

Realizing the Paris Climate Agreement to Improve Cardiopulmonary Health

Where Science Meets Policy

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A Synopsis of the 2017 American Thoracic Society Scientific Symposium in Washington, DC

Climate change continues to be a topic of global concern affecting agriculture, urban living, risk of severe weather, wildfires, and dust storms, with wide-ranging consequences for the environment and public health. The scientific basis of climate change worldwide is undeniable. The Paris Climate Agreement of 2015 set ambitious goals for the reduction of carbon dioxide (CO₂) emissions, but individual nations were left to decide how to meet the reduction goals. Energy policy choices can have different implications for human health. A symposium at the 2017 international conference of the American Thoracic Society held in Washington DC addressed these issues with three objectives: 1) to create a science policy forum where scientists and Washington policymakers could have a dialogue to improve future interactions, 2) to educate American Thoracic Society (ATS) members about the potential human health benefits of climate mitigation, and 3) to inspire ATS members to get involved in enhancing the role of scientific evidence and the consideration of human health in Washington policy making.

Weeks after this symposium was held, U.S. President Trump announced his decision to withdraw from the Paris Climate Agreement. Without decisive action to reduce greenhouse gas emissions, the health consequences of climate change will escalate. With this synopsis, we aim to expand the audience of the Symposium and to encourage efforts at the level of physicians and other healthcare professionals, scientists, hospitals, cities, states, and the federal government to achieve the goals set forth by the 2015 international agreement.

A Primary Care Physician's Perspective from Cameroon, Africa

By: Nganda Motto Malea, M.D.

The health of any population relies on clean air, safe water, adequate food, tolerable temperatures, stable climate, and high level of biodiversity. Globally, climate change has resulted in devastating changes to these essential resources (1). African nations have a very small carbon footprint—we emit only about 4% of total world carbon emissions (2)—and yet we suffer disproportionately from the adverse health effects of climate change.

As a practicing physician in Cameroon, I have experienced the effects of climate change among the people in my country in the form of dehydration and heat stress from drought and extreme heat, malnutrition from crop loss, respiratory effects of dust, and water-borne illnesses promoted by flooding and stagnant water, including onchocerciasis and schistosomiasis. Displacement of communities due to changes in the food supply often results in crowded living conditions that foster the spread of diarrheal and respiratory disease. These health effects reduce my patients' capacity to cope with poverty, which is widespread in Cameroon, where many people depend on subsistence farming to survive.

Because of the unfortunate synergistic effects of climate change (including drought, heat and extreme precipitation), combined with the conditions of extreme poverty, malnutrition, and social unrest, there is little doubt climate change will worsen the common health problems we already experience in Africa. Scientists have systematically underestimated or overlooked the threat of climate change for the people of Africa. We do not have the political power to reduce carbon emissions by the polluting nations of this planet, and

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we need advocates from your healthcare community to help solve the health crisis of climate change.

Understanding Climate Science and Policy: What Doctors Should Know

By: Mary B. Rice, M.D., M.P.H.

The fact that greenhouse gases warm the atmosphere has been known for more

than a century. In 1896, Svante Arrhenius was the first scientist to report that changes in the levels of CO₂ in the atmosphere could substantially alter the surface temperature through the greenhouse effect (Figure 1) (3). It is now clear that the greenhouse effect, by which CO₂, water vapor, methane, and other greenhouse gases absorb and emit infrared radiation, has a major effect on the Earth's climate. In fact, without any greenhouse gases from natural processes in our atmosphere, our planet would be very cold.

The problem is that humans, through the burning of fossil fuels, have tipped this balance by releasing vast quantities of CO₂ into the atmosphere. CO₂ persists for many decades and has a direct effect to heat up the Earth's surface. The warming of our planet since the 1950s is "unprecedented" over the past 1,000 years and has been concluded to primarily be the result of CO₂ emissions from human activities (1).

In addition to higher average temperatures, atmospheric scientists expect



Svante Arrhenius

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XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS *.

