

ISSUE BRIEF

Public Health: Adapting to Climate Change

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Resources for the Future is an independent, nonpartisan think tank that, through its social science research, enables policymakers and stakeholders to make better, more informed decisions about energy, environmental, natural resource, and public health issues. Headquartered in Washington, DC, its research scope comprises programs in nations around the world.



Public Health: Adapting to Climate Change

Jonathan Samet¹

As defined by the Intergovernmental Panel on Climate Change, adaptation includes a set of actions to moderate harm or exploit beneficial opportunities in response to climate change. To date, little research has addressed public policy options to frame the nation's approach to adapt to a changing climate. In light of scientific evidence of extreme and unpredictable climate change, prudent policy requires consideration of what to do if markets and people fail to anticipate these changes, or are constrained in their ability to react. This issue brief is one in a series that results from the second phase of a domestic adaptation research project conducted by Resources for the Future. The briefs are primarily intended for use by decisionmakers in confronting the complex and difficult task of effectively adapting the United States to climate change impacts, but may also offer insight and value to scholars and the general public. This research was supported by a grant from the Smith-Richardson Foundation.

Policy Recommendations

SHORT-TERM POLICIES

Climate change poses a threat to human health; it already causing excess mortality and morbidity through heat-related deaths and changing patterns of infectious diseases. Climate change does not create new health problems but may worsen known clinical problems and alter geographic patterns of disease occurrence. Public health programs in many countries already target the problems that are directly linked to climate change. Consequently, policy recommendations related to climate change and public health reflect the need to sustain and refine current measures to enhance their sensitivity to climate change. Policy actions related to climate change and health should:

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- make certain that existing public health surveillance systems are sufficiently comprehensive and sensitive to detect potential effects of climate change on health;
- assure specifically that infectious disease surveillance systems can detect potential “signature” diseases that may affect the United States consequent to climate change;
- establish and implement heat warning systems and take steps to increase public awareness of consequences of heat exposure;
- enhance awareness of climate change and health among public health and medical practitioners; and
- alert practitioners and their patients to the potential for changes in patterns of exposure to aeroallergens that exacerbate allergic diseases like asthma and allergic rhinitis (“hay fever”).

Introduction

HOW CAN CLIMATE CHANGE AFFECT HEALTH?

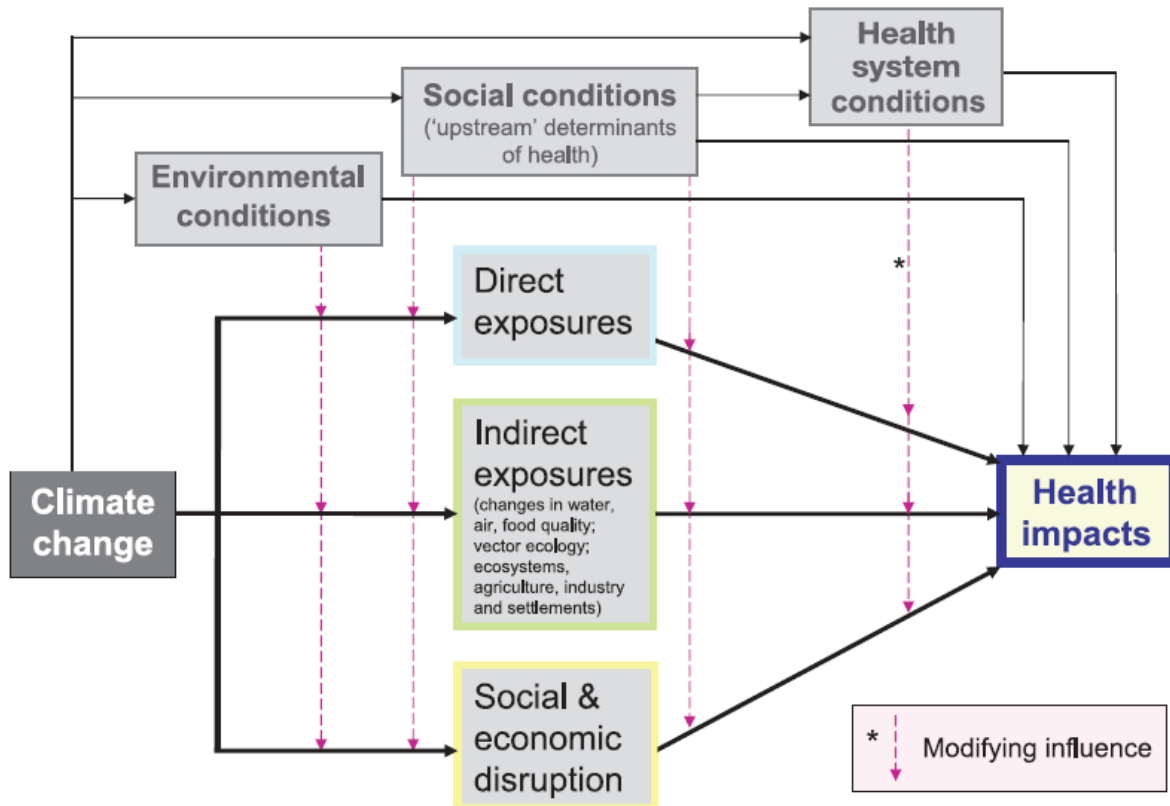
Climate change is projected to have sweeping adverse effects on the Earth, imposing diverse threats to ecosystems and people. The threats extend to the health of the public, with warming of the planet projected to have positive and negative consequences that will vary temporally and spatially. All scenarios indicate that some populations will be harmed and that the harms of climate change will outweigh the co-benefits of greenhouse gas reduction (World Health Organization 2009). A recent report from the *Lancet* and University College London Institute for Global Health Commission labeled climate change as “...the biggest global health threat of the 21st century” (*The Lancet* 2009, 1659). The World Health Organization (2009, 3) has been similarly forceful, declaring in a recent report, “Protecting human health is the ‘bottom line’ of climate change strategies.” Estimates of the global burden of disease attributable to climate change now and in the future are substantial (McMichael et al. 2004). The public health threat posed by climate change is a powerful policy lever for motivating action to minimize harm to the public’s health.

