engaged and informed on climate action (135). The world's health professional societies must come together in one voice to educate their members, their leaders, and their nations' policymakers about the health threat posed by climate change and call for a strong response.

A climate change communication guide (136) suggests that public health officials use the following talking points:

- Climate change is real and human-caused.
- Climate change is bad for us and our community in a number of ways.
- We need to start taking action now to protect the health of our community's most vulnerable members—including our children, our seniors, people with chronic illnesses, and the

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poor—because our climate is already changing and people are already being harmed. [Our top priorities for protecting people's health from our changing climate are (list your organization's top three priorities here).]
- Taking action creates a "win-win" situation for us because, in addition to dealing with climate change, most of these actions will benefit our health too.

By objectively informing their patients and the public of the human health threat posed by climate change, physicians can help depoliticize the issue and encourage cooperation in the development of necessary adaptation and mitigation strategies.

The federal government should also develop and disseminate communication plans to assist state and local public health departments in their efforts to educate the public about health risks associated with climate change (137).

4. Physicians are encouraged to become educated about climate change, its effect on human health, and how to respond to future challenges. Medical schools and continuing medical education providers should incorporate climate change–related coursework into curricula.

The survey of National Medical Association members found that a substantial majority believed that continuing medical education (CME) and patient education resources would be helpful to increase their knowledge and better convey messages to patients about climate change and its health effects (90). Climate change–related coursework should be incorporated into medical school and CME coursework so that physicians can accurately articulate the immediacy of climate change and its potential effects on human health. The American Medical Association has hosted many CME courses on climate change (138) and has approved policy encouraging physicians to assist in educating patients and the public on environmentally sustainable practices (20). Physicians can also work with public health officials to develop and familiarize themselves with disaster preparation and response plans.

5. Governments should commit to providing substantial and sufficient climate change research funding to understand, adapt to, and mitigate the human health effects of climate change.

Since 1993, the U.S. federal government has invested billions of dollars in emissions-reducing technology, efforts to better understand climate change, and international assistance for developing countries (139). Many health-related federal agencies receive funding to study climate change and health. Priority should be given to providing such climate research funding to the EPA, the National Institutes of Health, the National Institute of Environmental Health Sciences, the CDC, the U.S. Department of Health and Human Services, and other related agencies. The fiscal year 2012–2017 strategic plan for the National Institute of Environmental Health Sciences charges the agency to "identify and respond to emerging environmental threats to human health, on both a local and global scale" (140), including better understanding of the health effects of climate change exposures. The National Institute of Environmental Health Sciences also seeks to provide research on human health effects related to climate change and adaptation, raise awareness and create new partnerships to advance key areas of health research and knowledge development on human health effects of climate change, and serve as an authoritative source of information on the human health effects of climate change, among other goals (141).

The U.S. Interagency Working Group on Climate Change and Health outlines the extensive research needs related to climate change and human health (142). Ongoing and adequate funding should be made available to carry out this agenda. Because climate change is a global issue, the United States should continue to fund international efforts to assess and address climate change throughout the world. From fiscal years 2001 to 2010, the United States provided a total of $31.1 million (in 2010 dollars) to the IPCC (143). In fiscal year 2015, the IPCC received $10 million from the United States. Similarly, the United States provides financial support to the World Health Organization. Because both entities are crucial to the effort to research and direct international efforts to understand the human health effects of climate change, the United States should continue to financially support their efforts and consider increasing its contributions to them.

Conclusion

There is broad consensus among climate scientists that the planet is warming, despite the continued public policy debate and the dissenting views of a relatively small number of persons in the scientific community. The ACP concurs with the scientific consensus, as supported by the evidence, that climate change is mostly the result of human activity and unless aggressive, concerted efforts are made to curb greenhouse gas emissions, irrevocable damage could be done, including negative effects on human health, such as elevated risk for cardiovascular and respiratory diseases, food and water insecurity, infectious disease, and compromised mental health.

Physicians, both collectively and individually, are encouraged to take action by adopting lifestyle changes that reduce environmental impact, increasing the environmental sustainability of their practice and the broader health system in which they work, educating the public on the potential effects and health con-

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sequences of climate change, and advocating for policies in their own countries and globally to reduce greenhouse gas emissions and address the health effects of climate change. The Lancet Commission on Health and Climate Change states that addressing climate change could be the greatest global health opportunity of this century. The medical profession—by being an objective and trusted source of information about the effect of climate change on health—must be at the fore of this opportunity to make Earth a sustainable home for future generations.

Web-Only References

10. **U.S. Environmental Protection Agency.** Climate Change Indicators in the United States, 2014. 3rd ed. EPA 430-R-14-004. Washington, DC: U.S. Environmental Protection Agency; 2014. Accessed at www.epa.gov/climatechange/pdfs/climateindicators-full-2014.pdf on 3 April 2015.

11. **Oreskes N.** Beyond the ivory tower. The scientific consensus on climate change. Science. 2004;306:1686. [PMID: 15576594]

12. **Anderegg WR, Prall JW, Harold J, Schneider SH.** Expert credibility in climate change. Proc Natl Acad Sci U S A. 2010;107:12107-9. [PMID: 20566872] doi:10.1073/pnas.1003187107

13. **Cook J, Nuccitelli D, Green SA, Richardson M, Winkler B, Painting R, et al.** Quantifying the consensus on anthropogenic global warming in the scientific literature. Environ Res Lett. 2013;8.

14. **American Association for the Advancement of Science.** AAAS Board Statement on Climate Change. 18 February 2007. Accessed at www.aaas.org/sites/default/files/migrate/uploads/aaas_climate_statement.pdf on 3 September 2015.

15. What we know about climate change and its interactions with people and ecosystems. In: America's Climate Choices: Panel on Advancing the Science of Climate Change; Board on Atmospheric Sciences and Climate; Division on Earth and Life Studies; National Research Council. Advancing the Science of Climate Change. Washington, DC: National Academies Pr; 2010. Accessed at www.nap.edu/catalog/12782/advancing-the-science-of-climate-change on 3 September 2015.

