



# Global Climate Change and Children's Health

COUNCIL ON ENVIRONMENTAL HEALTH

## abstract

Rising global temperatures are causing major physical, chemical, and ecological changes in the planet. There is wide consensus among scientific organizations and climatologists that these broad effects, known as “climate change,” are the result of contemporary human activity. Climate change poses threats to human health, safety, and security, and children are uniquely vulnerable to these threats. The effects of climate change on child health include: physical and psychological sequelae of weather disasters; increased heat stress; decreased air quality; altered disease patterns of some climate-sensitive infections; and food, water, and nutrient insecurity in vulnerable regions. The social foundations of children's mental and physical health are threatened by the specter of far-reaching effects of unchecked climate change, including community and global instability, mass migrations, and increased conflict. Given this knowledge, failure to take prompt, substantive action would be an act of injustice to all children. A paradigm shift in production and consumption of energy is both a necessity and an opportunity for major innovation, job creation, and significant, immediate associated health benefits. Pediatricians have a uniquely valuable role to play in the societal response to this global challenge.

FREE

*This document is copyrighted and is property of the American Academy of Pediatrics and its Board of Directors. All authors have filed conflict of interest statements with the American Academy of Pediatrics. Any conflicts have been resolved through a process approved by the Board of Directors. The American Academy of Pediatrics has neither solicited nor accepted any commercial involvement in the development of the content of this publication.*

*Policy statements from the American Academy of Pediatrics benefit from expertise and resources of liaisons and internal (American Academy of Pediatrics) and external reviewers. However, policy statements from the American Academy of Pediatrics may not reflect the views of the liaisons or the organizations or government agencies that they represent.*

*The guidance in this statement does not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.*

*All policy statements from the American Academy of Pediatrics automatically expire 5 years after publication unless reaffirmed, revised, or retired at or before that time.*

[www.pediatrics.org/cgi/doi/10.1542/peds.2015-3232](http://www.pediatrics.org/cgi/doi/10.1542/peds.2015-3232)

DOI: 10.1542/peds.2015-3232

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2015 by the American Academy of Pediatrics

## INTRODUCTION

It is clear from observations across a range of indicators that many fundamental measures of climate are changing. These broad changes, known as “climate change,” threaten the biological systems on which the life, health, and prosperity of all children depend. On the basis of well-established evidence from the past 20 years, there is now wide consensus among scientific organizations and approximately 97% of climatologists that human-generated greenhouse gas emissions are the cause of climate change.<sup>1–4</sup> Although the effects of climate change are already being felt across the world, the magnitude of the effects of future changes depends on our ability to substantially reduce greenhouse gas emissions and implement adaptation strategies within the ensuing decades.<sup>5</sup> Thus, it remains possible to protect children, families, and communities from the worst potential effects of climate change.

Warming of the planet is unequivocal. According to the Intergovernmental Panel on Climate Change,<sup>6</sup> each of the last 3 decades has been successively warmer than any preceding decade since 1850. The globally averaged temperature (combined land and ocean surface) increased approximately 1°C between 1850 and 2012. This warming is associated with a range of climactic changes that have been observed by scientists worldwide.

Over the last 20 years, there has been a worldwide shrinkage of glaciers, decreasing mass of the Greenland and Antarctic ice sheets, and diminished spring snow cover in the Northern Hemisphere.<sup>6</sup> Since recordkeeping began in 1880, the global sea level has risen approximately 8 inches because of melting of glaciers and thermal expansion of warmer water. Heat waves have become more frequent and or/prolonged in many regions, and the number of extreme cold waves in the United States is the lowest since recordkeeping began.<sup>7</sup>

Warmer air can hold more moisture than cooler air, which has contributed to an increase in heavy precipitation events in many regions. Conversely, drier regions, including the southwestern United States, have experienced drought. This outcome is consistent with projections that, with climate change, wet regions will become wetter and dry regions will become drier.<sup>7</sup> The intensity, duration, and frequency of North Atlantic hurricanes have increased, although causality remains uncertain. Wildfires have also increased in frequency, duration, and severity in North American forests.<sup>8</sup>

The heat-trapping nature of carbon dioxide (CO<sub>2</sub>) and other greenhouse gases has been recognized since the 1800s<sup>9</sup> and is easily demonstrated with simple experiments. Human activities (primarily, fossil fuel emissions; secondarily, land use changes such as deforestation<sup>6</sup>) have caused a rapid increase in the atmospheric concentration of greenhouse gases.