Climate change will not introduce new causes of morbidity and mortality, but will change the factors—such as disease vectors and environmental exposures—that affect the occurrence of morbidity and premature mortality (Table 1). Climate change may affect health by direct and indirect pathways (Metz et al. 2007). Figure 1 highlights three broad pathways linking climate change to health impacts: 1) exposures resulting directly from climate change, such as increased frequency of heat waves; 2) exposures following indirectly from climate change, such as scarcity of water and increased transmission of infectious diseases because of climate change’s influence



on vectors; and 3) societal and economic disruption that could affect health through population displacement, conflict, interruption of safe food and water supplies, and failure of governments to assure environmental quality. Some direct and indirect threats are already the target of control programs embedded in public health and medical systems, themselves vulnerable to disruptive social, economic, and environmental conditions.

Figure 1. Schematic Diagram of Pathways by which Climate Change Affects Health, and Concurrent Direct-Acting and Modifying (Conditioning) Influences of Environmental, Social, and Health System Factors



Source: Metz et al. 2007.



Table 1. Potential Health Consequences of Climate Change

Threat	Consequence
Increased frequency and intensity of heat waves	Increased mortality from heat waves, particularly in elderly
Altered distributions of aeroallergens	Increased frequency and severity of allergic diseases and symptoms
Altered distributions of vectors of infectious diseases	Spread and increased frequency of infectious diseases
Increased air pollution	Increased morbidity and premature mortality
Changing agricultural yields	More undernourished people in low-income countries
Social and economic disruptions, displacement	Various, with acute and chronic consequences

The Health Threats of Climate Change

INCREASED EXPOSURE TO EXTREMES OF HEAT AND COLD

Temperature has long been associated with adverse effects on health and mortality. At the extremes of temperature exposure, the long-recognized clinical entities of hypothermia and hyperthermia are well-documented causes of death (Basu and Samet 2002). Scientists have extensively documented the phenomenon of excess mortality during heat waves, even in high-income countries, and recognize it as a consequence of global warming (Metz et al. 2007). In recent decades, the dramatic epidemics of hundreds of excess deaths associated with the 1995 heat wave in Chicago (Semenza et al. 1996) and thousands of excess deaths in Europe in 2003 (Vandentorren et al. 2004; Kovats et al. 2006) alerted the public to the danger of heat waves and motivated governments and public health agencies to take protective actions. Moreover, warmer temperatures are associated with mortality even at times when heat waves are not in progress (Basu and Samet 2002; Kovats et al. 2006). The recent heat waves in Chicago and Europe show the vulnerability to heat of the elderly, persons with medical problems, poorer people without air conditioning, and those lacking social support.

