

Interest Group 19: Climate and Health: The Impact of Wildfires, Extreme Heat and Drought

Michele Barry: Good morning, everyone to Interest Group 19: Climate and Health. I'm Michelle Barry, the Dean for Global Health at Stanford and the Director of the Stanford Center for Innovation in Global Health.

I started my life off as a tropical disease doctor and then directed my research toward global health. It soon became clear that the greatest threat to global health, the planet, and my grandchildren was climate change. In response, we started a human and planetary health program at Stanford and a unique planetary and human health program fellowship with the London School of Tropical Medicine. I've jumped into area of climate and health and really have had the privilege of working with the Biden administration transition group.

Today, this steering committee consisting of Maureen Lichtveld, Francesca Dominici, Phil Landrigan, and my co-chair, Jonathan Patz, have designed a hot day as we will hear about the impact of wildfires, extreme heat, and drought on health.

Please put your questions in the chat function, because we have over 100 people signed up and we don't want to miss your hands. We will ask you to unmute as we call you from the chat function. Please also frame a question. We do very much hope that you give suggestions and commentary, but we'll be unmuting for questions only.

The first person to talk and welcome you is Victor Dzau, and he needs no introduction. As many of you know, he's the President of the National Academy of Medicine, but I just want to say one word, that Victor has really been instrumental in bringing climate, and particularly these issues, to the forefront of global conversation. Victor, on to you.

Victor Dzau: Thank you, Michelle, and thank you, John. Thank all of you, particularly the organizing committee. I think that's Maureen, Francesca, Philip, and I bet I'm missing somebody else. I think the point I wanted to make is, thank you.

This interest group started 2 years ago, and you can see already, even at the first meeting, tremendous interest. As we go forward, I think the members are truly activated and believe in this important issue.

I have to thank a number of people, because I was looking back a few years ago. This was not in the major agenda for us, but it was people like Charlie Halpern, and Lynn Goldman, and Dick Johnston, and others who said this is really important. Of course, they are right. As I said, how can we serve the members we serve in the nation, we serve globally, and I can't think of a more important issue than this.

We have indeed, as Michelle said, have put a lot of effort into this. I would say, for me, the majority of my time among many things that I do, this is certainly the one that takes up the most time, because it needs that kind of guidance and development. Because it is a very complex issue; it's new, as we're looking at human health from the area of climate change. I think, as we take this project forward, as I see it, the community has responded really, and to a large extent, the climate community and those who support climate say, "Wow! You know what? You guys have a unique story." To really focus on

human lives and the public health crisis and what it means in equity shines a light to the urgency of the issue, because most people think about it somewhat differently, from multi-future regeneration. I think there's a slide that has a polar bear sit on a piece of ice and people think about climate change that way, but I think, importantly, we are really talking about human lives. That's what we're about.

With that, with a lot of hard work we have now worked for about 2 years through planning, through gathering, through advising, through consultation, and of course, through fundraising and building the program to be where we are today.

I would say that last year at the annual meeting, I launched the grand challenge on human health and climate change. A year later, we have lots to report in terms of progress. Importantly, as we look at our grand challenge, which we believe—well, it is the second grand challenge in the history of IOM—and we believe it's a phenomenal challenge that will engage public, private—from all sectors—to focus on human health and equity. In this regard, I'm very pleased to tell you the four areas that we are working on, which is communication; critically communicating as a public health crisis; mobilizing our community as messengers, nurses, doctors, researchers, and all aspects of committee of the biomedical health community, to message to patients, to each other, to practice what we should be practicing; and, importantly, to communicate to the public. We have a program we're working on that will be quite extensive in doing that.

Second issue, as you know, is a roadmap, which is looking at transforming systems, all the systems that in fact intersect between climate and human health. That would include agriculture and food, and transportation, energy—the idea would be to bring everybody together and see, what can we do to change the system? That will be the product of a major consensus study, which will have policy implications.

Third is actionable items to transform our own sector, and I'll come back to that. Fourth is research and innovation; and we're moving along. As you will hear in my remarks, that we work with Burroughs Wellcome Fund. They are starting a new grant program that looks intersectional climate change and health. We're going to host several workshops and bring scientists together from different fields to look at, what is it? What do we need? How do we actually begin to have research programs, RFP and others? So that's very exciting.

Now, on the third one, our actionable. As Michelle said, you might have seen our paper in the *New England Journal of Medicine*. It is written by the four co-chairs of what we call the Collaborative on Decarbonizing the US Health Sector. I think if you look at the co-chairs, you can see we certainly have brought together unique people who's going to have to make a difference. We have the government—Rachel Levine, the Assistant Secretary of Health who's overseeing and suggests climate at the Center for Climate and Health Equity. We have Sir Andrew Witty, who used to be the GSK CEO and now is at United and Optimum, looking at both insurance and also the care delivery side. We have George Barrett, who is the former CEO of Cardinal, who, in fact, is a big supply chain. Then, of course, we have the engagement of all the major players of hospitals, CEOs of bio and pharma, and also policy people, including Don Berwick, and Liz Fowler from CMMI, and others. We're coming together to say, how do we actually reach the goal of decarbonizing the US health sector, supporting present Biden's goal of 50% reduction in emission by 2030 and then neutral by 2050?

As you can imagine, this is going to be, you know, I would say a lot of hard work. Because we have to start thinking about how to measure each other; how to measure scope one, two, and three; how to report it; and how to actually have people agree that these are the measurements, and then begin to set standards for ourselves to reach those goals.

I won't take any more your time because you may have questions for me. Suffice to say... [[WEBCAST CUTS OUT]] ...area, and we're going to do a lot more. In fact, if you do join the campaign that we're going to launch later on, I tell you this is a big campaign that we are launching.

We have already got great staff; we're going to add more staff. We obviously need more resources to enable us to move in this direction. We're also working across the Academies—engineering, other sciences—to make sure that this is across Academies' initiative as well.

Let me stop here, Michele and Jonathan, except to say: really, thank you. A heartfelt thank you; I can't thank you enough. This is so important to us.

By the way, the President's Forum that I have set at the end of the day with Gina McCarthy kicking off is going to be all about the whole grand challenge. Please join us and help us, guide us, to say what we're missing, what we need to do.