I. *Introduction: Observations of Langley on Atmospherical Absorption.*

A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall† in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of the temperature that were lessened by this circumstance. Another side of the question, that has long attracted the attention of physicists, is this: Is the mean temperature of the ground in any way influenced by the presence of heat-absorbing gases in the atmosphere? Fourier‡ maintained that the atmosphere acts like the glass of a hot-house, because it lets through the light rays of the sun but retains the dark rays from the ground. This idea was elaborated by Pouillet§; and Langley was by some of his researches led to the view, that "the temperature of the earth under direct sunshine, even though our atmosphere were present as now, would probably fall to -200° C., if that atmosphere did not possess the quality of selective

Figure 1. Svante Arrhenius was a Swedish physicist and recipient of the Nobel Prize for chemistry in 1903. He calculated the effect of carbon dioxide on the Earth's temperature, known as the Arrhenius Effect, first published in the *Philosophical Magazine and Journal of Science* in 1896 (shown here). Portrait was obtained from Wikipedia. Photocopy reprinted by permission from Reference 3.

climate change to result in more frequent heat waves, droughts, wildfires, dust storms, heavy rainfall, hurricanes, and floods (1). All such events have adverse consequences for human health, including: the spread of vector-borne diseases, pollen seasons that are longer and more potent, malnutrition and dehydration due to water and crop shortages, and cardiopulmonary disease and death due to heat waves, dust storms, forest fires, and ozone pollution. Hurricanes and floods, such as those experienced during Hurricanes Katrina and Sandy, result in human displacement and loss of healthcare access and infrastructure and foster the spread of infection, including diarrheal illness and pneumonia. Because of the myriad consequences for health, the Lancet Commission on Climate Change and Health concluded that “tackling climate change could be the greatest global public health opportunity of the 21st century” (4).

The U.S. Supreme Court ruled in 2006 that the U.S. Environmental Protection Agency (EPA) is required to regulate CO₂ as an air pollutant. The decision was based on the fact that CO₂ pollution causes climate change, which endangers human health. In 2015, nearly 200 nations agreed to the historic Paris Climate Agreement, with a common goal of holding the increase in the global average temperature to less than 2°C above preindustrial levels to avoid the worst consequences of climate change. This agreement is nonbinding, and each country sets “nationally determined contributions” that become increasingly ambitious goals over time. The Obama administration committed to reducing CO₂ emissions 26% to 28% below 2005 levels by 2025, primarily through the Clean Power Plan for power plant emissions and the Corporate Average Fuel Economy fuel efficiency standards for motor vehicles. As of this writing, the Clean Power Plan is stalled in the judicial system, and both the Clean Power Plan and the Corporate Average Fuel Economy standards are being revisited by the administration. On June 2, 2017, President Trump announced his decision to pull out of the Paris Climate Agreement.

Over the past several decades, a great deal of confusion and skepticism about climate science has emerged in the United States, largely as a result of active efforts by the fossil fuel industry (and the politicians they finance) to generate doubt. But the science on climate change is clear. We have a diagnosis. The majority of U.S. and

international ATS members report that climate change is directly relevant to patient care, and many have observed how changing weather patterns are harming their patients’ health (5, 6). We also have options for treatment and prevention of climate change. It is time for doctors and other health professionals to join in the conversation, document the problem, and become part of the solution to climate change, just as the healthcare community spoke up when it was clear that tobacco was the cause of widespread illness and death. As healthcare specialists, we can no longer ignore climate change as a “political issue.” Climate change is a public health problem that increasingly affects patients everywhere.

Temperature and Ozone-related Mortality in a Changing Climate

By: Joel Schwartz, Sc.D.

Climate change is causing average temperatures to rise, and is causing heat waves (periods of extreme heat) to occur more often. The physiologic adaptation to

heat takes weeks, which is important from a public health standpoint, because changes in temperature occur much faster than that. It has been found that the mortality risk of temperature depends on how unusual that temperature is for a given time of year. For example, a large U.S. study of mortality using 30 years of data found that the effects of heat were larger in the spring and early summer, and the effects of cold were larger in the late fall, likely because those temperatures were unusual for that time of year, and therefore people had not had sufficient time to adapt to the ambient temperature (Figure 2) (7). Generally speaking, heat wave warnings are reserved for extremely hot summer days and therefore only address a small fraction of the days that are hot enough to increase deaths. As climate change increases the number of “unseasonably” warm days, the public health system needs to find a way to deal with more common hot (and cold) days. People who are the most vulnerable to unseasonably warm temperatures have an impaired ability to adapt appropriately, which includes people with chronic medical conditions (including dementia, diabetes,

