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CLIMATE CHANGE: A CHALLENGE FOR PUBLIC HEALTH

HEARING

OF THE

COMMITTEE ON HEALTH, EDUCATION, LABOR, AND PENSIONS

UNITED STATES SENATE

ONE HUNDRED TENTH CONGRESS

SECOND SESSION

ON

EXAMINING CLIMATE CHANGE, FOCUSING ON IT AS A CHALLENGE FOR PUBLIC HEALTH

APRIL 10, 2008

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CLIMATE CHANGE: A CHALLENGE FOR PUBLIC HEALTH

THURSDAY, APRIL 10, 2008

U.S. SENATE,
COMMITTEE ON HEALTH, EDUCATION, LABOR, AND PENSIONS,
Washington, DC.

The committee met, pursuant to notice, at 10:03 a.m. in Room SD–430, Dirksen Senate Office Building, Hon. Edward M. Kennedy, chairman of the committee, presiding.

Present: Senators Kennedy, Sanders, and Enzi.

OPENING STATEMENT OF SENATOR KENNEDY

The CHAIRMAN. I welcome our committee members to today's hearing on the health effects of climate change, and I welcome, too, our distinguished witnesses. I look forward to hearing from them on this important topic.

Over the past few years, the American public's awareness and concern about climate change has reached unprecedented levels, and we have heard about what climate change means for the Earth, about the melting ice caps, and about the rising sea levels. The issue of climate change is not just about polar bears or melting distant glaciers. It is about our communities and our health and the health effect on our children.

History is full of examples of health problems ignored until it was too late. We must see that climate change does not join that list. People across America and around the globe will be affected by changes in the Earth's climate. Those changes will have a profound impact on our health, and it is time that our committee turned our attention to this problem.

Leading scientists from across the globe have studied climate change and know that our health is at risk. Extreme weather events will become more common, more severe in the future. Climate change will cause heat waves, which we know result in heat stroke, heat stress, and even death in vulnerable populations like the elderly, and we have seen in the past the loss of life that can occur. The heat wave that hit Europe in 2003 was responsible for 30,000 deaths.

Extreme heat will also raise ozone levels in places that already have high pollution, causing problems for people with allergies, asthma, and chronic lung diseases. Illnesses spread by mosquitoes, such as malaria, and other diseases previously confined to the tropics will spread to areas of the country that have never experienced these problems before. We can expect that hurricanes become more

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frequent, and we know only too well the destruction these storms bring.

Public health must be a central part of the discussion about climate change. Sadly, vulnerable populations like the elderly, children, the poor, and the chronically ill are likely to experience these health effects disproportionately. They are also the least likely to have the resources to prepare for and respond to these events. That is why we need the public health community involved in discussions about climate change.

This week is National Public Health Week, and across the Nation, public health officials in communities are holding events to draw attention to climate change as a major public health challenge. We are holding this hearing today to draw attention and awareness to this issue to find out how prepared we are and where we need to focus our efforts in the future.

We are at an important moment in time. The decisions we make now can improve our health and our climate for years to come.

Today, we will hear from our expert panel about how prepared public health departments are to respond to these challenges, about the innovative and practical solutions that are already being adopted, and about the role the Federal Government should play in assisting them in responding to the threat. I look forward to their comments.

I welcome, Ranking Member Senator Enzi for his comments.

OPENING STATEMENT OF SENATOR ENZI

Senator ENZI. Thank you, Mr. Chairman.

I am a little concerned about us holding this hearing. This is one of the polarized issues, and we are adding to the polarization. Whenever you polarize something—and I understand that we need to get ready for the debate that is going to happen, I guess, around June 4, which will be on climate change. My prediction is that the Senate will work for about 3 weeks discussing climate change and will do nothing—not a thing—because we have already polarized this issue.

On the other hand, there are a whole bunch of solutions out there waiting for our work that can be taken one step at a time, done in relatively short periods of time. In fact, on bills that Senator Kennedy and I work on, we usually get them done by unanimous consent in both houses in a matter of minutes. That is because we didn't polarize them. When you polarize them, you encourage debate. Of course, you get news coverage, and we thrive on news coverage around here, but it doesn't get anything done.

We already have a whole bunch of issues on our plate. Some are related to global climate change, but they are not being called that. Consequently, we can get them done without the same polarization that is likely to take place when we get into climate change.

I am from Wyoming, and I was doing a radio interview recently. I always try to avoid talking about the weather because out here, you know, we have the cherry blossoms and the apple blossoms, and we have got things coming up. In Wyoming, it is snowing. In fact, what the announcer said was, "How is it out there? We are getting 6 more inches of global warming out here."

We get most of our snow in April, and we are very pleased with that because it is a nice, wet snow, and we are a dry part of the country.

I am afraid that taking this approach will stop some solutions. These will be stopped because of the time it will take us to debate climate change, and that will stop us from solving health problems regardless of their direct or indirect causes. So I think it would make more sense to focus on challenges that may deal with the same thing but are directed toward specific goals that we have.

We have a need to provide clean water to prevent disease. That hasn't been polarized. That is internationally recognized. In the United States and in Wyoming, we are very blessed. We have abundant resources of natural, human, intellectual, and financial capabilities. It isn't that way everywhere, and we have a moral obligation to solve some of those problems for people less fortunate than us, even outside the United States.

Whatever the health effects of climate change may be, Americans are resilient, and we have the resources to adapt. The witnesses today, I appreciate their testimony and having the opportunity to look at it in advance. We will learn about how climate change may cause disease, air pollution, and extreme weather events. Some of those assertions will come to pass. Some of them won't.

I am not sure that the devastating impacts that are described will dramatically affect the people of Wyoming or even the United States as a whole. Passing health legislation that we already have in the works would make an immediate difference and can blend into future problems. We will develop drugs and vaccines to deal with new diseases. We will come together as communities in the Nation to get new prediction tools to better understand weather risks. We will invent new technologies such as sea water desalting techniques to adapt to a changing world.

Take another industrialized Nation, Australia, for example. That country desalts at night with wind power. I agree that the decades ahead of us hold challenges, but we have to face and meet the challenges.

I am going to do an inventors conference this weekend, and we will be concentrating not on climate change, but on having a better environment and ways that people can get into the mix of the economy by inventing something that will improve our way of life and the way of life around the globe. We get past that discussion about whether there is or whether there isn't and get solutions for problems that are happening and will happen, and we can avoid them.

For me, the health effects of climate change are inextricably intertwined with poverty. What we do today to provide clean water, clean energy, and public health infrastructure in the developing world will not only reduce poverty but will mitigate the health problems that many face today and lessen any potential future health effects that may come about because of climate change. I believe access to clean water is the keystone to those efforts. Water is a bridge to health, and health is a bridge to peace and prosperity for all of the people on this planet.

This is something that kind of sticks in my mind since I visited Mozambique. That country's goal is to get everybody within 5 miles of water. In this country, we can't even imagine being 5 miles from

water. If we saw the water, we would be appalled. A pond that animals drink out of and bathe in, that people do their laundry in and bathe in, if it is within 5 miles of your house, that is your drinking water, regardless of climate change.

In Sub-Saharan Africa, climate change could make access to water even more difficult and survival more precarious. Before we get ahead of ourselves on solving a problem that may come about because of climate change, we have to remember that more than a billion people in the world today don't have access to safe drinking water. That is a sixth of the world's population.

We can wring our hands and say the problem is too big and turn our backs to focus only on ourselves. The technology exists to put clean water into the hands of all people and not 5 miles away. Simple interventions are available. I can name two—the Safe Water System and LifeStraw. The Safe Water System is a suite of approaches suitable for the developing world. LifeStraw is a portable personal instant purification device that requires no power or spare parts, but can filter at least 700 liters of water.

We can improve on that. By helping other nations become more prosperous in the cleanest, most efficient way possible, we mitigate the effects of climate change. As a member of the Senate, I have long opposed any measures to deal with climate change by shutting down the economy, and I oppose trying to deal with climate change by shutting down someone else's economy.

I think it is the height of arrogance to tell impoverished people that they must remain impoverished because we developed in an inefficient way. Instead, there is an obligation to take what we have learned and help others out of poverty, and water is just one example.

Yes, climate change could be a challenge for public health in the future, but we face challenges with malaria, air pollution, and HIV-AIDS today. We need to do more in many areas of public health, but we can't be so narrow-minded as to focus only on ourselves. We need to shine the light on the global public health challenges we face to see our way forward.

I have a number of statements from outside groups, and I ask unanimous consent that they be entered into the record. I won't be here for the testimony this morning. I am going to a meeting on genetic nondiscrimination.

[The information referred to may be found in additional material.]

The CHAIRMAN. There you go. We wish you the best of luck with that meeting.

Senator ENZI. Another problem that we need to solve, and we have been working on, and we can.

The CHAIRMAN. Thank you.

We will hear from Dr. Jonathan Patz, who is Professor and Director of Global Environmental Health, University of Wisconsin-Madison. He has written 75 peer-reviewed papers as well as a textbook on the health effects of climate change. Co-author for the Health Expert Panel on the U.S. National Assessment on Climate Change. He was the convening lead author for a similar United Nations assessment.

For the past 4 years, Dr. Patz has been the lead author for the United Nations Intergovernmental Panel on Climate Change and

the organization that shared the 2007 Nobel Peace Prize with Al Gore.

Dr. Kristie Ebi—correct?

Dr. EBI. Ebi [Ee-bi].

The CHAIRMAN. Ebi, thank you. Dr. Ebi is an independent consultant based in Alexandria, VA. She has worked in the field of global climate change for more than a decade. She has a master's degree in toxicology from MIT, and Ph.D. and M.P.H. degrees in epidemiology from the University of Wisconsin.

Dr. Ebi has worked at the World Health Organization's Center for Environmental Health, Electric Power Research Institute. She recently conducted an analysis for the Environmental Protection Agency on the effects of climate change on the human health.

Dr. John Balbus is the Chief Health Scientist, Program Director, Environmental Defense Fund. As a physician and public health professional, he consults on a broad range of environmental health issues. A member of the Advisory Committee for the National Academy of Science, Institute of Medicine, Environmental Protection Agency.

Ambassador John McDonald, currently Chairman and Co-Founder of the Institute for Multi-Track Diplomacy in Washington, which focuses on national and international ethnic conflicts. Served for 40 years as a diplomat of the Foreign Service, spending 20 years in Western Europe and the Middle East, working for 16 years on the United Nations Economic and Social Affairs.

You all are very welcome here.

Dr. Patz.

STATEMENT OF JONATHAN PATZ, M.D., PH.D., PROFESSOR OF ENVIRONMENTAL STUDIES AND POPULATION HEALTH SCIENCES, UNIVERSITY OF WISCONSIN-MADISON, MADISON, WI

Dr. PATZ. Thank you very much, Mr. Chairman. Senator Kennedy—is this on?

The CHAIRMAN. Yes.

Dr. PATZ. Senator Enzi, as you have mentioned, yes, I have been quite engaged with this issue. Co-chaired the U.S. National Assessment on Climate Change and Climate Variability, Health Expert Panel, and have been on the IPCC, and I have studied this for over 15 years, the issue of climate change and health.

One thing that I would like to really start with is the uniqueness of this health hazard. Climate change will affect our health through multiple direct and indirect pathways, be it from heat waves and air pollution, as you have mentioned, to threats to our water quality as well, and other issues. And so, the multiple pathways through which climate change can affect our health are very important to recognize. It is not just a single toxic, a single agent of disease. It is a multifactorial problem.

And for the record, I would like to submit this recent revision from the World Health Organization that summarizes the health effects.

[Editor's Note: Due to the high cost of printing, previously published materials are not reprinted. The World Health Organization's summary can be found at www.who.int/globalchange/publications/cchhsummary/en/.]

The CHAIRMAN. Fine.

Dr. PATZ. Because there are so many pathways through which climate change can affect our health, in addition to confronting these specific hazards—be it water quality, air pollution, heat waves, or other infectious diseases—it is important to also go upstream and consider targeting policy toward the root of the problem. That is greenhouse gas emissions and climate change.

Following Senator Enzi's good advice, I do think that it is extremely important not to view climate change in isolation from other environmental problems because there are potentially dangerous synergies that may occur as climate happens across our landscape, be it an extreme heat wave that happens over a sprawling urban city that intensifies the heat, and you get this urban heat island, or an extreme hurricane like Hurricane Katrina that hit New Orleans, and part of the destruction and what made that city so vulnerable was the destruction in the coastal wetlands. What we do on our landscape actually can play into the risks from climate change.

Regarding solutions, public health concerns of climate change should absolutely be included as the Congress considers the transportation bill, for example, or the energy bill because these issues are very linked. Some of the testimony that will follow will also point out how energy and transportation policy really are one and the same—as public health policy—as we approach this problem.

I think that I also agree that the polarization of this issue is not at all healthy. I think that when you look at many of the effects of climate change, they are across many issues that we already are grappling with, like water quality, air pollution, and when you think about issues that are in crisis today, like HIV-AIDS, malaria, diarrheal disease, climate change can exacerbate all of those.

Mosquito-borne diseases are extremely sensitive to climate fluctuations because they are cold-blooded animals, and just a fraction of a degree in temperature can affect the transmission of these diseases. Places that already have water stress could be further exacerbated from climate change.

I would say that my background is that I am a physician and a public health scientist. If you have an emergency coming into the ER, that is someone who is bleeding to death versus someone with high blood pressure, you need to treat that acute problem first. You also have to recognize that more people die from high blood pressure, and you need to look at the long-term issues at the same time.

Thank you.

[The prepared statement of Dr. Patz follows:]

PREPARED STATEMENT OF JONATHAN PATZ, M.D., PH.D.

Good morning Mr. Chairman, Senator Kennedy, and other distinguished members of the committee. Thank you for the opportunity to appear before your committee for this hearing, "Climate Change: A Challenge for Public Health," a topic that I have studied for over 14 years. I served as Co-chair for the Health Expert Panel of the U.S. National Assessment on Climate Variability and Change and have been a Principle Lead Author on five reports of the UN Intergovernmental Panel on Climate Change (IPCC) since 1995. I am a Full Professor at the University of Wisconsin at Madison, and have active research and teaching in the field of environmental public health, specifically addressing global climate change.

THE NATURE OF THE PROBLEM

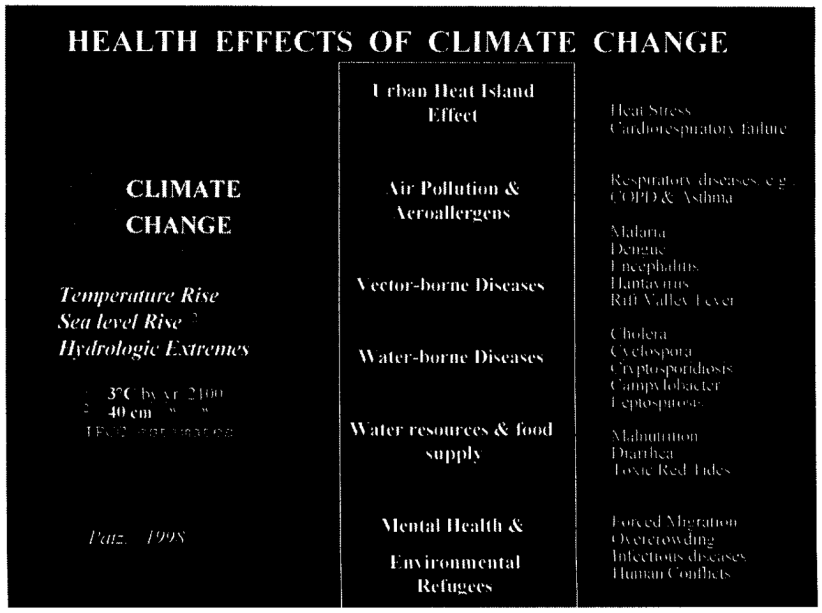
Global warming is unlike many other health threats with which we have confronted because unlike "single agent" toxins or microbes, *climate change affects multiple pathways of harmful exposures to our health*. Climate change can affect human health either from direct heat waves and severe storms to ground level smog/ozone pollution and airborne allergens, as well as many climate-sensitive infectious diseases.

Disease risks originating outside the United States must also be considered because we live in a very globalized world. Many poor nations of the world are expected to suffer even more health consequences due to climate change compared to the United States. *With global trade and transport, however, disease flare-ups in any part of the world can potentially reach the United States.* Additionally, climate extremes, e.g. droughts and storms, can further stress environmental resources by destabilizing economies and potentially creating security risks both internally and to other nations.

Finally, while climate change is a long-term environmental threat, *health ramifications are already occurring*. The World Health Organization finds that warming in just the past 30 years may already be adversely affecting the global burden of disease. And while single climate events can not be attributed to climate change, 70,000 deaths in the 2003 European heat wave remind us of the risk of extreme weather events (a study in Nature concluded that global warming over the recent decades doubled the "probability" of the occurrence of such an extreme heat wave).

What Are Some of the Potential Impacts of Climate Change on Health in the United States?

Climate-related disease risks occur throughout the United States, and many are expected to be exacerbated by climate change. Some health benefits could result, including reduced cold-related mortality and Rocky Mountain Spotted Fever in the southeastern United States. However, the net health effects have been assessed to be adverse. Our country has experienced deadly heat waves (e.g, the 1995 heat wave killed >700 persons in Chicago alone), and according to climate models, heat waves will become more frequent and intense. For example, a study of Los Angeles projected a 3-fold increase in heat waves by the end of this century. Major portions of the United States are expected to have a higher number of extremely hot days (the figure below shows the changing probability for days >100°F in Minneapolis).



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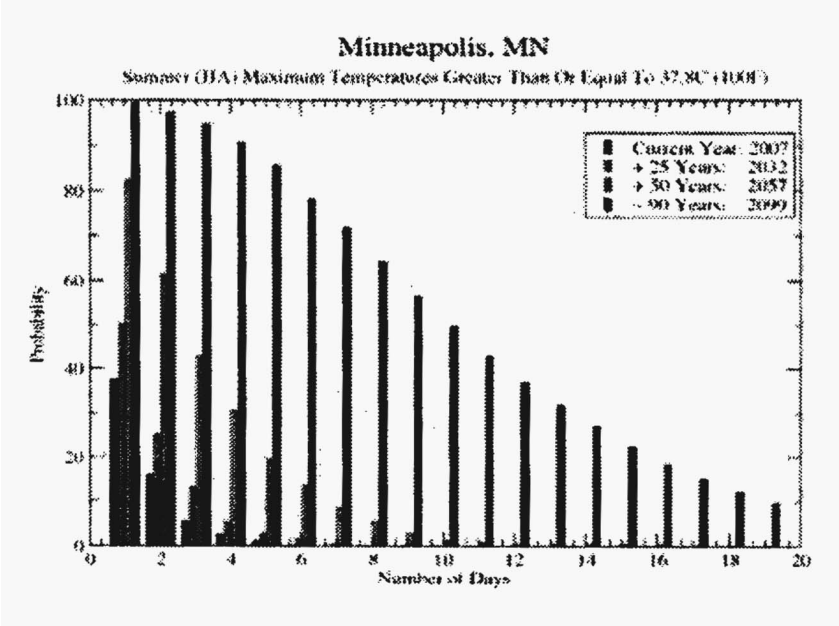

Preliminary analysis from our own research finds that the frequency of extreme heat waves in Wisconsin will increase disproportionately compared to a smaller decline in the frequency of extremely cold temperatures. *Poor and elderly populations are especially at risk of dying in heat waves*.

Air pollution accompanies heat waves, due in part to the temperature sensitivity of the chemical reaction that forms ozone smog pollution. A recent study of the 50 largest cities in the eastern United States finds that by mid-century, "Red Ozone Alert Days" could increase by 68 percent due to projected regional warming alone. The projected increase in stagnant air masses for the Midwest and Northeast, according to the IPCC, may exacerbate this problem further. *Ozone is especially dangerous to children with asthma*. Recall the findings during the 1996 Atlanta Olympics when traffic restrictions resulted in a 28 percent decrease in ground-level ozone, and subsequent 42 percent decline in asthma admissions to emergency rooms.

Pollen, another air contaminant, may increase with elevated temperature and CO_2. For instance, a doubling of the atmospheric CO_2 concentration stimulated ragweed-pollen production by over 50 percent.