16. Joint science academies' statement: global response to climate change. 2005. Accessed at http://nationalacademies.org/onpi/06072005.pdf on 15 September 2015.

17. **American Chemical Society.** Global Climate Change. ACS Position Statement. Accessed at www.acs.org/content/acs/en/policy/publicpolicies/promote/globalclimatechange.html on 13 January 2016.

18. **American Meteorological Society.** Climate Change: An Information Statement of the American Meteorological Society. 20 August 2012. Accessed at www2.ametsoc.org/ams/index.cfm/about-ams/ams-statements/statements-of-the-ams-in-force/climate-change on 13 January 2016.

19. **Council on Environmental Health.** Global climate change and children's health. Pediatrics. 2015;136:992-7. [PMID: 26504130] doi:10.1542/peds.2015-3232

20. **American Medical Association.** H-135.938 Global Climate Change and Human Health. Chicago: American Medical Association. Accessed at www.ama-assn.org/ssl3/ecomm/PolicyFinderForm.pl?site=www.ama-assn.org&uri=/resources/html/PolicyFinder/policyfiles/HnE/H-135.938.HTM on 3 September 2015.

21. **Bergoglio JM.** Encyclical Letter Lautido Si of the Holy Father Francis on Care for Our Common Home. Vatican City: Vatican Pr; 2015. Accessed at http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html on 3 September 2015.

22. **International Islamic Climate Change Symposium.** Islamic Declaration on Global Climate Change. Istanbul, Turkey: International Islamic Climate Change Symposium; 2015. Accessed at http://islamicclimatedeclaration.org/islamic-declaration-on-global-climate-change on 3 September 2015.

23. **Schmidt CW.** A closer look at climate change skepticism. Environ Health Perspect. 2010;118:a536-40. [PMID: 21123146] doi:10.1289/ehp.118-a536

24. Summary. In: America's Climate Choices: Panel on Advancing the Science of Climate Change; Board on Atmospheric Sciences and Climate; Division on Earth and Life Studies. Advancing the Science of Climate Change. Washington, DC: National Academies Pr; 2010. Accessed at www.nap.edu/catalog/12782/advancing-the-science-of-climate-change on 13 January 2016.

25. **Carlowicz M.** World of Change: Global Temperatures 1995–2004. NASA Earth Observatory. Accessed at http://earthobservatory.nasa.gov/Features/WorldOfChange/decadaltemp.php on 13 January 2016.

26. **Brown D, McCarthy L.** NASA, NOAA Analyses Reveal Record-Shattering Global Warm Temperatures in 2015 [Press release]. 20 January 2016. Accessed at www.nasa.gov/press-release/nasa-noaa-analyses-reveal-record-shattering-global-warm-temperatures-in-2015 on 21 March 2015.

27. **National Oceanic and Atmospheric Administration.** Greenhouse Gas Benchmark Reached [Press release]. 6 May 2015. Accessed at http://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/11153/Greenhouse-gas-benchmark-reached-.aspx on 10 November 2015.

28. Summary for Policymakers. In: Stocker TF, Qin D, Plattner GK, Tignor M, Allen SK, Boschung J, et al, eds. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Cambridge Univ Pr; 2013.

29. **National Aeronautics and Space Administration.** Vital Signs: Land Ice. Washington, DC: National Aeronautics and Space Administration. Accessed at http://climate.nasa.gov/vital-signs/land-ice on 3 September 2015.

30. **National Aeronautics and Space Administration.** Climate Change: How Do We Know? Washington, DC: National Aeronautics and Space Administration. Accessed at http://climate.nasa.gov/evidence on 11 November 2015.

31. **U.S. Global Change Research Program.** National Climate Assessment, 2014. Accessed at http://nca2014.globalchange.gov on 3 September 2015.

32. **Costello A, Abbas M, Allen A, Ball S, Bell S, Bellamy R, et al.** Managing the health effects of climate change: Lancet and University College London Institute for Global Health Commission. Lancet. 2009;373:1693-733. [PMID: 19447250] doi:10.1016/S0140-6736(09)60935-1

33. **Neira M.** Climate Change: An Opportunity for Public Health. Geneva: World Health Organization; 2014. Accessed at www.who.int/mediacentre/commentaries/climate-change/en on 3 April 2015.

34. **Patz JA, Frumkin H, Holloway T, Vimont DJ, Haines A.** Climate change: challenges and opportunities for global health. JAMA. 2014;312:1565-80. [PMID: 25244362] doi:10.1001/jama.2014.13186

35. **Karl TR, Melillo JM, Peterson TC, eds.** Global Climate Change Impacts in the United States. New York: Cambridge Univ Pr; 2009. Accessed at http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf on 8 April 2015.

36. **U.S. Environmental Protection Agency.** Reducing Urban Heat Islands: Compendium of Strategies. Washington, DC: U.S. Environmental Protection Agency; 2008. Accessed at www2.epa.gov/heat-islands/heat-island-compendium on 15 September 2015.

37. **Centers for Disease Control and Prevention.** Extreme Heat Prevention Guide. Atlanta, GA: Centers for Disease Control and Prevention; 2015. Accessed at www.bt.cdc.gov/disasters/extremeheat/heat_guide.asp on 8 April 2015.

