American Thoracic Society Documents

An Official American Thoracic Society Workshop Report: Climate Change and Human Health

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CONTENTS

This document presents the proceedings from the American Thoracic Society Climate Change and Respiratory Health Workshop that was held on May 15, 2010, in New Orleans, Louisiana. The purpose of the one-day meeting was to address the threat to global respiratory health posed by climate change. Domestic and international experts as well as representatives of international respiratory societies and key U.S. federal agencies convened to identify necessary research questions concerning climate change and respiratory health and appropriate mechanisms and infrastructure needs for answering these questions. After much discussion, a breakout group compiled 27 recommendations for physicians, researchers, and policy makers. These recommendations are listed under main issues that the workshop participants deemed of key importance to respiratory health. Issues include the following: (*1*) the health impacts of climate change, with specific focus on the effect of heat waves, air pollution, and natural cycles; (*2*) mitigation and adaptation measures to be taken, with special emphasis on recommendations for the clinical and research community; (*3*) recognition of challenges specific to low-resource countries when coping with respiratory health and climate change; and (*4*) priority research infrastructure needs, with special discussion of international needs for cooperating with present and future environmental monitoring and alert systems.

Keywords: climate change; respiratory; pollen; greenhouse gases; cobenefits

EXECUTIVE SUMMARY

Climate change is due to average global surface temperature increase over the past several decades from greenhouse gases in the troposphere reflecting infrared radiation back to the earth's surface. Greenhouse gases are dominated by CO_2, but important contributions come from methane, nitrous oxide, carbon black, ozone, and small amounts of chemicals, including hydrofluorocarbons, hydrochlorofluorocarbons, and others. Importantly, the recent increased greenhouse gases chronicled by reports of the Intergovernmental Panel on Climate Change are anthropomorphic in origin. The year 2010 tied 2005 as the warmest year since records began in 1880 and was the 34th consecutive year with average temperatures above the twentieth-century average. The National Oceanic and Atmospheric Administration chronicled seven rising indicators of climate change: (*1*) air temperature over land, (*2*) sea-surface temperature, (*3*) air temperature over oceans, (*4*) sea level, (*5*) ocean heat, (*6*) humidity, and (*7*) tropospheric temperature in the active weather layer of the atmosphere closest to the Earth's surface. Three indicators were declining: (*1*) Arctic sea ice, (*2*) glaciers, and (*3*) spring snow cover in the Northern hemisphere. How will a warming world affect pulmonary, critical care, and sleep physicians? Before the 2010 American Thoracic Society International Conference, the Workshop organizers invited national and international experts to consider these questions and make the following recommendations for research and investigation:

- Epidemiology: Explore how climate changes in heat, humidity, precipitation, and extreme weather events impact the distribution of respiratory disease.
- Heat Stress and Adaptation: Understand how extreme heat affects the individual and the community.
- Vulnerable populations: Increase knowledge of how climate-forced heat increases impact the young, impoverished, and those with chronic cardiorespiratory conditions.
- Human Exposure Studies: Conduct chamber studies to understand how the human body responds to airborne exposures in conjunction with heat.
- Climate-Forced Air Pollution: Examine how climate change influences the production, distribution, and interaction with air pollutants, especially heat and ozone.
- Biomass Fuel Cooking: Charcoal, animal matter, and plant matter in indoor cooking and heating increase mortality from children's respiratory infections and chronic obstructive pulmonary disease; explore the impact and control on the release of black carbon into the atmosphere.

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- Seasonal Disease Cycles: Understand how changing climate will impact the seasonal pattern of infectious diseases involving the respiratory system.
- Human Migration: Study how climate change effects on water and food will potentially impact human migration patterns and conflict causing respiratory health challenges (e.g., tuberculosis).
- Allergy: Explore how changing weather patterns, increased CO_2, heat, and changing temperate zones will impact human exposures to pollen in terms of intensity, allergenicity, duration of growing seasons, and expanded pollen range.
- Vector- and Zoonotic-Borne Disease: Investigate how respiratory health will be impacted by climate-induced vector-borne disease and their shifting ranges (e.g., dengue fever).
- Mold: Study how changes in humidity, precipitation, and extreme weather events will impact respiratory exposures to mold, especially those brought on by flooding.
- Desertification: Understand how climate-forced desertification and the long-term transport of mineral dusts will impact respiratory health.
- Forest Fires: Recognize how climate change will impact the frequency and intensity of forest fires and their likely impact on human exposures to respiratory irritants.

