Testimony of

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Summary

Climate change poses a risk for U.S. populations. Climate change is projected to increase heat-related mortality, increase the number of cases of diarrheal diseases, and increase mortality from diseases exacerbated by high concentrations of ozone and by aeroallergens. Extreme weather events (floods, droughts, and windstorms) also could affect human health and safety. A very limited research base means there are few quantitative projections of health risks at the local and regional scales needed to implement programs to prepare for and effectively respond to these risks. The groups most vulnerable to the health impacts of climate change depend on the region of interest, the health outcome, and population characteristics, including human, institutional, social, and economic capacity. Trends in factors that affect susceptibility, such as a larger and older U.S. population, will increase overall vulnerability to climate-related health risks. In addition, the U.S. population may be at risk from climate-related diseases and disasters that occur outside her borders, with travelers and refugees importing diseases not currently present.

Adaptation and mitigation are the primary approaches for addressing the risks of climate change. Neither is sufficient in itself; focusing only on mitigation would leave communities ill-prepared for changes expected in the short term, and focusing only on adaptation would increase the amount of future climate change.

Climate change will make more difficult the control of climate-sensitive health determinants and outcomes. Therefore, health policies need to explicitly incorporate climate-related risks in order to maintain current levels of control. Examples of adaptation measures range from developing and deploying early warning systems and emergency response plans that specifically incorporate projections of climate change-related health risks to establishing surveillance programs in regions where projections suggest disease vectors may change their geographic range. Proactive policies and measures should be identified that improve the context for adaptation, reduce exposures related to climate variability and change, prevent the onset of climate-sensitive health outcomes, and increase treatment options. However, the ability to incorporate the risks of climate change into public health programs and activities is constrained by limited awareness and data, few decision support tools, and very limited human and financial resources.

In addition to increasing the public health capacity to prepare for and effectively respond to climate change, there is a need to evaluate the possible health consequences of policies and technologies being developed to reduce emissions of greenhouse gases, from energy efficiency policies to carbon capture and storage.

Adaptation to climate change across all sectors would be facilitated if there were a central (or regional) responsible agency. The elements needed, from weather forecasting to air and water quality regulations to vector control programs to disaster response, are spread across multiple agencies and organizations, with lack of consistent collaboration and coordination. Identifying and supporting a lead agency that can provide access to the information and tools, and that can support the adaptation process, will advance preparation for the risks of climate change.

1.0 Introduction

Over the past decade, the fact that the world's climate is changing has become clear. In 2007, the Intergovernmental Panel on Climate Change (IPCC 2007a) concluded: *warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.* In addition: *most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.* Ambient temperatures increased 0.74°C worldwide over the period 1906-2005. The rate of warming averaged over the past 50 years (0.13°C $\pm$ 0.03°C per decade) is nearly twice that for the last 100 years. Changes in extreme temperatures (such as the 2003 European heatwave) are consistent with warming over recent decades.

Climate change is increasing the frequency and intensity of heatwaves, droughts, floods, and storms; altering agricultural productivity and food security; reducing water quantity and quality; and increasing the geographic range and incidence of climate-sensitive infectious diseases, particularly certain vector-, rodent-, tick-, water-, and foodborne diseases (IPCC 2007b). Impacts are projected to increase with increasing climate change, and will be greatest in developing countries in tropical regions because of their geographic location, low incomes, and low institutional capacity, as well as their greater reliance on agriculture and other climate-sensitive sectors. The extent to which impacts are experienced will depend, in the short term, on the speed with which effective and timely adaptation measures can be developed and deployed, and will depend, in the longer term, on rapid reduction of greenhouse gas emissions.

2.0 Summary of the Potential Health Impacts of Climate Change in the United States

The observation that major causes of ill health exhibit distinct seasonal patterns suggests *a priori* that weather and/or climate influence their distribution and incidence. Weather, climate variability, and climate change affect a wide range of health outcomes directly and indirectly. Directly, heatwaves, floods, droughts, windstorms, and fires annually affect millions of people and cause billions of dollars of damage. In 2003 in Europe, Canada, and the United States, floods and storms resulted in 101 people dead or missing and caused $9.73 billion in insured damages (Swiss Re 2004). More than 35,000 excess deaths were attributed to the extended heatwave in Europe the same year (Kostasky 2005). The frequency and intensity of extreme weather events are expected to increase over the coming decades as a consequence of climate change, suggesting that the associated health impacts also could increase.