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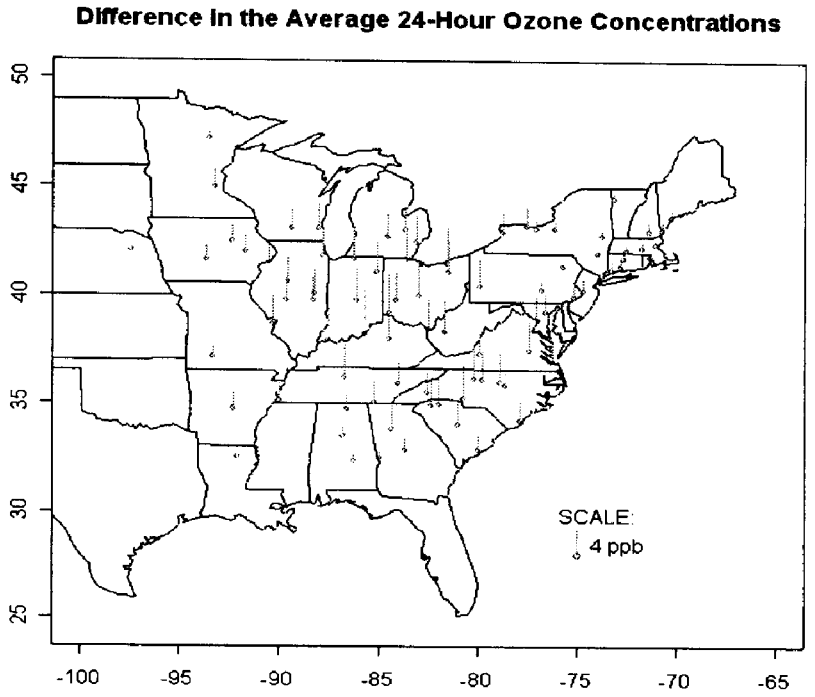

Many infectious diseases are sensitive to climate fluctuations. For example, 67 percent of reported water-borne disease outbreaks in the United States (between 1948–94) were preceded by very heavy rainfall; projections are for increases in extreme rainfall and runoff, placing more risk on already deteriorating water systems in many cities. Combined sewage overflows (CSOs) will likely become a more frequent problem. West Nile virus (WNV) emerged for the first time in North America during the record hot July 1999. While international transport likely explained its entry, this particular strain of WNV requires warmer temperatures than other strains around the globe. The greatest WNV transmissions during the epidemic summers of 2002–04 in the United States were linked to above-average temperatures.

Can't We Adapt to Climate Change Risks?

Relying on adaptation alone is a dangerous strategy. Building adaptive capacity takes time and it is unlikely to be reliable for climatic changes that might be more rapid or more extreme than expected. In addition, according to an energy policy expert at SAGE (Dr. Greg Nemet) a majority of greenhouse gas emissions in the future will come from developing countries. Therefore, by relying on adaptation to deal with climate change, the United States provides no basis for leadership or persuasion to enlist developing countries in reducing their emissions—in the end, we may have to adapt even more. Dr. Nemet further notes that global greenhouse gas emissions have been *accelerating* over the past decade and outside the upper end of scenarios predicted a decade ago.

Are There Co-benefits to Reducing Greenhouse Gas Emissions That Also Improve Public Health Simultaneously?

Considering the multiple health outcomes and potential for adverse synergies between global warming, urban sprawl, and land degradation, climate change poses a major threat to the health of the U.S. population. The policy changes needed to address this problem are going to be very large if we are serious about protecting the public from the adverse health effects of climate change. Adopting a modest emissions reductions policy, which may be riddled with loopholes, in the interest of pushing the United States to finally adopt a climate policy seems like a risky ap-

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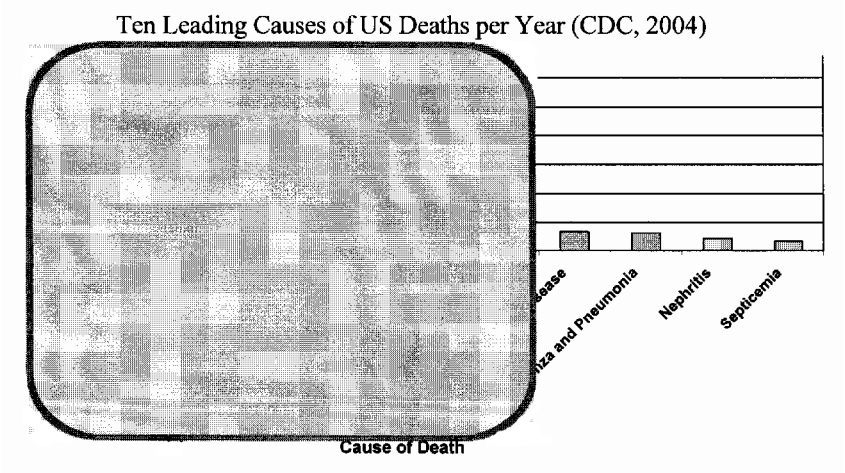
proach. With such large ramifications at stake and so many potential health co-benefits to be gained by reducing greenhouse gas emissions, major policy measures to mitigate climate change seem like an obvious component to protecting our health.

Scientific assessments caution that *climate change will have dangerous synergies with other environmental public health risks* and so must not be viewed as an isolated health risk. Dangerous synergies will include, for example: the "urban heat island" effect over sprawling cities with asphalt highways; destruction of storm-buffering coastal wetland, e.g., near New Orleans; and increased allergens in the air along with a lengthening ozone pollution season.

Yet, these dangerous synergies also point to potential co-benefits of mitigating greenhouse warming. *There are potentially large opportunities and co-benefits in addressing the health risks of global warming*. Certainly, our public health infrastructure must be strengthened, e.g., fortify water supply systems, heat and storm early warning and response programs, and enhance disease modeling and surveillance. However, *energy policy now becomes one and the same as public health policy*. Reducing fossil fuel burning will: (a) further reduce air pollution—all reductions of fossil fuel burning will reduce NO_x and CO emissions, as well as SO_2, $PM_{2.5}$, Hg, VOC and/or air toxic emissions as well (depending on the sectors, fuels, and technologies affected); (b) improve our fitness—only 40 percent of the U.S. population meets the minimum daily recommended level of exercise (60 percent of Americans are overweight), and if urban transportation planning allows for more Americans to travel by foot or bike and public transportation rather than by car, these percentages would inevitably improve); and (c) lessen potential greenhouse gas emissions and subsequent global warming. Note from the figure below that *most of the 10 leading causes of death in the United States are linked either to sedentary lifestyles, air pollution, or motor vehicle crashes*.

In short, the challenges posed by climate change urgently demand improving public health infrastructure AND energy conservation/urban planning policies—as such, climate change can present both enormous health risks *and opportunities* quite directly via improved fitness, reduced obesity (with its multitude of associated diseases), and improved air quality.



The scientific rationale for regulating CO_2 is absolutely clear when considering the health risks described above. The legal nuances, however, are beyond my expertise. My colleague and energy policy expert, Dr. Greg Nemet, shared with me his concern that if CO_2 is regulated by the EPA, then CO_2 regulation will be subject to a cost/benefit risk assessment analysis. The dilemma is that since many of the impacts of climate change will be only weakly captured in that type of analysis: (1) most impacts of U.S. emissions will be outside the United States; (2) impact assessments are focused on likely ranges, and ignore tails (or extremes) of distributions; and (3) impacts will be mostly in the future, so will be discounted heavily. Thus, a worrisome outcome is that EPA could end up regulating CO_2, but set only modest reduction targets which do not adequately protect the health of Americans. From my standpoint as a public health scientist, I view the health threats of climate change as extremely large in magnitude, and therefore requiring equivalently significant

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policy change—both in areas of public health preparedness and in greenhouse gas mitigation to avert this threat by whatever best policy interventions are required.

Dr. Tracey Holloway, a climate-air pollution expert at SAGE, pointed out to me that policy analyses for Europe have quantified the economic and physical interactions between climate change and air quality, and they find that integrated policies to address both issues simultaneously could reduce total costs by well over 1 billion Euro/yr by 2020 (vs. the cost of considering air quality and climate separately). *http://www.iiasa.ac.at/rains/gains-presentations.html?sb=12*.

CONCLUSIONS AND RECOMMENDATIONS

The broad and interconnected exposures stemming from climate change will require a well-coordinated, cross-sector and comprehensive disease prevention strategy. In addition to enhancing disease preparedness, this would include proactive energy conservation and transportation policies, and in so doing, will provide substantial health co-benefits.

The Department of Health and Human Services, that includes CDC and NIH, are responsible for protecting the health of the American public. To the extent that extremes of climate can have broad population-wide impacts, neither the CDC nor NIH have directed adequate resources to address climate change, and to date, funding has been minimal compared to the size of the health threat. Coordinated efforts on climate change & health also will need to cut across agencies—EPA, NASA, NSF, and NOAA have already been engaged on the issue, though funding historically has been insufficient in the health impacts area.

Strategic planning should take place across Federal, State, and local government, academia, and the private sector to look for co-benefits of solutions in combating climate change. The multimodal transportation scenario (reducing obesity and associated diseases while also reducing greenhouse gas emissions and improving local air quality) is a clear example. Such cases of co-benefits bring me to the conclusion that policies towards sustained mitigation of the threat of global warming could, in the end, represent one of the largest public health opportunities that we've had in over a century.

The CHAIRMAN. Doctor.

STATEMENT OF KRISTIE EBI, PH.D., M.P.H., PRESIDENT, ESS LLC, ALEXANDRIA, VA

Ms. EBI. Mr. Chairman, Senators, thank you very much for the opportunity to speak with you today. I have a few short points I would like to make.

In talking about how we handle the health risks of climate change, it is useful to put it into a risk management framework. This is one more risk. As Dr. Patz mentioned, there is a range of risks that are affecting health here in the United States and throughout the world. And looking at how public health can address those risks, I think there are four issues that would be useful to bring forward to the committee.

The first is there is, as you mentioned, very keen interest across the United States in understanding what the risks might be within the United States to our health and the health of our communities. There has been very little research conducted in the United States. The amount of funding going to this issue means that we cannot tell you at local and regional scales what kinds of impacts people might experience.

Without understanding at the local and regional level what those impacts might be, we are then constrained in how well we can inform public health on the kinds of activities they have to undertake.

The second issue is we do have a very strong public health system in the United States, and we do know it is under stress for a lot of different reasons. We do not have enough capacity to deal with large-scale issues. Climate change is providing the oppor-

tunity to have more large-scale issues. We saw Hurricane Katrina and we saw how difficult it has been for our public health system to respond to those kinds of issues.

A second part of this is as we go forward, one of the things that the climate scientists are telling us is the future will not be like the past. We have to change the way we plan. We do not have sufficient information within our public health system for people to look at the programs and activities that are in place to see if they need to be modified, how they need to be modified, and do they have the human and financial resources to do so?

A third issue, as highlighted very clearly by Senator Enzi, is what happens around the world affects us here. Disease is spread from one country to another. Problems in other countries affect us. I personally am working with about 15 different low-income countries in developing adaptation to climate change. I can tell you what people are seeing on the ground is things changing much faster than what is listed in the literature.

People in Kenya and Bhutan are reporting vector-borne diseases changing their range. Their public health systems are straining to try and adapt to those changes. As we see those changes, again, they will affect us. If we ignore what is going on internationally, there will be impacts here.

Finally, there is a whole range of policies that are being discussed here in Congress. There are technologies that are being developed across the various agencies from energy efficiency policies to carbon capture and storage. All of those have potential consequences for health. Public health has not been a player in the development of those policies, in the assessment of those policies, and the evaluation of those technologies.

As you noted in your opening statement, if public health is not at the table, then typically at some point when something goes wrong and it affects the health of a community, we have to come and help solve the problem. It would be better to get out in front of these and make sure that we make effective and efficient choices today.

Thank you.

[The prepared statement of Ms. Ebi follows:]

PREPARED STATEMENT OF KRISTIE L. EBI, PH.D., M.P.H.

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 + 0.03°C per decade) is nearly twice that for the last 100 years. Changes in extreme temperatures (such as the 2003 European heat wave) are consistent with warming over recent decades.

Climate change is increasing the frequency and intensity of heat waves, 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, heat waves, 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 heat wave 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 nonclimatic 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 United States. 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 United States 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 heat wave. 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 heat waves in the Midwest, using two definitions of a heat wave (the warmest average minimum temperatures over 3 consecutive nights in a given year, and exceedance of particular thresholds, suggested an increase in the average heat wave frequency of about 24 percent for Chicago (from 1.7 to 2.1 heat waves per year); 50 percent for Cincinnati (from 1.4 to 2.1 heat waves per year); and 36 percent for St. Louis (from 1.4 to 1.9 heat waves per year) (Ebi and Meehl 2007). The average duration of heat waves was projected to increase by 21 percent for Chicago (from 7.3 to 8.8 days); by 22 percent for Cincinnati (from 8.8 to 10.7 days); and by 38 percent for St. Louis (from 10.3 to 14.2 days). Combining changes in duration and intensity of heat waves implies an overall increase of about 70 percent in the annual number of heat wave days for the Midwest by the late 21st century. Moreover, these extreme days will be hotter on aver-

age than at present. The projections also suggested that areas such as the Northwest, where heat waves are not severe at present and where use of air conditioning is less common, future increases in heat wave intensity could result in more heat-related illnesses and deaths.

Hayhoe et al. (2004), the most recent study focused on the United States, 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 seven-fold under a high emission scenario by 2070–99.

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 vector-borne 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

[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.

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 percent 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. 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 percent of worldwide deaths) and 5,500,000 Disability Adjusted Life Years (DALYs)[2] (0.4 percent worldwide), with malnutrition accounting for approximately 50 percent 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. Subpopulations 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 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.

[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.

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 United States 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 fiscal year 2008 budget cut CDC funding by 2.8 percent of what would maintain 2007 funding levels adjusted for inflation. The proposed fiscal year 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 vector-borne 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 vector-borne 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 UNITED STATES CAN AFFECT THE POPULATION HEALTH IN THE UNITED STATES

Health security in the United States 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 United States. 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 vector-borne diseases were once prevalent in the United States, and the mosquitoes that can carry these diseases remain common in the United States. 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 decisionmakers with information about how any policy, programme or project may affect the health of people. HIA seeks to influence decisionmakers 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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The CHAIRMAN. Good. Dr. Balbus.

STATEMENT OF JOHN BALBUS, M.D., M.P.H., CHIEF SCIENTIST AND PROGRAM DIRECTOR, ENVIRONMENTAL DEFENSE FUND, WASHINGTON, DC

Dr. BALBUS. Good morning, Chairman Kennedy and Ranking Member Enzi, and thank you very much for having this hearing today during National Public Health Week. I chair a small climate change task force for the American Public Health Association, and we are very delighted to be able to air these issues and have this discussion this week.

I am the Chief Health Scientist for the Environmental Defense Fund, which is an environmental nonprofit organization that has been working for over two decades on the issue of climate change. We could not agree more, that polarization is a damaging thing for making progress on the issues that we face, and we focus on economically sound and nonpartisan science-based solutions to environmental problems.

My goals in testifying today are really two-fold. First, to convince you that increased attention and resources are needed in order to increase and ensure public health preparedness for the problems

that climate change will be bringing. Second, that public health professionals need to be more engaged in the monumental challenge ahead of us of reducing greenhouse gas emissions, both as communication and behavior change experts and also as health-risk assessors to help steer our energy, transportation, and land use policies toward a state of healthy sustainability. I have specific recommendations toward those ends.

I just want to mention two other pieces of work. In order to better understand the current state of preparedness, the Environmental Defense Fund collaborated with the National Association of City and County Health Officials and also with the George Mason University to conduct a survey of a representative sample of local public health departments around the country.

Most of the health department directors were aware of climate change as an issue and felt that it was going to affect their jurisdiction, but relatively few reported that climate change was either a top priority or an area in which they felt that they had adequate resources or expertise. There is a gap there between the recognition and their ability to respond to it.

Second is an example of health-risk assessment supporting this kind of policy decisionmaking. We have also conducted a preliminary analysis of the ancillary health benefits that would come from just the particulate matter reduction associated with specific greenhouse gas emission reduction measures, which are on the table now.

We only have very preliminary results, but they suggest the ancillary benefits are on the order of $10 billion to $30 billion per year by the year 2020, looking at just the health effects of the particulate matter reductions.

The health threat of climate change is emerging in a context of declining support for public health preparedness in general. This isn't just about climate change. It is about public health preparedness for the country in general. Of course, many of the measures that we need to improve the health resilience for climate change effects are the same ones that we need for preparedness for bioterrorism, pandemic influenza, and the natural disasters we know we are going to be facing.

In addition to us using an adaptation to changes in climate to which the planet is already committed, public health has crucial roles to play in preventing the more severe impacts of climate change and helping us to optimize the policy measures implemented to reduce greenhouse gases. The work we are doing indicates that the readiness of the public health community to take on this challenge is there if given the needed resources.

Thank you very much.

[The prepared statement of Dr. Balbus follows:]

PREPARED STATEMENT OF JOHN M. BALBUS, M.D., M.P.H.

SUMMARY

While it is essential that we strengthen the resilience of communities and individuals against the health threats that will be associated with climate change, public health also has critical roles to play in reducing greenhouse gas emissions and thereby preventing the more severe impacts of unchecked climate change, and also in enhancing public health by identifying those climate change policies that provide the greatest ancillary benefits for health.

Global climate change currently contributes to disease and premature deaths across the planet, and these impacts are likely to increase with progressive warming and other changes in climate. Although the health impacts of climate change will be less severe in the United States than in poorer countries, the U.S. public health infrastructure may not be adequately prepared to address the health effects of climate change.

In order to better understand the current state of preparedness for health effects of climate change, Environmental Defense Fund (EDF) collaborated with the National Association of City and County Health Officials and George Mason University to conduct a survey of a representative sample of local health departments from around the country. Most health department directors believed that climate change was an important threat, yet relatively few reported that climate change was a top priority for their health department. Most directors also perceived a lack of required expertise to prepare for climate change impacts.

Because public health can not protect the population from all anticipated climate-related health threats, prevention of the more severe impacts through reduction of greenhouse gas emissions is a health imperative. The public health community has expertise in social marketing and behavioral change that should be called upon to assist the Nation in meeting greenhouse gas reduction goals.

Climate change policies can provide immediate and short-term health and economic benefits. Measures that reduce fossil fuel combustion can reduce both carbon dioxide and criteria air pollutant generation at the same time. In addition to air pollution effects, there are other types of health effects associated with options for greenhouse gas reduction policies. Preliminary results of an EDF study of specific greenhouse gas reduction measures suggest the ancillary benefits resulting from just the associated particulate matter reductions could be substantial.

In addition to assisting in adaptation to changes in climate to which the planet is already committed, public health has crucial roles to play in preventing the more severe impacts of climate change and optimizing the policy measures implemented to reduce greenhouse gas emissions. Our work indicates the readiness of the public health community to take on these challenges if given the needed resources.

INTRODUCTION

Protect, Prevent and Enhance. This is the bottom line of our report, discussed below, that will be released later this month on climate change and public health. I start with these three words to emphasize that public health has more than one critical role to play with respect to climate change. While it is essential that we strengthen the resilience of communities and individuals against the health threats that will be associated with climate change, public health also has critical roles to play in reducing greenhouse gas emissions and thereby preventing the more severe impacts of unchecked climate change, and also in enhancing public health by identifying those climate change policies that provide the greatest ancillary benefits for health.

BACKGROUND

Global climate change currently contributes to disease and premature deaths across the planet, and these impacts are likely to increase with progressive warming and other changes in climate.[1] The World Health Organization estimates that climatic changes are already causing more than 150,000 deaths and about 5 million disability adjusted life years lost per year due to diarrheal disease, malaria, malnutrition, and flooding. This burden is borne mostly by poor countries in Asia and Africa.[2]

Health impacts are usually divided into those that result directly from warmer temperatures and extreme weather, like heat stress, and those that result indirectly through climate and weather impacts on atmospheric chemistry (like increased ozone air pollution) or other forms of life (like bacterial or insect-borne infectious diseases).

More frequent and severe heat waves,[3 4] hurricanes, wildfires, and floods will cause deaths and injury[5] while simultaneously damaging health infrastructure.[6] Behavioral[7] and emotional[8] responses to these disasters, contact with contaminated floodwater,[9] and displacement contribute to additional morbidity and mortality.

Warmer temperatures will favor formation of ozone air pollution; higher CO_2 and other climate changes may increase allergenic pollen formation.[10 11 12] These effects are likely to worsen asthma and allergic diseases. Ozone air pollution also has been associated with premature mortality from cardiovascular causes.

Climate-related increases in disasters and warmer ambient temperatures could increase the burden of food- and water-borne diseases (for example infections from

Salmonella,[13] *Campylobacter*[14] *Vibrio* species,[15] [16] *Leptospira*,[17] *Giardia*,[18] and *Cryptosporidium*[19]).

Some health effects of climate change will be unpredictable. For example, climate change could contribute to the emergence of novel or foreign diseases like the pathogenic fungus *Cryptococcus gattii* that recently emerged in British Columbia.[20] In this instance, a lethal fungus that had been confined to Australia killed several people in British Columbia and Washington State after emerging during an unusual period of wetter and then drier weather.