38. **Rey G, Jougla E, Fouillet A, Pavillon G, Bessemoulin P, Frayssinet P, et al.** The impact of major heat waves on all-cause and cause-specific mortality in France from 1971 to 2003. Int Arch Occup Environ Health. 2007;80:615-26. [PMID: 17468879]

39. **Dear K, Wang Z.** Climate and health: mortality attributable to heat and cold. Lancet. 2015;386:320-2. [PMID: 26003381] doi:10.1016/S0140-6736(15)60897-2

rich4/zai-aim/zai-aim/zai00816/zai5806d16z | xppws | S=1 | 3/23/16 | 12:16 | Art: M15-2766

40. **Luber G, McGeehin M.** Climate change and extreme heat events. Am J Prev Med. 2008;35:429-35. [PMID: 18929969] doi:10.1016/j.amepre.2008.08.021
41. **Blum LN, Bresolin LB, Williams MA.** From the AMA Council on Scientific Affairs. Heat-related illness during extreme weather emergencies. JAMA. 1998;279:1514. [PMID: 9605881]
42. **World Health Organization.** Burden of Disease from Household Air Pollution for 2012. Geneva: World Health Organization; 2014. Accessed at www.who.int/phe/health_topics/outdoorair/databases/FINAL_HAP_AAP_BoD_24March2014.pdf?ua=1 on 14 January 2016.
43. **U.S. Environmental Protection Agency.** Climate Change Indicators in the United States: Ragweed Pollen Season. Washington, DC: U.S. Environmental Protection Agency; 2014. Accessed at www3.epa.gov/climatechange/pdfs/print_ragweed-2014.pdf on 12 November 2015.
44. **Ziska L, Knowlton K, Rogers C, Dalan D, Tierney N, Elder MA, et al.** Recent warming by latitude associated with increased length of ragweed pollen season in central North America. Proc Natl Acad Sci U S A. 2011;108:4248-51. [PMID: 21368130] doi:10.1073/pnas.1014107108
45. **Reid CE, Gamble JL.** Aeroallergens, allergic disease, and climate change: impacts and adaptation. Ecohealth. 2009;6:458-70. [PMID: 19908096] doi:10.1007/s10393-009-0261-x
46. **U.S. Environmental Protection Agency.** A Review of the Impact of Climate Variability and Change on Aeroallergens and Their Associated Effects (Final Report). Washington, DC: U.S. Environmental Protection Agency; 2009. Accessed at http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=190306#Download on 10 September 2015.
47. **Rogers CA, Wayne PM, Macklin EA, Muilenberg ML, Wagner CJ, Epstein PR, et al.** Interaction of the onset of spring and elevated atmospheric CO_2 on ragweed (*Ambrosia artemisiifolia* L.) pollen production. Environ Health Perspect. 2006;114:865-9. [PMID: 16759986]
48. **Wan S, Yuan T, Bowdish S, Wallace L, Russell SD, Luo Y.** Response of an allergenic species, *Ambrosia psilostachya* (Asteraceae), to experimental warming and clipping: implications for public health. Am J Bot. 2002;89:1843-6. [PMID: 21665612] doi:10.3732/ajb.89.11.1843
49. **Singer BD, Ziska LH, Frenz DA, Gebhard DE, Straka JG.** Increasing Amb a 1 content in common ragweed (*Ambrosia artemisiifolia*) pollen as a function of rising atmospheric CO_2 concentration. Funct Plant Biol. 2005;32:667-70.
50. **Institute of Medicine.** Climate Change, the Indoor Environment, and Health. Washington, DC: National Academies Pr; 2011. Accessed at www.nap.edu/catalog/13115/climate-change-the-indoor-environment-and-health on 9 September 2015.
51. **Institute of Medicine.** Damp Indoor Spaces and Health. Washington, DC: National Academies Pr; 2004. Accessed at www.nap.edu/read/11011/chapter/1 on 12 March 2016.
52. **Centers for Disease Control and Prevention (CDC).** Health concerns associated with mold in water-damaged homes after Hurricanes Katrina and Rita–New Orleans area, Louisiana, October 2005. MMWR Morb Mortal Wkly Rep. 2006;55:41-4. [PMID: 16424858]
53. **U.S. Environmental Protection Agency.** Health Effects of Ozone in the General Population. Washington, DC: U.S. Environmental Protection Agency; 2016. Accessed at www.epa.gov/apti/ozonehealth/population.html on 8 April 2015.
54. **U.S. Environmental Protection Agency.** Policy Assessment for the Review of the Ozone National Ambient Air Quality Standards. Second External Review Draft. EPA-452/P-14-002. Washington, DC: U.S. Environmental Protection Agency; 2014. Accessed at www3.epa.gov/ttn/naaqs/standards/ozone/data/20140131pa.pdf on 8 January 2015.