And also, you'd be very pleased if you looked at the election results, a good number of people who work in climate are now part of this Academy, and they will help us drive, in fact, many changes. Thank you.

Jonathan A. Patz: You're muted, Michele, so I'll first say a quick thank you, Victor, for your incredible leadership; that's why we're accelerating.

Go ahead, Michele.

Michele Barry: Thank you, Victor.

I now have the pleasure of introducing our first speaker, who is Paul Schramm. Paul is the Climate Science team lead with the Climate and Health Program at the Centers for Disease Control in Atlanta. Paul coordinates the Climate and Health Program's science, activities, and partnership, and serves as the co-chair of the federal Climate Change and Human Health Group. His work at the CDC focuses on the human health effects of climate change, including the impacts of heat waves, extreme weather events, and vector-borne diseases. He will be talking about heat, climate change, and health.

And then leading the commentary after Paul's presentation, because we thought it would be nice, a yin-yang, Jonathan is the director—we're going to have Jonathan Patz—who's the director of the Global Health Institute at the University of Wisconsin at Madison. He served as the lead author for the United Nations' Intergovernmental Panel on Climate Change and co-chaired the Health Expert Panel of the US National Assessment of Climate Change. As mentioned, he'll be leading the commentary on Dr Schramm's presentation.

Paul, can you share your screen now?

Paul Schramm, CDC (he/him): Great. Thank you, Michelle. Is that coming through? Alright, excellent.

Thank you for that introduction, and it's great to be here and great to see this topic. Of course, I think it's incredibly important, so it's great to see a growing and increasing interest in the health effects of climate change.

At CDC we have a Climate and Health Program that's been funded since 2009. We work on a wide variety of climate hazards, but today in my brief presentation, I'm going to focus on heat.

I'll start with just a very basic extreme heat summary. I'll talk about some populations that are disproportionately affected, and then I'll go into some of the work that CDC has on heat, as well as some of the health departments and other partners that we work with. I'll end with a few different resources that may be of use to you and your colleagues.

Extreme heat has definitely been in the news a lot this year. We had the record-breaking heatwave in the Pacific Northwest and in Canada back in June and July. There were a number of heat waves in New England. The Olympics in Tokyo actually set a record as the hottest Olympics of all time. This is because heat waves are becoming worse; they're becoming more frequent; they're becoming hotter; and they're becoming more intense. It's something that is starting to enter or be reflected in the media a lot more.

This has health impacts. As climate change increases heat, we are seeing increased humidity; longer, more frequent heat waves; the direct health impact of that is dehydration, heat stroke, and unfortunately, death and mortality. This can affect anyone, but there are certain populations that are more impacted from extreme heat. There's a list at the bottom of this slide of some of those. I'll just mention a few: Outdoor workers, especially agricultural workers and especially earlier in the year. For example, if there's a heat wave in April, student athletes—also certain medications. People taking beta blockers, for example, are more impacted by exposure to extreme heat. As reflected by socioeconomic status, people without access to air conditioning. While heat can affect anybody, it certainly is certain communities and populations that are more disproportionately impacted by heat.

It is a major health impact. There are more people that die from heat in the United States, for example, than from any other natural disaster, like flooding or hurricanes.

I mentioned that people are disproportionately impacted. One way to look at that is by overlaying social vulnerability with exposure. This is just an example from a study that one of my colleagues did looking specifically at cardiovascular mortality and using a vulnerability index, overlaying it with exposure at the county level. This shows, even on a geographical basis, there are parts of our country—of course you could do this globally as well, but this study only looked at 48 states, looking at which areas are at greatest risk. Studies like this are really important because, as you all know, we have very limited resources in health care and in public health, and this helps to be able to target those resources to work with communities that are most impacted by heat and where the health outcomes are the greatest.

Now I'm going to talk a little bit about what we do at CDC as well as what some of our partners do. One thing that we do is surveillance. We have to have a baseline, we have to know what's happening with heat. Through our National Syndromic Surveillance Program as well as a number of other surveillance programs, we do track of variety of health outcomes related to heat.

On the left here, you can see an *MMWR* that we published earlier this year on the Pacific Northwest heatwave. This was looking at emergency department visits and near real-time data. We were able to track the hospitalizations that were occurring in the Pacific Northwest during this heat wave. That's what you can see, with the black line on that graph where, even though the population in that region is much lower than in many other parts of the US, there was a huge spike in hospitalizations. And then on the right is a paper published last year, where we looked at a baseline of long-term heat-related deaths throughout the United States.

It's really important to have systems in place that track what is happening with heat-related morbidity and mortality. These are important efforts that we have across CDC in collaboration with a variety of hospital systems and health departments.

We also, in addition to surveillance, have grants to help communities around the country prepare and respond to the health impacts of climate change. This includes heat. Most of the jurisdictions that we fund through our Climate-Ready States and Cities Initiative as well as our Climate-Ready Tribes and Territories Initiative, work on heat. They don't have to work on heat. We actually have a framework to help them decide what is of greatest impact in their community; so some are working on flooding or wildfires, but almost all of them do work on heat because it is a problem everywhere.

And just a few examples that I'll mention here. Boston noticed that their messaging on heat wasn't getting out to certain communities that were at higher risk, so they did translation of all of their materials into 10 different languages. An example from New York City, they launched a program called Be a Buddy, where they actually trained people to check in on their elderly neighbors during heatwaves. Another example was the state of Arizona, which we directly fund several counties within that state, established heat relief networks including cooling centers, and then the State Health Department tracked and mapped those cooling centers and helps to share that information.

There's a lot more examples than this—and these are just ones that CDC funded—of course, there are a variety of cities, tribes, counties across our country and then internationally that are working on heat to help prevent those health impacts. We do have more examples of that on our website if you'd like more information.