Indirectly, climate can affect health through alterations in the geographic range and intensity of transmission of vector-, tick-, and rodent-borne diseases, and food- and waterborne diseases, as well as through changes in the prevalence of diseases associated with air pollutants and aeroallergens. Climate change could alter or disrupt natural systems, making it possible for diseases to spread or emerge in areas where they had been limited or had not existed, or for diseases to disappear by making areas less hospitable to

the vector or the pathogen (NRC 2001). Climate-induced economic dislocation and environmental decline also can affect population health.

The cause-and-effect chain from climate change to changing patterns of health determinants and outcomes is often complex and includes factors such as wealth, distribution of income, status of the public health infrastructure, provision of medical care, and access to adequate nutrition. Therefore, the severity of future impacts will be determined by changes in climate as well as by concurrent changes in non-climatic factors and by policies implemented to reduce negative impacts. It is important to note that even if total burdens of some climate-sensitive health outcomes decrease in the future, the attributable burden due to climate change is projected to increase.

The Climate Change Science Program is coordinating the development of 21 synthesis and assessment products to enhance scientific understanding of the potential impacts of climate change. The U.S Environmental Protection Agency is the lead agency for the development of Synthesis and Assessment Product 4.6 " Analyses of the effects of global change on human health and welfare and human systems." The third draft will be posted in April 2008 (www.climatescience.gov). Included in this assessment is a chapter on the potential health impacts of global change.

An assessment of the potential impacts of climate variability and change on human health was published in 2000 as part of the First National Assessment of the Potential Impacts of Climate Variability and Change undertaken by the U.S. Global Change Research Program. This Health Sector Assessment examined potential impacts and identified research and data gaps to be addressed in future research; results appeared in a special issue of *Environmental Health Perspectives* (May 2001).

Ebi et al. (2006a) updated this assessment and concluded that climate change poses a risk for U.S. populations, with uncertainties limiting quantitative projections of the number of increased injuries, illnesses, and deaths attributable to climate change. Future climate change could increase heat-related mortality, increase the number of cases of diarrheal diseases, and increase mortality from diseases exacerbated by high concentrations of ozone and by aeroallergens. Trends in factors that affect vulnerability, such as a larger and older U.S. population, will increase overall vulnerability to these health risks, which currently cause injuries, illnesses, and deaths in the U.S. In addition, the U.S. population may be at risk from climate-related diseases and disasters that occur outside her borders, with travelers and refugees importing diseases not currently present. The unprecedented nature of climate change also may bring surprises for public health.

The capacity of the U.S to develop and deploy effective and timely policies to address climate change is assumed to remain high throughout this century, thus reducing the likelihood of severe health impacts if appropriate programs and activities are implemented. However, the nature of the risks posed by climate change means that some adverse health outcomes may not be avoidable.

Extreme Weather Events

Heatwaves affect human health via heat stress, heatstroke, and death, as well as exacerbations of underlying conditions that can lead to an increase in mortality from all causes of death (not just heatstroke). Older adults, children, city-dwellers, the poor, and

people taking certain medications are at the highest risk during a heatwave. The number of heat-related deaths are projected to increase with climate change (Confalonieri et al. 2007).

Recent projections of the impacts of climate change on heatwaves in the Midwest, using two definitions of a heatwave (the warmest average minimum temperatures over three consecutive nights in a given year, and exceedance of particular thresholds, suggested an increase in the average heatwave frequency of about 24% for Chicago (from 1.7 to 2.1 heatwaves per year); 50% for Cincinnati (from 1.4 to 2.1 heatwaves per year); and 36% for St. Louis (from 1.4 to 1.9 heatwaves per year) (Ebi and Meehl 2007). The average duration of heatwaves was projected to increase by 21% for Chicago (from 7.3 to 8.8 days); by 22% for Cincinnati (from 8.8 to 10.7 days); and by 38% for St. Louis (from 10.3 to 14.2 days). Combining changes in duration and intensity of heatwaves implies an overall increase of about 70% in the annual number of heatwave days for the Midwest by the late 21st century. Moreover, these extreme days will be hotter on average than at present. The projections also suggested that areas such as the Northwest, where heatwaves are not severe at present and where use of air conditioning is less common, future increases in heatwave intensity could result in more heat-related illnesses and deaths.

Hayhoe et al. (2004), the most recent study focused on the U.S., projected the impacts of extreme heat on heat-related mortality in California. Taking some acclimatization into account (but no change in the prevalence of air conditioning), assuming a linear increase in heat-related mortality with increasing temperature, and assuming no change in the population, expected heat-related deaths in Los Angles were projected to increase (from a baseline of about 165 excess deaths annually) two- to three-fold under a low emission scenario and five- to sevenfold under a high emission scenario by 2070–2099.