In addition, the Workshop participants suggested opportunities to mitigate the adverse effects of Climate Change through a variety of approaches:

- Educational Outreach to Clinicians and Public Health Practitioners: Provide information about climate change and its potential impacts on respiratory health. Clinicians and public health providers can influence public opinion and policy makers on how climate change affects human health.
- Climate Change Research Centers: Develop and fund climate change and Human Health Research Centers. These Centers should adopt a multidisciplinary approach and include cross-disciplinary training based in public health and medical schools to foster scientific skills sets for the study of climate change and human health.
- International Research Collaboratives: Incorporate into the mission of existing international research collaboratives the study of how climate change affects human health.
- Build Healthy Buildings and Community: Construct energy-efficient healthy buildings located in communities designed to foster exercise and minimize exposure to vehicular emissions.
- Alternative Energy: Identify and protect against any respiratory health risks that new alternative energy processes possess (e.g., acetaldehyde, acrolein).
- Monitoring and Alert Systems: Develop national air quality, pollen, and weather-alert systems; develop potential of personal technologies to alert individuals and communities of climate-related health threats.

We, as pulmonary physicians and scientists, currently have minimal capacity to respond to climate change and its impacts on health. The extent to which climate change influences the prevalence and incidence of respiratory morbidity remains largely undefined. However, evidence is increasing that climate change does drive respiratory disease onset and exacerbation as a result of increased ambient and indoor air pollution, desertification, heat stress, wildfires, and the geographic and temporal spread of pollens, molds, and infectious agents associated with increased allergenicity, temperatures, and atmospheric concentrations of carbon dioxide (1–6).

The American Thoracic Society (ATS) Climate Change and Respiratory Health Workshop was held in New Orleans, Louisiana, on May 15, 2010. The purpose of the 1-day meeting was to address the threat to respiratory health posed by climate change (7–9). Domestic and international experts convened to identify necessary research questions as well as appropriate research mechanisms and infrastructure needs. The ultimate goal was to present recommendations for the health sector to implement efficient approaches to limit the respiratory health impact of climate change. The proceedings from the workshop are presented below.

METHODS

The workshop cochairs, in consultation with members of the American Thoracic Society's Environmental Health Policy Committee, invited U.S. and international experts on respiratory health and climate change to participate in the workshop. International respiratory societies and key U.S. federal agencies were also represented. All members of the writing committee submitted Conflict of Interest statements prior to the workshop. No important conflicts of interest were identified or became apparent during the workshop.

After viewing a series of expert presentations on the respiratory health effects of climate change, participants were assigned to breakout groups to discuss key research questions and needs. A facilitator and reporter were assigned to each breakout group. All participants were encouraged to express opinions and recommendations. The discussions of the breakout groups were presented to the entire workshop for additional input and then transcribed, collated, and summarized in this manuscript. Additional recommendations were formulated during teleconferences among writing committee members after the workshop. Any disagreement was resolved by discussion and consensus. All workshop attendees had the opportunity to review and revise the manuscript prior to submission.

A summary of the methodology is presented in Table 1.

RESPIRATORY HEALTH IMPACTS OF CLIMATE CHANGE

Preliminary research has shown climate change has potentially direct and indirect adverse impacts on respiratory health. Published studies have linked climate change to increases in respiratory disease, including the following: changing pollen releases impacting asthma and allergic rhinitis, heat waves causing critical care–related diseases, climate-driven air pollution increases exacerbating asthma and chronic obstructive pulmonary disease, desertification increasing particulate matter (PM) exposures, and climate-related changes in food and water security impacting infectious respiratory disease through malnutrition (pneumonia, upper respiratory infections). There has been concern about increased aeroallergens and mold exposure associated with allergy and respiratory health after the flooding that occurred from Hurricane Katrina, which deluged the southern United States in 2005 (10–15). The impact of climate change on pollen and mold spores and allergic respiratory diseases is of growing concern (16, 17). Workshop participants suggested links between climate-forced migration, crowding, and tuberculosis, as evidenced in large areas of Africa as deserts spread in this continent. Climate change may also cause seasonal shifts impacting seasonal flu patterns (7, 18, 19).