In addition to the surveillance and the direct funding of programs, we also track a wide variety of data and make it publicly available. This example that I'm showing is from CDC's National Environmental Public Health tracking portal, which hopefully, most of you have heard of. There are a variety of environmental health metrics on this, but there's a whole section on climate change. That includes quite a bit of information on heat. We have historical heat information at the county level; there is projected heat information from The National Climate Assessment; and then a wide variety of vulnerability metrics. You can map those side by side; you can graph them; you can download them. And just one example I have pulled up on the screen right now, the map on the left is a vulnerability metric that is looking at a number of extreme heat days, so that that's really the exposure side of things, and then on the right is percent of population over age 65 that lives alone. You can kind of pair sensitivity and exposure, and again, this helps to show where the greatest risk might be.

There are a lot more metrics than just these two I'm showing here. There's a whole suite of heat indicators and heat exposures that are publicly available at the county level and in some cases, even the Census-tract or the Census-block level.

We also have the Heat and Health Tracker, which is a more specific focus on heat including on the communication side of things. If you just Google CDC Heat and Health Tracker, this will come up. It has syndromic surveillance data. It also has projected temperatures for the next month; we actually worked with the National Weather Service to develop that forecast specifically for this purpose, and it allows health departments to look at what heatwave metrics will be for the forthcoming month. Again, to help them really look at if they need to be planning for it and where they should target their resources. Again, this is all the way down to a county level. I've pulled up a few graphics here from Douglas County, Nebraska as an example—that's Omaha. It shows risk factors and compares them to the national average and allows you to look at current and forecasted heat data. And then that's paired with all of the resources that we have, as well as a variety of other heat resources to help with response. We continue to grow and expand the heat and health tracker.

The last thing I wanted to mention is we do also have a variety of resources for communities, some of it aimed at the general public, some aimed at health departments and their partners. There are just a few shown here. We've done some of those with FEMA, with EPA, with NOAA. All of those—the three listed here as well as quite a few others—are available on our Resources web page. So please give that a look if you'd like to see any of these.

That's just a quick overview of the health impacts of heat, how climate changes is affecting it, and then some of the data and resources that we have to help communities respond.

With that, I'll turn it over to Jonathan.

Jonathan A. Patz: Paul, thank you so much for your presentation. You mentioned Tokyo's record heat for the Olympics. It reminds me that the late Kirk Smith published a paper and found that by the year 2085, only 8 of 543 cities outside of Western Europe would have temperatures and the ability to have an Olympics because of the exhaustion that happens with internal heat generated from the marathon and competing in Olympics.

One of your first slides, you talked about how extreme heat is in the news, and I'm reminded that, at the same time, not only did we have extreme heat, but we had droughts and fires, which we're going to hear in the next session, and we also saw record flooding in Europe and in China.

I'd like to just share a slide to remind us that we really, you know, I want to just hammer my key point, which would be that we need to—[unrelated audio]—that as we see these headlines of these extreme events, we're now able to focus a little bit more on the root cause of them. As we know, climate change increases the probability of these extremes. It used to be that you'd say, well, you can't tell if that extreme event was climate change or not; but now with this new World Weather Attribution Initiative across many institutes, they're able to statistically look at an extreme event. Their conclusion of that heat dome that you talked about in the Northwest was that it was virtually impossible to have that extreme event without human-induced climate change. Statistically, today's 1°C average warming above preindustrial levels increase the likelihood of that event by 150-fold.

We're able to begin to look at the root causes, and I think that we should and must really have side by side with the heat event like that the headline of what's causing it, what's behind it.

I want to just focus lastly, and then I'll stop. Then we want questions. Put your questions in the chat, please.

You showed the heat-related social vulnerability map. I just want to drill down on that just by showing one example of why it's so important to look at this and recognize that equity is one of the key aspects. The risks of climate, of the climate crisis. Drilling down here in Phoenix, this is the heat, looking at the urban heat island and across Phoenix, and that's the poverty map—heat, poverty; and you just see them. I just wanted to drill down on that as an example that you had brought up as so important as far as social, the social aspect of this

Those are my key points reflecting on your wonderful presentation. To really, let's bring in the cause. We don't want to be mopping up the mess on the floor without thinking about turning off the faucet. A stitch in time saves nine—all that stuff. We really need to be including the upstream causal issue of climate change as we see these record-breaking events unravel and be in the news.

With that, we are open for questions. Please put your questions in the chat.

Michele Barry: Andrea, do you want to? Andrea Baccarelli, do you want to start?

Andrea Baccarelli, Columbia University (he/him): Thank you, very interesting.

I wrote the question before seeing this. [[WEBCAST CUTS OUT]]

It strikes to me that the cities that have grown the most in the United States in the past 10 years are the areas that are particularly hot. So I want to ask how much growth impacts the mortality. Phoenix, I think has had significant growth in the past 5 years.

And also what type of measures we can think of in terms of adapting to heat as we see this growth as special new developments are built, or whether there is any way to become wiser and convince people that it is not the time to move into...

Michele Barry: Did everybody...?

Paul Schramm, CDC (he/him): Yeah, and I can see it. You cut out a little bit, Andrea, but I can see what you wrote as well in the chat. It sounds like the question is we have growing populations in area that have high levels of heat, such as Phoenix, Arizona, and how is that impacting risk and mortality?

It's quite a complicated question because it is true, a lot of the growth, especially if you look just in the US, are in areas that experience very extreme heat. One thing I will say is that our adaptive capacity has really grown over the past few decades. If you look at the Chicago heatwave in the 1990s, or in the European heat wave in 2003, communities weren't really prepared for it. And now, I won't say we're prepared, but more and more, especially with funding over the last decade, communities are starting to

become more prepared. There are cooling centers, there are programs to help people pay their electricity bills so that they can run air conditioning.

It certainly is a higher risk as more people move into warm areas, but we also have higher capacity there than we have in the past.

But then there's a big threat there with compounding hazards. What happens, for example, if there's a major heat wave in Phoenix and the power goes out and you don't have air conditioning? That would be a huge public health disaster.

Another thing I'll say, part of your question, as you pointed out, was about increasing in heat mortality. We're actually per capita, at least in the United States, not seeing an increase, and I think that is in large part due to the capacity that's been built. It is in the news more, people pay more attention to it, health departments are preparing for it, there are more cooling centers than there ever were. It's really hard to measure that exact effect because you don't really have a good counter example. Either the city—they don't not put cooling centers in one community in order to see what happens.

Luckily, I think some of the health impact that we could be having from heat is being avoided by all the great work that health departments have been doing.