And although the health impacts of climate change will be less severe in the United States than in poorer countries, the U.S. public health infrastructure may not be adequately prepared to address the health effects of climate change. The increasing burden of chronic and emerging diseases has added new responsibilities to already-overburdened public health systems,[21] but spending and hiring has not kept pace.[22] The public health infrastructure that will respond to climate-related health threats remains seriously underfunded.[23]

HOW WELL PREPARED FOR CLIMATE CHANGE IS THE U.S. PUBLIC HEALTH SYSTEM?

The inadequate public health response to Hurricane Katrina,[24] for example, raises concerns about our ability to address climate-related increases in the frequency and severity of disasters.[25] A 2007 survey of local health departments on preparedness for public health disasters found that over three-quarters of the departments were not highly prepared, and over half reported that Centers for Disease Control and Prevention (CDC) funding was insufficient to meet the preparedness deliverables required of them.[26] Between fiscal year 2002 and fiscal year 2007, CDC funding for all-hazards preparedness declined by nearly 28 percent from $918 million to $665 million.[27] Many cities at risk of heat waves have inadequate response plans or lack written planning entirely.[28] Current disease surveillance and response capabilities are likely inadequate to effectively address novel and emerging spread of disease as may occur with climate change.[29]

An updated nationwide climate change health sector assessment in 2006 noted that while the United States has a high capacity to respond to climate change, little implementation of adaptive measures has been documented.[30] The Director of the Division of Environmental Hazards and Health Effects at CDC asserted in March 2007 that the "public health effects of climate change remain largely unaddressed."[31]

SURVEYS OF PUBLIC HEALTH DEPARTMENTS GIVE INSIGHT INTO PREPAREDNESS FOR CLIMATE CHANGE

In order to better understand the current state of preparedness for health effects of climate change, EDF collaborated with the National Association of City and County Health Officials and George Mason University to conduct a survey of a representative sample of local health departments from around the country. Directors of local health departments were asked to discuss their perceptions of climate-related health risks and the status and adequacy of their departments' programmatic activities in response to these risks.

These public health professionals generally recognized the reality of climate change impacts. Nearly 70 percent believed that signs of climate change had already affected health problems in their jurisdiction, and 78 percent believed that climate change would have impacts on their jurisdiction over the next 20 years. Roughly 60 percent believed that climate change would affect health in their jurisdiction over the next 20 years, and slightly over half of the directors felt the climate change was an "important priority," yet relatively few health department directors surveyed reported that climate change was a top priority for their health department. Only 19 percent of respondents indicated that climate change was among their department's top 10 current priorities, and only 6 percent indicated climate change was one of their health department's current top five priorities.

This lack of high prioritization of climate change health impacts was accompanied by a lack of perceived expertise to prepare for them. Seventy-seven percent of local health directors felt they lacked the expertise to assess local health impacts of climate change in their region, and 82 percent felt they lacked the expertise to craft adaptation plans. Local health directors did not perceive that much help would come from the State or Federal public health agencies. Only 26 percent felt their State had the needed expertise to assist with adaptation plans, while only 34 percent believed the CDC had such expertise. In addition to lacking expertise, 77 percent of the directors felt they lack necessary resources to address climate-related health threats, with additional funding and staff most frequently cited as being needed. The report concludes that additional funding is necessary to increase public health

resiliency for climate change, and that the programs needed for climate change effects have synergy and overlap with those needed for other preparedness needs, including bioterrorism, emerging infectious diseases, and existing weather extremes.

Our findings were very similar to those from a survey of local public health officers from the State of California that was released in February 2008 by the Public Policy Institute. In this survey, 94 percent of local health officers perceived climate change to be a serious threat to public health, with extreme weather events, wild fires, air pollution, vector-borne illnesses, and heat stress identified as the climate-related health problems of greatest concern. And yet in California, only 24 percent of respondents were aware of programs in their departments that were developed with climate change in mind.

Public Health has a Role in Reducing Greenhouse Gas Emissions as Well

The American Public Health Association, in its newly revised policy on global climate change, states,

> "The public health community must communicate the critical importance of primary prevention, namely the mitigation of climate change, in addition to preparing to provide secondary and tertiary prevention of climate change health effects."

This is out of recognition that there are likely to be a number of "tipping points" for climate-related health effects in different parts of the world, beyond which protecting populations will be extremely challenging. The most imminent appears to be triggering and initiating irreversible melting of the Greenland ice sheet, which would ultimately lead to inundation of low-lying coastal areas and massive population displacement with attendant health problems of refugees. Similar tipping points may exist for severe droughts and consequent crop failure, or ecosystem disruption and infectious diseases. Identifying such climate thresholds for public health is extremely challenging, and I was unable to identify any publications in this area. However, the Intergovernmental Panel on Climate Change (IPCC) in its Summary for Policy Makers from Working Group II notes a number of health drivers that either greatly increase in risk with increasing temperature rise, such as species extinctions and significant ecosystem disruption.[32] In the case of food production, the direction of change is anticipated to go from an increase to a global decrease with temperature increases above 1.5–2.5 °C.[33] Given the enormous difficulty accommodating coastal flooding and declines in food supply, preventing temperature increases above these thresholds is imperative from a global public health standpoint.

Identifying the need to reduce greenhouse gas emissions to avoid the most dangerous outcomes is one thing; achieving the necessary modifications in personal behaviors is another. This is one area in which the expertise of public health professionals can assist in preventing more severe climate change. Public health has to tackle complex personal behavior problems as a matter of course. Examples include early efforts at smoking cessation, use of condoms and other changes in sexual practice, and discouraging drug use. This expertise in social marketing and behavioral change should be called upon to assist the Nation in meeting greenhouse gas reduction goals.

CLIMATE CHANGE POLICIES CAN PROVIDE IMMEDIATE AND SHORT-TERM HEALTH AND ECONOMIC BENEFITS

The recognition that policies that reduce greenhouse gas emissions will have both positive and negative ancillary effects on public health is not new. Because carbon dioxide and criteria air pollutants such as particulate matter, ozone (and its precursors nitrogen oxides and volatile organic compounds) and sulfur dioxide are all produced by fossil fuel combustion, measures that reduce fossil fuel combustion can reduce both carbon dioxide and criteria air pollutant generation at the same time. In addition, technologies designed to separate and capture carbon dioxide will facilitate the separation and removal of toxic air pollutants as well. Several studies estimating ancillary health benefits of climate change policies were released at the beginning of this decade, but there has been relatively little development of this literature since, and this important point has been more or less absent from recent debates regarding greenhouse gas reduction policies. Especially with an ongoing discussion of the economic costs of meeting greenhouse gas reduction goals, it is all the more important that the public health community seize the opportunity to identify and assess the ancillary benefits and costs of different greenhouse gas reduction options.

While most analyses have focused on the ancillary benefits related to reductions in toxic air pollution, there are a range of other types of health effects associated with options for greenhouse gas reduction policies. For example, transportation poli-

cies that augment the use of public transportation or provide safer and more convenient means for individuals to walk or bicycle provide co-benefits not just related to any reductions in toxic air pollution that may result from reduced personal automobile use, but also co-benefits resulting from the increases in physical activity. With the ongoing epidemic of obesity and diabetes in this country, greater understanding of the potential for such synergies between climate and public health goals is critically needed.

EDF has conducted a preliminary analysis of ancillary health benefits accruing from just the particulate matter reductions associated with greenhouse gas reduction policies. We have looked at specific categories of greenhouse gas reductions, using a "wedge-based" approach similar to that developed by Professors Pacala and Sokolow in their seminal 2004 Science Paper.[34] We updated our baseline emissions scenarios to reflect major air pollution reduction rules such as the Clean Air Interstate Rule. Assuming full implementation of these air pollution reductions means that ancillary benefits from further reductions related to climate change policies are far smaller than they would be were air pollution emissions to remain constant into the future. Nonetheless, our preliminary results suggest the ancillary benefits could still be substantial. The total economic benefits in the year 2020 associated with improved fuel efficiency and reductions in projected miles driven for heavy duty vehicles, for example, were estimated at $8.7 billion. For a cluster of electric utility substitutions for coal-fired power plants, the total economic benefits were estimated to be over $32 billion. These results are preliminary, and a good deal of additional modeling studies are needed to gain confidence in such numbers, but these health benefits must not be forgotten in the debates over how we go about reducing greenhouse gas emissions. And it must be emphasized that the health benefits associated just with reduced particulate air pollution are not the only significant positive health and economic outcomes associated with greenhouse gas reductions. Health benefits from reductions in other air pollutants and from policy measures that improve physical activity profiles will also be substantial.

CONCLUSIONS

The growing threat to public health from climate change is emerging in the context of declining support for public health preparedness in general. Many of the measures needed to improve health resilience for climate change effects are the same as those needed for preparedness for bioterrorism, pandemic influenza and other viral infections, and natural disasters. These include improved modeling and assessment capacity, enhanced and integrated monitoring and surveillance networks, and development of rapid response units. But in addition to assisting in adaptation to changes in climate to which the planet is already committed, public health has crucial roles to play in preventing the more severe impacts of climate change and optimizing the policy measures implemented to reduce greenhouse gas emissions. Our work indicates the readiness of the public health community to take on these challenges if given the needed resources.

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The CHAIRMAN. Thank you.

Ambassador McDonald.

STATEMENT OF AMBASSADOR JOHN W. McDONALD, CHAIRMAN AND CEO, INSTITUTE FOR MULTI-TRACK DIPLOMACY, ARLINGTON, VA

Ambassador MCDONALD. Thank you, Mr. Chairman. It is an honor and a privilege to be with you today. I totally agree with my three fellow panelists on the points that they have been making.

From my perspective and since we are the world's greatest polluters, the best way to reduce the impact on individuals in this country is to develop a policy on climate change and make it happen. I would urge that we take a look at the U.N. Conference in Bali last November and see if we can join the rest of the world and sign up and start acting.

My own involvement in this basic issue of water and sanitation, which is certainly a part of climate change today, started way back in 1978. I tell people when I talk about this, that this glass of water, which is clear and clean and beautiful, is a miracle to well over a billion people in the developing world. And as the Senator stated, there are ways and means that we can do something about this.

In 1978, I came back to Washington, DC, from Geneva, and this committee will be pleased to know that I was Deputy Director General of the International Labor Organization, one of your concerns on this committee, for 4 years. I read a document from the U.N.

water conference in 1977, and there was one paragraph in about 100 recommendations for an action which said there should be a 10-year period, a decade, focused on drinking water sanitation.

While I was at the State Department, I plucked out this one paragraph and then, in the next year and a half, was able to present my resolution to carry that out to the United Nations General Assembly and the first U.N. decade on water and sanitation was adopted and started in 1981.

At the end of that decade, according to WHO figures, 1.1 billion people in the world got access to safe water. Seven hundred and sixty-nine million people got access to sanitation. These are massive figures, major steps forward was taken by putting our focus on that particular issue. Then it dropped off the radar screen for a dozen years or more.

In 2002, now I, as a private citizen, thought maybe we should have a second water decade. And so, I picked up on recommendations and said the world shall reduce by half by 2015 the number of people in the world without access to water and sanitation. I had to get a government, of course, to introduce that resolution at the General Assembly. I went to my friends at the State Department, who patted me on the head and said, "no, thank you", with no interest. I went to eight other countries during that time, no success. They were all from the West.

Finally, in August 2003, I went to the government of Tajikistan, who had set up a year on fresh water and knew the subject and knew the issues. With their help and the help of many other people, the General Assembly adopted the second water decade called Water for Life on December 23, 2003. It was launched on Water Day 2005.

The world was recognizing this issue. Now what is exciting is that this Congress and this committee and many others began to recognize that something had to be done on a global scale, and at the end of 2005, the House passed a bill called the Paul Simon Water for the Poor Act. Then this esteemed body adopted it unanimously, and it was signed into law on December 1, 2005 by Mr. Bush.

Unfortunately, there was not one word in the press, TV, radio, anywhere. Not a single word about this momentous event, which was a major bipartisan act on the previous Congress.

The idea was to focus on the rural poor, where the real problems lay. The State Department was responsible for carrying out this act. Last December, Congress and the President signed into law a bill allocating $300 million to carry out the Paul Simon Water for the Poor Act. Again, State Department level.

Well, I have written three times to the State Department—to Secretary Rice and never received a reply—urging that the State Department carry out this mandate, this law, now that they have money and appoint an ambassador-at-large, as I was appointed in the first decade, to focus on these issues and then to set up an ad hoc committee to advise that person how to act.

We are in a position for world leadership on this issue, which ties in directly with health issues, directly with the climate change because the worse the climate gets, the more difficult drinking water and sanitation will be for the entire world. I hope that this com-

mittee will push the State Department to take the action that has been mandated by law.

Thank you very much.

[The prepared statement of Ambassador McDonald follows:]

PREPARED STATEMENT OF JOHN W. MCDONALD

SUMMARY

All of the Nations of the world have agreed three times, at UN world conferences in 2000, 2002, and 2003 to reduce by half the number of people in the world without access to safe water and sanitation by the year 2015. The U.S. Congress has risen to this challenge by passing the Paul Simon Water for the Poor Act in December 2005 and December 2007, allocating $300 million in order for the State Department to begin implementation of the Paul Simon Water for the Poor Act. The State Department's response has been inadequate.

BACKGROUND

In 1977 the United Nations hosted a World Conference on Water. One of the many recommendations made by the Conference was to recommend a Decade focused on drinking water and sanitation. In 1978, as a career Foreign Service Officer working on U.N. economic and social affairs, I lifted that paragraph out of the larger World Conference document and decided to make that recommendation a reality. On November 10, 1980 the United Nations General Assembly adopted my resolution unanimously and the Decade was launched (1981–1990). I was named the U.S. Coordinator for the Decade by the State Department in 1979.

Dr. Peter Bourne, a former White House Special Assistant to President Carter, was named United Nations Coordinator for the Decade in 1982, with the rank of Assistant Secretary General and was based in New York. The goal of the Decade was for all people in the world to have access to safe drinking water and sanitation. The Decade was very successful as it provided 1.1 billion people with access to safe water and 769 million people with access to improved sanitation.

During this period, I traveled extensively to developing nations and saw first hand the problems that unclean water causes people to endure. Nothing I had ever seen in my life prepared me for the day I landed in Africa. I saw villages where people trekked miles in the hot sun just to get clean water for the day. Even more tragic were the children I saw suffering from the lack of clean water. Many seemed to be just hours from death, and others had lost their vision to trachoma, an easily preventable disease caused by contaminated water.

GLOBAL WATER

In 1982, Dr. Peter Bourne and I founded GLOBAL WATER to help save the lives of people in developing countries that are lost due to unclean water.

Global Water is based upon the belief that the lack of access to safe drinking water is the primary cause of hunger, disease and poverty throughout the world. Our program is designed to provide safe water supplies in rural villages to enable the rural poor to help themselves.

To achieve this goal, Global Water's strategy is to provide permanent solutions to a region's water needs by providing appropriate equipment (to include state-of-the-art technology) to:

- Secure, purify, store and distribute new sources of water for domestic uses and agricultural purposes; and
- Drill new water wells to allow access to groundwater.

Rather than providing short-term supplies like food and bottled water that are quickly consumed, GLOBAL WATER focuses on permanent solutions to a region's water needs. A handout fills a stomach for a few hours. Global Water enables entire villages to have clean, healthy water forever in order to change their lives—forever.

Global Water is also a volunteer-based organization and therefore none of us receive a salary for what we do. All the money that is donated to Global Water goes right into water projects implemented by non-profit organizations in the developing countries, themselves (often referred to as nongovernmental organizations or NGOs). Working directly with NGOs, Global Water provides funding for specific projects (either partial or total), program management assistance, and technical support with water treatment technologies and equipment.

Over the past 25 years, Global Water has developed a model called the "Rural Outreach Water Supply (ROWS) Program." This model identifies local NGOs in de-

veloping countries that are already working with rural water supply projects to help complete Global Water projects. The ROWS model has worked well for implementing projects in remote villages in many challenging developing countries.

To date, Global Water has carried out projects in Brazil, Guatemala, Honduras, Kenya, Laos, Liberia, Nicaragua, Romania, Somalia, South Africa, Sudan, Togo, Zaire, and Zimbabwe.

And yet, over 1 billion men, women, and children (more than four times the population of the United States and Canada combined) **do not have safe water to drink** and therefore cannot live a healthy life. Who are these people?

They are the innocent children and desperate families living in overcrowded urban ghettos, in refugee encampments, and in towns and villages too numerous to count in rural areas of developing countries.

They are unfortunate victims of drought and ever-changing environmental conditions. When drought occurs, their countryside is transformed into an arid wasteland where every living thing seems to cry out for lack of water.

They do not have enough water to grow and harvest food, enough water to keep their livestock alive, enough clean water to protect themselves and their children from hunger and disease.

Worldwide hunger problems are really water problems.

Without water, crops and livestock wither and die. People go hungry and become weak. Weakness allows disease to run its course and finally the "Quiet Killer"—hunger, takes its toll.

At this moment, many communities in over 50 countries throughout the world are suffering needlessly because water is either insufficient or polluted or may not exist at all. A sad irony is that many times there is life saving water just 100 feet away! Directly underground. So near, yet too far for people lacking the tools and knowledge to reach it.

With technologies ranging from simple and inexpensive to state-of-the-art, Global Water is helping poor communities in developing countries find new supplies of clean, life-sustaining water. And when clean, fresh water begins to flow in a community—a whole new life begins—free from the threat of food shortages and a myriad of health-related problems that are associated with hunger.

Daily, tens of thousands of men, women, and children die from diseases directly related to drinking polluted water.

Even if there is enough food to eat, families may still be slowly dying from another form of hunger called "invisible hunger" and it comes from drinking unsafe water. Waterborne parasites, received from drinking contaminated water, multiply continuously in already weakened bodies—robbing their hosts of the nourishment and energy they need to grow and develop normally.

A full 80 percent of fatal childhood diseases that kill children and destroy families worldwide are caused—not by shortages of food and medicine—but by drinking contaminated water. When you think of fighting hunger, you may think only of emergency relief efforts bringing shipments of food. When you think of healing disease, you may think only of doctors, nurses and medicine.

You can actually stop hunger, heal disease and save many thousands of precious lives with the simple gift of water. And long after a humanitarian relief effort has ended and temporary medical teams have gone—the gift of water continues to heal.

Water can overcome poverty. Water is the lifeblood of a community. When water is unsafe to drink, the entire community suffers.

Sick children lack the energy to learn and weak young men lack the drive to work hard—and so poverty continues. In many rural communities, it is the women and children who are responsible for locating and transporting water. Fulfilling this daily responsibility often leaves little or no time for women to pursue developmental opportunities and for the young to get an education—and so poverty continues.

Nothing can change a community like providing a source of clean water for the first time. It creates a complete transformation. It has the power to actually stop the cycle of poverty. The entire community becomes healthier. For the first time, children become eager to learn while young men and women are able to work harder to produce an income and more food.

Everyone can envision better futures and begin working towards them. Giving clean water to a poverty-stricken community is like giving a blood transfusion to a dying man. Water means new potential, new hope for a better tomorrow, and a new life.

UNITED NATIONS SECOND WATER DECADE

In 2002, now as a private citizen, because water and sanitation for health had fallen off the map as a critical issue, I decided it was time to launch a Second U.N.

Water Decade. I drafted a U.N. Resolution which was designed to carry out the Millennium Development Goals, proclaimed at a U.N. World Conference in New York in 2000 focusing on water and sanitation for health. I focused on Millennium Development Goal #7 dealing with the environment which called on the world to reduce by half by 2015 the number of people in the world without access to safe water.

In September 2002, the United Nations held its Third World Conference on the Environment in Johannesburg, South Africa and repeated the above goal, adding the word sanitation.

I took my draft resolution to the State Department and asked if they would support this resolution in the U.N. General Assembly because a government has to introduce such a resolution. They refused. Over the course of the next year, I contacted seven other Western countries and asked the same question. They all refused.

On August 1, 2003, I had a great idea. Because the Government of Tajikistan had launched a U.N. Year of Fresh Water in 2003, I approached the Ambassador of Tajikistan with my idea and he agreed, with the approval of his president, to introduce my resolution to the U.N. General Assembly. The Second U.N. Water Decade, "Water for Life" (2005–2015), was adopted on December 23, 2003 by the U.N. General Assembly and began on World Water Day, March 22, 2005.

The United Nations has opened branch offices in Bonn, Germany and Zaragoza, Spain whose primary goal is to push the Second U.N. Water Decade to a successful completion of its mandate.

CONGRESSIONAL LEADERSHIP

Congressman Blumenauer (D-Portland, OR) in 2002 returned from the Johannesburg Conference determined to focus U.S. Government attention on the drinking water and sanitation issue. Senator Frist (R–TN) returned from Mozambique in 2004 with the same determination. In 2005, many people, including myself and David Douglas, Chairman of an NGO in Washington, DC called Water Advocates, helped to push the Blumenauer bill through Congress. On November 10, 2005 the House passed the Blumenauer bill 319–34 and renamed it the "Paul Simon Water for the Poor Act" and passed the bill to the Senate. Senator Frist, in an act of statesmanship, withdrew his proposal and introduced the Blumenauer bill which was adopted unanimously by the Senate 1 week later.