Although all of these factors were discussed at the workshop, the most serious and direct health risk of climate change was believed to be heat-related disease resulting from increased frequency and severity of heat waves, which have been demonstrated to increase morbidity and mortality (20). Higher surface temperatures, especially in developed urban areas, promote the formation of ground-level

TABLE 1. METHODOLOGY

Methods Checklist	Yes	No
Panel assembly		
Included experts from relevant clinical and nonclinical fields	x	
Included individuals who represented patients and society at large	x	
Included methodologist with appropriate expertise (documented expertise in development of conducting systematic reviews to identify the evidence base and development of evidence-based recommendations)		x
Literature review		
Performed in collaboration with a librarian		x
Searched multiple electronic databases	x	
Reviewed reference list of retrieved article	x	
Evidence synthesis		
Applied preselected inclusion and exclusion criteria		x
Evaluated included articles for sources bias		x
Explicitly summarized benefits and harms	x	
Used PRISMA1 to report systematic review		x
Used GRADE to describe quality of evidence		x
Generation of recommendations		
Used GRADE to rate the strength of recommendations		x

Definition of abbreviations: GRADE = Grades of Recommendation Assessment, Development and Evaluation; PRISMA1 = Preferred Reporting Items for Systematic Reviews and Meta-Analyses 1.

ozone (4, 21), and ozone exposure has been linked to exacerbations of chronic obstructive pulmonary disease, asthma, idiopathic pulmonary fibrosis, lung cancer, and acute lower respiratory infection. During heat waves, health effects can be due to combined exposures to excessive heat and air pollution. A recent analysis of European heat waves (1990–2004) measured higher respiratory than cardiovascular mortality, although specific causes could not be determined (22). The impacts of climate change on surface ozone, SO_2, and NO_x concentrations in the United States and elsewhere have been examined in numerous recent studies (23–28), with potentially important morbidity and mortality implications for human health (29–32). In addition, as the demand for air conditioning increases during heat waves, power consumption and the production of fine PM increases, which is a contributor to cardiopulmonary disease.

Workshop participants identified key climate change factors—heat, air pollution, and airborne allergens—that they believed present significant challenges to respiratory health worldwide. Corresponding research needs and questions for each climate change factor were discussed. The results of the discussion are presented below.

Heat Research Needs

- Epidemiology: Explore how climate changes in heat, humidity, precipitation, and extreme weather events impact the distribution of respiratory disease.
- Heat Stress and Adaptation: Understand how increased heat, particularly extreme heat, affects a community's ability to adapt.
- Vulnerable Populations: Increase knowledge of how climate-forced heat increases impact vulnerable populations (e.g., old, young, impoverished, those with chronic cardiorespiratory conditions, or chronic disease overall).

Air Pollution Research Needs

- Human Exposure Studies: Conduct chamber studies to understand how the human body responds to airborne exposures in conjunction with heat.
- Climate-Forced Air Pollution: Examine how climate change influences the production and distribution of air pollutants (e.g., how increased ambient temperatures will amplify known hazardous exposures or modify the effect of known exposure–outcome relationships).
- Co-benefits and Trade-offs: Elucidate the interactions between air quality control measures, sustainable development, and climate change mitigation and adaptation measures. Topics include cobenefits research (biomass fuel cooking/heating alternatives), PM reduction and its impact on the atmospheric energy balance, air pollution and cloud formation, urban planning, renewable energy, and energy consumption.