ALTERED PATTERNS OF INFECTIOUS DISEASES

The myriad known infectious diseases, still a leading cause of disease and death in the United States, differ in their causative organisms, pathways of transmission, clinical manifestations, responses to therapy, and outcomes (Nelson et al. 2007). Vector-borne diseases are of greatest concern with regard to potential adverse consequences of climate change. Environmental conditions that promote a vector or extend its geographic range increase the potential for infection by the agent. Warming may also expand the geographic area where an infectious agent is present. Climate change potentially affects various vector-borne diseases (Table 2). Empiric



evidence already links such epidemics as cholera and Rift Valley fever to climate change, while controversy surrounds the consequences of climate change on others, such as malaria.

Table 2. Examples of Vector-Borne Diseases Likely To Be Sensitive to Climate Change

Vector	Major diseases
Mosquitoes	Malaria, filariasis, dengue fever, yellow fever, West Nile fever
Sandflies	Leishmaniasis
Triatomines	Chagas disease
Ixodes ticks	Lyme disease, tick-borne encephalitis
Tsetse flies	African trypanosomiasis
Blackflies	Onchocerciasis
Snails (intermediate host)	Schistosomiasis

Source: Haines et al. 2006.

WORSENING ALLERGIC DISEASES (ASTHMA AND HAY FEVER)

Aeroallergens—biological agents associated with allergic responses—are ubiquitous in indoor and outdoor environments. Contact of these agents with the mucosal surfaces of the eyes and nose causes allergic responses, as does inhalation into the lung. The two principal diseases associated with aeroallergens are allergic rhinitis, also referred to as hay fever, and asthma. For persons with allergic rhinitis and asthma, climate change might increase the risk of exacerbation through altered local and regional pollen production. Warming already has caused an earlier onset of the spring pollen season in the Northern Hemisphere (Metz et al. 2007). It may also increase the duration of the pollen season, change the spatial distribution of vegetation, and possibly alter pollen production (Beggs 2004; Beggs and Bambrick 2005; Metz et al. 2007). More prolonged and intense exposure to aeroallergens could result in more severe disease, greater morbidity, and even mortality from asthma.

INCREASED RISK OF MORBIDITY AND PREMATURE MORTALITY

Climate change could worsen air pollution either directly, through increased tropospheric (ground-level) ozone production, or indirectly, through greater power plant emissions as power generation increases to meet demand for greater air-conditioning capacity. The anticipated changes in ozone and possibly in particulate matter would happen over a relatively long time frame, approximately over decades. Over this same time period, increasing numbers of polluting motor vehicles and power plants are anticipated in low- and middle-income countries. On the other hand, as petroleum supplies lessen and fuel prices increase, the growth of motor vehicle use may slow, and efforts at conservation may reduce emissions as well.



Ozone is a secondary pollutant, formed via sunlight-driven photochemical reactions involving precursor hydrocarbons and oxides of nitrogen. Ozone pollution is projected to increase because warmer temperatures enhance these reactions (Metz et al. 2007). Fossil-fuel burning contaminates the atmosphere with primary particles generated by combustion and secondary particles formed from gaseous emissions components. Both ozone and airborne particles are associated with premature mortality and a wide range of other adverse health effects of both clinical and public health significance (Pope and Dockery 2006; World Health Organization 2006).

INDIRECT CONSEQUENCES

The public health threat posed through the indirect pathways, while quite uncertain, is potentially of great magnitude and not subject to direct management (*The Lancet* 2009). Climate change could threaten access to safe water, as well as food security and supply, leading to dehydration, disease, and malnutrition. Competition for diminishing resources and forced migration in the face of climate change could spark competition. More general social and economic disruption could affect the stability and actions of governments and reduce the extent and quality of medical and public health services.