On December 1, 2005 President Bush signed into law the Senator Paul Simon Water for the Poor Act (H.R. 1973). For the first time in our history, the Department of State has made drinking water and sanitation a major foreign policy goal of the United States. I believe that to be properly implemented, H.R. 1973 requires an individual, with the rank of ambassador, to be appointed to the Office of the Under Secretary for Global Affairs in the State Department. This ambassador would coordinate development of strategy and oversee implementation of the new law. An Ad Hoc NGO Advisory Committee would also be put in place to advise the Ambassador on the development and implementation of strategy.

STATE DEPARTMENT INACTION

Because there was zero publicity about the Paul Simon Water for the Poor Act, I wrote Secretary Rice on December 30, 2005 and informed her of the act and my two recommendations for action, the Ambassadorial Post and the Advisory Committee. I did not receive a reply.

In August 2006, I wrote Secretary Rice, again proposing my two ideas and saying that the State Department's June 1 report to Congress on the Water for the Poor Act was inadequate because it did not propose a future strategy as the law required. I did not receive a reply.

In December 2007, the Congress allocated $300 million to implement the Paul Simon Water for the Poor Act. I wrote Secretary Rice a third time congratulating her and asking her to appoint an ambassador to manage these funds and to appoint an Ad Hoc Advisory Committee to advise the ambassador. I have not yet received a reply.

RECOMMENDATION

I urge this distinguished committee to push the State Department for immediate implementation of the Paul Simon Water for the Poor Act.

The CHAIRMAN. Thank you very much. That is an enormously interesting historical pathway that you have described. Very helpful

in terms of the issues on safe water and I think very helpful to have that as part of our record.

Dr. Patz, perhaps you could describe to us a little bit about what we are really talking about, the health implications? I want to get your assessment eventually about how prepared the public health community is in dealing with these issues. At some time, we will come to that. I think it is important to try and sort of get a little flesh on this body in terms of understanding what the real potential dangers are for Americans, for children, for elderly, for vulnerable people with these changes that are coming.

There are a lot of committees that are considering what is causing these changes. Let us just assume that these changes are on their way, and public health is going to be presented with these challenges. As I understand, mosquitoes and dengue fever is moving up in Texas, for example, a place where it has never been sort of thought about or even kind of considered. What are some of these kinds of things that are on the horizon that you think are real?

We are not trying to alarm the American people unduly, although this committee did take steps in bioterrorism before 9/11, and we also want to be able to try and recognize that there are very, very important public health implications in terms of climate change. That hasn't been sort of a focus of the institution of the Senate just generally, and we want to try and relate it in real terms that families can sort of understand.

Dr. PATZ. Sure, thank you. I appreciate the question.

I would like to caveat my answer by saying this is a global problem, and we do need to recognize that the risks do not just lay within our boundaries and that we are in a globalized world with international trade and transportation. Disease increase anywhere in the world can affect the United States.

Let me focus now on some immediate risks in the United States, though. Certainly, we know about heat waves, and we had over 700 people die in the Chicago heat wave of 1995. I will actually quickly update your figure from the European heat wave of 2003. A new paper this year actually puts that figure at 70,000 deaths in less than 2 weeks.

But back to the United States. Heat waves are important—air pollution, especially ground-level ozone. A study targeting the United States looking at the eastern United States found that just from warmer temperatures alone projected for the middle of this century—just from warmer temperatures, ground-level ozone smog pollution will increase such that we could have an increase of 68 percent more ozone red alert days, which are very dangerous for asthmatics, especially children with asthma. That is a real issue.

The projections are for increased frequency and intensity of heat waves in the United States, increased stagnant air masses, which would then, of course, exacerbate this air pollution issue. These are projections for the United States.

Regarding water-borne diseases, our group asked the question how many reported water-borne disease outbreaks in the United States—and this was from 1948 to 1994, how many outbreaks were preceded by heavy rainfall events? And we found 67 percent. Two

thirds of water-borne disease outbreaks are preceded by heavy rainfall.

What does that have to do with climate change? Well, the climatologists remind us that it is not just global warming, it is extremes of the water cycle, the hydrologic cycle. More floods, more droughts.

Our research group at Wisconsin is modeling this work—this effect in the Great Lakes region, and the projections are for more intense heavy rainfall events. This can threaten our water safety. Already we have problems with these combined sewage overflow events. When it rains too hard, sewage and storm water overflow into surface water. It is a problem today. Climatologists are showing us that the projections are for more extreme precipitation events that can put further stress on our water quality.

That, in conjunction with some of our municipalities that have failed water systems, they are rusting away. This is an infrastructure problem that is going to demand a lot of resources. This is where in the United States we do have some real threats that can affect us here, and at the same time, not to forget the nature that this is an international problem. If we truly want to do an adequate assessment, we have to look both nationally and internationally.

Internationally, of course, climate change will exacerbate many of the major health challenges that Senator Enzi mentioned—issues of diarrheal disease, malaria, and malnutrition.

The CHAIRMAN. Dr. Ebi, the climate change expect to affect the incidence and distribution of malaria, West Nile fever, other diseases spread by mosquitoes. Can you tell us about some of the concerns in this area and what we ought to be thinking about?

Dr. EBI. Yes, I would be happy to.

I would like to go back to something that Jonathan Patz said at the beginning. That when we look at climate change issues, human health is just one of them. When we look across the spectrum of events that are changing—and I should say that climate change is not only for the future, climate change has already occurred. We are seeing impacts today in many parts of the world. It is a problem for the here and now.

The kinds of problems we are seeing with diseases spreading, such as malaria, dengue fever, chikungunya in Southeast Asia, is similar to the kinds of changes we are seeing in ecosystems. If we look within the United States, if you look at the pine bark beetle, which is chewing its way across the United States and Canada and has destroyed millions of acres of forest, and it is doing so because it used to be contained by cold nights during the winter. It no longer is as cold as it used to be. It is not killing off the beetles, and it doesn't look like we can stop it from moving across the United States.

It is not different for the pathogens that we are concerned about for human health. We are providing opportunities for mosquitoes to live places that are currently too cold. I have been on the ground in Bhutan. It is more or less a vertical country, and they are seeing dengue fever and malaria move up the highlands in ways that they have never seen, and they are having to deal with it.

Will it happen here? Of course. We are providing an opportunity for these diseases to live places they have never been. Lyme disease is moving into places in Canada it has never been. We are seeing it happen. The question is how effective we in public health can be in designing our surveillance and response systems to make sure that we identify disease outbreaks before they occur and put in the kind of prevention activities that we do know need to be established.

Thank you.

The CHAIRMAN. I will ask Dr. Balbus—we are delighted to welcome my friend and colleague from Vermont, Bernie Sanders, here.

Dr. Balbus, perhaps you will tell us a little bit about our public health systems. I was asking my staff before coming over here, when we were looking through the testimony thinking about the hearing, about these public health systems. How are they going to be able to tell? They are generally more contained systems. How are they going to be able to tell about the projections that we just heard from our last two witnesses?

We are reminded that there is a lot of information, worldwide information from various studies about what we are going to be facing in terms of drought and range and climate change, temperature change is out there. I mean, you can look at various charts. They may be accurate. They may not be. There are very, very substantial amounts of scientific information.

What is your kind of sense about how do you evaluate our systems? We know that we are going to deal with these issues. We need systems to be able to deal with these things. What is your sense? And maybe from others, Ambassador McDonald, anyone can comment about it. Your evaluation of our existing systems, and how alert are they to these dangers in terms of climate change?

Dr. BALBUS. That is a very good and a somewhat complex question.

The Nation's public health system is a bit of a complex web. Right on the ground, we have the local public health departments, over 2,300 of them. Then there is a hierarchy of State health departments and, of course, the Federal CDC. The money tends to flow downhill from the Feds and the States down to the local public health departments. The action is really primarily on the ground at the local public health department level, and that is where the integration of all of this information really has to occur.

The public health departments are not going to see these problems as climate change problems. They are going to see them as disease outbreaks, as heat waves. There are kind of two pieces to it. One, is the climate change aspect of this really comes in in the preparedness and in the planning and the predictive capability.

Right now, we have a lot of systems around to address climate-sensitive health problems. The most well-developed for the climate aspect are the heat wave early warning systems, and these exist in a number of different localities, and Kris and John may be able to speak more to them.

We also have monitoring and surveillance around the country for viral diseases and for other kinds of infectious agents and infectious disease vectors. In many cases, these monitoring and surveillance systems are not well integrated. We don't have great integra-

tion, for example, between monitoring and surveillance that goes on in animals and the monitoring and surveillance that goes on in people. A lot of the diseases we are concerned about cross between animals and people. We need better integration there.

In terms of the current state, I would characterize it just very briefly as being somewhat fragmented and not as well integrated as it should be and severely hampered for the task of addressing the planning and the responsiveness to climate change by the fact that we just don't have either the research or the modeling tools to be able to make predictions down at the scale where it all happens, down at the local public health departments. They don't have either the tools and, in many cases, lack—and I am sure they feel they lack the expertise and the resources to be able to do this down at the local level.

The CHAIRMAN. I yield at this time to my friend and colleague, Senator Sanders.

Senator SANDERS. Thank you, Mr. Chairman, and thanks for holding this important hearing, and thank you for our panelists being here. I apologize for being late. I may well have missed some of what I am going to ask, and if so, I will get the information later.

It seems to me that in addition to everything else we are talking about, that if we are talking about global warming and we are talking about drought and we are talking about problems like even in California where they are wondering in 20 or 30 years where they are going to get their water from, and if you are talking about that problem all over the world, you are talking about the likelihood of more conflict as nations fight for scarce resources and agricultural land and so forth and so on.

I know that it is not—a little bit—an immediate health issue, but war is a health issue. People get killed and wounded. We think that is a health issue. I don't know, have you discussed that, Mr. Chairman, yet, or does anyone want to say a word about that? What does it mean if there are countries in the world that lack potable drinking water from a health point of view?

Ambassador MCDONALD. If I could start by focusing on that question? I totally recognize the concern that you have expressed. As a matter of fact, next month, I am co-hosting a colloquium at Columbia University on water and peace. I do believe that with care and preparation and skill, it is possible to ensure that we will not have water wars, as so many people have been talking about.

I think the heart of that is doing something that we haven't been doing very well recently, and that is bypassing corrupt governments in the Third World, who receive a lot of our international aid and aid from other countries, and then many of them pocket that money.

There is a group out of Houston called the Millennium Water Alliance, which is made up of a dozen nongovernmental organizations focusing on water and sanitation of which my NGO called Global Water, which I started in 1982, is a part of. We focus, as the Paul Simon Water for the Poor Act does, on the rural poor. If we can bypass governments and go directly to the village leaders and the village elders, I think we can have much more of a powerful impact.

Thank you.

Senator SANDERS. Lack of water and health.

Dr. EBI. I would like to add that this certainly is an area that is very important. The State Department and the Department of Defense are both looking at this because it does affect U.S. security. Water will be a major issue. By and large, areas that are drier are going to get drier. Areas that are wet are going to get wetter.

I, a year or so ago, did a project with USAID working with farmers in Mali, and the farmers told me that they have, over the course of their lifetime, seen the rainy season go from 120 days to less than 100. The traditional rice takes 120 days to reach maturity. USAID had a very small project working with these farmers to plant different cultivars.

There are some possible solutions. We have to start looking at the complexity of these problems and start looking at the kinds of solutions that we can implement to help these farmers so that as they do have less water, they are still able to feed their families. They still can do the kinds of things that they want to do. We have a problem.

Senator SANDERS. Are we looking at the possibility of mass migration of people leaving areas where they have traditionally lived to go elsewhere for water?

Dr. EBI. It certainly is a distinct possibility. The fourth assessment report of the Intergovernmental Panel on Climate Change said that their projections for rain-fed agriculture in parts of Sub-Saharan Africa, is that within a decade, the crop yields could fall by 30 percent, which is an enormous impact. So, yes, I have been talking with organizations such as the International Federation of the Red Cross/Red Crescent Societies, and they are looking at how they can be prepared if there is mass migration on a scale that we haven't seen before.

People are starting to say that there are these possibilities. We would all be very happy if they never came about, but they are real possibilities. We need to get ahead of them and really start planning and doing the kinds of activities this committee is talking about.

Dr. BALBUS. If I could just add to that one more point? There is obviously a problem of too little water, but we have a very certain problem of too much water in the oceans. We have seen a surprising rate of the melting of the Greenland ice shield and the other Arctic and Antarctic ice shields. There are hundreds of millions of people in low-lying coastal areas around the world, a lesser problem probably in terms of refugeeism and the health threats of refugeeism in the United States, but certainly worldwide this is something that needs immediate attention.

Senator SANDERS. The bottom line is that global warming could lead to drought, water conditions—either flooding or lack of ability to grow food, which could lead to migrations, which could lead to international conflict, among other things, or mass dislocation, which causes all kinds of other problems.

OK, Mr. Chairman, I would ask unanimous consent, if I could, that my opening remarks be——

The CHAIRMAN. Yes. Yes, those will be included.

[The prepared statement of Senator Sanders follows:]

PREPARED STATEMENT OF SENATOR SANDERS

Good morning. As a member of the Environment and Public Works Committee, I spend a significant amount of my time thinking about how we appropriately respond to the tremendous challenge of global warming—we talk about allowances, auction, solar power, and safety valves. We have heard, however, only a little about the public health threats that global warming creates.

That is why I am glad that *this* committee is holding *this* hearing today.

I am also glad that the American Public Health Association decided to focus its National Public Health Week on global warming this year.

And, just yesterday, I introduced a resolution to correspond with the APHA's efforts in this area. The resolution, which lays out in plain English just some of the ways our health is going to be affected if we don't significantly reduce global warming, was cosponsored by many of my colleagues, including Senators Snowe, Kerry, Clinton, Menendez, Whitehouse, Bingaman, Boxer, Leahy, and Bill Nelson. I ask that a copy of the resolution be included in the committee record.

Let's quickly consider some of what we already know about the public health threat associated with global warming:

- The World Health Organization estimates that human-induced climate change lead to at least 5 million cases of illness and more than 150,000 deaths each year.
- The Intergovernmental Panel on Climate Change suggests that global warming contributes to the global burden of disease, premature death, and other adverse health impacts due to changes in infectious disease patterns, air quality, and water quality.
- And, we know, based on the work of the World Health Organization, that the negative health impacts of global warming are likely to disproportionately affect communities that are already vulnerable, including developing countries, young children, the elderly, and people with chronic illnesses or otherwise compromised health.

Basically, we know that global warming is a real threat to our collective public health, that we must do much more to get our public health infrastructure prepared to deal with the crisis, and **dare I say we know that we must act aggressively to reduce our greenhouse gas emissions and help to set the world on a path to reduce global warming**.

Let me say it a different way: we have a moral responsibility to enact policies to address the global warming crisis.

While we work to pass such policies, I must also suggest that the Administration is long overdue in its leadership on the issue. Last year the Supreme Court basically rebuked the Administration's position on regulation of carbon dioxide and ever since, we have been waiting for the Administration to make the obvious determination that CO_2 is an endangerment to public health. But, it is pretty clear that they are sidestepping their national—and international—responsibility on what is the largest environmental crisis the planet has ever faced.

But, today, we aren't focusing on this lack of leadership or how to get the needed reductions in CO_2 emissions. Instead, we focus

our attention to experts as they detail some of the concrete public health challenges that will confront us as our climate warms.

Mr. Chairman, I look forward to hearing from today's witnesses, who are clearly some of the most knowledgeable individuals on how public health is at risk from global warming, and again, I appreciate the committee holding today's hearing.

The CHAIRMAN. Senator Sanders is here and I am here, and we are interested in the Northeast and interested in the problems of the ozone and the pollution. We have seen—for example, I am the father of a chronic asthmatic, who happens to be in the House of Representatives, but he has been a chronic asthmatic since he was a child.

We have seen the problems, the deaths from asthma grow in our part of the country and the region, just gradually been growing. These lung-congested kinds of complications have increased significantly that we have seen over a period of time. If you are talking about the increasing pressure that is going to be on populations, I mean, he is obviously fortunate that he is able to get treatment for it. It is very costly. That comes back to another issue on health insurance. It is very, very costly. Many families obviously can't afford this.

I'd like to talk about the kinds of pressure that is going to be on populations from this ozone and from what you see just generally in terms of the heat population and these other kinds of environmental challenges that we face. What do you see down the line in terms of—let us just take the Northeast, for example, Dr. Patz.

Dr. PATZ. Well, there is, of course, concern about ground-level ozone because ozone is the most temperature-sensitive air pollutant. These models have shown that just a small amount of temperature increase in the eastern United States can significantly increase the amount of ozone. Put on top of that the projections for more stagnant air masses, it could be even worse.

I hope that we would adjust and have reduced emissions of ozone precursors, and so the scenario may not be so bad. The potential is that global warming in the eastern United States can increase ozone. As far as asthma is concerned, there is another issue that climate change can affect, and that is allergens.

There have been studies that show that with increased temperatures and increased CO_2 in the air, ragweed pollen can increase. In fact, doubled CO_2 increased ragweed production by 50 percent in one study.

One concern I have is that your summer ozone season lengthens in calendar time and overlaps with the pollen season, you may have a dangerous synergy between more ozone and pollen in the air. That is one area in this, as far as respiratory health, that is concerning.

The CHAIRMAN. Good.

Yes.

Dr. BALBUS. If I could just add, but as John pointed out in the beginning, it doesn't necessarily have to be a bad news story. What was going to play out in terms of climate change is also going to play out in terms of what we are doing in transportation and energy. We have to do it right. As we go to alternative fuels, it looks

like there may be paths that may be beneficial for ozone and paths that may not be so beneficial for ozone.

Some recent studies, for example, show that corn ethanol may actually have a negative effect on ozone concentrations, at least in the West. This is where the public health community, I think, has an important role to play to help look at these problems, look at the potential risks ahead of us, but also steer us away from them by moving toward energy solutions, transportation solutions that, as John says, reduce the emissions, reduce the precursors so that we actually can have a world of cleaner air despite the fact that the temperatures are warmer and the setting for making more ozone is there.

The CHAIRMAN. Thank you.

Ambassador MCDONALD. If I could add a point in support of your concern, Senator? The coal-belching plants in Ohio impact, harm the Northeast by destroying trees and bringing pollution to your part of the world. I think strong action by this committee and the Congress itself could avoid that from taking place in the future.

The CHAIRMAN. That is good.

Dr. Patz.

Dr. PATZ. If I can just follow up that comment? Again, I think it is very important to not look at climate change in isolation, and this point about fossil fuel burning, the coal-fired power plants is very important to recognize that there could be co-benefits. Dr. Balbus mentioned this in his introduction. That fossil fuel burning creates greenhouse gases and global warming, but fossil fuel burning creates all of the other criteria air pollutants. So that by reducing greenhouse gases and targeting mitigating climate change, there are co-benefits—you know, reduced air pollution.

The other issue is transportation that, in fact, 60 percent of the U.S. population does not meet the minimum recommended daily levels of exercise, and we have that problem on our hand. If we were to modernize our transportation system so that we had multimodal mass transit, more bikeable, walkable cities, we could have multiple co-benefits—reduced air pollution, better fitness, and reduced greenhouse gases.

The CHAIRMAN. Dr. Ebi.

Dr. EBI. I would like to go back to one of the points I raised at the beginning that to look at what we need to do in the Northeast, we really don't have research focused on the Northeast. We have very little research that has been done in any particular region. We can tell you on a general basis what we know from research done primarily in other countries, other developed countries.

To focus now on—I know Maryland is not really part of the Northeast, but I had the opportunity over the past several months. Maryland is one of the very few States in the Nation that is looking at what they need to do in public health to adapt to climate change. As part of the Maryland Climate Change Commission that will be finished sometime in June, I have been working with the Maryland Department of Health and Mental Hygiene, and several issues that have come out to support the survey that Dr. Balbus talked about.

They can deal with the day-to-day issues that they are faced with, but if they are faced with more sea-level rise, they are wor-

rying not only about human health. They are worried about human well-being and livelihoods. There is an awful lot of industry in Maryland that relies on well water. And if you have problems with storm surges, you have drought, you are going to have contamination of wells that will affect livelihoods. They are trying to figure out how they could handle that.

They have looked at a whole range of issues and have basically said if we are presented with additional pressures because of climate change, we do not have the human and financial resources to be able to deal with them.

The CHAIRMAN. I think this is very interesting that Maryland—are the public health systems about as good as they get? Pretty good.

Well, I think that is very important. I think what we are hearing, too, is the importance of keeping in mind public health in each and every one of these judgments and decisions that is going on because it has broad implications. I am not sure that we have done that quite as much and as effectively as we should.

We might try and see if we—with the experience of the public health, maybe we could communicate with these other States about mentioning this hearing here and about what has happened up in Maryland is something that has caught our attention that they may want to take a look at for themselves, may want to take a look at reviewing and studying similarly their own States. I think that is what we are going to have to do.

