



## Children and Temperature: Taking Action Now

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Rising global temperatures have already begun to harm children’s health and wellbeing, particularly by expanding the range of disease-carrying mosquitoes. A case in point is the spread of *Aedes aegypti*, which transmits the Zika virus—thought to cause microcephaly in infants—as well as yellow fever, dengue fever, and chikungunya. We consider the Obama administration’s plan for responding to the Zika virus, highlighting four important aspects: promoting readiness and response capacity in states and territories, especially those that have evidence of Zika infections; improving laboratory capacity to test for Zika and other infectious diseases; implementing a surveillance plan to track the virus in communities and in mosquitoes; and enhancing international capacity for dealing with Zika.

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The articles in “Children and Climate Change,” the Spring 2016 issue of the *Future of Children*, show that the rise in temperatures associated with carbon emissions is already damaging children’s health and wellbeing. Although the world’s nations, including the United States, should intensify their efforts to reduce carbon emissions, we cannot wait patiently for action on carbon emissions while children’s health is in danger. Considering the immense barriers, especially economic ones, that stand in the way of action to control emissions, even under the best-case scenario carbon emissions will continue to rise well into the middle of this century. It follows that the effects on children won’t moderate soon and may well intensify. Our goal in this policy brief is to summarize the evidence that global temperatures are rising, review how rising temperatures affect children’s health, and highlight a modest set of policies that could minimize

both the spread of diseases and the harm they cause to children's health.

## Global Temperatures Are Rising

The National Oceanic and Atmospheric Administration recently published the results of an extensive study of changes in global temperatures since 1880. One report details the annual departure from long-term average temperatures. Between 1880 and approximately 1950, the global average temperature dropped slightly in most years. But beginning in 1950 or so, despite considerable year-to-year variation, the trend in global temperature has been distinctly upward. During this period, the global average temperature has risen by over 1° Fahrenheit, and some regional increases have been well above that figure.

Based on data from the climate scientists who serve on the Intergovernmental Panel on Climate Change, the World Resources Institute recently estimated the future increase in temperature under four scenarios of reduced carbon emissions. All the scenarios envisioned a global rise in temperature of at least 2° Celsius (1.8° F) by 2100; under the scenario that assumed the highest emissions caused by the least effective actions to limit them, global temperatures would rise by 4.8° C (8.6° F).

Another aspect of warming that directly affects children's health is the number of days of extreme temperatures. Here the work of James Hansen at NASA's Goddard Institute for Space Studies and his colleagues provides a clear answer to whether the earth is experiencing more days of extreme temperatures. Using 1951–80 as a baseline, Hansen and his colleagues compared the distribution of temperatures for each decade, through the decade beginning in 2001. In the decades beginning in 1981, 1991, and 2001, the distribution of temperatures shifted upward. The shift was especially noticeable in the part of the distribution representing extreme hot temperatures. Under the Hansen team's definition of extreme hot temperatures, the estimated percentage of the earth's surface that experienced such temperatures in the summer months during the base period was 0.1–0.2 percent. But in the past several years, the share of the earth's surface that actually experienced extreme hot temperatures was about 10 percent. Under any definition, that is a spectacular jump.

Hansen concludes “with a high degree of certainty” that the extremely hot summer temperatures in Texas and Oklahoma in 2011 and in Moscow in 2010 “were a consequence of global warming.”

Research shows that temperatures above roughly 90° F can have an immediate impact on children's health (as well as the health of the elderly). Economists Olivier Deschênes (one of the authors of this brief) and Michael Greenstone found that when temperatures reach that level, death rates triple relative to death rates at 80° F. Death rates increase more among infants than among any other age group except the elderly. Given that both average daily temperatures and the number of days of extreme temperature are rising and are likely to continue to do so, heat-related mortality and illness will fall heavily on children, especially infants.