Jonathan A. Patz: Thank you, Andrea and Paul.

Next up is Sten Vermund. Do you want to ask your question? And then, Elvis, you're on deck.

Sten Vermund (he/him/his): My question is a simple one.

We have a very long border with Mexico, and I was curious if CDC was able to coordinate with Mexican counterparts, particularly in the northern Mexican States that border the United States, and if there could be some sharing of technology, sharing of epidemiologic strategy so that we could have a wider swath of information to benefit people in both countries?

Paul Schramm, CDC (he/him): Thanks, great question.

I can only speak for the Climate Health Program at CDC. We haven't done much of that. We have coordinated with Mexico in the past as part of a North American Climate Health Group. I don't think we've worked specifically with them on heat. We have worked with Health Canada specifically on heat, but I think that's a good point. That's something, especially some of the border states who might be experiencing heatwave at the same time, as some of the northern Mexican States, there certainly is a chance to share best practices and EpiData for that.

Michele Barry: Elvis Paul, want to unmute?

Elvis Paul, Nfor Tangem: Yes, thank you very much, Paul, my namesake.

You talked about heatwaves, and we learned this year, or we did last year, that the heatwaves actually moved and affected the US, right down to Florida or one of the states. I wonder what, how your program is looking at that issue.

I think it'll be interesting to see whether you have any collaborative to what's going on between, maybe CDC-US and CDC-Africa. In fact, I'm sitting in the CDC-Africa, the CDC bureau here at the Africa.

Thank you.

Paul Schramm, CDC (he/him): Thanks for that question, and that's an area I would love to expand and grow in. Right now, our program is funded yearly by Congress, and it is a domestic program. Our specific funding is for adaptation within the United States.

That doesn't mean we can't work internationally; we're just not specifically funded for it. I think there's definitely a role, not just for CDC but across the US Government to work on some of these international collaborations because this is a problem everywhere. As you said, weather patterns and climatology in one place affect other places. So that's another area that I would hope to grow in and expand our international collaboration.

Jonathan A. Patz: Paul, thank you very much, and Elvis, thanks for that.

We are about out of time, except that since you mentioned international, Paul—if I can ask the very last question and then introduce the next speaker.

You know, the President's budget would increase CDC's funding in climate and health by tenfold. What are the plans for scaling up CDC's effort in this area?

Paul Schramm, CDC (he/him): We are absolutely working on that, and we don't have finalized publicly available plans yet, but what I will say relevant to that is I'm within the National Center for Environmental Health, which is the only place that has received climate and health funding in the past. Now we are working very closely with CDC's Center for Global Health and trying to tie into the work that they're doing. We now have a CDC-wide Climate Health Task Force, with over 140 people participating. We've developed strategies and mission and vision, and I think it'll really help us to expand the work globally. Because other centers within CDC do have a global mission and they might already be doing, they are doing some climate-relevant things internationally, and I think this will help us to make it more intentional and actually bring funding to that.

Jonathan A. Patz: Thank you very much, Paul. Thanks for your questions, everyone. We're going to move to the next panel, and I'm going to introduce the two, the speaker and our commentator.

Dr Kari Nadeau is the Naddisy Foundation Endowed Professor of Medicine and Pediatrics and the Director of the Sean N. Parker Center for Allergy and Asthma Research at Stanford University. Dr Nadeau is one of the globe's foremost experts in adult and pediatric allergy, immunology, and asthma and how these are impacted by environmental, immune, and genetic factors.

Kari will be talking about wildfires' impact on health. So Kari I turn this—oh wait. But then following Kari, Professor Phil Landrigan will be providing comment. He's the Director of the Program for Global Public Health and the Common Good. He's also the Director of the Global Pollution Observatory at Boston University—I'm sorry—at Boston College, BC. He is world-renowned for his work on pediatric, environmental, health and recently led a *Lancet* commission report on pollution and health as well as a Monaco Commission on human health and ocean pollution.

Dr Landrigan will be providing commentary after Dr Nadeau's presentation and opening the Q&A.

Over to you, Kari, on wildfires.

Kari Nadeau, MD, PhD: Thank you so much for inviting me here today. It's a pleasure to be among the NAM. I'll be talking about wildfires and their impact on human health.

I want to show you this video, which is particulate matter 2.5 μ or less that exists when wildfires expose us to the consequences of their toxins. This is one of many pollutants in wildfires. Today I'll be talking about why wildfires are increasing, what is actually in wildfire smoke, what levels of wildfire smoke do we get exposed to, and then what are the health consequences of short-term and long-term exposures to wildfire? And then, finally, how can we mitigate harm? What can we do to help our patients and communities?

So, as you know, in the West and all around the world, there's no longer just one fire season. Due to climate change and increased temperatures we're seeing a rise in wildfires around the world. For example, this is the wildfire extent of the United States plotted out over years on the y-axis as the areas burned in millions of acres. Unfortunately, this is due to increase and with the intensity of the fires that we're seeing, for example in the West, we have up to a football field being burned per second.

This leads to disastrous consequences. For example, the 2017 Paradise fire in California had a plan in which people were supposed to evacuate to the hospital, but unfortunately the hospital was one of the first buildings to burn in the Paradise fire.

In addition, when we think about other issues that are developing in wildfires and how to best promote education, people need to understand that air quality indices over 100, for example, with vulnerable populations and children, where they breathe more air per pound of body weight, they are particularly at risk for the health consequences of wildfires. In addition, this little girl pictured has the wrong mask on. We need to also explain and educate about what filters work and what filters don't work.

What's actually in wildfires? We've been taking samples among many other groups, and the chemistry is showing that wildfire smoke is 10 times as toxic as air pollution. And they're not wild anymore; this includes burning of residences, commercial buildings, as well as vehicles. We explain wildfire in the same data collection system as air pollution as particulate matter. For example, 100 AQI is equal to 35 $\mu\text{g}/\text{m}^3$ of particulate matter. To put that into perspective, 22 AQI is similar to smoking one cigarette.