Systems are going to be the answer down the line. If we have got a good example and a good model for it, it ought to be shared and replicated where necessary.

Well, I want to——

Senator SANDERS. Well, I just wanted to pick up on the point that Senator Kennedy made. I could tell you I go to a lot of schools in Vermont. Asthma is a huge problem. I think the point here is that we have problems today, health problems today, and how are they going to be exacerbated as a result of global warming and what can we do to pay attention to that and prepare for that is something that is very important.

The CHAIRMAN. We have heard a number of thoughtful comments, recommendations, and the health effects of climate change. We know that this isn't a challenge we need to confront in the distant future. It is something we need to deal with now.

Our hearing today is sort of a first step in addressing these important matters, and we look forward to working with our colleagues on the committee, as well as colleagues throughout the Senate who view some recommendations on the issue. We can develop proposals to see that addressing the health concerns are a central part of our response to the climate change. We are very grateful for our panel this morning.

We will stand in recess. Thank you very much.

[Additional material follows.]

ADDITIONAL MATERIAL

PREPARED STATEMENT OF SENATOR OBAMA

Mr. Chairman, I commend you for holding this hearing on an issue that rarely receives the attention that it deserves—the effect of climate change on the health of the American people.

Over the past decade, our knowledge about the impact of climate change on the physical health and well-being of the world's population has grown considerably. According to the World Health Organization (WHO), climate change is a substantial and escalating menace to the world's overall health. The WHO estimates that alterations in the Earth's climate, generated by human behaviors, have led to at least 5,000,000 cases of illness and more than 150,000 deaths each year. The Intergovernmental Panel on Climate Change (IPCC) has reported that changes in the earth's climate have contributed to the global burden of disease, premature death, and other adverse health effects. Because of extreme weather events, we are experiencing adverse changes in infectious disease patterns, air quality, quality and quantity of water and food, ecosystem equilibrium. Collectively, these changes have led to elevated risks for a number of debilitating health problems such as asthma, allergies, and chronic obstructive pulmonary disease.

Unfortunately, the harmful health consequences of climate change disproportionately affect our most vulnerable populations, particularly young children, the elderly, patients with chronic illnesses, and individuals from underserved communities, including communities of color, traditional societies, and coastal populations. Sadly, more than 900,000,000 of the world's people live in impoverished conditions and are especially susceptible to the possible health impacts of climate change because of lack of access to health care, poor sanitation, and vulnerability to displacement.

We, as individuals and as a nation, must change our behaviors in order to reduce the negative impacts of climate change on our health. This will not be easy. As first steps we must establish and strengthen collaborations between health and environmental stakeholder groups and foster interdisciplinary partnerships that can help us better tackle this issue. Research efforts must be increased in order to identify creative solutions to mitigate the human impact of global warming. Public education and awareness initiatives should be expanded. It is important that each and every American understand climate change and its effects on health, and more importantly, what actions can be taken to protect and promote their health. Thank you.

PREPARED STATEMENT OF SENATOR TOM COBURN, M.D.

"CLIMATE CHANGE: A CHALLENGE FOR PUBLIC HEALTH"

I want to start off by noting misguided priorities of this committee. This hearing is on the *potential* public health threats of climate change, and yet the committee has done very few oversight hearings on the $29 billion at the National Institutes of Health (NIH) and $9 billion at the Centers for Disease Control and Prevention (CDC) being used to fight *real and current* public health threats.

This committee should be more aggressive in protecting the public's dollars as we work to protect their health. Time after time we see calls for funding, subsequent increases in funding, and then a failure to follow-through on whether or not our investments are working. This is mismanagement of taxpayer money and a failure to make sure we are really protecting the public's health. We should be holding regular hearings on how the NIH and the CDC are using their money to protect the public health.

Forty-seven million dollars is being spent by the NIH today on climate change research, mainly through the National Institute of Environmental Health Sciences. And yet, at this hearing on climate change, we haven't invited someone from the NIH to share the results of that research.

Few people doubt that the Earth has recently warmed. By scientific estimates, it has slowly and erratically warmed approximately 0.8° Celsius since 1850. However, there isn't scientific consensus on an imminent climate disaster as global warming alarmists contend. In fact, history tells us that warming trends happen periodically: the Medieval Warming (950–1300 A.D.) and the Roman Warming (200 B.C. to 600 A.D.). There are hundreds of scientific peer-reviewed papers that support the fact that global warming—and subsequent cooling—is a natural and moderate pattern throughout history.

According to the *Journal of Geophysical Research*,

> "Research in 2006 found that Greenland has been warming since the 1880's, but since 1955, temperature averages at Greenland stations have been colder than the period between 1881–1955. Another 2006 peer-reviewed study concluded the rate of warming in Greenland from 1920–1930 was about 50 percent higher than the warming from 1995–2005. One 2005 study found Greenland gaining ice in the interior higher elevations and thinning ice at the lower elevations. In addition, the often media-promoted fears of Greenland's ice completely melting and a subsequent catastrophic sea level rise are directly at odds with the latest scientific studies."

There is not yet scientific consensus proving that humans have caused recent warming and climate change. A recent news article stated,

> "Few scientists agree with the idea that the recent spate of potent hurricanes, European heat waves, African drought and other weather extremes are, in essence, our fault [a result of manmade emissions]. There is more than enough natural variability in nature to mask a direct connection, [scientists] say."[1]

Let me be clear, while I don't doubt some climate change has happened in recent years, it is a part of a long-term pattern. Scientists are divided on the extent to which it is happening today. Even the U.N. Intergovernmental Panel on Climate Change changes its story from time to time.[2] This committee should be wary of considering and passing knee-jerk legislation based on fear instead of sound science. As my colleague from Oklahoma, Senator

[1] April 23, 2006, the *New York Times* by Andrew Revkin.

[2] *http://epw.senate.gov/public/index.cfm?FuseAction=PressRoom.Facts&ContentRecord_id=8EA35336-7E9C-9AF9-7025-4B6CD20B983A.*

Inhofe, has stated, "We can approach climate policy in a more methodical way that recognizes the long-term nature of the issue that requires a long-term solution." Senator Inhofe's complete statement has been entered into the committee record.

This committee should be cautious about legislating based on the weak premise that humans contributed to climate change. Furthermore, it is important to remember that human life unfortunately suffers during periods of extreme cold as well as extreme heat. This committee needs to carefully consider the issues related to climate change and the most effective way to mitigate potential risk to human life in the long term.

The American Public Health Association has sponsored "National Public Health Week" and asked Congress to examine "Climate Change: Our Health in the Balance." It is a good opportunity to look closely at health risks potentially related to climate change and other varied factors.

For example, the American Public Health Association's Web site lists potential geographic impact of climate change in the United States on its Web site: *http://www.nphw.org/nphw08/08_pg_facts.htm*. In the Southeast Atlantic and Gulf Coast Region, the Web site lists,

> "Hurricanes and other weather events are expected to be more intense, meaning bigger storm surges, more damage to buildings and roads, and contaminated food and water."

While we've all seen those results from hurricanes, it is scientifically untenable to contend that hurricanes are directly related to recent global warming. The Intergovernmental Panel on Climate Change admitted in a 2001 report that "No systemic changes in the frequency of tornadoes, thunder days or hail events are evident in the limited areas analyzed" and that "changes globally in tropical and extratropical storm intensity and frequency are dominated by inter-decadal and multi-decadal variations, with no significant trends evident over the 20th century."[3] Scientists at the NOAA have cited evidence of natural swings between hurricane highs and lows over 25–40 year periods.

A New York Times bestseller cites fascinating historical records from the British Navy about hurricanes in the Caribbean over the last several centuries.

> "Historic records tell us the region had nearly three times as many major hurricanes per year during the Little Ice Age from 1701 to 1850 as during the 'warming' years from 1950 to 1998."[4]

The American Public Health Association Web site also lists climate change as a factor for diseases carried by insects and mosquitoes—like Lyme Disease and West Nile Virus—"extending their reach" up to the Northeast United States. While I wish that the solution to mosquito-borne illnesses was simply moving farther north, science indicates differently. ". . . Malaria epidemics have occurred as far north as the Arctic Circle, and the worst outbreak was in

[3] IPCC, *Climate Change 2001, Summary for Policymakers*.
[4] *Unstoppable Global Warming Every 1,500 Years*, by S. Fred Singer and Dennis T. Avery.

Russia during the 1920s, with 16 million sick and 600,000 deaths."[5]

I could go on with other examples, but I will end this topic with a final thought about the effects of extreme temperatures on human life. No one can doubt heat stroke, heart attacks, and asthma attacks are related to *heat* waves. Yet it's important to remember the devastating effects of extremely *cold* weather—elderly dying in poorly-heated homes, skull fractures from falls on ice, car accidents from black ice, men dying of heart attacks while shoveling snow, etc. According to the U.S. Department of the Interior's Indur Goklany, from 1979 to 1997, "extreme cold killed roughly twice as many Americans as heat waves did."[6] It's important to note that cardiovascular disease is a leading killer in the United States, and cold weather exacerbates that condition far more than warm weather.

As this committee examines mitigating the potential effects of climate change and other public health risks, we must act responsibly and effectively. For too long the mode of operation on this committee has been to pass new spending authorizations and programs before we ensure the ones we have are working to mitigate risk and protect the public health. I hope that we act more responsibly than to continue that status quo of creating new programs and spending that propel our country deeper and deeper into debt.

This country is more than $9 trillion in debt. Paying for the Medicare program *alone* means every American household shares a $320,000 IOU.[7] Long-term economic solutions and debt control—that will enable individuals to afford air conditioning in their homes, for example—must be part of the solution in mitigating the potential risks from climate changes.

I look forward to reviewing the testimony of today's witnesses and effective strategies they may have to mitigate real, long-term risks. Should this committee take specific legislative action on this issue, it should be a balanced approach based on sound peer-reviewed science—not on hyped up fear from a politically charged agenda.

PREPARED STATEMENT OF SENATOR INHOFE

Once again it appears that the issue of health and climate change, like so many areas, has fallen prey to politics. With all of the dire consequences that many advocates are rushing to predict as a result of global warming, I believe it is important to remind ourselves of one simple truth. It is economic development that is the key factor in saving lives. Bringing people out of poverty has done more to advance health and well-being than any other indicator in history. As the debate on climate policy progresses, I believe it will be important to continue to remind ourselves of this truth, and that the policy choices that we make in the near term will have real effects, and with them unintended consequences.

Consider current ethanol policy as an example, which was greatly expanded upon in last year's energy bill and originally touted for

[5] *Unstoppable Global Warming Every 1,500 Years*, by S. Fred Singer and Dennis T. Avery.
[6] *Unstoppable Global Warming Every 1,500 Years*, by S. Fred Singer and Dennis T. Avery.
[7] *http://www.heritage.org/Research/HealthCare/wm1869.cfm.*

its climate benefits. As a result of the mandate, corn prices have skyrocketed in the past year, making food more expensive and exports less available to supply World Food Aid Groups and the effects are only just beginning to take place. Clearly, the global demand for food places a severe limit on the feasibility of using grain supplies for producing a large percentage of U.S. motor fuel, yet the scale implications as it relates to food aid were never considered during the energy policy debate.

One issue that does currently receive a lot of attention for its supposed link to climate change is malaria. Reducing issues such as malaria to a simple and naïve view that higher temperatures equal higher malaria rates is not only simple, but simply wrong. Temperatures are a factor, but it is also true that malaria can spread when and where it is relatively colder. According to Paul Reiter of the Pasteur Institute in testimony before the Senate Commerce Committee last year:

> "The most catastrophic epidemic on record anywhere in the world occurred in the Soviet Union in the 1920s, with a peak incidence of 13 million cases per year, and 600,000 deaths."

More important than temperatures are preventative measures and economic standards of living, which—make no mistake—will be worsened by rash action to pass costly symbolic measures. As the record will point out, when you look beyond the rhetoric at the facts, malaria is very much a disease that we can greatly diminish or help flourish, depending on how we live and what policies we put into place.

The facts are this: malaria was nearly wiped out a few decades ago by the use of DDT. This is not disputed. The disease now claims 1 million lives or more every year—again, not disputed. Regardless of the science of DDT—and it appears it did not support a ban—selective spraying can greatly diminish cases of malaria. But it was only recently, after millions of deaths, that policies began to shift away from alarmism and toward a genuine concern for the people who were paying for that alarmism with their lives. Let us not repeat history here.

Even if temperatures do rise, natural environmental forces might save more lives due to a warmer climate. Professor Bjorn Lomborg has stated recently, that while global warming might result in 400,000 more heat-related deaths a year, there will be a decrease in 1.8 million cold-related deaths. This is a net of 1.4 million lives saved due to higher global temperatures.

It all comes down to how do we want to be remembered? We can rush to leap before we look and spend hundreds of billions of dollars on carbon controls and a market-based trading system that may or may not prevent some of these extreme scenarios. For much less money, there are many other problems where we can do much greater good. The United Nations estimates that for $75 billion per year, we can solve all major basic problems plaguing the developing and developed world, including clean drinking water, sanitation, basic healthcare, and primary education.

At the same time we can approach climate policy in a more methodical way that recognizes the long-term nature of the issue that requires a long-term solution. A good starting point is heavy investment in R&D of non-carbon emitting energy technologies, while si-

multaneously working on the international front on country specific measures through a sector by sector, share-the-technology-style-approach. In this manner, the developing world is engaged at the outset and clean energy trade barriers are broken, while the focus can remain on the pressing public health issues that demand our attention.

PREPARED STATEMENT OF JOHN DALE DUNN, BOARD CERTIFIED EMERGENCY PHYSICIAN

Members of the committee, Senator Enzi's staff asked me to testify and because of short notice, and time pressures, I was subsequently asked to submit my testimony in writing.

Thank you for this opportunity to address the issues.

My name is John Dale Dunn and I am a 36-year physician, a Board Certified Emergency Physician, member of the civilian faculty in emergency medicine at Carl R. Darnall Army Medical Center, Fort Hood, TX where we see 75,000 emergency patients a year in a Department that trains physicians, physician assistants, and other Army personnel in emergency care. I was the Public Health Authority for 10 years and Emergency Department Director in Brownwood, Brown County, TX. I have studied environmental regulation and science for more than 10 years and taught college level environmental regulation and law. My abbreviated *curriculum vitae* is attached to this written submission. I reference supportive materials in the appendix.

I assume the committee is concerned about the human health effects in America from projected global warming. Climate change is not pertinent. Weather and climate are always changing.

BACKGROUND ON A WARMER CLIMATE AND ITS EFFECT ON HUMAN HEALTH

The World Health Organization (WHO) has claimed that global warming killed 150,000 people in 2000 and that warmer temperatures will put 65 percent of the world's population at risk for insect borne tropical diseases. Paul Reiter of the Pasteur Institute, an expert in vector disease studies says that the WHO is not providing reliable information. I refer staff to his work and focus here on the health effects of warming.

I assert that people suffer more from cold than from hot around the globe and in the United States and the evidence is unequivocal.

Daily change in temperature in any location on the planet is more than even the most exaggerated warming projection changes of the IPCC: Any discussion of human health effect should start first with the concept that the human species has a wonderful ability to adapt to temperature change. In a year the adaptation in temperate climes is 100° F. or more.

More important for human health are the basics—clean water, good nutrition, effective sewage and quality clothing and housing (including heat and air conditioning as needed). Modern medicine works around the edges, but the life expectancy of Americans is effected more by basic quality of life and infrastructure than modern medicine. Read the reports of cholera, typhus, dysentery, malaria and yellow fever epidemics, all seen in America and all eliminated by basic housing and infrastructure improvements. Vaccines are important, but adequate quality of living is essential.

SO IS WARM GOOD OR BAD FOR HEALTH? I SAY BRING ON THE WARM

People die more often during the cold winter months. People of all ages, infants to the elderly get sick in the winter more than summer. The World Health Organization, claims that global warming will kill 150,000 or twice that number and fails to comment on the well-known observation that twice or more of that number die from cold waves and cold exposure. Warm is good for circulation, arthritis, respiratory health, and well-being. It reduces strokes and heart attacks. Cold weather brings on viruses, asthma and pneumonia because of temperature change, bugs in the air and close living.

A study by Keatinge published September 16, 2000 in the *British Medical Journal* showed a *ten-fold increase in deaths in the elderly (age 65–74)* from cold waves versus heat waves (2,000 deaths per million attributed to cold stress, 200 deaths per million attributed to heat stress.) Cold wave death effects are not only more severe, but last longer than heat wave effects, probably because of prolonged illness tail due to physiological and infection exposure.

The rates of stroke and other cardiovascular events like myocardial infarction are higher in cold weather, explained by the effects of cold on blood vessels.

In 1st world cultures, climate has no significant effect on the general health of the population because only the vulnerable and poor live at risk of heat and cold stress.

Global warming will moderate, not exaggerate temperature extremes. It's a physical principle related to air circulation and the way the planet warms up. This more moderate and pleasant weather without cold snaps blows a hole in the theory of catastrophe proposed by the WHO. Warmer climate will not kill more people, it will reduce the nasty effects of winter and cold without causing any dramatic warming or increase in heat waves.

HEAT ILLNESS

So the scaremongers point to heat illness. The evidence is the Chicago deaths of elderly living in non-air-conditioned old buildings in summer of 1995 and the European heat wave of 2003 that was associated with about 35,000 deaths. That's the WHO case for panic in a nutshell.

The human organism operates in a controlled, very small range of internal temperature, regardless of ambient temperature. Humans in good health not exposed to extremes have no problem keeping body temperature in the right range. That's what mammals do. People are about 99.6° F rectally, dogs 102° F, horses at 100.5° F. Ambient temperature is not a factor.

Heat stress and illness is caused by lack of adaptation and loss of thermoregulation. 100° F is an emergency for the isolated, ill and disabled if air conditioning, ventilation and fluids are inadequate. That's the answer to Chicago and European deaths.

People who are at risk of heat illness or effects can avoid the risk by being quiet, drinking fluids and staying in a well-ventilated place, even if they don't have air conditioning.

Improvements in heat wave survival in Germany and United States since 1995 and 2003 are due to awareness, prevention, and most important, air conditioning. The typical high risk range for the healthy human is temperature and heat index factors in excess of 100° with the margin at 105° F, humidity 10 percent or more.

Dry desert produces the extremes of heat. The 130 degree desert summer temperatures of Iraq and military training conditions in the Southern United States, are an excellent laboratory for heat illness. At Fort Hood the last 2 years, intense training of thousands of soldiers of varying degrees of fitness, has produced less than 50 cases of heat illness per year.

The WHO has not been a responsible source of information on heat death numbers or analysis of deaths allegedly due to heat. Death during hot weather is not always death from heat. The same is true of deaths attributed to cold. However net deaths favor warm over cold for all age groups.

CONCLUSION

The current environmental movement actions to increase the cost of energy will definitely result in the poor and disabled living less safely and with less access to air conditioning and heat. I think current environmental proposals will be very damaging to the people of 3rd or 2nd world economies and societies.

I ask the committee to be skeptical about the claims of authoritarian global warming advocates. The poorly clothed and housed will suffer and die from environmentalist experiments.

The Copenhagen Consensus group of international economists (including 4 Nobel Prize winners) has reviewed the moral and economic choices available to the advanced countries of the world.

They placed basic public health as high priority and global warming as low priority for addressing the problems of the human race on planet Earth. I hope the committee shares my outrage at the attitude of comfortable and arrogant European and American snobs who insist that global warming be first on any list of policy priorities while ignore the desperate conditions of the poor and deprived of the third world.

There is nothing charming and quaint about open sewage and bad water, children dying of diarrhea and malaria, people suffering when we have the ability to spend a small percentage of the billions proposed for environmental anxieties for people who just need a little help to get clean water, sewage, better clothes and shoes and a decent place to live.

Mr. Gore is right, there is a moral imperative, the imperative is humans, not his anxiety or his ambition about carbon dioxide controls. More about humans and less

about warming should be the committee priority. In emergency medicine we find out a lot about what kills people—I assure the committee it is not global warming.

I hope the committee was assisted by my comments and I thank you for your attention.

APPENDIX

1. The work of Dr. Paul Reiter of the Pasteur Institute of Paris will set the committee right on the WHO junk science claiming the plague of vector-borne diseases that is alleged to be the consequence of warming.

2. For studies that show the benefit of warming on human health, I reference the work of Lawrence Kalkstein in *Environmental Health Perspectives*, vol. 96 pages 145–50 1991, Laschewski in *Climate Research* vol. 21 pages 91–203 2002, Hong in *Epidemiology* vol. 14 pages 473–78 2003, Gouveia in *International J. of Epidemiology* vol. 32 pages 390–97 2003, Davis in *Environmental Health Perspectives* vol. 111 pages 1712–18. All of these studies show the benefits of warmer climate, reducing strokes, promoting general health and reducing death rates.