Adaptive Measures in Place

Public health refers to the approaches taken to protect and improve the health of *communities*, contrasting to clinical medicine, which addresses health and disease of *individuals*. Prevention is fundamental to public health, and the principles of prevention map directly to climate change (Frumkin et al. 2008). Many public health measures needed to track and mitigate the effects of climate change on health are already in place in the United States. Some measures reflect the routine functions of public health and environmental management, while others have been refined to be more sensitive to particular issues of climate change and health, particularly related to heat waves and infectious disease.

PUBLIC HEALTH SURVEILLANCE: A FUNDAMENTAL TOOL

Surveillance refers to the systematic tracking of the health of a population—whether in general or for particular indicators, such as the occurrence of cancer—and the ongoing use of the surveillance data for public health management (Langmuir 1963).

As part of the approach to identifying and mitigating public health problems, surveillance involves more than passively collecting data; it is grounded in process, such that the surveying organization analyzes data, reviews findings, and takes action when needed (Teutsch and Churchill 2000). If intervention is undertaken, the continued monitoring provides a way to track its consequences. In the United States, the Centers for Disease Control and Prevention have an increasingly broad set of surveillance activities in place. Motivated by concern for quickly identifying emerging infectious



diseases and infectious agents used for bioterrorism, systems track such known threats as influenza and rapidly identify new agents. Surveillance systems that provide tracking, although not highly accurate, are also in place for allergic diseases. The existing spatial and temporal data provide a major resource for planning potential surveillance activities related to climate change in the United States. Regional, state, and local bodies maintain additional databases. Analytic tools have also been developed that facilitate scanning of these data for patterns indicative of potential consequences of climate change or other factors. The World Health Organization plays a lead role in surveillance at the global level, interacting extensively with the United States and other nations.

DEALING WITH HEAT: TEMPERATURE WARNING SYSTEMS AND AIR CONDITIONING

The tools necessary for protecting people from heat stress are available in the United States and have been shown to work. These include tools that measure temperature widely and forecast weather conditions that lead to dangerous heat stress. The many epidemics of heat-caused deaths have identified those who need to be protected during heat waves, and there is a single stressor, heat, to avoid. Heat watch systems have been implemented and proven effective (Ebi and Schmier 2005). The approach involves the characterization of conditions in a particular locale that are likely to produce dangerous heat stress and trigger an aggressive protective response from public health and municipal authorities.

The development and implementation of a system for Philadelphia is illustrative. Kalkstein and colleagues (1995) established one model for such systems based on identifying the weather conditions historically associated with increased mortality in a particular location and then giving warning prospectively when such conditions arise. The approach uses exploratory and clustering statistical methods to identify synoptic conditions, “oppressive air masses” that have been linked to increased mortality. Anticipated occurrence of such conditions triggers a protective response from public health and municipal authorities, who alert the public and provide shelters. In a paper describing this approach for the city of Philadelphia, Kalkstein et al. (1996) suggest that implementation of this type of system may have reduced the impact of a heat wave in Philadelphia during the summer of 1995. They extended this approach to other cities around the world, again with evidence of benefit (Sheridan and Kalkstein 2004).

Housing style and the use of air conditioning can lessen the impact of heat waves. The availability of air conditioning reduces the risk of mortality during a heat wave. As a longer-run strategy, increased use of air conditioning in homes would be expected to protect against heat-associated mortality, although the strategy has associated costs of implementation and the electric power to support the air conditioning.



AIR QUALITY MONITORING AND MANAGEMENT

Many countries, including the United States, have adopted air quality regulations or guidelines, along with extensive air quality management programs to control air pollution levels. These programs have led to strong trends of improving air quality over the half-century in many high-income countries, including the United States. However, even at current levels in these countries, air pollution poses a continued threat to public health. A substantial proportion of the world's population is exposed to outdoor air pollutants at concentrations exceeding the World Health Organization's guideline values.

Ozone and particulate matter are monitored routinely across the United States and in an increasing number of cities worldwide. Data are available to track pollution trends, though time-trend analysis will probably be insufficiently sensitive for identification of the specific contribution of climate change, given the many contributors to urban air pollution. On the other hand, air quality management strategies are directed at limiting emissions of ozone precursors and controlling particle sources. Strategies for control of greenhouse gas emissions will also benefit ambient air pollution (Davis and Working Group on Public Health and Fossil-Fuel Combustion 1997). To date in the United States and many countries of Europe, levels of major urban and regional air pollutants have dropped, showing that air quality management strategies can be effective (World Health Organization 2006; U.S. Environmental Protection Agency 2009). Over the short term, these same strategies should be effective in controlling air pollution concentrations. Longer-run predictions are difficult because of uncertainty around power plant emissions, which might rise given the greater need for electricity for cooling, and because of potential changes in the powering of motor vehicles.