To summarize, both the historical data and reasonable scientific projections indicate that global temperatures have been rising for more than half a century and that the number of extremely hot days has been rising for three decades. These increases are likely to continue even under optimistic assumptions about a decline in carbon emissions.

## Effects of Rising Temperature on Children

Joshua Graff Zivin and Jeffrey Shrader's article in the *Future of Children* thoroughly examines how rising temperatures affect children's health by reviewing evidence on three categories of direct impacts—mortality, illness, and human capital. They find substantial evidence for detrimental impacts in all three categories. For example, as we've established, extreme heat is associated with a substantial rise in infant deaths. Studies show that heat kills in many ways, including directly through heat stroke and cardiovascular failure and indirectly through means such as crop failure or the spread of infectious diseases (see below). Similarly, researchers are beginning to show that excess heat compromises children's ability to acquire human capital such as education. Excess heat while fetuses are still in the womb is associated with physical defects, delayed brain development, and various nervous system problems that affect later development. In older children, excess heat can directly reduce learning.

Thus, although scientists still have a lot to learn about temperature and children's health, the evidence that rising temperatures harm children's health both directly and indirectly is abundant and growing.

## Heat and Vector-Borne Diseases

In this policy brief, we examine one way that the earth's warming seems to increase the spread of vector-borne diseases. We pursue this course for two reasons. First, we think the evidence is strong that this effect is already occurring and that children are now experiencing more illnesses as an indirect consequence of rising temperatures. Second, outbreaks of disease can impose very large costs on many nations, in both human and financial terms. As the National Academy of Sciences points out in a recent report, "countless millions" have died throughout human history from virulent infectious diseases such as the plague, cholera, and influenza. Even without global warming, infectious disease would be a primary public health issue. But it now seems clear, as we'll see, that warming is adding significantly to the threat of diseases. Recent outbreaks of contagious diseases such as SARS, Ebola, and AIDS suggest that the magnitude of the threat from the spread of infectious illnesses justifies additional investments in prevention and control. Careful thought and modest investments now can lead to substantial savings in health expenditures and human misery later, even without substantial progress in reducing carbon emissions.

These claims will be especially true if the Zika virus continues to spread and winds up having major impacts on children's health, such as the microcephaly now thought to be caused by the virus. In fact, the rise of Zika illustrates the causal chain initiated by rising temperatures that can increase death and illness among children. Zika is transmitted chiefly by mosquitoes, especially *Aedes aegypti*. As entomologist Marten Edwards puts it, the *Aedes aegypti* mosquito "loves us. It loves our cities. It loves our blood. It functions very well with us." Nor is Zika the only disease that the *Aedes aegypti* carries. It is also a major culprit in the spread of yellow fever, dengue fever, and chikungunya. It follows that anything that helps *Aedes aegypti* expand its territory or reproduce more often or more efficiently could lead to the spread of Zika and other diseases.

Although mosquitoes' role in spreading infectious illnesses is complex, several factors associated with warming promote the spread of disease. First, along with increased global trade and travel, warming has now led to the widest geographic distribution of *Aedes aegypti* ever recorded, according to research by Moritz Kraemer and colleagues at Oxford University. It has been predicted that its range will soon extend to traditionally cooler US states such as Missouri, Kentucky, and North Carolina, and even to Washington, DC. Still more important, *Aedes aegypti* breeds primarily in small, stagnant pools of water such as pools in old tires and flower pots, in buckets and cans, in open sewers, and in other similar sources of standing water. Warming temperatures often provide expanded opportunities for breeding because, especially in traditional societies, people tend to store more water in open containers.

Warmer temperatures affect the spread of viruses in other ways as well. Not only do warmer temperatures stimulate the mosquitoes to be hungrier and take more frequent blood meals; hotter temperatures also promote more rapid growth of viruses in the mosquito's gut. Adding insult to injury, unlike most other mosquitoes, *Aedes aegypti*, rather than drawing one big drink of blood from its human victims, extracts very small portions of blood from several victims, thereby potentially infecting many people with any virus it happens to be carrying. As Margaret Chan, the head of the World Health Organization, put it recently, *Aedes aegypti*'s ability to infect several people in rapid succession is part of the reason that the Zika virus has spread so "explosively" in the Americas.