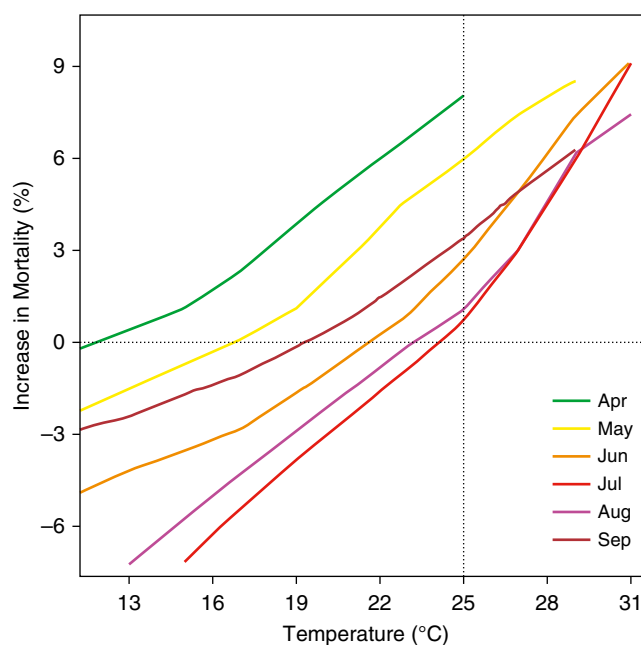


Figure 2. The percentage change in mortality in association with heat compared with the mortality at the mean temperature in corresponding month. The association between temperature and mortality varies by how unusual the temperature is for the time of year: at 25°C (dotted vertical line), there is no relative increase in mortality in July (red line), but in May (yellow line) there is a 6% greater mortality compared with the mean temperature in May. Data are from 38,005,616 deaths from 148 cities in the United States from 1973 through 2006. Reprinted by permission from Reference 7.

heart failure, chronic obstructive pulmonary disease, and atrial fibrillation), people of advanced age, and those with socioeconomic disadvantage, including people of black race, low education, and poverty (8, 9).

As temperatures rise, ground-level ozone levels have also increased in many places because of increases in temperature and reduced wind speed, which promote ozone formation (10). Ozone is a component of photochemical smog. The health effects of these climate change–related increases in ozone levels have already been observed, and these health effects are expected to increase (11, 12). Weather changes have been estimated to have caused 20,300 excess deaths due to higher ozone levels between 1994 and 2012 (13). People with chronic disease and socioeconomic disadvantage are the most at risk for ozone-related mortality (14, 15). As a public health community, we must address the disproportionate burden of climate-related health effects on disadvantaged populations and target interventions to help at-risk groups.

Climate Mitigation and the Air Pollution Health Effects of Energy Sources

By: George D. Thurston, Sc.D.

Climate change mitigation policies are largely aimed at reducing emissions of CO₂ arising from combustion, but the question remains as to how best to maximize the public health benefits of those mitigation measures. Sources of CO₂ also emit air pollutants that adversely affect human health, including fine particulate matter (particulate matter ≤ 2.5 μm in aerodynamic diameter [PM_{2.5}]), nitrogen oxides (NO_x), sulfur oxides (SO_x), and the precursors leading to formation of ozone, a secondary pollutant. Exposure to these pollutants have been associated with respiratory, cardiovascular, and oncologic disease (16). The global health impact of atmospheric air pollution is especially high for PM_{2.5} (17). Globally, West and colleagues (18) found that the reduced PM_{2.5} and ozone air pollution resulting from the implementation of greenhouse gas mitigation can avoid 0.5 and 1.3 million premature deaths globally in 2030 and 2050, respectively. Associated global marginal health cobenefits were estimated at U.S.\$50

to \$380 per ton of CO₂ emission reduced, exceeding abatement costs in both 2030 and 2050. Moreover, recent evidence indicates that the toxicity of PM_{2.5} can vary, depending on its composition and source. PM_{2.5} from coal-burning facilities has been associated with a higher ischemic heart disease mortality risk than PM_{2.5} from other common sources (Figure 3) (19). Choosing climate mitigation measures that reduce fossil fuel combustion emissions, especially those that phase out coal burning for heat and electricity, will provide the greatest human health benefits. The financial valuation of these benefits will more than offset the costs of the climate change mitigation action.