Climate change is projected to increase the intensity and frequency of floods, droughts, and windstorms in many regions (IPCC 2007a). The impacts of an extreme event, including loss of life and livelihood, are determined by the physical characteristics of the event, attributes of the location affected, and interactions of these with human actions and social, economic, institutional, and other systems. The adverse health consequences of flooding and windstorms often are complex and far-reaching, and include the physical health effects experienced during the event or clean-up process, or from effects brought about by damage to infrastructure, including population displacement. The physical effects largely manifest themselves within weeks or months following the event, and may be direct (such as injuries) and indirect (such as water and food shortages and increased rates of vectorborne and other diseases). Extreme weather events are also associated with mental health effects, such as post-traumatic stress disorder, resulting from the experience of the event or from the recovery process. These psychological effects tend to be much longer lasting and may be worse than the direct physical effects.

Infectious Diseases

Climate change will likely have mixed effects on the health burdens of infectious diseases. Climate is a primary determinant of whether a particular location has environmental conditions suitable for the transmission of several vector-, rodent-, and tick-borne diseases, including West Nile virus, St. Louis encephalitis, Lyme disease, and

dengue. A change in temperature may hinder or enhance vector and parasite development and survival, thus lengthening or shortening the season during which vectors and parasites survive. Small changes in temperature or precipitation may cause previously inhospitable altitudes or ecosystems to become conducive to disease transmission (or cause currently hospitable conditions to become inhospitable). The many determinants of infectious diseases often form an interconnected web with positive feedbacks between transmission dynamics and other factors, making modeling of the impacts of climate change challenging.

Several food- and waterborne diseases are climate sensitive, suggesting that climate change may affect their incidence and distribution. For example, studies report an approximately linear association between temperature and common forms of foodborne diseases such as salmonellosis (Confalonieri et al. 2007).

Air Pollutants

Climate change may increase concentrations of selected air pollutants, particularly ozone in some regions, and decrease concentration of other pollutants, such as particulate matter. Air pollution concentrations are the result of interactions among local weather patterns, atmospheric circulation features, wind, topography, and other factors. Climate change might affect local to regional air quality directly through changes in chemical reaction rates, boundary layer heights that affect vertical mixing of pollutants, and changes in synoptic airflow patterns that govern pollutant transport. Indirect effects may result from increasing or decreasing anthropogenic emissions via changes in human behavior, or from altering the levels of biogenic emissions because of higher temperatures and land cover change. Establishing the scale (local, regional, global) and direction of change (improvements or deterioration) of air quality is challenging.

There is extensive literature documenting the adverse health impacts of exposure to elevated concentrations of air pollution, especially particulates with aerodynamic diameters under 10 and 2.5 micrometers, ozone[1], sulphur dioxide, nitrogen dioxide, carbon monoxide, and lead. More is known about the potential impact of climate change on ground-level ozone than on other air pollutants. Changes in concentrations of ground-level ozone driven by scenarios of future emissions and /or weather patterns have been projected for Europe and North America (Confalonieri et al. 2007). Increases in ozone concentrations will likely increase respiratory problems in susceptible individuals. Based on projections of county-level pollutant concentrations, summer ozone-related mortality was projected to increase by 4% in the New York area by the 2050s based on climatic changes alone (Knowlton et al. 2004).

Global Assessments of the Health Impacts of Climate Change

Two studies have estimated the aggregated global health burdens attributed to climate change. Hitz and Smith (2004) reviewed the literature on the projected health impacts of climate change and concluded that health risks are more likely to increase than decrease with increasing global mean surface temperature, particularly in low latitude countries.

[1] The aerodynamic diameter of a particle determines the depth to which it will be inhaled into the lungs, and, therefore, the degree of damage that may be caused to various parts of the lung.

In addition to greater vulnerability to climate, these countries have some of the highest populations, tend to be less developed, and generally have poorer public health infrastructure, suggesting greater damages.

In the most comprehensive evaluation of the health burden due to climate change, McMichael et al. (2004) used a comparative risk assessment approach as part of the Global Burden of Disease study to project total health burdens between 2000 and 2030 and to project how much of this burden might be avoided by stabilizing greenhouse gas (GHG) emissions. The health outcomes included were chosen based on sensitivity to climate variation, predicted future importance, and availability of quantitative global models (or feasibility of constructing them). Specific health outcomes included were episodes of diarrheal disease, cases of *Plasmodium falciparum* malaria, fatal unintentional injuries in coastal floods and inland floods/landslides, and non-availability of recommended daily calorie intake (as an indicator for the prevalence of malnutrition). Inclusion of a limited number of health outcomes suggests that the estimated impacts are likely to be underestimates. In the year 2000, climate change-related changes in temperature, precipitation, and other weather variables were estimated to have caused the loss of more than 150,000 lives (0.3% of worldwide deaths) and 5,500,000 Disability Adjusted Life Years (DALYs)[2] (0.4% worldwide), with malnutrition accounting for approximately 50% of these deaths and DALYs. These estimates are for a period when limited climate change occurred, suggesting larger health burdens in the near future.