Natural (Seasonal) Research Needs

- Disease Cycles: Understand how changing climate will impact the pattern of infectious disease (i.e., flu, colds).
- Human Migration: Study how climate-forced changes in water/food security, risk of extreme weather events, and heat will potentially impact established and novel human migration patterns as well as how communities and regions will likely adjust to these migration patterns in terms of health care and respiratory disease, such as tuberculosis.
- Allergy: Explore how climate change (increased atmospheric CO_2 concentrations and temperatures) will impact human exposures to pollen and mold spores in terms of intensity, allergenicity, duration, and timing of growing and pollen-production seasons and changed flora and pollen range.
- Vector- and Zoonotic-Borne Disease: Investigate how respiratory health will be impacted by climate change-induced vector-borne diseases and their shifting ranges.
- Humidity, Precipitation, and Mold: Study how climate changes in humidity, precipitation, and extreme weather events will impact respiratory exposures to mold, especially those brought on by flooding of dwellings or high humidity.
- Desertification: Understand how climate-forced desertification and the long-term transport of mineral dusts will impact respiratory health.
- Forest Fires: Recognize how climate change will impact the frequency and intensity of forest fires and its likely impact on human exposures to respiratory irritants along with effective adaptations to lessen or avoid such effects.

MITIGATION AND ADAPTATION

Efforts to prevent and prepare for climate change include mitigation strategies, defined as actions to limit further climate change by reducing the production of greenhouse gases, and adaptation strategies, defined as actions to lessen adverse impacts by preparing for inevitable changes in climate and climate variability (3, 33). Generally, mitigation and adaptation strategies are being developed independently of each other, and to date, the public health and clinical perspective has not been well represented (34). In this context, the following broad-based and specific recommendations relevant to respiratory health were proposed. Each recommendation has elements that can be implemented in the short term as well as a planning component for making changes that occur over the medium to longer term (5–10 and 10–100 year time frames).

Recommendations for Clinicians and Researchers

- Educational Outreach to Clinicians and Public Health Practitioners: Provide information about climate change and its potential impacts on respiratory health (11, 18). Medical societies should develop guidelines for medical alerts. Public health measures need to be in place to reach vulnerable populations during specific climate change–related events, such as heat waves or severe air pollution episodes and other extreme weather events (e.g., extreme rainfall and floods) or rising sea levels and storm surges that challenge or threaten community infrastructure. This might include but not be limited to information on how to get to cooling centers, optimal dosing for medications that affect thermoregulation, and access to care (e.g., planning surge capacity).
- Cross-Disciplinary Training Programs: Develop and fund cross-disciplinary training programs based in public health and medical schools to foster the scientific skills sets needed to understand the interactions between climate change and human health. Encourage clinicians and researchers to participate in the development of mitigation and adaptation strategies and share their expertise with policy makers at the local, state, federal, and international levels.
- Climate Change Research Centers: Develop and fund climate change/human health research centers. These centers should adopt a multidisciplinary approach to studying interactions between human health links and climate change.
- International Research Collaboratives: Incorporate into the mission of existing international research collaboratives the study of how climate change affects human health.

Recommendations for Mitigation and Adaption

- Behavior: Understand the factors that impact the capacity and willingness to adopt effective greenhouse gas–mitigation strategies by individuals and communities and design educational programs to increase communities' awareness of the health benefits (35).
- Power of Clinical Community: Clinicians and health care providers influence the public and policy makers. They should be proactive in identifying and contributing to solutions and capitalize on that power by creating venues and pathways by which their voices can be heard.
- Build Healthy Buildings and Community: Construct energy-efficient, healthy buildings (e.g., include adequate ventilation to prevent/reduce indoor mold-fostering moisture and exposure to air pollution, natural light, air conditioned spaces) located in communities designed/modified to foster exercise and minimize exposure to vehicular emissions (36).
- Increase Respiratory Resilience to Environmental Stressors: Improve overall population health (e.g., address the global obesity epidemic in developed countries and nutritional deficiency in developing countries) and reduce exposure to ambient and indoor air pollution.
- Alternative Energy: Identify and protect against any respiratory health risks that new, alternative energy processes possess.

ISSUES AFFECTING LOW-RESOURCE COUNTRIES

Although all countries will be affected by climate change, workshop participants acknowledged that low-resource countries are uniquely vulnerable to the respiratory health risks brought on by climate change. This is due to low-resource countries often lacking economic resources, having a close dependence on natural systems for basic food and water provision, and suffering from inadequate housing, energy, and waste management (1) (Table 1). These challenges limit societal adaptation to climate-related shocks (37) or the ability to even consider implementing mitigation strategies.

