

National Institute of Environmental Health Sciences
Division of Extramural Research and Training

NATIONAL ADVISORY ENVIRONMENTAL HEALTH SCIENCES COUNCIL
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Concept Clearance

Human Health Impacts of Global Climate Change

Introduction:

Global climate change is one of the most pressing environmental and public health concerns of the 21st century. Major human health impacts of climate change are anticipated to occur due to associated changes in the environment, such as direct effects from heat, sea level rise, changes in precipitation resulting in flooding and drought, more intense hurricanes and storms, degraded air quality and increased exposure to toxic environmental pollutants including persistent organic pollutants, metals, and pesticides. Strategies for mitigating and adapting to climate change also may have associated human health consequences, both beneficial and potentially adverse. Therefore, a better understanding of how climate change will directly and indirectly alter human health risks in the United States and globally, as well as who will be most vulnerable to health effects, is critical to prevent illness and death in current human populations while simultaneously protecting the environment and health of future generations.

As the lead NIH institute on human health and the environment, the National Institute of Environmental Health Sciences (NIEHS) has a significant contribution to make in understanding the mechanisms by which climate change both causes and exacerbates human morbidity and mortality, as well as in helping to inform, design, and evaluate effective mitigation and adaptation strategies. A recent analysis of the NIH research portfolio supports this point by demonstrating that, while NIH currently supports very little research that directly investigates the links between climate and health outcomes, NIEHS and other NIH Institutes and Centers (ICs) support significant research on climate-relevant topics, such as the health effects of air pollutants and pesticides. Thus, while much of the relevant expertise and infrastructure already exist within the NIH community, a coordinated effort and targeted research funding are needed to maximize the contribution of NIH to climate change research.

This proposed Human Health Impacts of Climate Change (HHICC) program concept builds on NIEHS activities to redirect the focus of climate change science and the discussion of climate's effects to the impact on human health. Recognizing the need for new emphasis in this area, in 2009 NIEHS created an ad hoc Interagency Working Group on Climate Change and Health (IWGCCH) with participation by several other sister agencies, including the Center for Disease Control and Prevention (CDC), the

U.S. Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), and the U.S. Global Change Research Program (USGCRP). NIEHS led this group in developing a white paper outlining research needs in eleven categories of consequences of climate change for human health. These categories include several high priority disease areas for NIEHS, such as asthma and respiratory disease, cancers, cardiovascular disease and stroke, developmental disorders, and neurological diseases. The report also identifies crosscutting themes: identifying vulnerable populations; enhancing public health and health care infrastructure; developing capacities and skills in modeling and prediction; and improving risk communication and public health education. This report was recently released and is available on the NIEHS website at: www.niehs.nih.gov/climatereport.

NIEHS also co-chairs the Trans-NIH Working Group on Climate and Health with the NIH Fogarty International Center (FIC). This group sponsored a workshop in December 2009 to bring together leading investigators in the field of climate and health, elicit their ideas on specific scientific opportunities and public health needs in this area, and begin developing NIH research priorities on climate change and health. Findings from the IWGCCH white paper report and the December 2009 workshop were heavily drawn upon in developing the HHICC program concept described below.

Framework and Goals:

The Human Health Impacts of Climate Change (HHICC) program will provide a structure to coordinate and support a variety of NIEHS-sponsored research and mission-related activities to better understand how climate change will directly and indirectly affect human health risks. Given the complexity of the science needs and the potential overlap of research questions across disciplines, a major goal of the program will be to develop a comprehensive research agenda, to coordinate collaborative research initiatives across the NIH and with other federal agencies, and to leverage the resources and capacities of each agency.

Five major research categories relevant to the NIEHS mission are identified for emphasis within the HHICC program:

- Research on the health impacts of climate change and weather variability
- Research on the health impacts of climate change mitigation and adaptation strategies
- Research to assess and characterize population vulnerability to climate change
- Research methods and model development
- Research on risk communication and education

Each of these research categories is described in detail below. Given the complexity of the research topics, we plan to systematically address each category through a series of funding opportunity announcements over the next **10** years. This effort will be supplemented by “seeding” of ongoing, relevant NIEHS initiatives with added emphasis on climate change, identifying opportunities to partner with other NIH ICs and federal

agencies, and working with the NIH Center for Scientific Review to facilitate more successful review of unsolicited research grants in this area.