55. **Kinney PL.** Climate change, air quality, and human health. Am J Prev Med. 2008;35:459-67. [PMID: 18929972] doi:10.1016/j.amepre.2008.08.025
56. **World Health Organization.** Air Quality Guidelines. Global Update 2005. Copenhagen: World Health Organization; 2006. Accessed at www.euro.who.int/__data/assets/pdf_file/0005/78638/E90038.pdf on 12 March 2016.
57. **Barne C, Alexis NE, Bernstein JA, Cohn JR, Demain JG, Horner E, et al.** Climate change and our environment: the effect on respiratory and allergic disease. J Allergy Clin Immunol Pract. 2013;1:137-41. [PMID: 23687635]
58. **Kim CS, Alexis NE, Rappold AG, Kehrl H, Hazucha MJ, Lay JC, et al.** Lung function and inflammatory responses in healthy young adults exposed to 0.06 ppm ozone for 6.6 hours. Am J Respir Crit Care Med. 2011;183:1215-21. [PMID: 21216881] doi:10.1164/rccm.201011-1813OC
59. **Johnston FH, Henderson SB, Chen Y, Randerson JT, Marlier M, Defries RS, et al.** Estimated global mortality attributable to smoke from landscape fires. Environ Health Perspect. 2012;120:695-701. [PMID: 22456494] doi:10.1289/ehp.1104422
60. **D'Amato G, Cecchi L, D'Amato M, Annesi-Maesano I.** Climate change and respiratory diseases. Eur Respir Rev. 2014;23:161-9. [PMID: 24881071] doi:10.1183/09059180.00001714
61. **Meason B, Paterson R.** Chikungunya, climate change, and human rights. Health Hum Rights. 2014;16:105-12. [PMID: 25474599]
62. **Fischer D, Thomas SM, Suk JE, Sudre B, Hess A, Tjaden NB, et al.** Climate change effects on Chikungunya transmission in Europe: geospatial analysis of vector's climatic suitability and virus' temperature requirements. Int J Health Geogr. 2013;12:51. [PMID: 24219507] doi:10.1186/1476-072X-12-51
63. **Campbell-Lendrum D, Manga L, Bagayoko M, Sommerfeld J.** Climate change and vector-borne diseases: what are the implications for public health research and policy? Philos Trans R Soc Lond B Biol Sci. 2015;370. [PMID: 25688013] doi:10.1098/rstb.2013.0552
64. **Ermert V, Fink AH, Morse AP, Paeth H.** The impact of regional climate change on malaria risk due to greenhouse forcing and land-use changes in tropical Africa. Environ Health Perspect. 2012;120:77-84. [PMID: 21900078] doi:10.1289/ehp.1103681
65. **Siraj AS, Santos-Vega M, Bouma MJ, Yadeta D, Ruiz Carrascal D, Pascual M.** Altitudinal changes in malaria incidence in highlands of Ethiopia and Colombia. Science. 2014;343:1154-8. [PMID: 24604201] doi:10.1126/science.1244325
66. **Ogden NH, Radojevic M, Wu X, Duvvuri VR, Leighton PA, Wu J.** Estimated effects of projected climate change on the basic reproductive number of the Lyme disease vector *Ixodes scapularis*. Environ Health Perspect. 2014;122:631-8. [PMID: 24627295] doi:10.1289/ehp.1307799
67. **Dhimal M, Ahrens B, Kuch U.** Climate change and spatiotemporal distributions of vector-borne diseases in Nepal–a systematic synthesis of literature. PLoS One. 2015;10:e0129869. [PMID: 26086887] doi:10.1371/journal.pone.0129869
68. **Shuman EK.** Global climate change and infectious diseases. N Engl J Med. 2010;362:1061-3. [PMID: 20335580] doi:10.1056/NEJMp0912931
69. **Patz JA, Vavrus SJ, Uejio CK, McLellan SL.** Climate change and waterborne disease risk in the Great Lakes region of the U.S. Am J Prev Med. 2008;35:451-8. [PMID: 18929971] doi:10.1016/j.amepre.2008.08.026
70. **The Partnership for Maternal, Newborn & Child Health.** PMNCH Knowledge Summary #19 Food Security and Climate Change. Geneva: The Partnership for Maternal, Newborn & Child Health; 2012. Accessed at www.who.int/pmnch/knowledge/publications/summaries/ks19/en on 9 April 2015.
71. **Intergovernmental Panel on Climate Change.** Climate Change 2014: Impacts, Adaptation, and Vulnerability. New York: Cambridge Univ Pr; 2014. Accessed at www.ipcc.ch/pdf/assessment-report/ar5/wg2/ar5_wgII_spm_en.pdf on 9 April 2015.
72. **Seifert CA, Lobell DB.** Response of double cropping suitability to climate change in the United States. Environ Res Lett. 2015;10. doi:10.1088/1748-9326/10/2/024002
73. **Stanford Woods Institute for the Environment.** Climate Change Impact on Agriculture: Implications for Food Security and Hunger. Stanford, CA: Stanford Woods Institute for the Environment; 2015. Accessed at https://woods.stanford.edu/sites/default/files/files/2015