3. Keetinge in *British Medical Journal* vol. 321 pages 670–73, as mentioned in the text, shows dramatically the ten-fold death benefits of warm versus cold.

4. Finally, I reference Roy Innis, who speaks for the impoverished and neglected of the world, of any ethnic or national identity, when he speaks from the podium and writes in his book. *Energy Keepers Energy Killers—The New Civil Rights Battle*

"Your anti-energy, anti-insecticide, anti-biotechnology ideologies and policies have killed millions of African and other Third World babies, children and parents."

I agree with Mr. Innis. I hope the committee and the Senate wake up before they kill more innocents with bad energy policy pandering to neurotic greenies like Al Gore.

PREPARED STATEMENT OF T. A. KUEPPER, EXECUTIVE DIRECTOR, GLOBAL WATER

A BRIEF DISCUSSION—HEALTH EFFECTS CAUSED BY CLIMATE CHANGE SHOULD INCLUDE THE DEVELOPING WORLD

Most people knowledgeable of the developing world and climate change agree that health effects felt by rural populations in developing countries will be more severe than that felt by the developed world. The simple reason is water, or more precisely, a lack of it.

Rural populations in the developing world, now numbering over 2 billion people, must fend for themselves when it comes to the basics of life, such as water, food and shelter. The reality is rural populations in the developing world live basically as humans lived thousands of years ago. Although their life could be made much easier if a safe water supply was provided by the governments of the developing world (as is done today in the developed world) the simple truth is leaders of countries in the developing world often do not feel responsible to take care of their own people.

Most climate experts agree that one of the primary effects of climate change will be that droughts will occur in ever-expanding areas of the world. In today's drought-prone areas of the world, especially on the African continent, the search for water is a true life and death situation that is played out everyday of people's lives. Even in areas without drought, such as Central America, microbiologically-unsafe water is the primary reason why infant mortality is some of the highest in the world as rural populations must fend for themselves to find water for their everyday needs.

The bottom line is the fact that water is the major factor causing hunger, disease and poverty throughout the developing world and it is not going away. From all indications, it is going to get worse and its going to get worse relatively soon as already the effects of climate change are being felt in water-short areas of the world that are expanding as we speak.

So that is why the developed world should consider the rural populations of the developing world when it comes to climate change.

The solution to the coming water crises in the developing world is far from hopeless, but it requires political will. What is necessary is for the developed world to "encourage" the leaders of the developing world to help their own people. This can be done by doing just two things:

1. Adding humanitarian clauses to business transactions between the developed world and the developing world, especially those which include the extraction of natural resources; when the U.S. government and U.S.-based international businesses create business dealings in the developing world that include natural resources, it should be stated that a percentage of gross revenues be set aside to provide the ne-

cessities of life, such as water and food production, for rural populations of that country (a suitable percentage would not be less than 20 percent). This type of clause is justifiable since the rural populations of a developing country "own" its natural resources as much as anyone in that country and the leaders of the country should have a moral obligation to share its rewards.

2. Mandate international lending institutions (such as the World Bank) to provide funding to local non-governmental organizations (NGOs) in the developing world instead of only funding governments. This practice of only funding governments has allowed the developed world to say that they show their concern for the people of the developing world by providing money to developing countries earmarked for humanitarian projects. But the reality is little, if any, of that money actually goes towards humanitarian projects to actually help people. Most of that money goes to pay salaries of supporters of the current regime and in the bank accounts of the countries leaders. As such, often money earmarked for humanitarian purposes has encouraged corruption and little else.

Global Water has worked with many local NGOs in the developing world and has found them to be the most cost-effective way to initiate and manage humanitarian projects. But there is very little funding for local NGOs since major humanitarian funding ignores them and gives directly to governments of developing countries.

Lastly, the United States continues to ignore the greatest opportunity in the world to increase its own security through winning the hearts and minds of people outside the United States by not combining its water technology expertise (which happens to be the finest in the world) and foreign aid in a way that is effective. My experience in working in developing countries is that people are most appreciative when receiving the basics for life, especially safe water.

U.S. foreign policy spends billions per year in the category of foreign aid but little of this money actually goes towards helping ordinary people of the world which is the best way to raise the prestige and popularity of the United States and this is directly connected to its worldwide security. Unfortunately, endemic forms of corruption have been created by international business and misdirected foreign aid. Throughout this process, a developing country's population knows very well what is going on and the fact that they are being exploited under the guise of international trade.

I was in Guatemala last year when President Bush visited that country. The headlines in the newspapers read "President Bush Brings Millions of Dollars to Guatemala for Education." The NGOs I was visiting told me none of that money will go to education and the people know that. It's only purpose is to make sure Guatemalan politics continue as usual and politicians are friendly to U.S. businesses.

I then visited a hospital in a rural area of Guatemala that was staffed by doctors from Cuba. Cuba has initiated a program in Central America that has brought Cuban doctors to help a Guatemalan medical system which has historically been dysfunctional and dangerous. It is currently training Guatemalan students to become doctors and to bring that knowledge back to Guatemala. In the meantime, Cuban doctors help in Guatemala directly.

The people of Guatemala understand what foreign governments are actually doing in their country, whether the residents of the developed world are aware or not. I was told by ordinary Guatemalan citizens, the United States is helping the current batch of national politicians while the Cuban government is helping our people.

This lost opportunity is being played out all over the developing world and is a major contributing factor why U.S. security around the world continues to deteriorate.

PREPARED STATEMENT OF HOWARD MACCABEE, PH.D., M.D.

INTRODUCTION

We note that moderate climate warming is already occurring, due to anthropogenic causes and more powerful natural causes, especially increased solar activity.

BACKGROUND

There have been prior threats of health disaster due to "nearly global warming." Remember that the Antarctic, which contains 90 percent of the world's ice, is *cooling*. Recent measurements show one-third more ice than prior decades. Increases in malaria, infections and other vector-borne diseases have been considered by McMichael, et al. (Lancet, 2006). Malaria claims have been refuted by Dr. Paul Reiter (Int'l. Conf. on Climate Change, NYC, 2008).

Direct threats to health from warming were predicted by McMichael, et al. from his model (see Slide A). Thomas G. Moore, however, published skeptical analysis in *The Public Interest* (1995), and there is increasing data consistent with increasing human health and decreasing death rates with moderate temperature increase.

As a clinical physician with a background in engineering and biophysics, I have also become skeptical about threats of direct harm to health from climate change. As a member of hospital "house-staff" in several urban hospitals, I observed that many more people are admitted to hospital on cold winter days and nights than in the summer, and many more die in the following weeks. Reliable public health data show that mortality in winter due to cardiac, vascular and respiratory disease is *seven* times greater than summer (Moore, 1998) in the United States. The ratio is 9 to 10 in Europe.

Death rates in the developing world have been decreasing because of better nutrition, as agricultural yields improve with the "Green Revolution." As the CO_2 concentration in the atmosphere increases, photosynthesis becomes more efficient, leading to more food production. Climate-related death rates have been decreasing globally for the past 70 years (Goklany, 2007).

My conclusion is that the world is already *adapting* to the 0.7°C temperature warming so far, with no direct health disaster.

WHAT DOES THE DATA INDICATE?

The mechanisms of serious illness from cold are dominated by hemoconcentration (like sludging of the blood), causing death from ischemic heart disease and cerebrovascular disease, which together account for half of all excess cold-related mortality (The Eurowinter Group, Keatinge, et al. 1997). Thus mortality in Europe in winter is much greater than summer. (See Slide C, Keatinge, et al., 2000.)

Mortality in the United States in winter is also much greater than summer. (See Slide D, Deschenes & Moretti, 2007.)

I have revised the model proposed by McMichael, et al., to account for the shape of the actual data from the United States and Europe. This shows the mechanism of the significant reduction of overall mortality expected from moderate warming. (See Slide E.)

These explanations and expectations are consistent with existing data showing long-term environmental trends of decreasing death rates from tornadoes, hurricanes and extreme temperatures (the dominant factor). (See Slide F. Goklany, 2007.)

CALCULATIONS OF BENEFIT

I have evaluated the slopes of the straight lines drawn by The Eurowinter Group through their data. These are consistent with a reduction estimate of 1 to 2 percent for each °C warming. This would lead to an estimated decrease of 30,000 to 60,000 U.S. deaths per year. This is very significant by comparison with 30 thousand deaths per year from breast cancer in the United States, a similar number from prostate cancer and about 40,000 from motor vehicle accidents. Bjorn Lomborg, the distinguished Danish environmental economist, has estimated 1.7 million fewer deaths in the world per year, or 170 million fewer by year 2100. (He also notes that deaths from cold are nine times greater than deaths from warmth.)

Consider that heat deaths often represent "displacement" i.e., weakened people die a few days or weeks before prior expectation, but deaths due to cold usually result in months to years of life lost. Thus the benefits in lifespan from warming in cold periods may be much more than 10 times greater than lifespan lost in warm periods.

Note also that deaths from warmth are preventable with improvements in air conditioning, architectural shades, public health measures, etc., and already are falling in European and American cities.

WHAT ABOUT SEVERE CLIMATE WARMING?

Cities have already warmed by 2–4°C, much more than the climate average, due to the "urban heat island" effect. Mortality has not increased, because of better buildings, air conditioning, health care, etc. *Adaptation* to climate change is not only possible, but already working.

Large populations have already migrated south in the United States (and Europe) with average temperatures increased by more than 5°C, resulting in improved health and life expectancy.

CONCLUSIONS ON EFFECTS OF CLIMATE CHANGE

I expect better health and better health statistics, with moderate warming, in both the developing and the industrialized world. We still need more research on health effects of climate change, and more effort in *adaptation*, given the excessive costs of greenhouse gas reduction and the impossibility of preventing natural events.

2008 UPDATE ON NEARLY-GLOBAL WARMING . . . OR IS IT COOLING?

The Antarctic Continent, containing 90 percent of the world's ice, has been cooling such that its ice and snow are now one-third greater than in the recent past. Most of the melted ice in the Arctic has frozen again. It snowed in Baghdad for the first time ever. Average temperatures for the last year appear to be cooler by 0.7° C, equal to the entire average warming for the prior century! There has been no increase in average temperatures since 1998. Solar activity is at a dramatic slowdown. World class solar scientists from Russia, China and Germany are predicting that this could be the beginning of a major cooling cycle. These are news items of early 2008.

They are a dramatic counterpoint to earlier events of 2007, including the IPCC summary for policymakers, which backed off on its estimate of anthropogenic climate forcing, down to 1.6 watts/meter^2, and reduced its estimate of ocean level rise to 17 inches (worst case), leaving Al Gore's estimate of 20 feet very high, but not dry. What happened to his "consensus?" Oh, yes, Al Gore shared the Nobel Prize with the U.N. Intergovernmental Panel on climate change (IPCC), but it was the very political "Peace" Prize, *not* an award for *science*. In the realm of physical science, however, Svensmark and Calder published "The Chilling Stars," a new theory of climate change that correlates solar magnetic activity with earth's climate much more accurately than anthropogenic CO_2 production. Also, in the realm of economic science, Bjorn Lomborg published "Cool It," in which he shows that Kyoto protocols, carbon taxes, and "cap and trade" schemes are the most wasteful and lowest priority use of scarce resources for the purpose of fighting poverty and disease.

Finally, the claims of direct risks to human health from moderate warming have been refuted by scientists such as Thomas G. Moore and physicians such as W.R. Keatinge of the UK and Howard Maccabee of California. They have shown that warming of 1–2° C is likely to *reduce deaths* from cardiac, vascular and respiratory disease by 1–2 percent.

For more on these subjects, contact: Howard Maccabee, Ph.D., M.D., Speaker, 2008 International Conference on Climate Change. E-mail: *maccabee@comcast.net*; fax: (925) 820–2567.

HEALTH BENEFITS of MODERATE CLIMATE WARMING

Howard Maccabee, PhD, MD

INTERNATIONAL CONFERENCE ON CLIMATE CHANGE

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A. MODEL OF McMICHAEL, et al., 2006

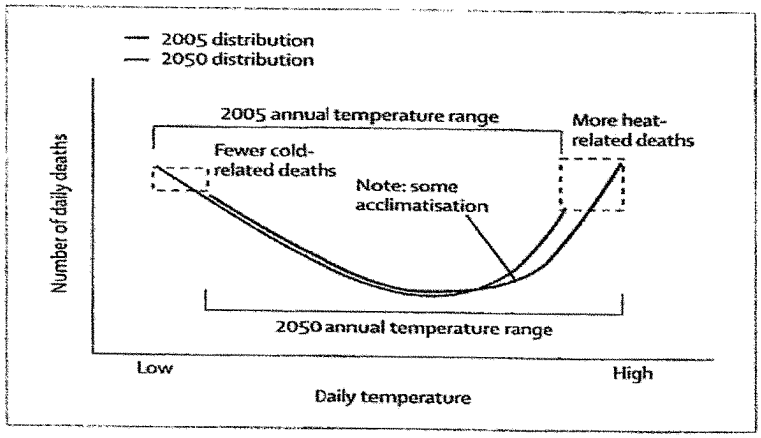
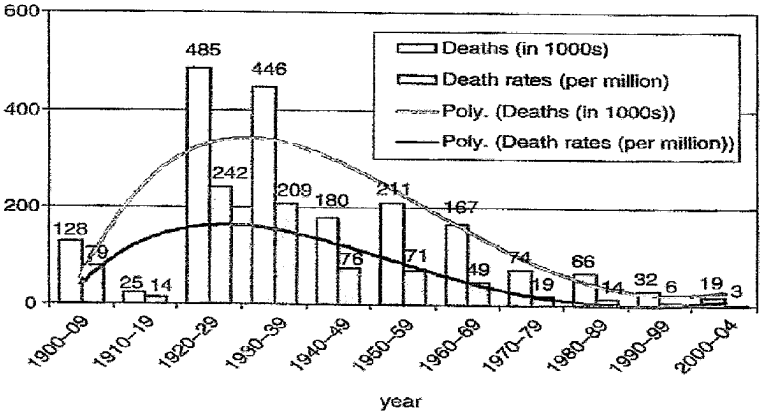


Figure 2: **Schematic representation of how an increase in average annual temperature would affect annual total of temperature-related deaths, by shifting distribution of daily temperatures to the right**
Additional heat-related deaths in summer would outweigh the extra winter deaths averted (as may happen in some northern European countries). Average daily temperature range in temperate countries would be about 5–30°C.

B. FROM GOKLANY (2007)
P. 173

Long-Term Environmental Trends

Figure 6.17
GLOBAL DEATHS AND DEATH RATES DUE TO CLIMATE-RELATED DISASTERS, 1900–2004



41817-6.eps 41817-7.eps

C. EUROWINTER GROUP, LANCET (1997) 349, 1342

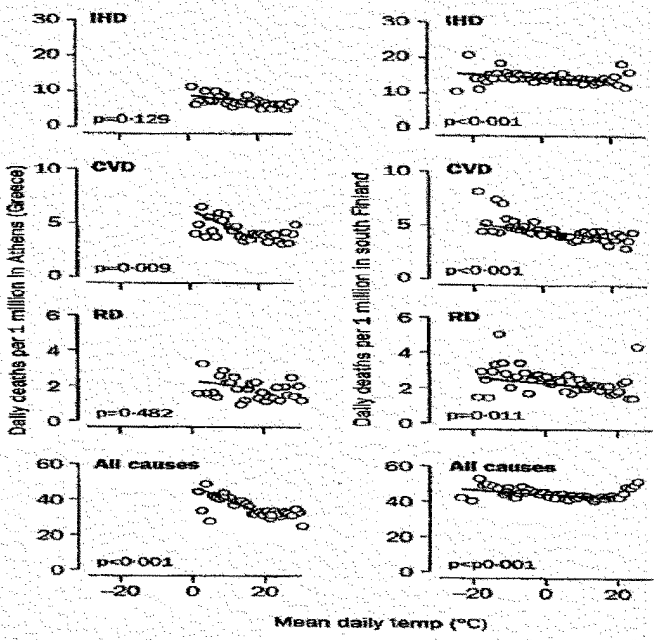
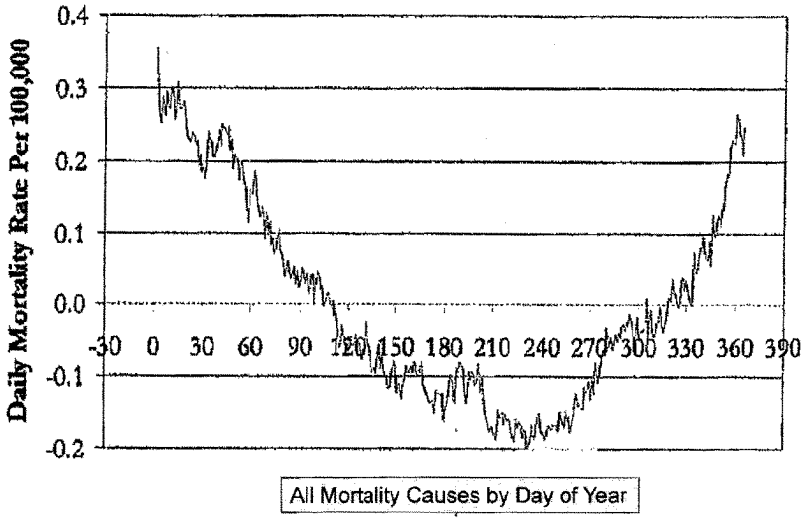


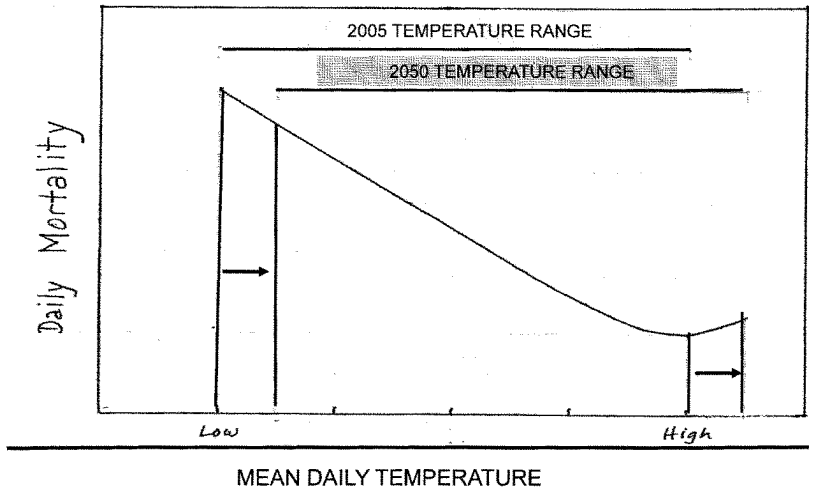
Figure 1: Deaths per day per 1·0* population in relation to mean daily temperature in one warm and one cold region
Lagged on temperature (see methods); no allowance for influenza.

D From Deschenes & Moretti (2007) NBER (USA)
Average Daily Mortality Rates for All-Causes 1972-1988, per 100,000 population



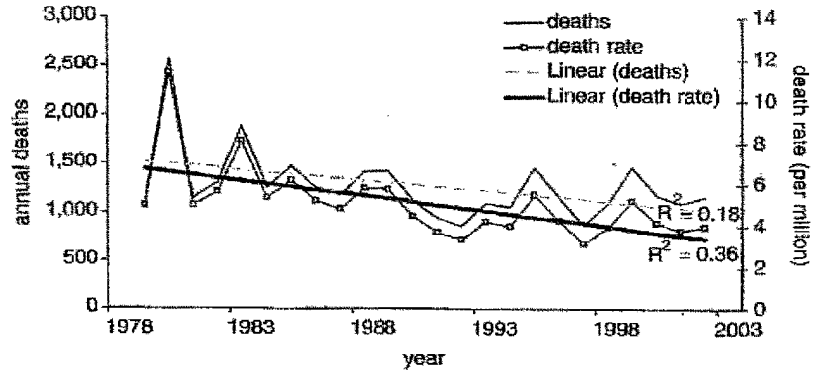
41817-8.eps 41817-9.eps

E. Revised schematic representation of how increased average temp. would affect mortality, by shifting distribution to right. Decreased cold-related deaths in winter would outweigh heat-related deaths In summer, reducing overall mortality.



F FROM GOKLANY (2007
P 169

Figure 6.15
U.S. DEATHS AND DEATH RATES FROM TORNADOS, FLOODS, LIGHTNING, HURRICANES, AND EXTREME TEMPERATURES, 1979–2002



41817-10.eps 41817-11.eps

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PREPARED STATEMENT OF PROFESSOR PAUL REITER, DIRECTOR OF THE INSECTS AND INFECTIOUS DISEASES UNIT OF THE INSTITUT PASTEUR, PARIS; AND ROGER BATE, RESIDENT FELLOW, AMERICAN ENTERPRISE INSTITUTE

Mr. Chairman, Senator Enzi, distinguished members of the committee, we are pleased to be able to share with you this morning what we believe are our well-considered views, grounded in considerable experience with issues of public health, development, and resource access in Africa and elsewhere in the developing world, as well as intensive research into the incidence and mechanisms of vector-borne diseases. For the record, please note that while Dr. Bate is testifying in his capacity as Resident Fellow at AEI, he also serves as Director of Africa Fighting Malaria, a nonprofit organization dedicated to the pursuit of "best practices" in preventing and treating malaria and reducing its incidence among affected populations.