Atmospheric CO<sub>2</sub> has increased from approximately 280 ppm before the Industrial Revolution to 400 ppm in April 2013, a level last reached about 3 million years ago.<sup>10</sup> Our nation's leading scientific organizations conclude that the observed temperature increase of the past century can only be explained by this change in greenhouse gas concentrations and not by the combined effects of natural drivers that have altered the earth's climate in the past.<sup>1</sup>

Climate change is already occurring, and past and present emissions make some continued changes inevitable. However, the most severe effects may still be prevented if greenhouse gas emissions are substantially reduced by 2030.<sup>5</sup> Mid–21st century projected levels of global warming, sea ice shrinkage, and sea level rise vary greatly for different greenhouse gas emission scenarios. Higher emission levels will result in more warming and, thus, more severe effects on the natural world and human society.<sup>7</sup>

Although uncertainties remain regarding risks and appropriate policy response, failure to take prompt, substantive action—given our current knowledge—would be an act of injustice to all children.<sup>11</sup> Pediatric health care professionals should increase their understanding of the health threats associated with climate change, thus enabling them to recognize and anticipate climate-associated effects and become engaged in the development and implementation of effective mitigation and adaptation strategies to address this global challenge. The present policy statement is supported by a technical report that offers an in-depth review of the nature of climate change and the observed and projected effects on the environment and children's health.<sup>12</sup>

### EFFECTS OF CLIMATE CHANGE ON CHILDREN'S HEALTH

The changing climate is causing physical, chemical, and ecological

changes that are fundamentally altering the planet.<sup>13</sup> These changes pose significant threats to human health,<sup>14</sup> with children representing a uniquely vulnerable group.<sup>15</sup> According to the World Health Organization, more than 88% of the existing burden of disease attributable to climate change occurs in children younger than 5 years.<sup>16</sup> The diverse health effects of climate change have been categorized as primary, secondary, and tertiary (Table 1). Although the primary effects are easiest to detect, many significant consequences will occur through climactic influences on environmental systems and social conditions. The most far-reaching effects are a result of broad societal impacts of unchecked climate change and can be categorized as tertiary effects.<sup>17,18</sup>

#### Primary Effects

Extreme weather events, including severe storms, floods, and wildfires, directly threaten children with injury and death. The frequency of reported natural disasters has increased over the past 40 years.<sup>19</sup> Three times as many extreme weather events occurred between 2000 and 2009 as occurred between 1980 and 1989. The scale of natural disasters has also increased because of deforestation, environmental degradation, urbanization, and intensified climate variables.<sup>20</sup> The distinctive health, behavioral, and psychosocial needs of children subject them to unique risks from these events.<sup>21</sup> Extreme weather events place children at risk for injury,<sup>22</sup> loss of or separation from caregivers,<sup>21</sup> exposure to infectious diseases,<sup>23</sup> and a uniquely high risk of mental health consequences, including posttraumatic stress disorder, depression, and adjustment disorder.<sup>24</sup> Disasters can cause irrevocable harm to children through devastation of their homes, schools, and neighborhoods, all of which contribute to their physiologic and cognitive development.<sup>25</sup>

**TABLE 1** Climate Change Risks to Child Health According to Causal Pathway

Risk Category	Causal Pathway
Primary	Mental and physical illness, injury, and death attributable to heat waves and extreme weather events
Secondary	Health effects mediated by ecological changes, including altered life cycle of infectious disease vectors and host animals, increased concentration of air pollutants and aeroallergens because of rising temperature or wildfires, altered crop yields, and rainfall patterns
Tertiary	Large-scale consequences of unchecked climate change. Includes depletion of basic resources such as food and water, ecological loss, population displacement, failing communities, resulting tensions, and increased risk of conflict

Adapted from McMichael.<sup>18</sup>

Children suffer directly from the increased severity and duration of heat waves. Studies performed in multiple countries have shown an increase in child morbidity and mortality during extreme heat events.<sup>26</sup> Infants younger than 1 year<sup>27,28</sup> and high school athletes<sup>29,30</sup> seem to be at particularly increased risk of heat-related illness and death. There is a >90% chance that by the end of the 21st century, average summer temperatures will exceed the highest temperatures ever recorded in many regions across the world,<sup>31</sup> putting children and their families at increasing risk of heat injury.