Effect of Climate Change on Children and Adults with Asthma

By: Kari C. Nadeau

An estimated 300 million people worldwide suffer from asthma, with 250,000 annual deaths attributed to the disease (20). Extreme weather events are projected to grow in frequency, duration, and intensity around the globe in response to climate change. The evidence is clear that increases in wildfires, dust storms, droughts, and thunderstorms—extreme climatic events brought about by climate change (1)—damage respiratory health for individuals with asthma. By 2025, it is expected that the prevalence of asthma will increase by 25% to about 400 million (21), increasing the population affected most by these changes.

Thunderstorms during the pollen season have been linked with increased asthma exacerbations and emergency room visits (22, 23). In 2016, several asthma deaths were observed during severe thunderstorms in Australia and Kuwait (24, 25). During thunderstorms, whole pollen grains are swept into the clouds, where they are broken up into smaller allergenic pollen fragments and eventually carried back to ground level (26). Increasing CO₂ levels observed with climate change have also been associated with increasing pollen levels (27–29). Pollen data collected in Europe indicate an increasing trend in pollen aeroallergens (30), and it is predicted that across Europe, sensitization to ragweed is likely to more than double by 2041 to 2060 (28).

Dry, hot conditions promote dust storms in many parts of Asia and the Middle

East, which have sometimes been linked to increased asthma and pneumonia hospitalizations (31–33). Climate change dramatically increases the risk of wildfires, particularly in the United States, which have been shown to increase respiratory hospitalizations among children and adults (34–38). For example, a study of the 2003 California wildfires found a 34% increase in asthma admissions during heavy smoke conditions (39).

Levels of ground-level ozone, an airway irritant, have been increasing as a result of warmer temperatures and are projected to further increase with climate change (13). One predictive model suggests that ozone-related emergency department visits for asthma in children are likely to increase by 7.3% across New York City by the 2020s as a result of climate change (12).

The clear evidence of the adverse health effects of climate change is a call to action for all nations and individuals to reduce their carbon footprint. Encouragingly, efforts to curb carbon pollution have been found to improve health and prevent asthma (40). For example, a study found improvements in lung function, exhaled nitric oxide, and school absenteeism in children with persistent asthma after the adoption of cleaner-fuel school buses (41). With a global concerted effort and investment in technology, products, and services that reduce climate change, we can hope to improve overall health.

Comments by Sheldon Whitehouse, U.S. Senator for the State of Rhode Island

Senator Whitehouse discussed the political history of the “campaign of misinformation,” financed by the fossil fuel industry, which has caused the American public to doubt climate science. He urged scientists and universities to promote clear messaging about climate change, health effects, and solutions. To succeed, academia will need to organize, collaborate, and mobilize an unprecedented, large-scale messaging campaign.