Mr. Chairman, many of today's witnesses will speak of the specific implications of climate change that they perceive as most important for human health. Doubtless malaria will top the menu, but we fear ignorance and disinformation may as well.

Dr. Jonathan Patz, of the University of Wisconsin-Madison the lead witness listed for today, has suggested that U.S. energy policy may be "indirectly exporting diseases to other parts of the world." Dr Patz, and even official bodies such as the World Health Organisation (WHO), claim that global warming is already causing increases in disease (160,000 deaths per year), particularly those, such as malaria transmitted by insects.

In 2007, for example, WHO implicated rising temperatures as the "cause" of an outbreak of a mosquito-borne virus, Chikungunya, in an Italian town. Yet WHO totally missed the point: it was modern transportation systems, not climate change that caused the outbreak.

The vector of the disease in that case, the Asian Tiger mosquito, is native to Asia, but exported worldwide in shipments of used tires. It is now abundant in the United States as far north as Chicago and in at least 12 countries in Europe. It breeds in man-made containers of water in the urban environment (saucers under flour-pots, buckets, water barrels, blocked gutters etc.). The virus was introduced to Italy by an infected Indian who flew from Delhi, where an epidemic was raging.

In short, human activities, not fossil fuel emissions, carried the exotic species of mosquito across the Pacific Ocean, soon followed by an exotic virus transported by a new and effective "disease vector," the jet aircraft. Absurd, then, that WHO stated "although it is not possible to say whether the outbreak was caused by climate change . . . conditions in Italy are now suitable for the Tiger mosquito." Environ-

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mental alarmists took WHO's statement as fact and chimed in with their apocalyptic pronouncements.

The globalization of vectors and pathogens *is* indeed a serious problem, and one that will not go away. It is not new. The yellow fever mosquito, and the yellow fever virus, were imported into North America from Africa during the slave trade. The dengue virus is distributed throughout the tropics, and regularly jumps continents when infected passengers travel by air. West Nile virus undoubtedly arrived in the New World in shipments of wild birds. Historically quarantines have prevented the transmission of disease by passengers, but quarantine regulations do not give us any protection from mosquitoes.

It may come as a surprise that malaria was once common in most of Europe and North America. In parts of England, mortality from "the ague" was comparable to that in sub-Saharan Africa today. Indeed, William Shakespeare, born at the start of the especially cold period that climatologists call the "Little Ice Age," was aware of the disease, as he mentions in eight of his plays. Malaria disappeared from much of western Europe during the second half of the 19th century, mainly because of changes in agriculture, living conditions, and a drop in the price of quinine, a cure for malaria still used today. However, in some regions it persisted until the era of the insecticide DDT. Indeed, temperate Holland was not certified malaria-free by the WHO until 1970.

Clearly, the concept of malaria as a "tropical" infection is nonsense—it is a disease of the poor. And it is obscene that for more than a decade, environmental alarmists in the richest countries have peddled the notion that the increase in malaria in poorer countries is due to "global warming," claiming that this will eventually cause mosquitoes and malaria to "spread" to areas that were "previously malaria free," including the United States. At the same time they oppose the use of the cheapest and best insecticide to combat the disease, DDT.

It *is* true that malaria has been increasing at an alarming rate in many regions of Africa and other parts of the world. Scientists ascribe this increase to a whole multitude of factors including population growth, deforestation, settlement in deforested highlands, rice cultivation in previously un-cultivated upland marshes, clustering of populations around these marshes, construction of dams for irrigation, population displacement due to war and civil strife, the evolution of drug-resistant parasites and insecticide-resistant mosquitoes, and the cessation of mosquito-control operations.

Of course, temperature is one factor in the transmission of mosquito-borne diseases and future incidence may perhaps be affected if the world's climate continues to warm. But throughout the world and throughout history, human behavior, human ecology, vector behavior, and vector ecology, and above all, living standards—poverty—have always been the critical factors that affect transmission.

To the lay person, it may be difficult to understand that scientists permit such abuse of the facts. But because public quarrels are intellectually tiresome, and rarely achieve the desired goal, people often opt for what alarmists offer: simplicity in place of complexity, ideology in place of scientific dialogue, and emotion in place of dry perspective. The alarmists always seem to win.

Those worried about malaria in impoverished countries should focus on improving interventions on the ground, rather than worrying about the weather.

In the following sections, we attempt to summarize for the committee the factors that based on the best research, sound science, and practical experience, *should* be taken into consideration when evaluating climate policy and its interrelations with aspects of public health.

HUMAN ECOLOGY AND HUMAN BEHAVIOR: CLIMATE CHANGE AND HEALTH IN PERSPECTIVE

1. INTRODUCTION

There is a remarkable constancy in many of the articles published on the impacts of climate change on infectious diseases. They name a disease, describe where it occurs and how it is transmitted, and make a succession of statements on the action of temperature, rainfall and other climate variables on specific components of the transmission cycle. These statements—often valid in themselves—are persuasive because they are intuitive, and their logic leads to obvious conclusions: tropical diseases will claim ever more victims in the (poorer) tropical countries and will move into temperate regions. Those of temperate regions will move towards the poles. All will move to higher altitudes, and so on. Many such articles focus on the vulnerability of people in poorer countries, placing the blame squarely on the activities of the industrial nations.

This analytical template, as it were, is not restricted to the popular media and several professional scientific journals which carry similar articles, but in many cases it is clear that these articles have been written by persons with little or no background in the relevant field. A deplorable trend is the inclusion of a political message, much as in the popular media.

2. MAN AND DISEASE

Human ecology and human behavior are the two factors which are key to the transmission of infectious diseases of humans. When the cycle of transmission includes mosquitoes, ticks, rodents or other intermediaries, their ecology and behavior are also critical. Lastly, the virulence[1] of the pathogen, the susceptibility of its hosts[2] and the immunity of the host populations can be critical at all levels to transmission of disease.

Climate and weather[3] are often invoked as the dominant parameters in transmission, but their true significance can only be assessed in the perspective of complex interactions of humans and ecology. Moreover, the key climatic parameters—temperature, rainfall and humidity—cannot be viewed independently. The effects of temperature are modified by humidity. The daily range of each may be more significant than the daily mean. Brief periods of atypical heat or cold can be more significant than long-term averages. Heavy storms can have a different impact than light prolonged rainfall. Events in 1 year may have critical impact on incidence in subsequent years.

The diseases most commonly cited at risk of re-emerging with a warmer climate—malaria, dengue, cholera, West Nile virus, among others—are not affected by climate to the extent commonly believed. Malaria epidemics raged in Russia until the 1950s, when man's ingenuity and resourcefulness finally controlled it. During that final crisis, people died of malaria in Archangel, a port inside the Arctic Circle. Cholera can flourish wherever faecal-contaminated water remains in contact with humans. Epidemics were common in England until the 1850s when the cause was discovered and public hygiene facilities were built on a massive scale. Sub-Saharan Africa remains prey to so-called tropical diseases primarily because they lack the resources which have allowed developed countries to free themselves from such diseases.

Enteric Diseases

Enteric infections kill nearly 2 million people per year. Among infectious diseases, only HIV/AIDS causes more deaths. Transmission is from person to person, either directly or through contaminated food and water. They are an outstanding illustration of the dominant role of human ecology and human behavior in the dynamics of transmission.

In much of the developing world, particularly in the crowded conditions of rapidly urbanizing populations, pervasive faecal contamination of food and water present ideal conditions for transmission of a host of bacterial, protozoal, parasitic and viral diseases. Even in the industrialized regions of the world, distinct patterns of diarrhoeal disease are occurring with increasing frequency, despite piped water, flush toilets, wastewater treatment, microbiologically monitored drinking water, adequate housing and widespread awareness of the importance of faecal-oral hygiene.

Enteric Diseases in Developing Countries—Urban Ecology

In most economically advanced countries, public sanitation, enforced by strict legislation, is so much a part of the urban infrastructure that many inhabitants are hardly aware of its existence. Such measures are non-existent, or at best inadequate, in much of the rest of the world. Rapid urbanization and high birth rates are dominant factors in the ever-increasing toll of viral, bacterial and protozoal diseases. In much of the world, it is not uncommon for children less then 2 years old to suffer severe diahrroeal illness for 4 to 6 months in the first 2 years of life, with more than one-third of all deaths in this age group attributable to such infections.

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[1] Strains of many pathogens show distinct differences in their infectivity towards a particular host. Here, this degree of infectivity is defined as virulence.

[2] In this context, host refers to any organism that is infected by the pathogen. In the case of arthropod-borne pathogens, the arthropod is generally referred to as the vector, and the organism that it infects as its host.

[3] Climate is always varying, so climatologists define it as the mean of a set of climate variables over a specific period, usually not less than 30 years. Weather is short-term variation of climate.

Changing Patterns of Agriculture

Human and animal faeces are used as fertilizer to boost food production in many countries, with obvious dangers. In addition, in many countries, the cultivation of cash crops for export has led to malnutrition, which in turn renders children prey to infection. In some countries rural people from relatively isolated hamlets and villages have moved to larger agricultural communities, with attendant problems of sanitation and disease transmission.

War and Civil Strife

Throughout history, war has been a major, often dominant human behavioral factor in public health. Today, as never before, conflicts in dozens of countries are responsible for mass displacement of populations, with accompanying malnutrition and disease. The ecology of enormous refugee camps provides an optimum environment for enteric disease and many other types of infection. Death rates are frequently measured in days, rather than years. This scenario is not restricted to the developing world. For example, disruption of public health infrastructure resulted in high incidence of diahrroeal disease in Europe during the Balkan wars in the 1980s.

Maternal Behavior

In many developing countries, the incorporation of women into the workforce has led to a major decline in breast-feeding as mothers return to work. Breast milk is bacteriologically sterile, and contains antibodies and non-immunological anti-bacterial systems that are highly effective against enteric infections. Infants deprived of this protective nutrition are particularly prone to intestinal infection.

Early weaning of infants is encouraged by availability of manufactured substitutes, often backed by persuasive advertising. Apart from the absence of anti-bacterial components, the dilution of such formulae with contaminated water is a dangerous route to severe infection.

Enteric Disease in Wealthy Industrialized Countries—Imports of Food From Developing Countries

The advent of cheap transport by air and sea has provided poor countries with a valuable source of foreign currency through exports of agricultural products. In a number of instances, unexpected outbreaks of bacterial and protozoal disease have been traced to these exports, such as an outbreak of cholera in Maryland, USA, which was traced to contaminated frozen coconut milk imported from Thailand.

Mass Production and Consumption of Food

Economies of scale have led to a revolution in food production and food consumption, particularly in industrialized countries. Intensive farming of chickens and eggs in densely packed, indoor colonies numbering hundreds of thousands of birds provide ideal environment for enteric pathogens, particularly Salmonella and Campylobacter. Consumption of uncooked or partly cooked products of such "farms" has resulted in several major epidemics in northern Europe and North America.

Fast food chains are a major component in food consumption in wealthy countries, and, to an increasing extent, in those with emerging economies. These chains rely on a brand identity that requires strict standardization of the end product on a national and even international scale. Here again, economies of scale require centralized, mass-production and mass-preparation of the basic ingredients, followed by dissemination over long distances. Unsanitary preparation and cooking practices can lead to huge, and widely disseminated outbreaks of enteric infection. A classic example was the entero-haemorrhagic strain of E. coli that emerged in Europe and the United States in the 1980s, infecting tens of thousands of people, with a significant proportion of severe, sometimes fatal illness. These epidemics were traced to intensive cattle rearing and insufficient cooking of meat processed as hamburgers. Interestingly, this pathogen is uncommon in poorer countries, where intensive livestock rearing and fast-food chains are relatively rare.

Day-care Centres

Just as in poorer countries, the children of working women in industrialized countries are weaned early in order for their mothers to return to work. Problems of infected food are lessened by sterile prepared foods, availability of clean water, and attention to personal hygiene, but the crowded conditions of nursery schools, par-

ticularly in low-income neighborhoods, have led to a high prevalence of enteric pathogens such as *Giardia* and *Shigella*.

Hospitals

Hospitals are closely packed communities of people under the care of staff who are in close contact with multiple patients, many of whom arrive with low defense against infection. For this and other reasons, diahrroeal disease among hospital patients is an increasingly serious problem in many technically advanced countries. In the UK, for example, hospital deaths as a result of infection by the spore-forming bacillus *Clostridium difficile* account for nearly as many deaths as those from road accidents. Control of *C difficile* is difficult because of rapidly increasing resistance to a wide range of antibiotics, and because normal alcohol scrubs and other sanitary measures are ineffective. Other pathogens, including viruses and protozoans, readily proliferate in the environment of large numbers of patients with suppressed immunity.

Geriatric Wards and Homes for the Elderly

A similar ecological niche exists in colonies of elderly persons. In many cases, low stomach acidity allows living pathogens to pass easily through the stomach. Other factors include chronic disease and poor personal hygiene. Breakdowns in food-hygiene in such institutions can result in outbreaks of enteric disease with high fatality.

International Travel

Traveler's diarrhoea is a familiar term for a condition that affects persons from affluent countries when they visit countries with relatively unhygienic conditions and a higher incidence of enteric disease. Cheap air-travel allows millions of people to experience such infections during holidays abroad, and to import them when they return home. Outbreaks of similar infections on cruise ships are another example of recreational exposure.

Summary

The dominant theme of the examples above, and of those that follow, is that human health is determined by a constellation of events and circumstances. In the developing world, the main defects are in the social matrix—a scarcity of basic needs: shelter; food; clothing; electricity; clean water; a safe living environment; education and access to healthcare. In the richer countries, new and challenging problems have arisen as a direct result of economic success. In both cases, straightforward strategies are available to correct the problems, given suitable economic circumstances. New technologies, such as the development of genetically modified-food crops and novel methods for control of pathogens, will also become available. In nearly all cases, climate is at most a minor, often irrelevant parameter. A continued, obsessive emphasis on climate change is unwarranted, and will misdirect efforts to implement these strategies.

3. MOSQUITO-BORNE DISEASES

Speculations on the potential impact of global warming on human health often focus on the mosquito-borne diseases. Predictions are common that malaria will move into Europe, that dengue is increasing its range in the tropics, that mild winters enabled West Nile virus to become enzootic in the United States, and so on. A search of the electronic catalogue of the National Library of Medicine (PubMED) listed more than 200 articles on climate change and health, the majority citing vector-borne diseases, particularly malaria. Many are simply speculative reviews with liberal quotations from other reviews, frequently written by the same authors.[4] These authors, their deluge of publications, and the enormous media attention that they generate, have had a major impact on public perceptions of climate and malaria.

Background

Many people are unaware that there are more than 3,500 species of mosquitoes, that they are found throughout the world in all climates, and that colossal numbers breed in snow-melt pools that overlie the permafrost in the Artic tundra.

[4] These articles all refer to malaria, and all propose that incidence and prevalence will increase as a direct result of climate change.

There is a widespread misconception that mosquito-borne diseases require tropical temperatures, or at least the warmer temperatures of the temperate regions. But if tropical mosquito-borne pathogens are introduced to temperate regions in the right season, they can be transmitted if suitable vectors are present.

There is also a misconception that mosquitoes die in winter, and that more die in colder winters, but mosquitoes have evolved strategies to survive low temperatures. In the tropics, comparable adaptations are necessary for surviving unfavorable dry periods, which may last for several years. In both cases, such adaptations merely impose a seasonality on transmission. Before eradication, for example, the transmission season for *Plasmodium falciparum* (the most dangerous species of malarial pathogen) in Italy was July to September. The same 3 months constitute the malaria season in Mali, where the disease is still endemic today.[5]

The physical environment is an important modifier of local climate. *Anopheles arabiensis*, an important vector of malaria in Africa,[6] can survive in Sudan when outdoor temperatures are above 55° C by hiding in the thatch of buildings in the daytime, feeding after mid-night, and ovipositing at dawn or dusk. In Lapland, *Anopheles* can survive the winter in houses and stables, feeding occasionally, and even (in the past) transmitting malaria when outdoor temperatures were below -40° C. *Culex pipiens*, a vector of West Nile virus in the northern hemisphere, is common as far north as Nova Scotia and Finland. It over-winters in the adult stage; Dr. Reiter has collected live specimens in Tennessee that were sheltering at -20° C. *Aedes aegypti*, the principal urban vector of dengue and yellow fever, is a tropical species for which temperatures below 0° C are fatal, but its range extends from Texas to South Carolina, surviving the sub-zero winter temperatures in niches protected from the cold. Thus, meteorological variables alone are of limited value as a guide to the development times, behavior and geographic range of vector species, and the same is true for the pathogens they transmit.

Malaria in Temperate Climates

Malaria is the most important of all mosquito-borne diseases. Each year between 350 and 500 million cases of malaria occur worldwide, and over a million people die, most of them young children in sub-Saharan Africa. This appalling toll is mainly restricted to the tropics, but less than 40 years have passed since the final eradication of the disease from Europe. It is instructive to review the history of the disease in Europe in the context of the continuous natural variation of climate.

More than 60 species of *Anopheles* mosquitoes are capable of transmitting human malaria. Those that exist in Europe probably began colonizing the region as the ice caps retreated, at the end of the Pleistocene. Hippocrates (460–377 B.C.) described the symptoms and treatment of "intermittent fevers" in ancient Greece and Rome and their association with wetlands. He even noted that splenomegaly (enlarged spleen, often a symptom of chronic malaria infection) was particularly prevalent in the Pontine Marshes, close to Rome. Today, it is clear from historic descriptions that three species of parasite—*P. falciparum, P. ovale* and *P. vivax*—were common.

During the "Medieval Warm Period," which reached its peak around the year 1200 "agues," "intermittent fevers," "tertians," and "quartans" were described from caliphate Spain to Christian Russia. In the first decades of the 15th century, a rapid cooling trend caused many years of famine, and a large-scale abandonment of farms, but malaria persisted, even in northern regions.

The first half of the 16th century was warm again, but the period from the 1550s to the early 18th century—dubbed the Little Ice Age—was probably the coldest of any time since the end of the last major ice age. Despite this spectacular cooling, malaria persisted throughout Europe. Data from burial records around the Thames estuary reveal mortality in "marsh parishes" comparable to that in areas of transmission in sub-Saharan Africa today. Temperatures were probably at their lowest from 1670 to 1700, yet during that period Robert Talbor (c.1642–1681) became an exceedingly wealthy man by selling an effective prescription for curing malaria to the European aristocracy. His concoction was based on cinchona bark (the origin on quinine), and he had developed it by experimenting on malarious patients in the malarial marshlands of Essex.

In the 18th and 19th centuries, malaria was common in most of England and in many parts of Scotland. It was endemic throughout Denmark, coastal areas of southern Norway, and much of southern Siden and Finland. In Russia it was com-

[5] Diseases that occur commonly in a population at a constant but relatively high rate are said to be endemic. An epidemic appears as new cases in a given human population, during a given period, at a rate that substantially exceeds what is expected, based on recent experience.

[6] In all parts of the world, malaria is transmitted by a group (genus) of mosquito species called *Anopheles*.

mon in the Baltic provinces and eastward at similar latitudes throughout Siberia. The northern limit of transmission was roughly defined by the present 15° C July isotherm (not the 15° C *winter* isotherm cited by the Intergovernmental Panel on Climate Change).

Spontaneous Decline

In the second half of the 19th century, malaria began to decline in much of northern Europe. Denmark suffered devastating epidemics until the 1860s, particularly in the countryside around Copenhagen, but thereafter transmission diminished and had essentially disappeared by the turn of the century.

The decline of malaria in northern European countries cannot be attributed to climate change, for it occurred during a warming phase, when temperatures were already much higher than in the Little Ice Age. Nor can it be attributed to deliberate mosquito control, for it came before recognition of the role played by the vector. A number of other factors, however, can be identified, all attributable to the ecology and behavior of both the vectors and its hosts.

Ecology of the Landscape

Improved drainage, reclamation of swampy land for cultivation and the adoption of new farming methods (there is an old Italian saying: "malaria flees before the plough") all served to eliminate mosquito habitat.

New Farm Crops

New root crops, such as turnips and mangel-wurzels were adopted as winter fodder. These enabled farmers to maintain larger numbers of animals throughout the year, thus diverting mosquitoes from feeding on humans.

New Rearing Practices

Selective breeding of cattle, and new introductions (e.g. the Chinese domestic pig), in combination with the new fodder crops, enabled farmers to keep large populations of stock in farm buildings rather than in open fields and woodland. These buildings provided attractive sites for adult mosquitoes to rest and feed, diverting them from human habitation.