Unfortunately, it's not just particulate matter that is being emitted from wildfires but also carbon monoxide, ozone, nitric oxide, polycyclic aromatic hydrocarbons, volatile organic compounds. Often these are not seen, and they're not filtered out appropriately, either, by common filters. What's worse is that there are soot balls in the air, pictured here, and those soot balls basically blanket the atmosphere and create even more trapping of greenhouse gases and warming of the atmosphere. Climate change is affecting wildfires, but wildfires are worsening climate change.

And when vehicles and buildings burn, we see a release of hydrogen cyanide; hydrochloric acid; phosgene; heavy metals like arsenic, lead, and cadmium; microplastics, pictured here in our sample of wildfire smoke recently in California; toluene; styrene; dioxins; and detergents.

You can see here in a video that was mapped from July of this year from our fires in California the extent to which the smoke travels so quickly to parts, thousands of miles away. There's really no safe distance from wildfire smoke, and unfortunately when the smoke now circumnavigates the Earth, the only thing that can actually drop it to the ground is rain, and then it gets into the water supply.

When we think about the way to relatively explain to our patients and communities how much they're being exposed to from wildfires, we need to really think about revising the scale. Because many of our fires are now even going over 300 AQI. In addition, this table only protects us from particulate matter, as it were. We also need to explain it in terms of the gases that are unseen and not filtered. And then, finally, and very importantly, the social determinants of health, vulnerable populations, comorbid conditions need to be incorporated into how we mitigate and how we manage wildfire exposure.

Unfortunately, wildfire smoke affects all parts of the human body. What you can't see or smell can actually harm you. Many publications have now been published on how wildfire smoke affects the human physiology, not just the lungs; that it is very powerful in their inflammation induction in the lung epithelium, and also once those small particles and gases get into the bloodstream that activates cardiovascular effects with heart attacks and stroke, premature births, asthma rates, as well as diabetes chronically, other autoimmune disorders, and then finally, importantly, is lower cognition in the brain. When people suffer from wildfires, it induces a lot of stress; there's a lot of posttraumatic stress disorder now in people that have been exposed in their communities to wildfires. And there's displacement and loss that we need to make sure that we address.

What do we call short-term exposures, and what are some of the health consequences? Short-term is defined as 1 day to 1 month after wildfire exposure. All-cause mortality and many organ-specific outcomes are positively associated with wildfire exposures. For example, here in California we're doing studies in South Lake Tahoe where the Caldor fire recently burned for within 60 days with over 15 days of 350+ AQI. This is where the community was about 30 miles distance from the fires, so even within the first 2 days we saw dramatic increase in asthma, heart attacks, and strokes. That's just not in California. In Indonesia, for example, in Singapore, where there's burning of peatmoss in forests in Indonesia and Singapore's, over 700 miles away they're seeing increases in ER visits, even in the first 2 to 4 days after the wildfires start in Indonesia.

Overall, there's much evidence showing that in 4 years and younger, asthma is increased by about 20% in areas that are exposed to wildfire smoke. In ages 65 years and older, heart attacks increased by up to 40% and strokes increased by up to 15%.

Importantly, it's not just about age. Vulnerable populations also include those of low socioeconomic status; environmental justice is a major issue in post-wildfire recovering communities due to decreased access to health care and to safety.

What about long-term exposure? There's less research in this. There are areas of the country that we study, for example in the Central Valley, that, for example, have increase their days per year of smoky days by up to 225%. In the Central Valley, they have over 60 days per year exposed to AQIs of over 100; this is about 150 miles distance from the fire. What about Brazil and Sao Paulo? They are about 2,000 miles away from the fires and the rainforest, and they spend over 240 days per year at 200+ plus AQI.

Firefighters' lifespan is reduced by 10 years, and they serve as the best example of a population that has been exposed to chronic wildfire. This is even controlled for other variables. You can see here from this publication by Navarro et al that the relative risk of lung cancer has increased by about over 1.4. We luckily just received a grant from the NHLBI, one of the first of its kind, to be able to study the long-term effects of wildfire exposure across the lifespan.

What can we do to advise our patients and help mitigate harm to communities? This is a great article that was published by the *New England Journal*. Personal actions can make a difference, for example, relocation; however, that might not be feasible, especially for vulnerable populations. We can close doors and set air conditioners to recirculation mode; however, that also might not be possible depending on the age of the house and the ability to buy those filters. We can stay indoors and avoid heavy and prolong physical activity, but that's also impractical for outdoor workers. Then, finally, wearing a face mask can help us mitigate the risk of PM2.5 exposure, but not necessarily to gases. They're not necessarily suitable for children; KN95 masks have just started to be produced for children.

Beyond personal mitigation, we need to think about policy changes and really be advocates, and study these policy changes. My colleagues at the Woods Institute have an example that was published in *PNAS* this year of modeling the burden of wildfire and how policy changes can mitigate their effects on health care.

This is an example of three different models of exposures and mortality to PM2.5 from wildfires, over 100,000 individuals per year just looking at the age of 65 and over and the additional premature births—excuse me—premature deaths that would occur if we didn't do anything about climate change.

Importantly is to look at, if we could reduce emissions from smoking, we can go upstream as Dr Katz mentioned and reduce climate change by changing emission and reductions of fossil fuels. You can see how much that will improve and decrease the rate of premature deaths in at least those populations of 65 years of age.

In summary, what I've spoken about today is that wildfire chemical makeup and toxic levels depends on materials, and temperature, oxygenation, ventilation. PM2.5 from wildfires is associated with inflammation-induced respiratory and cardiovascular effects, but more needs to be studied with the other pollutants in wildfire smoke. Climate change increases wildfire events and wildfires enhance the effects of global climate change; this is a vicious circle. More interdisciplinary, global research is needed to study the acute and chronic effects of wildfires on personal and public health, and especially in health economies. Vulnerable populations are at risk; environmental justice issues need to be addressed. With increases in wildfires likely in the future, there are ways to mitigate and adapt at the individual level;

public health level; local, country, and global levels via education, training, emergency preparedness plans, policy changes in global warming and fossil fuel emissions; and we can be advocates and be prepared to engage.

There is a need to prevent and manage wildfires and thereby decrease health risks via land-use management, prescribed burns, and agricultural/economic frameworks.

I want to thank you for inviting me here today, and for the NAM and all the people involved in this research that I presented. Thank you.