CLINICAL CARE

Medical care is a further mitigating factor for the adverse impact of climate change on health. Effective treatment strategies are available for heat stress, allergic diseases, and many infectious diseases with transmission affected by climate change. In fact, at the level of the individual patient, no signature exists for identifying those individuals whose health has been adversely affected by climate change. A further key role for clinicians is to recognize the occurrence of sentinel cases that signal a possible outbreak or an emerging illness. The first cases of AIDS, for example, were recognized in the United States in 1981 because clinicians noticed the occurrence of a cluster of cases of *Pneumocystis carinii* pneumonia in gay men with immunocompromise (Centers for Disease Control and Prevention 1981). Clinicians are an integral element of surveillance, a role better filled if they are alerted to the potential consequences of climate change and the possibility of emerging infections.



Conclusions: Preparing for Adaptation

Will the health consequences of climate change be a useful lever for engaging governments to more quickly address climate change? The 2009 reports from the *Lancet* and University College London Institute for Global Health Commission and from the World Health Organization are calls for immediate action in the face of a looming public health crisis (*The Lancet* 2009; World Health Organization 2009). Members of the public health community hold varying views on the urgency of addressing the public health consequences of climate change, but all concur with the need for “primary prevention”—that is, slowing climate change as quickly as possible. Some propose that the health sector needs to become more proactively engaged in pushing for solutions and advancing strategies for adaptation (Haines and Patz 2004; Menne and Bertollini 2005; Frumkin and McMichael 2008; McMichael et al. 2008). The burden of disease estimates show that the climate change threat will become ever larger.

At the least, the evidence on the health threat of global warming should advance the public health community’s understanding of climate change and health and push the World Health Organization and other global bodies to strengthen public health infrastructure and capacity. At the national level, the projected risks of climate change should motivate countries to enhance data systems and improve preparedness for addressing possibly more frequent and more severe disastrous weather events. However, it may be more difficult to motivate action at local levels, where the threat of climate change may appear remote, particularly when viewed in the context of pressing, local issues.

Much has been written on adaptation to climate change; books and reviews address not only the means of adaptation but the policy context (Fussel 2007). For example, the European Union funded a project, “Climate Change Adaptation Strategies for Human Health,” to systematically assess adaptation strategies for Europe (Menne and Ebi 2006). The recent report from the *Lancet* and University College London Institute for Global Health Commission views action related to adaptation as an urgent priority (*The Lancet* 2009). The use of the term “climate change adaptation science” implies the emergence of formal, evidence-based approaches to guide adaptation (Fussel et al. 2006). The methods for addressing the health consequences of climate change, as evident in this review, are those of public health and disease control generally. For such health consequences as emerging infections and heat waves, adaptation will take place through the routine functioning of effective public health systems, if in place. Some consequences, such as allergic diseases, will be managed through routine medical care. And others, such as morbidity and premature mortality from increased emissions of air pollution, will be addressed through regulatory mechanisms.



While the time frame over which climate change is anticipated to affect health is far longer than the time domains in which public health planning usually takes place, some steps can be taken immediately. One such step is to assess capacity and begin to address gaps (Ebi 2009). This effort should survey a variety of involved stakeholders; Ebi (2009) lays out the various “actors.” Some gaps should be plugged without delay. For example, places at risk for heat events should have warning systems in place, along with programs to reduce the consequences of thermal stress.

Recognition and quantification of the health consequences of climate change will be difficult, given their lack of specificity. Risk assessment methods, including burden of disease estimation, will remain central as a tool for estimating the need for implementation of adaptive strategies and quantifying their benefits. Tracking the benefits of adaptation for the purpose of “accountability” will likely prove difficult, given the multiplicity of factors affecting the health outcomes of concern (Health Effects Institute 2003). At the national level, the government should assure it has clear designated a locus within the government that will track the health consequences of climate change and assess the extent to which adaptation strategies are in place as well as their effectiveness. Absent this monitoring function, it will remain uncertain whether the right steps have been taken and whether they have worked.



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