Mechanization

Rural populations declined as manual labor was replaced by machinery. This further reduced the availability of humans vs. animals as hosts for the mosquitoes, and of humans as hosts for the parasite.

Human Living Conditions

New building materials and improvements in construction methods made houses more mosquito proof, especially in winter, another factor that reduced contact with the vector.

Medical Care

Greater access to medical care, and wider use of quinine (in part due to a major reduction in price) reduced the survival rate of the malaria parasite in its human host.

Control Campaigns

In countries where profound changes in crop production and stock rearing were absent, malaria did not decline "spontaneously." In Russia, for example, from the Black Sea to Siberia, major epidemics occurred into the 20th century. In the 1920s, in the wake of massive social and economic disruption, a pandemic swept through the entire Soviet Union. Official figures for 1923–1925 listed 16.5 million cases, of which not less than 600,000 were fatal. Tens of thousands of infections, many caused by *P. falciparum*, occurred as far north as the Arctic seaport of Archangel (61° 30′ N). A huge, multi-faceted anti-malaria campaign was initiated in 1951. It involved widespread use of DDT and other residual insecticides, antimalarial therapy, land reclamation, water management, public health education and other approaches. This mammoth effort finally brought about a dramatic reduction of transmission; by the mid-1950s the national annual incidence was below 1 per 10,000.

The contrast between the devastation caused by malaria in the Soviet Union until the 1950s, and its quiet withdrawal from other European countries in the previous century is a vivid illustration of the importance of non-climatic factors in transmission. Until the collectivization of farmland that began in the winter of 1929–1930, the Soviet Union had been largely unaffected by the agricultural revolution. By 1936, all farming was essentially in government hands, but in protest, many peasants had slaughtered their horses and livestock, and destroyed their equipment. These events ran counter to many of the changes that had reduced transmission in much of Europe.

The advent of DDT revolutionized malaria control. Cheap, safe, effective treatments could be targeted at the site where most infections occur—in the home. Initial efforts in Italy, Cyprus and Greece were so successful that a decision was made to eradicate the disease from all of Europe. The entire continent was finally declared free of endemic malaria in 1975. One of the last countries affected was Holland.

The history of the decline of malaria in North America is similar to that of Europe. In the 1880s, the disease was widespread in nearly all States east of the Rocky Mountains, particularly where rainfall is abundant, from the semitropical Gulf Coast States to the northern border and into Canada. As living conditions improved, and antimalarial drugs became more widely available, the incidence of the disease declined. In 1946 the United States Congress established a new agency, the Communicable Disease Center. This was the forerunner of the U.S. Centers for Disease Control and Prevention (CDC), and its principal mission was to eradicate malaria from the entire country. Its headquarters were in Atlanta, GA, because the southern States were the main region still affected by the disease; malaria was finally eradicated in the late 1950s. Today, as in Europe, there are many parts of the country where anopheline vectors are abundant, but disease transmission cycles have been disrupted and the pathogens are absent.

Malaria in the Tropics

Increases in the global incidence of malaria are frequently attributed to climate change but this ignores several fundamental concepts in the dynamics of transmission, including *stability*. Broadly, a disease is *stable* when it is endemic (occurs commonly at a fairly high rate) and is fairly constant from year to year. A disease is *unstable* when transmission can vary greatly from year to year, and the potential for epidemics is high. These terms are, of course, a simplification; there is a wide range of degrees of stability, depending on complex factors in local circumstances, illustrated in the examples below. These refer to sub-Saharan Africa, because it is the focus of much of the scientific and public debate, but the principles involved apply to many other parts of the world.

Stable Endemic Malaria

In regions where the anophelines are anthropophilic (prefer to feed on humans) and have a high survival rate, transmission is usually stable. Temperature and humidity are generally high, and there is relatively little seasonal variation. The disease is hard to control because transmission is efficient and transmission rates are so high that most people experience many infective bites per year. Severe illness and mortality is mainly among "new arrivals," i.e. children and non-immune immigrants. Older inhabitants have survived multiple infections and maintain a degree of immunity by repeated re-infection. They can have bouts of illness that may be life threatening, but are usually relatively mild, if debilitating.

Unstable Endemic Malaria

This generally occurs in regions where the anophelines are zoophilic (bite animals as well as humans), or their survival rates are low, or where both conditions apply. Transmission can vary greatly from year to year, with epidemics separated by many years of relatively low activity.

Behavioral and Ecological Factors That Affect Transmission

As in temperate regions, the behavior and ecology of vector and host are the dominant factors in transmission, and as with enteric diseases, many can be attributed to explosive population increase and poverty.

Birth Rate

The world's population has grown from 2.5 billion in 1950 to 6.2 billion in 2007. In sub-Saharan Africa, there are now nearly five times as many people (ca. 750 million) as there were in 1955. In some countries, more than half the population is

under 15 years of age. A high birth rate invokes a high incidence of "new arrivals," and thus of new infections. Clinical studies in parts of Africa quote 998 infections per 1,000 infants.

Forest Clearance

Many important malaria vectors breed in open sunlit pools. Forest clearance provides abundant new habitat for these species, a classic cause of the emergence of malaria problems.

Agriculture

Irrigation creates an ideal habitat for mass-production of mosquitoes, as can construction of dams for hydroelectric power. Rice cultivation provides an environment for many of the most efficient malaria vectors. Conversely, the cultivation of low-lying water-logged land can suppress such vectors and thereby reduce transmission.

Movement of People

Infected people in pursuit of work can introduce malaria to areas where it is rare. Non-immune people are at high risk if they move to areas of transmission. Extensive road building and modern transportation have greatly exacerbated this factor.

Urbanization

Water storage and inadequate waste water disposal can provide habitat for mosquitoes, particularly in rapidly expanding urban areas. The absence of cattle can promote stable transmission by forcing zoophilic species to feed on people. Moreover, many tropical cities are surrounded by densely populated satellite settlements that are essentially rural in nature.

Insecticide Resistance

Physiological resistance to insecticides is common in many regions. *Behavioral resistance* can also be a major problem: species that prefer to feed and rest indoors (*endophilic*) can switch to outdoor (exophilic) activity in response to treatment of indoor surfaces.

Drug Resistance

In many parts of the world, the malaria parasite has evolved resistance to commonly used anti-malarial drugs. Substitutes are available, but are much more expensive.

Degradation of the Health Infrastructure

Lack of funding, institutional difficulties, rapid urbanization and other problems associated with rapid development have eroded the public health sector of many countries. In addition, the AIDS pandemic has overwhelmed the ability of authorities to deal with other diseases.

War and Civil Strife

In times of conflict, mass movements of people, e.g. soldiers and refugees, often promote malaria transmission. The breakdown of public health services, damage to water distribution and drainage systems, and the destruction of homes often exacerbate the situation. High concentrations of people in camps for displaced persons can also be disastrous.

Climatic Factors That Affect Transmission

The distribution of climates suitable for endemic malaria transmission in sub-Saharan Africa is shown in Figure 1.[7] It is clear that the vast majority of people in Africa live in regions of stable endemic transmission. In other words, throughout their lives, people living in the red areas of the map are regularly exposed to multiple bites from infective mosquitoes; studies in some regions have shown that people experience up to 300 infective bites per year. Under such circumstances, just as

[7] Published by the MARA/ARMA (Mapping Malaria Risk in Africa / Atlas du Risque de la Malaria en Afrique) project, a major international project supported by International Development Research Centre (IDRC), the South African Medical Research Council (SAMRC) and The Wellcome Trust, UK. *http://www.mara.org.za/*.

it is impossible to pour more water into a glass that is already full, it is illogical to suggest that increased temperatures will result in an increased incidence of infections.

In regions of unstable, epidemic transmission (roughly from parts of the yellow areas to those in pale blue), incidence may be affected by variations in climatic factors, but the relationships are often complex and counterintuitive, and in many cases the factors that precipitate transmission are unclear.

Temperature

High temperatures should increase the likelihood of transmission because they reduce the extrinsic incubation period, but the frequency of biting, egg-laying and other behaviors are also likely to be accelerated. These are high-risk activities, so survival rate—and thus transmission rate—may also be affected.

Humidity

Survival rate may be reduced when hot weather is accompanied by low humidity, but in areas where such conditions are normal, local species are adapted to cope with them. For example, in the severe drought and extreme heat of the dry season in semi-arid parts of the Sudan, female *An. gambiae* survive for up to 11 months of the year by resting in dwelling huts, wells and other sheltered places. Blood feeding continues, so transmission is not interrupted, but eggs do not develop until the rains return. This *gonotrophic dissociation* is remarkably similar to the winter survival of *An. atroparvus* in Holland and other parts of Europe in the past. In both cases, inactivity leads to a high vector survival rate and continued transmission of malaria, even under adverse climatic conditions.

Rainfall

Rainfall can promote transmission by creating ground pools and other breeding sites, but heavy rains can have a flushing effect, cleansing such sites of their mosquitoes. Drought may eliminate standing water, but cause flowing water to stagnate. Thus, in arid areas, prolonged drought may cause malaria to decline, whereas in areas where rainfall is normally abundant, vast numbers of mosquitoes can be produced and "drought malaria" may follow. The same applies to artificial streams in irrigated regions and storm drains and sewers in urban areas. Drought may also stimulate people to store water in cisterns, drums and other man-made containers that serve as breeding sites.

Highland Malaria

A topic that is repeatedly cited in the climate change debate, both in the scientific and the popular press, is that warmer temperatures will drive malaria transmission to higher altitudes in the Highlands of Africa, particularly East Africa. Indeed, environmental alarmists often state that this is already happening.

It is certainly true that, just as in lowland regions, the incidence of malaria has increased in highland areas, and it is perfectly acceptable to cite the lower temperatures found at higher altitudes as a limiting factor in transmission; vectors such as *An. gambiae* are commonly found as high as 3,000 m above sea level, but endemic malaria disappears above 1,800–2,000 m. What is rarely mentioned is that less than 2 percent of the African continent (including North Africa) is above 2,000 m, and that much of this is so arid that it offers little opportunity for cultivation.

The fundamental cause of the spread of malaria to high altitudes in Kenya, East Africa, was widespread deforestation and development, as the areas were opened up for large farming ventures. The construction of roads and railways generated innumerable flooded "borrow pits," depressions left by excavation for materials, and also contributed to the dispersal of the mosquito. The introduction of the ox wagon caused a proliferation of rough cart roads; water in the wheel ruts provided a prolific breeding site for vectors. Milldams on rivers interfered with natural drainage. These and many other factors were components of a drastic ecological change, and it was this change that brought transmission to the Highlands. The disease continued to be a serious public health problem until the 1950s, when the colonial government organized an extensive control program, mainly based on DDT, after which the area was essentially malaria free until the 1970s, when control efforts were reduced and malaria returned.

Summary

Simplistic reasoning on future prevalence of malaria is close to irrelevant. Malaria is not limited by climate in most temperate regions,[8] nor in the tropics. In nearly all cases, "new" malaria at high altitude is well below the maximum altitudinal limits for transmission, and in sub-Saharan Africa the altitudes above the present limits are so small as to be insignificant. Moreover, there is no evidence that climate has played any role in the burgeoning tragedy of this disease at any altitude; as with the enteric diseases, most of the other significant variables are attributable to defects in the social matrix. Future changes in climate may result in minor changes in prevalence and incidence, but obsessive emphasis on climate change as the dominant parameter is unwarranted. There is a desperate need for cheap effective control campaigns, as were implemented during the DDT era. The development of new strategies, such as the release of transgenic mosquitoes carrying lethal genes, should be a priority.

4. MOSQUITO-BORNE ZOONOSES

Nearly six hundred viruses (arboviruses) transmitted by arthropods—principally mosquitoes, sandflies, biting midges and ticks—have been described. Of these, about a hundred are known to produce clinical infection in humans, though infection is often asymptomatic. All are zoonoses; they circulate in nature without involving humans. In most cases, infections in humans are incidental, acquired by an arthropod that has been infected by feeding on a bird or mammal. Thus, unlike malaria, infection of humans involves a third level of complexity.

Yellow Fever, Dengue and Chikungunya

These three viruses originated, and still exist, in forest cycles, transmitted between primates. They are among the few zoonoses that are regularly transmitted between humans. The majority are termed "dead end" because the level of virus in the blood during infection (viraemia) is insufficient to infect an arthropod and thus continue the chain of infection.

Humans are infected when they enter the forest to hunt, gather food (fruit, honey, etc.), harvest timber, make charcoal, and other activities. In recent years, a number of unvaccinated tourists from developed countries have died from these diseases.

For dengue, yellow fever, chikungunya and indeed many other viruses,[9] illness begins with a sudden onset of high fever and "flu-like" symptoms. The disease is usually self-limiting—fever rarely lasts more than a week—but a small percent of cases require hospitalization, up to 5 percent of which can die of haemorrhage and other complications. Unlike parasitic diseases such as malaria, viraemia for all three viruses—and indeed for most viral diseases—is short-lived, a matter of days, but a viraemic person entering a village or town can relay the virus to the community via mosquitoes living in the peridomestic environment. Chief among these is the Yellow Fever mosquito, *Aedes aegypti*, a highly effective vector of all three viruses because it feeds almost exclusively on humans. A safe, cheap and effective vaccine is available against Yellow Fever, but, apart from Brazil, very few countries routinely vaccinate populations at risk.

A second species, the Asian Tiger mosquito, *Aedes albopictus*, has generally been regarded as less effective because it does not discriminate between hosts; blood meals taken from animals and birds that are not susceptible to the viruses do not contribute to the transmission cycle. Nevertheless, in recent years, the species has proved highly effective in urban transmission of chikungunya, possibly because the blood titres of this virus are very high, and because it has a high rate of infection and replication in the mosquito; all would contribute to a high vectorial capacity. Both species live in close contact with humans because they have adopted man-made containers such as water storage vessels, abandoned tires, buckets and blocked gutters as a substitute for tree-holes and other natural containers in their original habitat.

Aedes aegypti, *Ae. albopictus*, and the three viruses share an important feature: all have been disseminated worldwide by human activities. *Aedes aegypti*, yellow

[8] Effective vector species are still present, sometimes common, in many of the regions that were previously malarious, and transmission can occur if the parasite is introduced by the arrival of infected people. Such local cases, however, are easily eliminated by treatment with antimalarial drugs. Unfortunately, these incidents are exploited by environmental alarmists as evidence of the impact of climate change.

[9] Many non-viral diseases also start with these symptoms. The author has had typhus, malaria and dengue. In the first days of illness, he diagnosed his typhus infection as malaria, his malaria as dengue, and his dengue as malaria. Apart from other considerations, it is not a good idea to consult a medical entomologist to diagnose a fever.

fever and dengue were introduced to the New World from Africa, transported in slave ships. Yellow Fever (and possibly dengue) is now enzootic in the forests of Latin America, and occasionally gives rise to urban transmission. In the past 30 years, *Ae. albopictus* has become widely established from Chicago to Buenos Aires in the Americas, in 12 countries in Europe, and at least 3 countries in Africa. Nearly all infestations are attributable to an international trade in used tires. Dengue and chikungunya viruses circulate freely around the world in aircraft, transported by infected passengers.

The global prevalence of dengue has grown dramatically in recent decades, and it is now endemic in more than 100 countries throughout the tropics, with some 2,500,000 people—two fifths of the world's population—at risk. The only effective approach to control is to eliminate the breeding sites of the mosquito.

Symptoms of chikungunya are similar to dengue, but also involve arthritic complications that may last for many months. Pandemics of chikungunya have been known in Africa and Asia for many decades, but only claimed world attention in 2005 when the disease appeared on the island of La Réunion, a *departement* (county) of France in the Indian Ocean. Modern transportation has enabled the vector, *Ae. albopictus* to extend its range worldwide. A small outbreak occurred in the autumn of 2007 in northern Italy, in the delta region of the River Po. The area was once notoriously malarious, but the disease disappeared when the marshes were drained at the beginning of the 20th century. The outbreak, which began in two small villages, was traced to a traveler from India.

West Nile Encephalitis

West Nile virus is transmitted between birds by ornithophilic mosquitoes, many of which rarely bite mammals. It is an Old World virus with a huge range from southern Europe, to South Africa, the Indian subcontinent, Southeast Asia and even Australia. For the most part, the virus goes unnoticed though it is clear that incidence is high in many parts of the world. Humans are incidental to transmission—dead end hosts. Infections are usually asymptomatic or mildly febrile, but a small portion involves inflammation of the brain and can be fatal, particularly in older people.

Human clinical cases are rare and sporadic; in many years, less than five are confirmed on the whole continent. Two exceptions stand out: a major epidemic involving at least a thousand cases in Bucharest, Romania, in 1996, and a similar outbreak in Volgograd (formerly Stalingrad), Russia, in 1999. In both cases, leaking water, heating and sewage pipes in the basements of Soviet-style "functionalist" apartment buildings created perfect breeding site for *Cx. pipiens*, an effective vector that breeds in organically polluted water. Inadequate refuse disposal encouraged high populations of House Sparrows to complete the zoonotic cycle. The problem is widespread in ex-Soviet bloc countries, and will undoubtedly get worse in coming years.

In 1999, the virus was identified in a sudden outbreak of encephalitis in the Queens district of New York. It had probably been imported in infected live birds; protection from local mosquitoes is not required by quarantine regulations. Once established, the speed of transcontinental spread was spectacular and totally unexpected. By 2003 it had reached the Pacific seaboard, and had been detected in every State except Washington and Oregon. It is now enzootic from Canada to Venezuela, including Mexico, Central America and the Caribbean Islands.

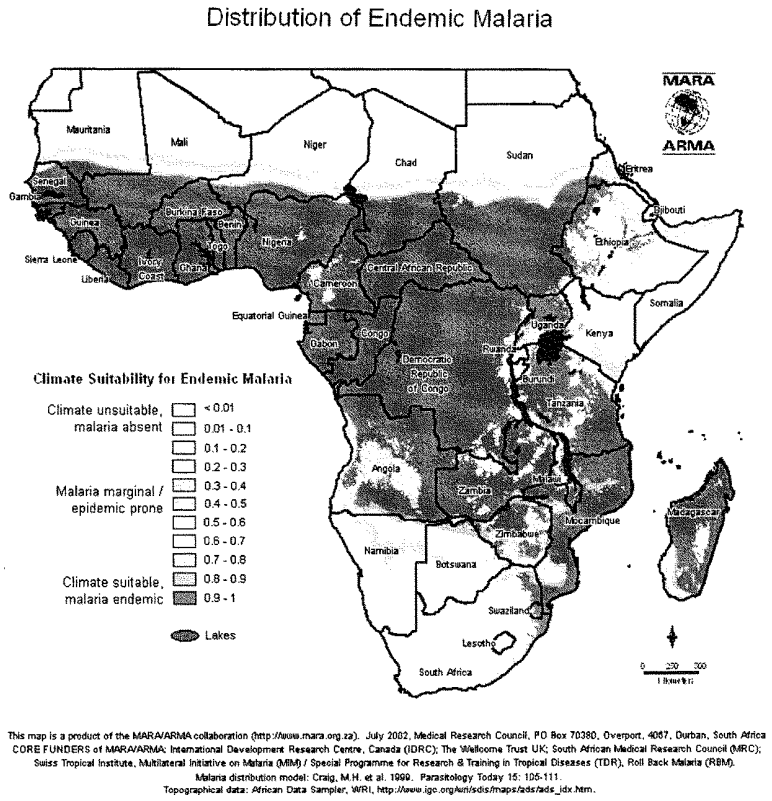
Dispersal is clearly by birds, both migrant and resident. Some 25,000 human cases—about 1 percent of the total number of infections—and just over 1,000 deaths have been reported in the United States. Viraemia in New World birds is very high, and lethal to at least 250 species of birds. For this reason, the introduction of the virus has had a catastrophic impact on wildlife, a phenomenon typical of the introduction of an exotic virus into a new environment.

Environmental alarmists have ascribed the conquest of the Americas by West Nile virus to unusually warm winters and other climatic phenomena, and have predicted future changes in range in many parts of the world. As with so many such claims, there is no scientific basis for this; temperatures can drop below $-300°$ C in the provinces of Canada where transmission is now an annual event.

FINAL COMMENT

The ecology and natural history of disease transmission involves the interplay of a multitude of interacting factors that defy simplistic analysis. The rapid increase in the incidence of many diseases worldwide is a major cause for concern, but the principal determinants are politics, economics, human ecology and human behaviour. A creative and organized application of resources to reverse this increase is urgently required, irrespective of any changes of climate.

Figure 1.—Theoretical suitability of local climatic conditions for malaria transmission in sub-Saharan Africa. Published by the MARA/ARMA (Mapping Malaria Risk in Africa/Atlas du Risque de la Malaria en Afrique) project, *http://www.mara.org.za/*.



[Whereupon, at 11:00 a.m., the hearing was adjourned.]

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