Michele Barry: Phil, take it away.

Philip Landrigan: Here we go.

Michele Barry: Thank you for a great presentation, Kari. As Phil is sharing his screen, please put chat questions in the chat.

Philip Landrigan: Thank you, Michelle. Thank you, Kari, for a lovely talk. Let me offer some reflection on your talk and specifically talk about how climate change and pollution are changing patterns of noncommunicable diseases, and what this means for clinical practice in the United States and in countries around the world.

One of the great triumphs of both public health and medicine in the last half century is this enormous decline in age-standardized mortality from heart disease—more than 75%—combination of public health interventions and medical interventions. Typically, when we think about the driving factors behind that decline, we think of the risk factors that were identified through the Framingham Heart Study, the Alameda County Heart Study, the other big longitudinal studies that I've listed here—especially tobacco use, hypertension, and diet and nutrition.

But as Kari has so beautifully illustrated, there's another big, highly preventable risk factor for cardiovascular disease, chronic obstructive lung disease, lung cancer, diabetes, and other noncommunicable diseases that is often overlooked, and this is pollution. Kari's talked about pollution from wildfires; there's pollution from industry; there's pollution from motor vehicles; there's pollution from toxic chemicals whose manufacturer is increasing exponentially around the world.

It's interesting to think about the fact that in those same 50 years that mortality from cardiovascular disease was declining and we were doing a better job of managing hypertension, reducing cigarette smoking, prescribing Lipitor for elevated cholesterol, we also saw a 70% reduction in air pollution that followed passage of the Clean Air Act with certain 95% reduction in airborne lead pollution. We now know that lead can increase both risk of heart disease and kidney disease down to extremely low levels. One unresolved question is, what precisely has been the contribution of pollution control to declines in noncommunicable disease mortality? That'd be an interesting question to answer historically, because it

points the way for the future. What's the contribution of pollution to chronic disease mortality today? What's going to happen in the future if we don't get on top of the twin, tightly conjoined problems of climate change and pollution?

From 2015 to 2018, as Jonathan mentioned, I had the privilege to co-chair *The Lancet* Commission on Pollution and Health. We found that pollution is responsible for 9 million deaths around the world each year. We found that pollution is the inevitable concomitant of climate change and that fossil fuel combustion is the major root cause of both of them.

Seventy percent of the 9 million deaths that are caused by pollution are due to noncommunicable diseases—a quarter of all stroke tests, a quarter of all cardiovascular deaths, and 35% of stroke deaths. In the United States, the best recent estimate published a few months ago in *JAMA* estimates that pollution is responsible for about 200,000 deaths per year, two-thirds of them from cardiovascular disease. It's obviously many fewer deaths than it would have been in the absence of pollution control, but it's still a big number. It's interesting to note that our *Lancet* Commission on the Trump Commission that Steffie Woolhandler and David Himmelstein led published in *The Lancet* a few months ago actually found that when pollution controls in this country were relaxed during the past 4-year administration, cardiovascular deaths due to pollution actually increased. The reduction in pollution is not inevitable; it's something we have to work at.

What's the take-home lesson here? Firstly, physicians, nurses, all of us who care for patients have to add pollution to our usual list of CVD risk factors in addition to tobacco, exercise, lipids, hypertension. We need to add pollution, take a brief history of pollution exposure, assess susceptibility. Kari's chart, the multicolored red, green, yellow, blue chart showed how important susceptibility is. Anticipatory guidance tailored to individual patients. And we need to advocate. Physicians have been powerfully successful advocates in the past in dealing with existential issues that confront our society. My favorite example is the IPANW, the International Physicians Against Nuclear War, led by Bernard Lown who 50 years ago basically persuaded the leaders of the United States and the Soviet Union to back away from the brink of nuclear disaster. I think we in the health professions have a responsibility to do the same today in the face of climate change, in the face of pollution.

We have to work on our own houses—in our hospitals, in our health care facilities—to reduce pollution and reduce greenhouse gas emissions, and we have to advocate across society for massive and rapid transition to nonburning renewable energy, which by the way does not mean nuclear energy.

We recently developed a chart; it's going to be published in a few weeks in the *New England Journal* laying down the roadmap for both individual-level actions as well as societal-level actions for preventing chronic disease caused by pollution. Here's a peek into the future

With that, I'll close it out. Jonathan, back to you for questions.

Michele Barry: Since we're running late, Jonathan, should we move on? I don't see any specific questions. There are a lot of, there's a lot of comments about greening.

Jonathan A. Patz: Well, if I could add.

One question to both speakers about the striking increase—of wildfire smoke, if you were to say one thing—I know, Kari, you had lots of reasons for wildfire smoke being so toxic—but what would be the lesson, or what would you'd like the journalists to know about why wildfire smoke, if you were to say one thing, why it's so much worse than we realized? What would you say?

Kari Nadeau, MD PhD: I think it's worse because the heat is so intense and more than just forests are being burned.

Jonathan A. Patz: That's a good answer; great.

Michele Barry: I'm going to move us on because we're running over; this is a very packed session. But again, please, people, put in their questions in the chat.

I'm going to introduce Elvis Paul Tangem, and he's coming to us from Ethiopia, Addis Ababa. And just to remind people, Africa, along with other great other areas of the global South, they're some of the world's gravest climate consequences often creating, really, creating displacement of people who have become known as climate refugees.

Many of the continent's communities are more vulnerable to the less developed water and sanitation infrastructure, weaker health systems, and various other structural legacies of colonialism. What's especially critical is involving local thinkers and leaders in conducting research, sharing knowledge, and codesigning solutions. Thus, we're very grateful to have Dr Elvis Paul Tangem here with us, talking about drought, its impact on health in Africa, and the Great Green Wall Initiative. This is an initiative that is the—he's the coordinator for the African Union Commission—and it's focused on building resilience in the dry lands of Africa, for sustainable land management, restoration, and economic development.

Elvis Paul, please take it over.

Elvis Paul Nfor Tangem: Thank you very much. I'll share my screen.

Yes, so thank you very much, and I'm privileged and feel very proud, for lack of a better word, to be among the best of the best. Yes, I'm calling from the African Union Commission in Addis Ababa, where we see.