Research on the Health Impacts of Climate Change and Weather Variability:

Climate change will impact human exposure to many of the environmental toxicants viewed as priority exposures for study at NIEHS. For example, the complex atmospheric chemistry that governs air quality is modulated by heat, humidity, degree of ultraviolet (UV) radiation, and other factors. Changes in any of these can increase exposures to a variety of toxic air pollutants including chemicals, fungi, and aeroallergens, potentially resulting in increases in asthma, cardiovascular disease, and other respiratory ailments. Climate change is also anticipated to lead to increased pesticide and herbicide exposure due to the need to combat climate-induced increases in pests, and increases in precipitation intensity, runoff, and subsequent water contamination. At the same time, changes in rainfall and other precipitation, extreme weather events, and melting of polar ice caps may result in increased exposure to toxic environmental pollutants such as persistent organic pollutants and metals. Many of these chemicals are known or suspected carcinogens, and cause a variety of developmental or neurological effects. The warming of ocean waters also will contribute to increases in incidence and severity of toxic algal blooms and changes in seafood quality and availability.

Examples of new research that could be supported under the HHICC program may include:

- Epidemiological research on the impacts of heat on morbidity (e.g., incidence of cardiac dysrhythmias) to elucidate how temperature impacts human health beyond mortality risk
- Retrospective studies using existing, integrated data sources to examine the complex synergistic effects of temperature, weather variability, long-term climate change, and altered environmental exposures (e.g., production and distribution of air pollution) on the prevalence, severity, and incidence of disease (e.g., respiratory or cardiovascular outcomes)
- Modeling-based research to examine the impacts of climate change (e.g., heavy precipitation and flooding) on the risk of toxic contamination of the environment (e.g., from storage facilities or toxic runoff from contaminated land) to identify vulnerable populations and likely health outcomes
- Research on how anticipated changes in nutritional status associated with climate change may increase individual susceptibility to the adverse health impacts of exposure to environmental toxicants (e.g., increased exposure to pesticides and heavy metals)

Some of these research topics may be addressed within ongoing NIEHS-sponsored initiatives, such as the Oceans and Human Health program, while others may be successfully funded via the NIH unsolicited grant application process. A major goal of the program will be to identify current and future initiatives that can be leveraged to address these research gaps and to coordinate research in this area supported not only by NIEHS, but also across NIH and other federal agencies. In parallel, research

initiatives targeting specific exposure-disease areas or fields of science will be developed to fill remaining gaps.

Research on the Health Impacts of Mitigation and Adaptation Strategies:

Major gaps exist in our understanding of the benefits or risks for human health of climate change mitigation and adaptation strategies. Here “mitigation” refers to actions being taken to reduce greenhouse gas emissions and to enhance the natural sinks that trap or remove carbon dioxide from the atmosphere. The major targets of mitigation strategies include alternative fuels and energy conservation, changes in land use patterns, sustainable development of the built environment, and carbon capture and storage. Though some mitigation strategies may exacerbate known human health stressors or introduce unanticipated harm, most such strategies will provide co-benefits for health. For example, reducing harmful air pollutants generally decreases global warming but is also just more healthful to people.

“Adaptation” refers to actions being taken to lessen the impact on human society, health, and the environment of changes in climate that cannot be prevented through mitigation. Most adaptation strategies seek to decrease the potential for illness and death by changing the human environment, for example, by preserving water and ensuring food security.

Examples of new research that could be supported under the HHICC program regarding mitigation and adaptation strategies may include:

- Laboratory or population-based research to examine chemicals used in energy efficient technologies to ensure that they are safe and healthy for humans
- Research to evaluate the potential human health risks throughout the life cycle of new mitigation technologies (e.g., potential cancer risks from biofuel production including risks from novel air pollutants and from increased exposures to toxic chemicals due to changes in agricultural practices).
- Exposure and health risk assessments to evaluate the indoor air quality implications of enhanced building insulation used for both mitigation and adaptation.