## What to Do

This brief review of facts established by research, and documented in great detail in the current issue of the *Future of Children*, shows beyond reasonable doubt that ambient temperatures are rising, that this rise in temperatures is already damaging children's health, that one major source of harm to children's health is the spread of diseases, and that the rise in diseases is due in large part to the correlation between rising temperatures and expanding mosquito populations that serve as a major vector of disease transmission. What can we do to control the spread of diseases associated with mosquitoes and thereby improve children's health?

On February 8, the Obama administration announced that it would submit a special request to Congress for a comprehensive plan “preparing for and responding to the Zika virus at home and abroad.” The plan’s cost was set by the administration at \$1.8 billion and is classified as emergency funding, meaning that it has the potential to be funded without offsetting savings achieved by cutting other programs or raising taxes. Attempting to persuade the public and Congress that emergency funding is justified, the administration laid out a careful case. The announcement points out that according to the Pan American Health Organization, 26 countries and territories in North, South, and Central America now have Zika cases caused by local transmission. Although officials have not yet seen any Zika infections caused by insect transmission in the continental United States, as of late February 2016 more than 100 cases of Zika had been confirmed among US residents who had traveled to foreign countries; moreover, officials had reported about 40 cases of mosquito transmittal in Puerto Rico and other US territories. It’s no surprise that the Centers for Disease Control is concerned that mosquitoes may begin to infect Americans living in the continental United States, especially in Southern states. The current attention to Zika should not be allowed to obscure the fact that dengue fever, also transmitted by *Aedes aegypti*, is spreading and that other diseases such as yellow fever and chikungunya are continuing to infect hundreds of thousands of children.

We consider the administration’s plan for responding to the Zika virus, and call attention to four aspects of the plan that we think are especially important: promoting readiness and response capacity in states and territories, especially those that have evidence of Zika infections; improving laboratory capacity to test for Zika and other infectious diseases; implementing a surveillance plan to track the virus in communities and in mosquitoes; and enhancing international capacity for dealing with Zika.

*Readiness and response.* One of the important aspects of readiness is mosquito control. There is a long history of attempts to control the *Aedes aegypti* mosquito, beginning with an effort in South America in 1900 that focused on treating breeding sites with insecticide. After initial success in reducing the

population, the eradication program was abandoned, whereupon the mosquito quickly reestablished itself. A 1947 eradication program initiated by the Pan American Health Organization was again initially successful, this time in 19 countries that were declared free of the mosquito. Yet another program in Florida’s 67 counties, conducted by Florida’s Department of Health and the US Public Health Service, was again initially successful. By the late 1960s, according to the World Health Organization, “most mosquito-borne diseases were no longer considered to be major public health problems outside Africa.” Despite this early success, *Aedes aegypti* has reestablished itself in recent decades. It is now common throughout the Americas and has actually expanded its range in the United States, perhaps in part because of climate change.

All the more reason, then, that the administration’s effort should include a strong eradication program, both in the United States and throughout the Americas. However, using pesticides raises the serious issue of unintended deleterious impacts on the environment, and we assume that the administration will aggressively employ at least two other eradication methods. The first is to prevent open containers from collecting water by removing old tires, treating swimming pools, keeping cans and other containers in covered bins, cleaning pet bowls daily, keeping gutters clean, and similar actions. This effort would be best accomplished by a campaign to inform the public of the danger of standing water and tell them about practical steps they can take to remove breeding sources. Second, Oxitec, a biotechnology company in the United Kingdom, has had some success in breeding a genetically modified sterile version of the *Aedes aegypti* mosquito. This work should be continued, especially by field testing.