rich4/zai-aim/zai-aim/zai00816/zai5806d16z | xppws | S=1 | 3/23/16 | 12:16 | Art: M15-2766

-07-09-LOBELL-CLIMATE-AG-ResearchBrief-FINAL_0.pdf on 13 November 2015.
74. **Hood GA.** Drinking Water: A Global Medical Crisis to Resolve Now. Medscape. 19 October 2015. Accessed at www.medscape.com/viewarticle/852510 on 4 November 2015.
75. **McKie R.** Why fresh water shortages will cause the next global crisis. The Guardian. 7 March 2015. Accessed at www.theguardian.com/environment/2015/mar/08/how-water-shortages-lead-food-crises-conflicts on 4 November 2015.
76. **McDonald RI, Green P, Balk D, Fekete BM, Revenga C, Todd M, et al.** Urban growth, climate change, and freshwater availability. Proc Natl Acad Sci U S A. 2011;108:6312-7. [PMID: 21444797] doi:10.1073/pnas.1011615108
77. **South Florida Water Management District Interdepartmental Climate Change Group.** Climate Change & Water Management in South Florida. West Palm Beach: South Florida Water Management District; 2009. Accessed at https://my.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/climate_change_and_water_management_in_sflorida_12nov2009.pdf on 4 November 2015.
78. **Kelley CP, Mohtadi S, Cane MA, Seager R, Kushnir Y.** Climate change in the Fertile Crescent and implications of the recent Syrian drought. Proc Natl Acad Sci U S A. 2015;112:3241-6. [PMID: 25733898] doi:10.1073/pnas.1421533112
79. **National Institute of Environmental Health Sciences.** Mental Health and Stress-Related Disorders. Research Triangle Park, NC: National Institute of Environmental Health Sciences; 2015. Accessed at www.niehs.nih.gov/research/programs/geh/climatechange/health_impacts/mental_health/index.cfm on 9 April 2015.
80. **Centers for Disease Control and Prevention.** Disaster Mental Health Primer: Key Principles, Issues and Questions. Atlanta, GA: Centers for Disease Control and Prevention; 2012. Accessed at http://emergency.cdc.gov/mentalhealth/primer.asp on 9 April 2015.
81. **Neria Y, Shultz JM.** Mental health effects of Hurricane Sandy: characteristics, potential aftermath, and response. JAMA. 2012;308:2571-2. [PMID: 23160987]
82. **Galea S, Brewin CR, Gruber M, Jones RT, King DW, King LA, et al.** Exposure to hurricane-related stressors and mental illness after Hurricane Katrina. Arch Gen Psychiatry. 2007;64:1427-34. [PMID: 18056551]
83. **OBrien LV, Berry HL, Coleman C, Hanigan IC.** Drought as a mental health exposure. Environ Res. 2014;131:181-7. [PMID: 24727641] doi:10.1016/j.envres.2014.03.014
84. **Afifi T, Govil R, Sakdapolrak P, Warner K.** Climate Change, Vulnerability and Human Mobility: Perspectives of Refugees from the East and Horn of Africa. Bonn, Germany: United Nations University Institute for Environment and Human Security; 2012. Accessed at www.unhcr.org/4fe8538d9.html on 10 September 2015.
85. **Banusiewicz JD.** Hagel to Address 'Threat Multiplier' of Climate Change. U.S. Department of Defense News. 13 October 2014. Accessed at www.defense.gov/News-Article-View/Article/603440 on 16 September 2015.
86. **Verisk Maplecroft.** Climate change and lack of food security multiply risks of conflict and civil unrest in 32 countries. 29 October 2014. Accessed at http://maplecroft.com/portfolio/new-analysis/2014/10/29/climate-change-and-lack-food-security-multiply-risks-conflict-and-civil-unrest-32-countries-maplecroft on 16 September 2015.
87. **Knowlton K, Rotkin-Ellman M, Geballe L, Max W, Solomon GM.** Six climate change-related events in the United States accounted for about $14 billion in lost lives and health costs. Health Aff (Millwood). 2011;30:2167-76. [PMID: 22068410] doi:10.1377/hlthaff.2011.0229
88. **Rice MB.** Climate change at the bedside? Observations from an ATS membership survey [Editorial]. Ann Am Thorac Soc. 2015;12:245-6. [PMID: 25706492] doi:10.1513/AnnalsATS.201412-590ED
89. **Sarfaty M, Kreslake JM, Casale TB, Maibach EW.** Views of AAAAI members on climate change and health. J Allergy Clin Immunol Pract. 2016;4:333-335.e26. [PMID: 26703816] doi:10.1016/j.jaip.2015.09.018
90. **Sarfaty M, Mitchell M, Bloodhart B, Maibach EW.** A survey of African American physicians on the health effects of climate change. Int J Environ Res Public Health. 2014;11:12473-85. [PMID: 25464138] doi:10.3390/ijerph111212473
91. **National Research Council.** Adapting to the Impacts of Climate Change. Washington, DC: National Academies Pr; 2012. Accessed at http://nas-sites.org/americasclimatechoices/sample-page/panel-reports/panel-on-adapting-to-the-impacts-of-climate-change on 15 April 2015.
92. **American Public Health Association.** Adaptation in Action: Grantee Success Stories from CDC's Climate and Health Program. Washington, DC: American Public Health Association; 2015. Accessed at www.cdc.gov/climateandhealth/pubs/adaptation-in-action.pdf on 15 April 2015.
93. **Kovats RS, Kristie LE.** Heatwaves and public health in Europe. Eur J Public Health. 2006;16:592-9. [PMID: 16644927]
94. **World Health Organization.** World Malaria Report 2014. Geneva: World Health Organization; 2014. Accessed at www.who.int/malaria/publications/world_malaria_report_2014/wmr-2014-no-profiles.pdf on 16 November 2015.
95. **Verbruggen A, Moomaw W, Nyboer J.** Annex I: Glossary, Acronyms, Chemical Symbols and Prefixes. In: Edenhofer O, Pichs-Madruga R, Sokona Y, Seyboth K, Matschoss P, Kadner S, et al, eds. IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. New York: Cambridge Univ Pr; 2011. Accessed at www.ipcc.ch/pdf/special-reports/srren/SRREN_Annex_Glossary.pdf on 15 April 2015.
96. **Environmental and Energy Study Institute.** Climate Change Mitigation/Reduction of Greenhouse Gas Emissions. Washington, DC: Environmental and Energy Study Institute. Accessed at www.eesi.org/policy/mitigation on 15 April 2015.
97. **Bollen J, Guay B, Jamet S, Corfee-Morlot J.** Co-benefits of Climate Change Mitigation Policies: Literature Review and New Results. Economics Department Working Papers no. 693. ECO/WKP(2009)34. Paris: Organisation for Economic Co-operation and Development; 14 April 2009. Accessed at www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=eco/wkp%282009%2934 on 11 September 2015.
98. **U.S. Environmental Protection Agency.** Climate Change in the United States. Benefits of Global Action. Washington, DC: U.S. Environmental Protection Agency; 2015. Accessed at www2.epa.gov/sites/production/files/2015-06/documents/cirareport.pdf on 11 September 2015.
99. **Haines A, McMichael AJ, Smith KR, Roberts I, Woodcock J, Markandya A, et al.** Public health benefits of strategies to reduce greenhouse-gas emissions: overview and implications for policy makers. Lancet. 2009;374:2104-14. [PMID: 19942281] doi:10.1016/S0140-6736(09)61759-1
100. **Younger M, Morrow-Almeida HR, Vindigni SM, Dannenberg AL.** The built environment, climate change, and health: opportunities for co-benefits. Am J Prev Med. 2008;35:517-26. [PMID: 18929978] doi:10.1016/j.amepre.2008.08.017
101. **U.S. Environmental Protection Agency.** Sources of Greenhouse Gas Emissions: Agriculture Sector Emissions. Washington, DC: U.S. Environmental Protection Agency. Accessed at www3.epa.gov/climatechange/ghgemissions/sources/agriculture.html on 11 January 2016.
102. **World Health Organization.** World Health Organization Conference on Health and Climate Change, 27–29 August 2014 [Conference report]. Geneva: World Health Organization; 2014. Accessed at www.who.int/globalchange/mediacentre/events/climate-health-conference/whoconferenceonhealthandclimatechangefinalreport.pdf on 15 January 2016.
103. **Friel S, Dangour AD, Garnett T, Lock K, Chalabi Z, Roberts I, et al.** Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture. Lancet. 2009;374:2016-25. [PMID: 19942280] doi:10.1016/S0140-6736(09)61753-0
104. **Tilman D, Socolow R, Foley JA, Hill J, Larson E, Lynd L, et al.** Energy. Beneficial biofuels–the food, energy, and environment trilemma. Science. 2009;325:270-1. [PMID: 19608900] doi:10.1126/science.1177970

rich4/zai-aim/zai-aim/zai00816/zai5806d16z | xppws | S=1 | 3/23/16 | 12:16 | Art: M15-2766

105. **InterAcademy Medical Panel.** Statement on the health co-benefits of policies to tackle climate change. Trieste, Italy: InterAcademy Medical Panel. Accessed at www.interacademies.net/File.aspx?id=14748 on 14 September 2015.