### Secondary Effects

Climate change is altering the environmental systems on which we rely and causing shifts in ecosystems and diseases of humans, crops, and natural systems. Air quality can be reduced through temperature-associated elevations in ground-level ozone concentration,<sup>32</sup> increased pollen counts and allergy season duration,<sup>33,34</sup> and wildfire smoke<sup>35</sup>; all of these factors exacerbate respiratory disease and asthma in children. Climate influences the behavior, development, and mortality of a wide range of living organisms,<sup>36,37</sup> some of which have the potential to cause pediatric infection. Determining the effects of climate change on infectious diseases is complex because of confounding contributions of economic

development and land use, changing ecosystems, international travel, and commerce.<sup>38</sup> Currently, climate warming has been identified as contributing to the northern expansion of Lyme disease in North America<sup>39</sup> and has been projected to increase the burden of child diarrheal illness, particularly in Asia and sub-Saharan Africa.<sup>40</sup> Concern has also been raised for climate links to emerging infections, including coccidioidomycosis<sup>41</sup> and amoebic meningoencephalitis.<sup>42</sup> Further investigation into climactic influence on infectious diseases is needed. Altered agricultural conditions, including extreme heat, expanded water demands, and increased severe weather events, will affect food availability and cost, particularly in vulnerable regions in which child undernutrition is already a major threat.<sup>43</sup> The decreased protein, iron, and zinc content of certain major crops has been demonstrated for plants grown under increased CO<sub>2</sub> conditions,<sup>44,45</sup> carrying significant implications for child nutrition.

### Tertiary Effects

Children's biological and cognitive development occurs within the context of stable families, schools, neighborhoods, and communities. Unchecked climate change threatens the safety and well-being of children via its effects on this broader social context. The social foundations of children's mental and physical health

and well-being are threatened by climate change because of: effects of sea level rise and decreased biologic diversity on the economic viability of agriculture, tourism, and indigenous communities; water scarcity and famine; mass migrations; decreased global stability<sup>46</sup>; and potentially increased violent conflict.<sup>47</sup> These effects will likely be greatest for communities already experiencing socioeconomic disadvantage.<sup>48</sup>

### MITIGATION AND ADAPTATION STRATEGIES

Mitigation strategies strive to prevent the most severe effects of climate change through reductions in greenhouse gas emissions. The following steps are all necessary to minimize planetary warming attributable to carbon pollution: reducing energy consumption and waste; decreasing reliance on carbon-intensive fuels such as coal, oil, and gas; increasing utilization of renewable energy sources such as wind and solar; and incorporating low carbon footprint building designs, transportation, and food supply systems. A paradigm shift in our production and consumption of energy is both a necessity and an opportunity for major innovation, job creation, and significant, immediate associated health benefits.<sup>49</sup>

Adaptation strategies involve the development of policies that increase preparedness for climate-associated changes which, because of past and ongoing emissions, are inevitable. Such policies cross a wide range of sectors and include early-warning systems for extreme weather events, physical protection against such events, hospital and health system preparedness, improved surveillance of climate-associated infectious diseases, development of climate-resistant crops, and enhanced community resilience.<sup>50</sup> They also include the education of health care providers and vulnerable patients regarding climate-associated health

risks, such as management of chronic diseases during periods of extreme heat or poor air quality.

## RECOMMENDATIONS TO PEDIATRICIANS AND THE HEALTH SECTOR

Pediatricians have a long history of advocating for social policies that protect the health and welfare of children. Informed by an understanding of the threat that climate change poses to current and future children, pediatricians can play a valuable role in the societal response to this global challenge. The following are recommendations to help achieve this goal.

1. Work to promote medical educational opportunities regarding the effects of climate change on the environment and child health. Programs during medical school and residency, as well as continuing medical education, can inform pediatricians on current and anticipated effects.
2. Seek ways to reduce the carbon and environmental footprint of health facilities, including hospitals, medical offices, and transport services. Consider ways to increase energy efficiency, incorporate renewable energy sources, reduce waste, and promote public and active modes of transport (eg, walking, bicycling) during new construction or remodeling.
3. Use existing anticipatory guidance as a framework for discussing climate change with families. For example, encouraging active modes of transport or promoting consumption of plant-based proteins helps reduce carbon emissions and promotes health. Encourage family choices that reduce fuel consumption, such as utilization of public transportation or fuel-efficient vehicles. Serve as a personal role model for practices that promote environmental sustainability.