*Testing for Zika.* A linchpin of any effort to control viral diseases is the ability to reliably test for the presence of the virus in hosts and victims. This part of the administration’s initiative would involve both purchasing testing equipment and training laboratory personnel to use it. Tracing the spread of the Zika virus is a vital part of control efforts, especially when it comes to directing resources where they are most needed.

*Surveillance.* This means collecting, analyzing, and interpreting data on the frequency and distribution both of disease vectors and of people who have been

victimized by a disease. Surveillance information can then be used to determine where intervention is needed and to design and implement intervention plans.

*International efforts.* Compassion isn't the only reason the United States should help other nations avoid epidemic outbreaks or deal with them once they occur. Given the large and growing volume of international travel for business and pleasure, combined with the huge number of ships, planes, and trucks involved in international trade, it is in our self-interest to help other nations avoid outbreaks of disease. As we've seen, in what appears to be the early stage of a classic spread of viral disease, more than 100 people have traveled to the United States with confirmed Zika infections and 40 cases have been locally acquired in US territories. These numbers are increasing daily. Even worse, the Centers for Disease Control is reporting that at least nine pregnant women have returned to the United States infected by the virus, with 10 more possible cases. Clearly, the United States would benefit from reducing the spread of the Zika virus in other nations.

No wonder the administration is proposing a comprehensive program of help for nations at the

highest risk of Zika outbreaks. The help would include training in epidemiology, laboratory testing, health care, and vector surveillance and control.

## **Conclusion**

A consequence of global warming that receives too little attention is its impact on the spread of diseases among children. Here we focus attention on how warmer temperatures facilitate the reproduction and spread of the *Aedes aegypti* mosquito, which is the main vector for transmission of the Zika virus (and other dangerous viruses as well). We emphasize that this specific impact of rising temperatures is now a reality and that policy can't focus exclusively on reducing carbon emissions to mitigate a major cause of rising temperatures. Reducing emissions is certain to be a very long and uncertain process; meanwhile, the consequences of rising temperatures are already with us. Fortunately, the Obama administration is requesting funds from Congress for a plan to expand current actions to deal with pathogens such as the Zika virus. We briefly review four especially important aspects of the administration's plan. As the recent spread of many viral diseases demonstrates, the longer we wait to tackle prevention and treatment, the more serious and expensive the consequences.

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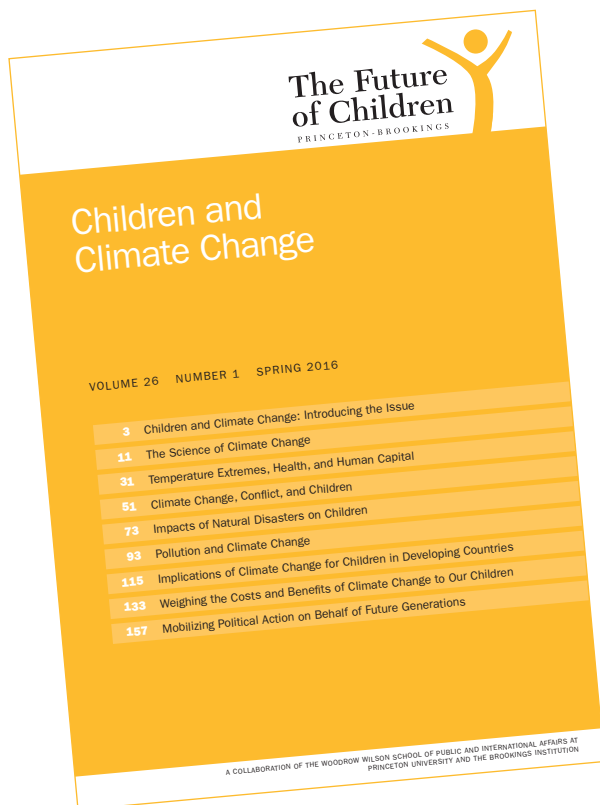
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