The projected relative risks attributable to climate change in 2030 vary by health outcome and region, and are largely negative, with the majority of the projected health burden due to increases in diarrheal disease and malnutrition, primarily in low-income populations already experiencing a large burden of disease . Absolute health burdens depend on assumptions of population growth, future baseline disease incidence, and the extent of adaptation.

Particularly Vulnerable Populations and Regions

Vulnerability to climate change will vary between and within populations. Sub-populations that are most vulnerable to the health impacts of climate change depend on the region of interest, the health outcome, and population characteristics, including human, institutional, social, and economic capacity, distribution of income, provision of medical care, and access to adequate nutrition. In general, children, older adults, those with chronic disease, and the poor and disadvantaged are most at risk.

3.0 Managing the Projected Health Risks of Climate Change

Adaptation and mitigation are the primary approaches for addressing the risks of climate change, with mitigation focusing on reducing greenhouse gas emissions to limit longer-term climate change and adaptation typically focusing on measures to reduce impacts in the shorter-term due to the climate change to which Earth is already committed. Mitigation and adaptation are not mutually exclusive; co-benefits to human health can

[2] DALYs are a metric used to express how a healthy life is affected by disease; it combines the years lost because of premature death and disability.

result concurrently with implementation of mitigation actions. Neither is sufficient in itself; focusing only on mitigation would leave communities ill-prepared for changes expected in the short term; and focusing only on adaptation would increase the amount of climate change to which future societies would need to cope.

Viewing adaptation within a risk management framework highlights some of the key differences between climate change and other environmental risk factors, including that the exposure cannot be prevented (i.e. increases in the frequency, intensity, and length of many extreme weather events); the rate of change is likely to increase over the next several decades; and the risks will vary over temporal and spatial scales, with the extent of impacts dependent on local and national factors. Therefore, adaptation will be a continual process of attempting to prevent adverse impacts from changing exposures and vulnerabilities.

Climate change will make more difficult the control of climate-sensitive health determinants and outcomes. Therefore, health policies need to explicitly incorporate climate-related risks in order to maintain current levels of control. In most cases, the primary response will be to enhance current health risk management activities. The health determinants and outcomes that are projected to increase with climate change are problems today. In some cases, programs will need to be implemented in new regions; in others, climate change may reduce current infectious disease burdens. The degree to which programs and measures will need to be augmented to address the additional pressures due to climate change will depend on factors such as the current burden of climate-sensitive health outcomes, the effectiveness of current interventions, projections of where, when, and how the health burden may change with changes in climate and climate variability, the feasibility of implementing additional cost-effective interventions, other stressors that might increase or decrease resilience to impacts, and the social, economic, and political context within which interventions are implemented (Ebi et al. 2006b). Examples of adaptation measures range from developing and deploying early warning systems and emergency response plans that specifically incorporate projections of climate change-related health risks to establishing surveillance programs in regions where projections suggest disease vectors may change their geographic range. Adaptation policies and measures need to consider how to effectively and efficiently reduce climate-related health risks in the context of sustainable development, considering projected demographic, economic, institutional, technologic, and other changes.

Because fossil fuel combustion is a source of urban air pollutants and greenhouse gases, policies to reduce greenhouse gas emissions may have health benefits in the near- and long-term. There are potential synergies in reducing greenhouse gas emissions and improving population health via sustainable transport systems that make more use of public transport, walking, and cycling.

4.0 Research Limits Projections of the Health Impacts of Climate Change in the United States

A severe limitation to understanding current and projecting future health impacts of climate change in the U.S. is the very low level of research aimed at providing quantitative projections of the number of increased injuries, illnesses, and deaths that

could be attributable to climate change. There is increasing interest by local and state public health agencies in understanding their climate change risks. However, the National Research Council, in its report "Evaluating Progress of the U.S. Climate Change Science Program: Methods and Preliminary Results" (2007), concluded that the U.S. Climate Change Science Program lags in understanding the human health impacts of climate change. Further, efforts to understand climate change impacts on society, to analyze mitigation and adaptation strategies, and to study regional impacts are "relatively immature." It was recommended that the Climate Change Science Program adjust the balance between climate science and application. That re-balancing has not yet taken place.