106. Historic Paris Agreement on Climate Change: 195 Nations Set Path to Keep Temperature Rise Well Below 2 Degrees Celsius. UN Climate Change Newsroom. 12 December 2015. Accessed at http://newsroom.unfccc.int/unfccc-newsroom/finale-cop21 on 15 January 2015.

107. **Executive Office of the President of the United States.** The President's Climate Action Plan. Washington, DC: Executive Office of the President of the United States; 2013. Accessed at www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf on 7 October 2015.

108. White House Blog. Your Health and Our Environment: How Can We Protect Both? 18 June 2015. Accessed at www.whitehouse.gov/blog/2015/06/18/public-health-climate-summit on 7 October 2015.

109. **Manangan AP, Uejio CK, Saha S, Schramm PJ, Marinucci GD, Brown CL, et al.** Assessing Health Vulnerability to Climate Change: A Guide for Health Departments. Climate and Health Technical Report Series. Atlanta, GA: Centers for Disease Control and Prevention; 2015. Accessed at www.cdc.gov/climateandhealth/pubs/AssessingHealthVulnerabilitytoClimateChange.pdf on 7 October 2015.

110. **The White House.** Progress Report: Highlighting Federal Actions Addressing the Recommendations of the State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience. Washington, DC: The White House; 2015. Accessed at www.whitehouse.gov/sites/default/files/docs/climate_preparedness_report_updated_070915.pdf on 7 October 2015.

111. **U.S. Environmental Protection Agency.** Fact Sheet: Overview of the Clean Power Plan. Washington, DC: U.S. Environmental Protection Agency; 2015. Accessed at www2.epa.gov/cleanpowerplan/fact-sheet-overview-clean-power-plan on 11 September 2015.

112. **The White House Office of the Press Secretary.** Fact Sheet: United States Support for Global Efforts to Combat Carbon Pollution and Build Resilience [Press release]. 15 November 2014. Accessed at www.whitehouse.gov/the-press-office/2014/11/15/fact-sheet-united-states-support-global-efforts-combat-carbon-pollution- on 7 October 2015.

113. **Green Climate Fund.** Pledge Tracker. Incheon, Korea: Green Climate Fund; 2015. Accessed at www.greenclimate.fund/contributions/pledge-tracker on 7 October 2015.

114. **Climate Policy Initiative.** The Global Landscape of Climate Finance. 2015. Accessed at www.climatefinancelandscape.org/#conclusions on 7 October 2015.

115. **Tamiotti L, Olhoff A, Teh R, Simmons B, Kulaçoğlu V, Abaza H.** Trade and Climate Change. A report by the United Nations Environment Programme and the World Trade Organization. 2009. Accessed at www.wto.org/english/res_e/publications_e/trade_climate_change_e.htm on 5 November 2015.

116. **Bowen A, Kuralbayeva K.** Looking for Green Jobs: The Impact of Green Growth on Employment [Policy brief]. March 2015. Accessed at www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/03/Looking-for-green-jobs_the-impact-of-green-growth-on-employment.pdf on 14 March 2016.

117. **Health Care Without Harm, Practice Greenhealth.** Addressing Climate Change in the Health Care Setting: Opportunities for Action. Accessed at https://practicegreenhealth.org/pubs/toolkit/reports/ClimateChange.pdf on 14 September 2015.

118. **U.S. Department of Energy.** Better Buildings Alliance: Healthcare. Washington, DC: U.S. Department of Energy. Accessed at www4.eere.energy.gov/alliance/sectors/private/healthcare on 11 January 2016.

119. **Rygielski L, Benz P.** Going Green While Improving Environment of Care. Sustainable Facility. March/April 2011. Accessed at http://digital.bnpmedia.com/article/Going+Green+While+Improving+Environment+Of+Care/691548/0/article.html on 11 January 2016.

120. **Kaiser Permanente.** Excerpts from Greening Healthcare: How Hospitals Can Heal the Planet. 12 August 2014. Accessed at http://share.kaiserpermanente.org/article/excerpts-from-greening-health-care-how-hospitals-can-heal-the-planet on 14 September 2015.

121. **Health Care Without Harm US.** Climate and Health. Reston, VA: Health Care Without Harm US. Accessed at https://noharm-uscanada.org/issues/us-canada/climate-and-health on 7 May 2015.

122. **World Health Organization.** Healthy Hospitals, Healthy Planet, Healthy People: Addressing Climate Change in Health Care Settings. Geneva: World Health Organization. Accessed at www.who.int/globalchange/publications/climatefootprint_report.pdf?ua=1 on 16 April 2015.

123. **UCSF Office of Sustainability.** Greening the Medical Center: UCSFMC's Second Sustainability Report. Fiscal Years 2013 and 2014. San Francisco: UCSF Office of Sustainability; 2015. Accessed at http://sustainability.ucsf.edu/greening_the_medical_center/mc_sustainability_report_fy12_14 on 16 April 2015.

124. **Peregrin T.** Strategies for sustainability: going green in the OR. Bull Am Coll Surg. 2015;100:10-7. [PMID: 26031118]

125. **Healthier Hospitals Initiative.** Gundersen Health System: Achieving Energy Efficiency and Cost Savings. 12 September 2003. Accessed at www.healthierhospitals.org/get-inspired/success-stories/gundersen-health-system-achieving-energy-efficiency-and-cost-savings on 15 September 2015.

126. **Health Care Without Harm Europe.** Climate & Energy Case Studies. Brussels, Belgium: Health Care Without Harm Europe. Accessed at https://noharm-europe.org/issues/europe/climate-change-and-health-case-studies on 7 October 2015.

127. My Green Doctor Web site. Accessed at Mygreendoctor.org on 14 March 2016.

128. **U.S. Department of Health and Human Services.** Primary Protection: Enhancing Health Care Resilience for a Changing Climate. Washington, DC: U.S. Department of Health and Human Services; 2014. Accessed at https://toolkit.climate.gov/topics/human-health/building-climate-resilience-health-sector on 15 September 2015.