4. Educate children, families, and communities on emergency and disaster readiness, using related policy on the Children and Disasters Web page within the American Academy of Pediatrics Web site as a guide (see <https://www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/Children-and-Disasters/Pages/default.aspx>).
5. Advocate for local, national, and international policies that reduce greenhouse gas emissions and for adaptation strategies that improve preparedness for anticipated climate-associated effects. Educate elected officials on the risks climate change poses to child health; speak at public hearings; and provide expert testimony. Help educate the public through letters to the editor and community engagement.
6. Help to build a broader coalition across disciplines to address climate change at the local and national levels. Pediatricians are uniquely positioned to advocate for sustainable electricity-generating systems, accessible public and active transportation, plant-based food availability, and green spaces that ultimately affect child and family health. Collaborate with health departments and research facilities to enhance surveillance, analysis, and reporting of climate-sensitive health effects and to strengthen disaster preparedness.

## RECOMMENDATIONS TO GOVERNMENT

1. Promote energy efficiency and renewable energy production at the federal, state, and local levels while decreasing incentives for continued production and consumption of carbon-intensive fuels such as coal, oil, and gas.<sup>51</sup>
2. Fund research, surveillance, reporting, and tracking of climate-associated health effects. Invest in

prudent and vital preparations for public health care systems, anticipating climate change effects.

3. Support education and public awareness of the threats from climate change for public and children's health now and in the future.
4. Develop essential adaptation strategies and assist state and local governments, public health agencies, and health professionals in implementation of these strategies. The specific needs of children should be addressed in disaster preparedness and response.<sup>21</sup>
5. Include the health sector in national and international policy-making meetings that address the threats of climate change.<sup>50</sup>
6. Fund public transportation systems and support urban planning designs that incorporate walkability, open space, green building design, reduced dependence on automobile transit, and climate change resilience.

## LEAD AUTHOR

Samantha Ahdoot, MD, FAAP

## COUNCIL ON ENVIRONMENTAL HEALTH EXECUTIVE COMMITTEE, 2014–2015

Jerome A. Paulson, MD, FAAP, Chairperson  
Samantha Ahdoot, MD, FAAP  
Carl R. Baum, MD, FAAP  
Aparna Bole, MD, FAAP  
Heather L. Brumberg, MD, MPH, FAAP  
Carla C. Campbell, MD, FAAP  
Bruce P. Lanphear, MD, MPH, FAAP  
Jennifer A. Lowry, MD, FAAP  
Susan E. Pacheco, MD, FAAP  
Adam J. Spanier, MD, PhD, MPH, FAAP  
Leonardo Trasande, MD, MPP, FAAP

## FORMER EXECUTIVE COMMITTEE MEMBERS

Alice C. Brock-Utne, MD, FAAP  
Kevin C. Osterhoudt, MD, MSCE, FAAP  
Megan T. Sandel, MD, FAAP

## LIAISONS

John Balbus, MD, MPH – *National Institute of Environmental Health Sciences*  
Todd Brubaker, DO – *AAP Section on Medical Students, Residents, and Fellowship Trainees*  
Nathaniel G. DeNicola, MD, MSC – *American Congress of Obstetricians and Gynecologists*  
Ruth A. Etzel, MD, PhD, FAAP – *US Environmental Protection Agency*