Comments by Carol Browner, Former EPA Administrator

I am frequently asked about my tenure at EPA—what was the best time and what was

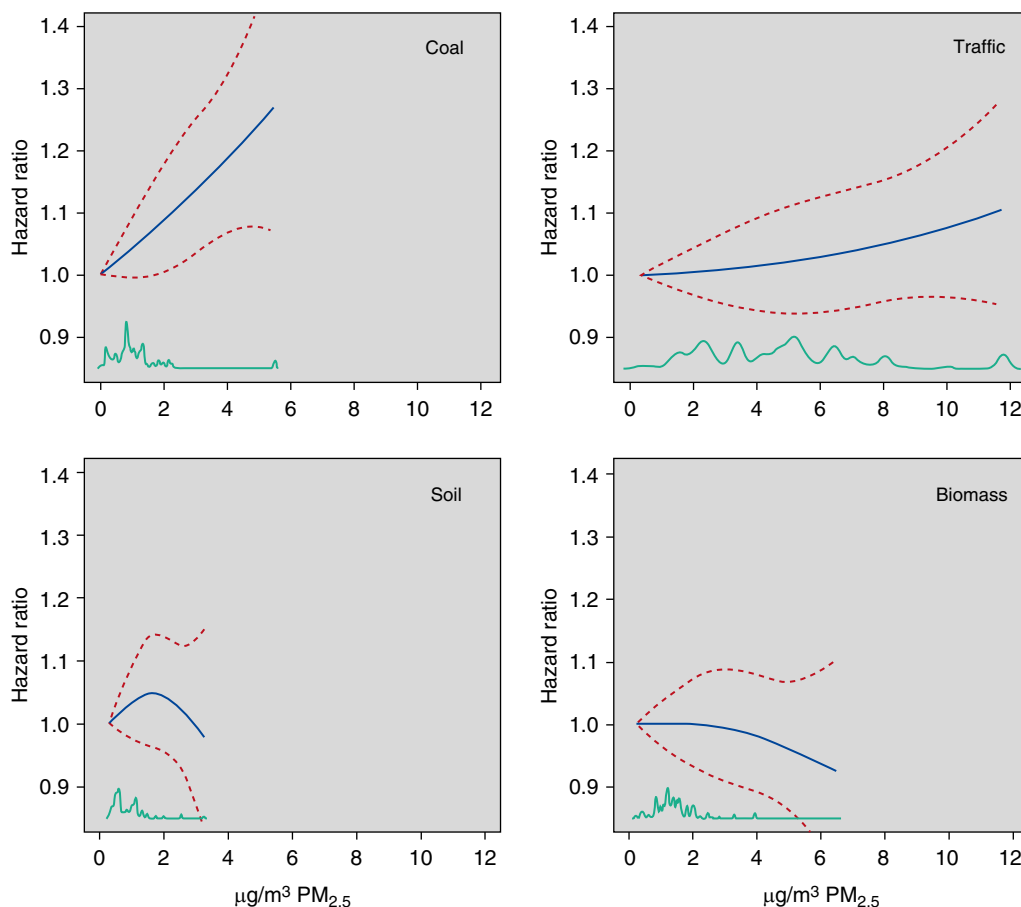


Figure 3. Particulate matter from coal burning and traffic emissions are associated with risk of ischemic mortality. Continuous associations (solid blue lines) and 95% confidence intervals (dashed red lines) between source-specific contributions to particulate matter less than or equal to $2.5\ \mu\text{m}$ in aerodynamic diameter ($\text{PM}_{2.5}$) mass from coal, traffic, soil, and biomass and ischemic heart disease mortality in the American Cancer Society cohort are shown. Green lines represent the distribution of the source-specific $\text{PM}_{2.5}$ mass. Reprinted by permission from Reference 19.

the worst? Some of you may remember the Gingrich era of the mid-1990s. The Congress basically shut down the EPA. It was certainly a bad moment, but it led to a best moment: the onslaught of attacks caught the American peoples' attention and allowed us to explain to the American people what EPA does—how important EPA is to the health of our children and our communities. That fight gave us strength and the public support to set tough air pollution standards, to strengthen the ozone (smog) standards and establish the first ever soot-fine particle standards. Public health air pollution standards were upheld by the U.S. Supreme Court 9 to 0. So many in the ATS community were instrumental in that fight, and I want to thank you for your support and leadership.

When George Thurston and I began discussing this meeting and today's panel,

we assumed the discussion would be about the Clean Power Plan—the EPA proposal to cut carbon pollution from power plants. We assumed we would be talking about how the United States would live up to the commitments it made at Paris—steps we would take to reduce our carbon footprint from cleaner cars to renewable power generation. Sadly, today we won't be discussing implementation of the Clean Power Plan, because the current administration doesn't appear likely to move forward with the plan.

So what is in fact happening? I would suggest nothing short of a full-scale attack on the very laws that have moved us toward cleaner air and water—the laws that form the underpinnings of our efforts to combat carbon pollution. More than 40 years ago, the modern environmental movement was launched because of wrongs we could see

and smell. In 1969 the Cuyahoga River caught fire; smog in our urban areas was so dense you could taste it. The American people demanded change. The Clean Air and Clean Water Acts were passed. The EPA was created. Today our skies are cleaner, our rivers healthier. Although there is more to do, we have made progress.

During my EPA tenure, in a congressional oversight hearing, then-Congressman Tom Delay asked me: did I think EPA had the authority to regulate carbon pollution? We took the question seriously. Although the law doesn't mention carbon pollution, we concluded that law gives EPA the authority to regulate dangerous pollution, whether or not the specific pollutant is named in the law, if EPA determines the pollutant "endangers public health and welfare." After I left EPA, the state of Massachusetts, relying in part on our

Box 1. Key Points

Scope of the Problem (“The Diagnosis”)

- Climate change disproportionately harms people from Africa and other disadvantaged parts of the world, who contribute relatively little to global carbon emissions.
- Health consequences of climate change include the spread of vector-borne disease, water and crop shortages, human injury and displacement by hurricanes and floods with spread of infectious disease, cardiopulmonary disease and death due to heat waves, dust storms, forest fires, and ozone pollution
- Not just heat waves, but “unusually warm” weather is associated with excess mortality. People with socioeconomic disadvantage are most vulnerable to heat-related death.
- Children and adults with asthma are especially harmed by climate change, because of effects on pollen seasons and air pollution from forest fires and ozone events.