My discussion this evening is about, it's about looking at the impacts of health on the adjacent population and also looking at the issues of the Great Green Wall impacts on drought and how the Green Wall was created by the Africa Union to mitigate some of these impacts.

When we talk about drought in Africa—generally drought has been a very serious curse on the world, drought is a very serious issue all over the world—the devastating impact of this in decades has cost more than 11 million deaths and directly affect millions of people—they say 2 billion people are affected—and the impact of drought seriously hurts all economies in the world. They say it's costing about \$10 billion annually.

Africa is particularly vulnerable to drought. Statistics show that in the last year we had about 84 drought incidents in more than 30 countries, notably in the Sahel region, which you can see the Sahel region is the yellowish part, and this extends right down to the to the Horn of Africa.

And, as we know about the Sahel, which is 3.5 million kilometers, the climatic impact on the Western Region, it's stretched all over the whole of Africa, 3.5 million kilometers.

[[WEBCAST CUTS OUT]]

One of the focus areas that I'm looking at is the Sahel, which is the most vulnerable areas that have been largely, badly affected by the impacts of climate change and drought in Africa. Here we have about four types of drought in Africa, which we will talk about: the meteorological drought, the hydrological drought, the agricultural drought, and also the socioeconomic drought.

Recurrent drought in the sub-Saharan Africa has caused extensive damage. The high seasonality of the rainfall, the number of people exposed, and the vulnerability of their societies and economies, this geographical area are very vulnerable. You can see the Sahel precipitation from 1900 to 2011, you see the drastic drought. The upper part shows areas of flourishing rainfall, but you realize that from the 1960s, from mid-1960s to the 1970s, there have been drastic drop in the amount of rainfall, which has caused a lot of droughts, with other dire consequences in the region.

One of the classical examples of drought in Africa—I don't know whether you are seeing this slide? This illustration of the Lake Chad region, if you look at the Lake Chad region from 1963 up to 2007, you realize that this very important water body has lost about 94% of its water. We are talking about an area that has about, today we're talking about 30 to 40 million inhabitants among all these countries: Nigeria, Chad, Niger, Cameroon, and part of the Central African Republic. This is a classical example of what drought has done in Africa over the last centuries. These have been seriously exacerbated by climate change and the capacities of nature.

And so, some of the causes of drought that are in this area is—we know about land use and land use change; we know about air circulation, especially with the El Nino and La Nina phenomena; we know about the depletion of moisture and the huge demand in supply of water; changes in jet stream and local landscapes; deforestation; land use; and land use changes. These are all different courses of drought in Africa.

Drought and desertification are huge, and it has badly, badly affected the adolescent population in this area in many more ways than one. If you look at these images, which are real images that we do, you will see that it depicts some of the challenges of land degradation, drought, and desertification. All of these are linked together, and all of them are exacerbated by climate change. Here we're talking about extreme weather; we're talking about land degradation; issues mixed up with population growth, lack of infrastructure, and everything that you can think of.

The impact has been huge: farming, hunger, malnutrition, exodus, increase in natural resource conflict, and now we have the new phenomenon of extremism, terrorism, arms trafficking—long-term vulnerabilities—they are huge in the whole of Africa, especially in the Sahel.

And so, one of the things that we really have to look at is the impact of drought on health. This is an area that has literally gone under the blanket. It is not talked about. When you talk about drought, the focus

is on the physical—what we are seeing on the land and the fact that the natural resources of the land are being reduced. There are both direct impacts of drought and indirect impacts of drought, as you can see from this diagram here. You can look at direct impact, which leads to the water shortages that leads to malnutrition, especially mental health; we have vector-borne diseases, airborne diseases with issues to do with dust, as was shown during the presentation on the heat and also on wildfires. We have all that related health challenges like mobility; we have waterborne diseases.

[[WEBCAST CUTS OUT]]

One of the biggest health impacts that is linked to drought is the issue of malaria, what we call *paludisma* in French, and you realize that: when drought reduced the amount of water that is found in these areas, and what happens is that it leads to standing water—and this is the best ecosystem that anopheles mosquitoes and other forms of mosquitoes really want—and so the increased incidence of malaria, which costs millions of deaths in Africa and annually, it [malaria] is of the issues that are related to drought.

On the next part of the impacts, we also have the issues of drought related to food and nutrition; we have issues of drought to go with issues of air quality. We have the issues of sanitation and hygiene, because when there's an absence of water, there was a complete breakdown of the health and the hygiene systems, which leads to serious issues of which we have the dysentery, we have the malaria—we have all of these things that are because of drought, which leads to not lack of water.

One of the biggest, biggest health issues that are related to drought is the mental health issues, mental illness. If you look at the Sahel, if you go to northern Nigeria, northern Burkina Faso, you will realize that there are so many people that are affected by mental health. Mental health is a big issue, and drought desertification is directly linked to this issue. Because, when people lost everything because of drought, when people lost their livelihood, when people lost their income generation, when people are forced to migrate, when people are affected by natural resource-related conflict, there's the big, big emotional challenges that leads to psychological and mental health.

This leads also to consumption of drugs. Drug consumption in Africa—I'm talking about very poor-quality drugs—is the biggest challenge in this area, especially among the youth population who have lost everything. Drought is a huge problem in the dry lands of Africa especially.

It is because of these impacts of drought desertification, which has seriously been exacerbated by climate change, that the African leaders came together to develop what today is called the Great Green Wall Initiative, or the Great Green Wall for the Sahara and Sahel. If you look at the map here, you will see the yellow areas, which depicts the dry lands of Africa. When you look at the topmost areas, and then there is the middle part, which shows you the Sahara Desert. Down the yellow part, you can see the Sahel and right down to the Horn of Africa. And right down to the southern Africa region, where we have the Kalahari and the Namib Desert are all areas that are very prone to drought. As we speak, Madagascar, Namibia, Angola are seriously being impacted by drought, leaving tens of millions of people hungry.

This is how the Green Wall came about. When the head of states of the continent analyzed the situation and said, look, we need to have an overt action policy response that is going to bring all of us, all the

member states of the African Union together, to work on this issue of desertification, drought, and to be resilience of the adjacent population to climate change.