Citing urgent threats including climate change, Centers for Disease Control and Prevention (CDC) Director Julie Gerberding advocated in March 2008 for an increase in CDC funding. Instead, the President's FY 2008 Budget cut CDC funding by 2.8% of what would maintain 2007 funding levels adjusted for inflation. The proposed FY 2009 budget will cut CDC funding further. Dr. Frumkin, the Director of the Division of Environmental Hazards and Health Effects at CDC, stated in March 2007 that the "public health effects of climate change remain largely unaddressed."

Significantly greater funding on climate change issues by the European Commission has resulted in greater understanding of the health risks of and public health responses to climate change in the European Union, including projections of health impacts at local and regional levels, as well as implementation of public health policies and measures to address these projected risks.

5.0 Public Health Capacity to Address the Risks of Climate Change

Realistically assessing the potential health effects of climate change must include consideration of the capacity to manage new and changing climatic conditions. Individuals, communities, governments, and other organizations currently engage in a wide range of actions to identify and prevent adverse health outcomes associated with weather and climate. Although these actions have been largely successful, recent extreme events and outbreaks of vectorborne diseases highlight areas for improvement. Further, climate change is projected to challenge the ability of current programs and activities to control climate-sensitive health determinants and outcomes (Confalonieri et al. 2007). Preventing additional morbidity and mortality requires evaluation of programs and activities in light of climate change projections to identify modifications that will increase resilience to the full range of health risks that may arise with climate change, and to ensure that these modifications reduce the sensitivity of those populations and regions most at risk. The effectiveness of these programs and measures will depend on the local context, including socio-economic, geographic, and other factors.

The risks of climate change are likely to place extraordinary demands on public health programs and activities designed to protect the health and safety of U.S. residents and visitors. Increases in illnesses, injuries, and deaths would be expected unless policies and measures are developed to ensure effective functioning of these programs and activities. National, state, and local plans are needed to ensure sufficient public health capacity during and following extreme events such as flooding, storms and storm surges, and to

address outbreaks of climate-related outbreaks of vector-, food-, and waterborne diseases. This capacity must be present, consistent, and effective in analyzing the safety of drinking water, monitoring for the appearance of vectorborne diseases, and providing acute and chronic care for persons suffering from the effects of climate-related events. Constraints include the financial, human, and institutional capacity at all levels of government and institutional service providers.

In his testimony, Dr. Balbus will discuss the results of a survey of the level of awareness of climate change risks by local public health departments and the extent to which they have begun to address those risks. The results suggest that there remains limited knowledge of the potential health impacts of climate change. Local public health officials are only beginning to recognize the risks and to implement policies to reduce current impacts and those projected to occur over the short and long term.

6.0 The Human Impacts of Climate Change Outside the U.S. Can Affect the Population Health in the U.S.

Health security in the U.S. is influenced by risks outside her borders, as illustrated by the introduction and spread of West Nile virus and the concerns over the possible spread of SARS in the U.S. Globalization, increased travel and trade, immigration, and other factors can introduce new health risks, and disasters can increase the flow of refugees. *Plasmodium vivax* malaria, dengue fever, and other vectorborne diseases were once prevalent in the U.S., and the mosquitoes that can carry these diseases remain common in the U.S. Climate change is providing an opportunity for these mosquitoes to increase their geographic range; this could put more people at risk for introduced diseases if vector control programs are insufficient or not prepared. Better understanding of how climate change could alter the current distribution and incidence of climate-sensitive health outcomes throughout the world is needed to ensure U.S.-based programs and activities have adequate knowledge and resources to protect the health of our citizens.

7.0 Health Impact Assessments Are Needed of Policies and Technologies Being Developed to Reduce Climate Change Risks

The policies and technologies being developed to reduce the risks of climate change, from energy efficiency policies to carbon capture and storage, may have considerable health consequences. Therefore, a mechanism is required to assess the consequences of proposed mitigation and adaptation policies and measures prior to their adoption. Health Impact Assessments (HIAs) are a proven approach to ensuring that potential public health concerns are identified and addressed before they become a problem. According to the World Health Organization, “HIA provides decision makers with information about how any policy, programme or project may affect the health of people. HIA seeks to influence decision makers to improve the proposal.” (http://www.who.int/hia/en) HIAs includes consideration of potential alternatives to reduce or mitigate potential health consequences of a proposed policy, as well as monitoring and evaluation of the adopted policy’s implementation, to make corrections as needed to ensure the policy’s effectiveness and its protection of human health. HIAs also can be used to identify the co-benefits of smart growth and development policies.

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