Solutions (“The Treatment”)

- Efforts to reduce carbon emissions improve air quality, and studies have found immediate cardiopulmonary health benefits of cleaner fuels, especially among children with asthma.
- Reducing coal burning and traffic-related fuel combustion will likely have the greatest health benefits.
- The scientific and healthcare community can reverse the misinformation, politicization, and public confusion about climate change by joining the conversation and explaining the need for clean energy to protect and improve human health.
- Engagement from the medical community is needed at the national, state, city, hospital, and clinic levels. To be successful, academia will need to engage in public-facing communication and advocacy campaigns.

legal analysis, sued EPA for failure to protect the people of Massachusetts from the effects of climate change. I am not sure anyone thought they would win, but in fact the U.S. Supreme Court ruled that if EPA determined that carbon pollution endangers public health and welfare, not only could EPA regulate the pollution, but in fact EPA would be required to regulate the pollution.

When Lisa Jackson came to EPA as Administrator under President Obama, the Agency finalized an endangerment finding and thus began the work to regulate and reduce carbon pollution from cars, trucks, power plants, and other sources. It is this work that formed the basis of President Obama’s commitments in Paris. Each country made a commitment toward reduction based on their individual laws. The United States committed to 26% to 28% reduction of 2005 emissions by 2025. This commitment is possible because of the car efficiency standards, the 54.5 miles per gallon by 2025, the Clean Power Plan, and other regulations.

But the current administration, while debating its participation in Paris, is revisiting the car standards, the Clean Power Plan, and many other regulations. (After this presentation, the administration announced its intention to withdraw the United States from the Paris Climate agreement.)

They have been asked to review the “endangerment finding,” which sits behind all regulations to reduce carbon pollution.

Fortunately, there are other players on these issues. Business, industry—1,000 companies, including Mars Candy, General Mills, Ikea—have signed a letter asking the President to stay in the Paris agreement. States are leading, from California to New York. Solar now accounts for a substantial percentage of our power generation. And individual companies are doing their part. Walmart cut 36.5 million metric tons of greenhouse gases from its global supply chain in just 5 years; that is the equivalent to taking 7.5 million cars off the road for a whole year. And even the U.S. Senate recently voted to preserve an EPA regulation requiring the reduction of natural gas emissions from activities on federal lands. It was a victory by only one vote, but still a victory.

I admit I can find it hard to be optimistic in these times, but I honestly don’t believe that people voted for dirty air or water. And I do believe that just about everyone can see that the climate is changing. The robins come back earlier, the storms are more furious, the streets flood even when it doesn’t rain. I must believe that we will not be the first generation to leave to another problem that cannot be solved,

that we will meet our responsibility and make the right decisions to combat climate change.

Conclusions and a Call to Action

The speakers of this symposium—which included a primary care doctor from Cameroon, a pulmonary and critical care physician and a pediatric allergist practicing in the United States, two environmental epidemiologists, a current U.S. Senator, and a former EPA administrator—each provided different perspectives about the importance of energy policy to human health. The first two original goals of the Symposium—1) to foster a dialogue between scientists and policymakers at the ATS conference, and 2) to educate ATS members about the health benefits of climate mitigation—were accomplished, to some extent, at the time of the 2017 symposium. But the third goal of inspiring ATS members to get involved in enhancing the role of scientific evidence and the consideration of human health in Washington policy making cannot be accomplished in one day. This long-term goal aligns with the call to action from Senator Whitehouse for healthcare

professionals and scientists to get out of their academic silos and to engage in an organized public-facing communications campaign that sets the record straight about climate change and its widespread,

devastating consequences for human health. The medical community must be a part of the solution (Box 1), by explaining these health effects in human terms and advocating for clean and healthy energy

choices at every level: national, state, city, hospital, and clinic. ■

Author disclosures are available with the text of this article at www.atsjournals.org.

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