## STAFF

Paul Spire

## ABBREVIATION

CO<sub>2</sub>: carbon dioxide

## REFERENCES

1. Molina M, McCarthy J, Wall D, et al. What We Know: The Reality, Risks, and Response to Climate Change. Washington, DC: American Association for the Advancement of Science; 2014. Available at: [http://whatwewknow.aas.org/wp-content/uploads/2014/07/whatwewknow\\_website.pdf](http://whatwewknow.aas.org/wp-content/uploads/2014/07/whatwewknow_website.pdf). Accessed January 29, 2015
2. Doran PT, Zimmerman MK. Examining the scientific consensus on climate change. *Eos Trans AGU*. 2009;90(3):22–23
3. Anderegg WR, Prall JW, Harold J, Schneider SH. Expert credibility in climate change. *Proc Natl Acad Sci USA*. 2010;107(27):12107–12109
4. Oreskes N. Beyond the ivory tower. The scientific consensus on climate change. *Science*. 2004;306(5702):1686
5. Intergovernmental Panel on Climate Change. *Climate Change 2014: Mitigation of Climate Change*. New York, NY: Cambridge University Press; 2014
6. Intergovernmental Panel on Climate Change. *Climate Change 2013: The Physical Science Basis*. New York, NY: Cambridge University Press; 2013
7. Climate Change Impacts in the United States. The Third National Climate Assessment. Washington, DC: US Global Change Research Program; 2014:841. Available at: <http://nca2014.globalchange.gov>. Accessed September 22, 2014
8. Intergovernmental Panel on Climate Change. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. New York, NY: Cambridge University Press; 2014
9. Arrhenius S. On the influence of carbonic acid in the air upon the temperature of the ground. *Philosophical Magazine and Journal of Science*. 1896;41:237–276
10. Monastersky R. Global carbon dioxide levels near worrisome milestone. *Nature*. 2013;497(7447):13–14
11. Hansen J, Kharecha P, Sato M, et al. Assessing “dangerous climate change”: required reduction of carbon emissions to protect young people, future generations and nature. *PLoS One*. 2013; 8(12):e81648
12. American Academy of Pediatrics Council on Environmental Health; Ahdoot SA. Technical report: global climate change and children’s health. *Pediatrics*. 2015; 136(5). Available at: [www.pediatrics.org/cgi/content/full/136/5/e1468](http://www.pediatrics.org/cgi/content/full/136/5/e1468)
13. Steffen W, Crutzen J, McNeill JR. The anthropocene: are humans now overwhelming the great forces of nature? *Ambio*. 2007;36(8):614–621
14. Patz JA, Frumkin H, Holloway T, Vimont DJ, Haines A. Climate change: challenges and opportunities for global health. *JAMA*. 2014;312(15):1565–1580
15. Sheffield PE, Landrigan PJ. Global climate change and children’s health: threats and strategies for prevention. *Environ Health Perspect*. 2011;119(3):291–298
16. Zhang Y, Bi P, Hiller JE. Climate change and disability-adjusted life years. *J Environ Health*. 2007;70(3):32–36
17. Butler CD, Harley D. Primary, secondary and tertiary effects of eco-climatic change: the medical response. *Postgrad Med J*. 2010;86(1014):230–234
18. McMichael AJ. Globalization, climate change, and human health. *N Engl J Med*. 2013;368(14):1335–1343
19. Guha-Sapir D, Below R, Hoyois P. Natural disasters reported. EM-DAT: international disaster database, Université Catholique de Louvain, Brussels, Belgium. Available at: [www.emdat.be/sites/default/files/Trends/natural/world\\_1900\\_2011/eveyr3.pdf](http://www.emdat.be/sites/default/files/Trends/natural/world_1900_2011/eveyr3.pdf). Accessed January 29, 2015
20. Leaning J, Guha-Sapir D. Natural disasters, armed conflict, and public health. *N Engl J Med*. 2013;369(19): 1836–1842
21. National Commission on Children and Disasters. 2010 Report to the President and Congress. AHRQ Publication No. 10-M037. Rockville, MD: Agency for Healthcare Research and Quality; 2010. Available at: <http://archive.ahrq.gov/prep/nccdreport/nccdreport.pdf>. Accessed September 22, 2014
22. Miranda DS, Choonara I. Hurricanes and child health: lessons from Cuba. *Arch Dis Child*. 2011;96(4):328–329
23. Ivers LC, Ryan ET. Infectious diseases of severe weather-related and flood-related natural disasters. *Curr Opin Infect Dis*. 2006;19(5):408–414
24. Goldmann E, Galea S. Mental health consequences of disasters. *Annu Rev Public Health*. 2014;35:169–183
25. Noffsinger MA, Pfefferbaum B, Pfefferbaum RL, Sherrib K, Norris FH. The burden of disaster: part I. Challenges and opportunities within a child’s social ecology. *Int J Emerg Ment Health*. 2012; 14(1):3–13
26. Xu Z, Etzel RA, Su H, Huang C, Guo Y, Tong S. Impact of ambient temperature on children’s health: a systematic review. *Environ Res*. 2012;117:120–131
27. Basu R, Ostro BD. A multicounty analysis identifying the populations vulnerable to mortality associated with high ambient temperature in California. *Am J Epidemiol*. 2008;168(6):632–637
28. Deschenes O, Greenstone M. Climate change, mortality, and adaptation: evidence from annual fluctuations in weather in the US. Washington, DC: National Bureau of Economic Research; 2007. Available at: [www.nber.org/papers/w13178](http://www.nber.org/papers/w13178). Accessed September 22, 2014
29. Centers for Disease Control and Prevention (CDC). Heat illness among high school athletes—United States, 2005–2009. *MMWR Morb Mortal Wkly Rep*. 2010;59(32):1009–1013
30. Gottschalk AW, Andrich JT. Epidemiology of sports injury in pediatric athletes. *Sports Med Arthrosc Rev*. 2011;19(1):2–6
31. Battisti DS, Naylor RL. Historical warnings of future food insecurity with unprecedented seasonal heat. *Science*. 2009;323(5911):240–244
32. Sheffield PE, Knowlton K, Carr JL, Kinney PL. Modeling of regional climate change effects on ground-level ozone and childhood asthma. *Am J Prev Med*. 2011; 41(3):251–257, quiz A3
33. Ziska L, Knowlton K, Rogers C, et al. Recent warming by latitude associated with increased length of ragweed pollen season in central North America. *Proc Natl Acad Sci USA*. 2011;108(10): 4248–4251