In addition, these countries are often plagued by several respiratory health challenges that defy analysis by simple, linear exposure models, including high rates of childhood pneumonia (38, 39), high levels of air pollution (40), increasing prevalence of chronic diseases (41), and a range of conditions related to inadequate nutrition and safe water. On a positive note, although climate change makes some health goals more difficult to achieve, it also offers an opportunity to accelerate achievement of health goals through actions that both reduce the risk of climate change and protect health, a "cobenefit."

PRIORITY RESEARCH INFRASTRUCTURE NEEDS

Workshop participants believed that for both low- and high-resource countries to benefit from climate change and respiratory health research, improved research infrastructure and concerted international cooperation among governments, agencies, scientists, and communities are paramount. Myriad research needs exist in low- and high-resource countries that should be remedied to effectively develop research partnerships that can address major climate-related risks to global respiratory health. A crucial step toward building research infrastructure is to understand the existing national surveillance systems, augmenting their efficiency and scope, and reinforcing the completeness and reliability in data collection. Considering the variability in currently existing surveillance systems worldwide, implementation of accurate and reliable surveillance systems is necessary to identify, capture, and monitor climate changes that can affect respiratory health and should include the following:

Monitoring and Alert Systems

- Pollen Tracking: Develop national and international pollen-monitoring networks.
- International Air Quality–Monitoring Network: Develop and fund improved national and international air quality–monitoring networks, particularly in rapidly growing cities of the developing world.
- Weather Forecasting: Improve weather forecasting to understand climate-forced change in weather and its impact on human health (heat, humidity, extreme weather events, precipitation, food and water security).
- Weather Alert Systems: Expand or develop effective alert systems to inform communities about pending extreme weather events that can link to air pollution–monitoring systems.

- Personal Technology Alert and Reporting Systems: Explore the potential of personal technologies as a way to both alert individuals and communities of climate-forced health threats as well as using such personal technologies to collect human health data.

SUMMARY OF KEY FINDINGS

The purpose of the ATS Climate Change and Respiratory Health Workshop was to identify necessary research questions as well appropriate mechanisms and infrastructure needs for limiting the respiratory health impact of climate change. A crucial step to be taken is improving public health and clinical educational programs to raise awareness of climate change and the potential health consequences and attract more of the work force to this area of study. There needs to be an emphasis on public recognition and early warning response to severe climate-related events with the awareness that these effects are likely to have the most impact on susceptible populations: the elderly, infants and children, those with existing respiratory/cardiovascular disease or autonomic dysfunction in temperature control, and those living in low-resource countries. In addition, multidisciplinary research efforts involving research scientists, clinicians, public health specialists, sociologists, local–state partners, climatologists, toxicologists, epidemiologists, and population scientists are required to address unanswered health-related consequences of climate change. Funding agencies should encourage multidisciplinary approaches and introduce newer funding mechanisms, collaborative program project grants, new investigator awards, and training awards to enhance research interest of newer investigators in this field. For example, research on climate and respiratory health can be enhanced by greater access to and coordination among existing Earth system science, technology, and data collection efforts underway at organizations such as the World Health Organization (WHO), National Aeronautics and Space Administration (NASA), U.S. Centers for Disease Control and Prevention (CDC), U.S. Environmental Protection Agency (USEPA), U.S. National Institute of Environmental Health Sciences (NIEHS), World Meteorological Organization (WMO), the United Nations (UN), and many others. Critical use of existing resources is likely to enhance cobenefits to several agencies partnering. Last, defined public health cohorts, disease surveillance programs, review of existing climate surveillance systems, and environmental tracking and registry systems need to be improved or developed globally. Domestic and international participants in the ATS workshop came together to collectively discuss the respiratory health challenges brought about by climate change. These proceedings present their concerns and recommendations to other members of the health, research, and policy sectors, so that they can be informed and act on a challenge that faces us all.

This official ATS Workshop Report was prepared by a writing committee of the American Thoracic Society Environmental Health Policy Committee.

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