129. **Dugan A.** Americans most likely to say global warming is exaggerated. Gallup. 17 March 2014. Accessed at www.gallup.com/poll/167960/americans-likely-say-global-warming-exaggerated.aspx on 7 May 2015.

130. **Motel S.** Polls show most Americans believe in climate change, but give it low priority. Pew Research Center. 23 September 2014. Accessed at www.pewresearch.org/fact-tank/2014/09/23/most-americans-believe-in-climate-change-but-give-it-low-priority on 7 May 2015.

131. **Ipsos Global Trends.** Global Trends 2014: Environment. Accessed at www.ipsosglobaltrends.com/environment.html on 7 October 2015.

132. **Sarfaty M, Bloodhart B, Ewart G, Thurston GD, Balmes JR, Guidotti TL, et al.** American Thoracic Society member survey on climate change and health. Ann Am Thorac Soc. 2015;12:274-8. [PMID: 25535822] doi:10.1513/AnnalsATS.201410-460BC

133. **Durban Declaration on Climate and Health.** 4 December 2011. Accessed at www.wma.net/en/20activities/30publichealth/30healthenvironment/Durban_Declaration_on_Climate_and_Health_Final.pdf on 7 October 2015.

134. **Health Care Without Harm.** Protecting Public Health From Climate Change: A Global Call to Action. Buenos Aires, Argentina: Health Care Without Harm; 2011. Accessed at https://noharm-global.org/content/global/protecting-public-health-climate-change-global-call-action on 7 October 2015.

135. **Global Climate and Health Alliance.** The Doha Declaration on Climate, Health and Wellbeing. 2012. Accessed at www.climateandhealthalliance.org/news/doha-declaration on 7 October 2015.

136. **Maibach E, Nisbet M, Weathers M.** Conveying the Human Implications of Climate Change: A Climate Change Communication Primer for Public Health Professionals. Fairfax, VA: George Mason University Center for Climate Change Communication; 2011. Accessed at http://publichealth.yale.edu/alumni/events/4C%20Communication%20Primer%20-%20Conveying%20the%20Human

rich4/zai-aim/zai-aim/zai00816/zai5806d16z | xppws | S=1 | 3/23/16 | 12:16 | Art: M15-2766

%20Implications%20of%20Climate%20Change_tcm223-86971_tcm223-1087-32.pdf on 7 May 2015.

137. **U.S. Government Accountability Office.** Climate Change: HHS Could Take Further Steps to Enhance Understanding of Public Health Risks. Washington, DC: U.S. Government Accountability Office; 2015. Accessed at www.gao.gov/assets/680/672913.pdf on 13 November 2015.

138. **Physicians for Social Responsibility.** Climate Change and Health. Washington, DC: Physicians for Social Responsibility; 2011. Accessed at www.psr.org/news-events/events/climate-change-and-health-1.html on 13 November 2015.

139. **U.S. Government Accountability Office.** Key Issues: Climate Change Funding and Management. Washington, DC: U.S. Government Accountability Office. Accessed at www.gao.gov/key_issues/climate_change_funding_management/issue_summary#t=0 on 7 May 2015.

140. **The White House.** Federal Climate Change Expenditures Report to Congress. Washington, DC: The White House; 2013. Accessed at www.whitehouse.gov/sites/default/files/omb/assets/legislative_reports/fcce-report-to-congress.pdf on 7 May 2015.

141. **National Institute of Environmental Health Sciences.** Climate Change and Human Health. Research Triangle Park, NC: National Institute of Environmental Health Sciences. Accessed at www.niehs.nih.gov/research/programs/geh/climatechange on 7 May 2015.

142. **Portier CJ, Thigpen Tart K, Carter SR, Dilworth CH, Grambsch AE, Gohlke J, et al.** A Human Health Perspective On Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change. Research Triangle Park, NC: Environmental Health Perspectives/National Institute of Environmental Health Sciences; 2010. doi:10.1289/ehp.1002272. Accessed at www.niehs.nih.gov/health/materials/a_human_health_perspective_on_climate_change_full_report_508.pdf on 14 March 2016.

143. **U.S. Government Accountability Office.** International Climate Change Assessments: Federal Agencies Should Improve Reporting and Oversight of U.S. Funding. Washington, DC: U.S. Government Accountability Office; 2011. Accessed at www.gao.gov/assets/590/587130.pdf on 8 May 2015.

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Annals of Internal Medicine

EDITORIAL

Addressing Air Quality and Health as a Strategy to Combat Climate Change

Poor air quality contributes to and is a consequence of global warming. The burning of fossil fuels to power our homes, businesses, and automobiles contributes to air pollution. When released into our atmosphere, some forms of pollution trap heat, leading to temperature elevation, and air pollution has direct effects on health, such as worsening cardiopulmonary disease (1). In this week's *Annals*, the American College of Physicians calls for action to combat climate change and its effects on health, including governmental action to reduce greenhouse gas emissions, health care sector implementation of environmentally sustainable and energy-efficient practices, physician advocacy for policies and practices that reduce emissions, and expanded education and research funding on climate change and its effects on health (2).

Combating climate change is a geopolitical issue involving the highest levels of government, with complex international negotiations and treaties. Can individual health care providers and institutions really do something meaningful?

We began asking ourselves this question not long ago. Because of Utah's mountainous geography, our region (the Wasatch Front) is subject to winter "temperature inversions," where the trapping of colder air below a warmer cap impedes atmospheric flow and results in the accumulation of air pollutants (**Figure**). Levels of particulate matter, nitrogen oxides, sulfur dioxide, carbon monoxide, and ground-level ozone increase, frequently exceeding the "safe level" designated by the U.S. Environmental Protection Agency, as reflected in an elevated Air Quality Index (>100). Winter inversions last an average of 14 days but can range from 1 to more than 30 days. In the summer, sunlight drives the creation of ground-level ozone from nitrogen oxides and volatile organic compounds; it is generally worse in hot, sunny weather and later in the day.