34. Ziska L, Caulfield F. The potential influence of rising atmospheric carbon dioxide (CO<sub>2</sub>) on public health: pollen production of common ragweed as a test case. *World Resour Rev*. 2000;12(3):449–457
35. Delfino RJ, Brummel S, Wu J, et al. The relationship of respiratory and cardiovascular hospital admissions to the southern California wildfires of 2003. *Occup Environ Med*. 2009;66(3):189–197
36. Altizer S, Ostfeld RS, Johnson PT, Kutz S, Harvell CD. Climate change and infectious diseases: from evidence to a predictive framework. *Science*. 2013; 341(6145):514–519
37. Parmesan C, Yohe G. A globally coherent fingerprint of climate change impacts across natural systems. *Nature*. 2003; 421(6918):37–42
38. Institute of Medicine, the National Academies of Sciences, Engineering, Medicine. Microbial threats to health: emergence, detection, and response. Available at: <http://iom.edu/Reports/2003/Microbial-Threats-to-Health-Emergence-Detection-and-Response.aspx>. Accessed September 22, 2014
39. 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(6):631–638
40. Hales S, Kovats S, Lloyd S, Campbell-Lendru D. *Quantitative Risk Assessment of the Effects of Climate Change on Selected Causes of Death, 2030s and 2050s*. Vol. 2014. Geneva, Switzerland: World Health Organization; 2014:1–128
41. Centers for Disease Control and Prevention (CDC). Increase in reported coccidioidomycosis—United States, 1998–2011. *MMWR Morb Mortal Wkly Rep*. 2013;62(12):217–221
42. Kemble SK, Lynfield R, DeVries AS, et al. Fatal *Naegleria fowleri* infection acquired in Minnesota: possible expanded range of a deadly thermophilic organism. *Clin Infect Dis*. 2012;54(6):805–809
43. Lloyd SJ, Kovats RS, Chalabi Z. Climate change, crop yields, and undernutrition: development of a model to quantify the impact of climate scenarios on child undernutrition. *Environ Health Perspect*. 2011;119(12):1817–1823
44. Taub DR, Miller B, Allen H. Effects of elevated CO<sub>2</sub> on the protein concentration of food crops: a meta-analysis. *Glob Change Biol*. 2008;14(3): 565–575
45. Myers SS, Zanobetti A, Kloog I, et al. Increasing CO<sub>2</sub> threatens human nutrition. *Nature*. 2014;510(7503): 139–142
46. CNA Military Advisory Board. *National Security and the Accelerating Risks of Climate Change*. Alexandria, VA: CNA Corporation; 2014
47. Hsiang SM, Burke M, Miguel E. Quantifying the influence of climate on human conflict. *Science*. 2013;341(6151): 1235367
48. Fritze JG, Blashki GA, Burke S, Wiseman J. Hope, despair and transformation: climate change and the promotion of mental health and wellbeing. *Int J Mental Health Syst*. 2008;2(1):13
49. Haines A, McMichael AJ, Smith KR, et al. Public health benefits of strategies to reduce greenhouse-gas emissions: overview and implications for policy makers. *Lancet*. 2009;374(9707): 2104–2114
50. McMichael AJ, Lindgren E. Climate change: present and future risks to health, and necessary responses. *J Intern Med*. 2011;270(5):401–413
51. The White House. *Executive Order: Federal Leadership in Environmental, Energy, and Economic Performance*. Washington, DC: The White House, Office of the Press Secretary; October 5, 2009. No. 13514