Some of these gaps may be addressed through the National Toxicology Program (NTP). However, it is also likely that targeted research initiatives will need to be developed to address these gaps. Many of these issues overlap heavily with the research interest of sister agencies, such as the US EPA.

Research to Assess Population Vulnerability to Climate Change:

Key to adapting to the effects of climate change is an understanding of the different risks experienced by various exposed or affected populations so that interventions may be more efficiently targeted and implemented. Certain populations are particularly at risk to the health effects of climate change including children, pregnant women, the elderly,

individuals from low socio-economic backgrounds, and those living in urban or coastal areas. Data to support a broad understanding of which populations will be most susceptible and vulnerable to certain diseases affected by climate change are generally lacking at this time, and research is needed to develop the strategies to adapt to climate changes and avoid excess health risks. This work will need to integrate local-scale data, such as demographics, climate vulnerability, and adaptation strategies may differ between cities and regions, however, research to define common principles will be valuable as well.

Examples of new research that could be supported under the HHICC program regarding assessing vulnerable populations may include:

- Research that uses existing, integrated data sources to identify and map populations and communities at increased risk of specific climate-related diseases (e.g., heat-related morbidity and mortality, respiratory illness, etc.)
- Community-based research assessment involving community organizations, environmental health scientists, climatologists, and community planners to determine and prioritize climate-related risks for a given community in order to facilitate allocation of resources for adapting to and mitigating climate change
- Research to develop general methods and models for identifying and understanding local vulnerabilities and needs that can be applied across varied geographic populations

Targeted research initiatives will be needed; however, this general research area also is likely to be of broad interest to multiple NIH ICs and other federal agencies such as CDC and EPA.

Research Methods and Model Development:

Identification and collection of integrated and appropriately temporally and spatially scaled data on climate/weather, sociodemographics, ecology, and epidemiology are needed for effective monitoring and modeling of the human health impacts of climate change. Presently, skills and methods needed to integrate health datasets with weather and climate information are not well established. Understanding of how best to conceptualize and conduct epidemiological analysis using weather and climate as exposures is also preliminary.

Examples of methods and model development that could be supported under the HHICC program may include:

- Developing and implementing models linking downscaled regional climate models with health impact data to better understand heterogeneity in responses across communities, and to provide information at a scale relevant to multiple layers of policymaking and decision-making
- Developing and validating of real-time remote sensing and other *in situ* monitoring techniques to evaluate air quality, aeroallergens, aerosolized

- pathogens, dust burdens, and other climate-sensitive exposures and directly linking these data to health outcomes (e.g., asthma and airway diseases)
- Developing and implementing models linking climate change and other environmental data (such as land use, land cover, hydrology) to crop and seafood production and contamination, to improve prediction and risk assessment
- Developing and implementing models linking health databases with real-time monitoring and prospective assessment of weather, climate, geospatial, and exposure data in order to better characterize the health impacts of extreme weather events

A goal of this research area is to develop methods and tools that will be directly relevant to public health implementation and policy decisions. Development of some tools (e.g., user-friendly GIS programs mapping climate change-related health risks) may be supported through the NIH Small Business Research Funding Opportunities (SBIR/STTR). Targeted research initiatives also likely will be needed to address these gaps.

Research on Risk Communication and Education:

While recent studies show that the majority of those living in the United States now believe that climate change is a real and serious threat that is caused by human activity, many if not most are skeptical of their personal risk or the need to alter personal behaviors in response to climate change. Research is needed that will aid climate change communicators and educators in adapting their messages and approaches so that they can effectively reach and be assimilated by various audiences. In addition to the general public, stakeholders such as natural resource managers, policy makers, infrastructure planners, health care providers, and others need access to credible and timely climate change information to inform their decisions.

Examples of risk communication and education research that could be supported under the HHICC program may include:

- Fundamental public health communications research to understand the range of public knowledge, attitudes, and perceptions regarding climate change and public health
- Development of novel communication strategies for identified vulnerable populations that will effectively reduce their climate-related health risk
- Research to evaluate heat response plans, focusing on environmental risk factors, identification of high-risk populations, effective communications strategies, and rigorous methods for evaluating effectiveness at a local level

This research area overlaps with the goals of the NIEHS Partnership for Environmental Public Health (PEPH) program, and it is anticipated that many of these needs can be addressed within ongoing and future initiatives released under PEPH. Opportunities may also arise to partner with other NIH ICs and federal agencies such as CDC.