Ozone exposure results in airway inflammation and places patients with established respiratory disease at particularly high risk for harm. Particulate matter causes pulmonary and systemic inflammation and oxidative stress and is associated with adverse cardiovascular effects, including vascular and endothelial dysfunction, alterations in heart rate variability, coagulation, and cardiac autonomic function (3). Thus, changes in air quality are routinely palpable in our community. What could we do?

Mounting evidence linking poor air quality with adverse health outcomes, coupled with the distinctly visible effect of air pollution on our community, prompted our health care system to form the Intermountain Air Quality and Health Workgroup in 2014 to achieve 3 aims: support ongoing research to further our understanding of air pollution exposure and health outcomes, expand sustainability efforts to reduce Intermountain's environmental impact on the community, and address physician and patient education about outdoor air quality and health outcomes.

Figure. Inversion layer over Salt Lake City, Utah.

COLOR

Studies in the Wasatch Front community by members of our workgroup have further evaluated the effect of air pollution on cardiovascular outcomes in our patients; specifically, the likelihood of myocardial infarction and unstable angina increases by 4.5% for every 10-μg/m^3 increase in fine particulate matter level. Of note, this risk was primarily identified among patients with existing coronary artery disease (4). The occurrence of ST-segment elevation myocardial infarction and decompensated heart failure requiring hospitalization also seems to be increased in association with increasing fine particulate matter levels in our community (5, 6).

The second prong of our system's efforts, aimed at addressing climate change and air quality, began with a charge from our chief executive officer: We must limit our own health system's effect on our environment. In response, Intermountain is transitioning its automobile fleet from gasoline to natural gas, hybrid, and electric. Driver tracking devices on fleet vehicles have reduced idling by more than 500 hours per year. Employee use of public transportation has contributed to a reduction in emissions of 3.5 million pounds. The addition of rooftop solar panels has saved an additional 45 tons of carbon. In addition, Intermountain set a goal for all new facilities to achieve Leadership in Energy and Environmental Design Silver certification and be Energy Star–certified. The Office of Sustainability also addresses

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medical waste, water quality, and water conservation—all areas of concern for the local community (7).

What can we teach individual physicians about air quality that can be used to protect individual patients? Educating our physicians and patients about our community's air quality and the actions that might help maintain good health has involved a multidisciplinary team of physicians, researchers, administrators, and writers working together to develop the Outdoor Air Quality and Health care process model (CPM) (https://intermountainphysician.org/_layouts/Custom/KnowledgeRepository/KrDocumentFetch.aspx?target=document&ncid=527926681&tfrm=default). The CPM provides evidence-based guidelines on the health effects of air quality and is primarily intended to help providers counsel patients about outdoor physical activity when air quality is poor. It is based on guidelines from the U.S. Environmental Protection Agency, current research on air quality and health, and advice from Intermountain experts. Included are an overview of common air pollutants, the health effects of poor air quality, and specific patient counseling recommendations. The CPM includes patient fact sheets for many conditions (https://intermountainhealthcare.org/health-information/health-library/patient-handouts/search-results/?SearchTerm=air%20quality) that are intended for distribution to patients at the point of care or community members accessing our patient education Web site. For example, a physician seeing a child with asthma could review the CPM to learn that even short-term exposure to air pollution is associated with disease exacerbation. If the Air Quality Index enters the moderate zone (51 to 100), the recommendation is to limit outdoor play time (or to play indoors if the child is symptomatic) and consider keeping a fast-acting inhaler nearby. If the Air Quality Index tops 100, the recommendation is to play indoors.

Our research efforts, our initiatives to reduce our own carbon footprint, and the educational tools and programs represent the practical actions that one health care system—and the people within it—can take to address climate change and poor air quality. Success has been possible due to the support and encouragement from our highest level of leadership, a passionate and committed Air Quality and Health committee, and deliberate collaboration and alignment with community partners. Future efforts will focus on dissemination of patient and provider educational materials along with adoption and implementation of the CPM and fact sheets across the continuum of care. Finally, we hope that efforts focused on energy conservation will serve as an example to other businesses in our local community and in the broader health care community to reduce the effect of health care on the environment while adapting to the challenges of climate change.

Combating climate change requires initiatives beyond the control of individual health care systems, clinicians, and patients, but we, as health care systems, clinicians, and patients, can bring about meaningful change if we act locally.

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References

1. **Centers for Disease Control and Prevention.** Air Quality. Atlanta, GA: Centers for Disease Control and Prevention; 2014. Accessed at www.cdc.gov/air/air_health.htm on 19 February 2016.
2. **Crowley RA; Health and Public Policy Committee of the American College of Physicians.** Climate change and health: a position paper of the American College of Physicians. Ann Intern Med. 2016. [Epub ahead of print]. doi:10.7326/M15-2766
3. **World Health Organization Regional Office for Europe.** Review of evidence on health aspects of air pollution–REVIHAAP project: final technical report. Copenhagen: World Health Organization Regional Office for Europe; 2013.
4. **Pope CA 3rd, Muhlestein JB, May HT, Renlund DG, Anderson JL, Horne BD.** Ischemic heart disease events triggered by short-term exposure to fine particulate air pollution. Circulation. 2006;114:2443-8. [PMID: 17101851]
5. **Pope CA, Muhlestein JB, Anderson JL, Cannon JB, Hales NM, Meredith KG, et al.** Short-term exposure to fine particulate matter air pollution is preferentially associated with the risk of ST-segment elevation acute coronary events. J Am Heart Assoc. 2015;4. [PMID: 26645834] doi:10.1161/JAHA.115.002506
6. **Pope CA 3rd, Renlund DG, Kfoury AG, May HT, Horne BD.** Relation of heart failure hospitalization to exposure to fine particulate air pollution. Am J Cardiol. 2008;102:1230-4. [PMID: 18940298] doi:10.1016/j.amjcard.2008.06.044
7. **Intermountain Healthcare.** Intermountain Healthcare Sustainability Annual Report 2014. Salt Lake City, UT: Intermountain Healthcare; 2015. Accessed at https://intermountainhealthcare.org/annual-report/pdf/sustainability-annual-report-2014.pdf on 29 February 2016.

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