Coordination across NIEHS, NIH, and the Federal Government:

Several ongoing programs within the Division of Extramural Research and Training (DERT) at NIEHS are highly relevant to this program concept, and should be leveraged to build the institute's overall investment in climate change and health. For example, issues surrounding changes in the ocean environment due to climate change and associated health impacts (e.g., harmful algae blooms) could be pursued within the Oceans and Human Health Program. Ongoing activities within the Partnerships for Environmental Public Health (PEPH) program could be used to address research on community-level vulnerability and the need for improving risk communication and public health education around the human health impacts of climate change. The Superfund Research Program (SRP) and Worker Education and Training Program (WETP) could support research and related activities to better understand how extreme weather events will impact the fate and transport of harmful toxicants that are known or suspected to adversely impact human health and disaster response.

NIEHS is also well positioned to contribute to the broader federal research agenda on climate change and health and to foster strong collaborations across the US government. NIEHS represents the Department of Health and Human Services as a principal of the US Global Change Research Program and also helps represent HHS on the Interagency Climate Adaptation Task Force sponsored by the White House and NOAA. NIEHS also co-chairs, along with representatives from EPA and the OSTP, a new crosscutting interagency Group on Climate Change and Human Health, which is tasked with coordinating federal activities in both climate change and health research and science-based response efforts. These activities will not only enhance the ability of NIEHS to establish collaborative research initiatives across the federal government; it will also allow the Institute to take full advantage of processes like the US National Climate Assessment to inform the research agenda and establish research priorities.

Timeline:

Planning for the HHICC program is envisioned for a **10-year** period. Integration of climate-specific language into ongoing or soon-to-be released research initiatives sponsored by NIEHS (e.g., the Oceans and Human Health Program, PEPH) and other relevant trans-NIH funding opportunity announcements will begin immediately. In addition, NIEHS staff will immediately begin working with the NIH CSR to address issues surrounding improving the success of peer review of unsolicited research grants in this area.

It is anticipated, based on funds available, that funding opportunity announcements (FOA) will be released annually under the HHICC program, including both Program Announcements and Requests for Applications. Efforts to release collaborative FOAs with other NIH ICs and sister federal agencies will be a priority for the program. **Under the proposed timeline**, work will begin on drafting a trans-NIH Program Announcement with Special Review (PAR) to be funded in late Fiscal Year 2011 to solicit research on

model development and applied modeling projects to assess population vulnerability to climate change. This topic was chosen on the basis of broad interest across multiple NIH I/Cs, including FIC, National Library of Medicine, National Institute of Child Health and Human Development, National Center for Minority Health and Health Disparities, National Institute for General Medical Sciences, and National Cancer Institute. There was general consensus that the skills and data necessary to carry out such projects are available at NIH, and that such projects could have a significant impact on the field within a brief period of time. It is expected that Research FOAs on the health impacts of climate change/weather variability and mitigation and adaptation strategies will take longer to develop, particularly given that they will likely involve partnerships with federal agencies outside of NIH.

Summary:

While it is clear that climate change is already endangering human health and will continue to do so in the future, the complicated relationships between climate change, the environment, and human health have not traditionally represented high priorities for scientific research in the United States. At present, there are abundant gaps in our understanding of these links. NIEHS has a significant contribution to make in understanding the mechanisms by which climate change both causes and exacerbates human morbidity and mortality, as well as in helping to inform, design, and evaluate effective mitigation and adaptation strategies. Tackling the diversity of research needs surrounding climate change will require a multidisciplinary and integrated approach in which NIEHS intends to leverage ongoing research programs and capacities, promote submission and funding of unsolicited grants in relevant areas, and provide specific funding opportunities for research that will be vital to our understanding of climate change's effects on health. Continued coordination with other NIH ICs, as well as federal agencies such as CDC, EPA, NOAA, and NSF is critical to meeting the nation's public health needs in this area, and will be an ongoing priority for this program.