This is how the Great Green Wall came about. Since its inception, the Great Green Wall has been implemented. Now we are going into 35 member states. We are looking at all the issues of drought and desertification that we're talking about. We are putting in all the systems, both policy and bringing all of our partners together, all the development partners including the world banks, the European Union, and all of our international partners; we are working with them on this.

Also, the Great Green Wall was created to also leverage on the huge potential that exists in the dry lands of Africa, because most of the poverty is structural. It's because of lack of investment. If you see the slide here, you will see that this is an area of huge, huge natural resource both underground and above ground. If you look at the renewable energy potential of the dry lands of Africa, most of them have not more than 14 hours of sunshine. They have some of the youngest populations, and they're very innovative; they are developing indigenous knowledge to cope with all of what is happening.

The Great Green Wall was also built to ensure that we leverage the economic investment potential of this region.

These are the objectives. Improve the living conditions and be the resilience of the people and biodiversity to climate change, drought, desertification, to do advocacy, and to raise funds to undertake these activities.

The guiding principle is looking at leveraging on existing experience, looking at South-South cooperation, of course North-South cooperation, and getting to work with the local population to ensure that what we are doing responds to their areas of interest.

Most of our areas of interest is about resilience, is about adaptation, and mitigation of climate change. We have this as what we call the silvopastoral systems approach, where we look at the issues of pastoralism because this area, especially in the Sahel, provides 60% of the animals that are consumed on the continent, so the silvopastoral systems are very important for all. Agroforestry, forestry, afforestation, conservation agriculture is very important at things that we do: tourism, especially natural and cultural tourism, renewable energy, and capacity building.

One of the biggest issues that we are handling now is wildfires. Wildfires is huge in Africa, so we are building capacity, we are trying to use data and innovation in this.

This slide here, I say, how much will land restoration cost in Africa? It is huge, but it's not as huge as the absence of undertaking land restoration. For you to restore 1 hectare of land, you need about \$440 to \$500 per hectare per year. This sounds very, very huge.

But I use this example of the FIFA World Cup. The FIFA World Cup that is coming up in Qatar stands at more than—today stands at more than \$300 billion for a 1-month show. I brought this because many people say, oh, it's really expensive. I say it's not expensive. So I just showed that there was a lot of money, and there's a need for a paradigm change and the need to shift our focus from things that are not so important to things that are an existential threat to our world.

These are some of the examples. If you can see this picture of the accomplishment or the achievement of the Great Green Wall, you see that we are introducing appropriate technology. Because these people

will usually do restorations with their hands. We are introducing appropriate technology, introducing tractors; we are bringing in capacity building especially focused on the women that bear the brunt of all of this hard work.

And we are also looking at issues to do with renewable energy. We are introducing solars, what we call a program with the African Development Bank, which is called a Desert to Energy where we're introducing a solar wind antenna energy in these communities. We are also focusing on the development of value chains, looking at small farmer holders, bringing in all kinds of support to them. And also looking at issues to do with conflict. The biggest problem now in that region is the natural resource-based assets land use conflict, where we have farmers that are fighting on these patches of land that has been degraded and affected by drought.

[[WEBCAST CUTS OUT]]

The conclusion is that the harmful effects of drought have been well-defined and explored in meteorology, hydrology, agriculture, and economics, but very, very little studies have been done about the health impact of drought, especially in Africa. The data is still very, very scarce. There's an urgent need for us to look at the issues of the research into the impact of health and drought. Also, if we look at what is happening now, what we're saying is that nature-based solutions and ecosystem services are the main, it should be the main focus that we are going to use to make sure that we look for lasting solutions when it comes to issues to do with drought, when it comes to issues to do with climate change and desertification.

We conclude by saying that the outbreak of the COVID pandemic and the fact that it was proportionally linked to zoonotic origin has shown us that our link between nature and man is dysfunctional. There's a high need for us to focus, to learn from this and to get things done, and to focus on nature-based solutions, because that is the only way we can have everlasting and sustainable solutions to the issues of drought and other climate change, wildfires and all the challenges that we have today.

Thank you very much, and I have some have some materials on the Great Green Wall on this slide. Thank you very much.

Michele Barry: Thank you very much, Elvis Paul, that was a wonderful description of what's happening in the global South and how no person needs to be left behind. Because these are very vulnerable populations.

Speaking about vulnerable populations, I'm going to switch over now. Please put any questions to Dr Tangem in in the chat. I'm going to switch over to David Hayes, who can talk to us about the vulnerable populations in the United States, because we are also facing this vulnerability.

We thought it was important to update, especially with what's going on with the current bills with the Biden administration around climate and clean energy. So we invited David Hayes who is Special Assistant to the President for Climate Policy at the White House. Just to let people know who David Hayes is, he served both Presidents Obama and Clinton as the Deputy Secretary and Chief Operating Officer of the Department of Interior, and during his tenure as Deputy Secretary, he led the

department's climate change–related activities, including all those renewable energy and the Interior’s response to the Gulf oil spill, deepwater drilling, fracking, and negotiation in [[WEBCAST CUTS OUT]].

I think this would be a good time, David, to take it over. Again, any questions to Elvis Paul about the Great Green Wall Initiative, please put into the chat and he will answer.

Jonathan A. Patz: One other comment. If you're not presenting, please mute yourself. A little bit of background noise. Thank you.

David Hayes: Thanks, Michele. It's a pleasure to be here. Can everyone hear me okay?

I'd like to, thanks Jonathan, just give a little bit of a sketch what's going on in the Administration on Climate Change. It's an incredible, important priority for the President, as you know. He identified at the beginning of his administration four crises facing America: the health COVID crisis, the economy, inequality, and climate. Climate, one of the top four issues that's facing our country.

On day one, he did an executive order that fulfilled a number of his campaign promises dealing with climate. He ordered immediate action on regulations that had been turned back by the Trump administration affecting climate, including the Trump rollback on methane restrictions from the oil and gas industry, fuel economy standards, energy efficiency standards, the power sector hazardous pollutant standards, the ozone standards, and the identification of the social costs of greenhouse gases as well. And then on day seven, the 27th of January, he put out the executive order that created my office in the White House and established truly an amazing, a whole-of-government effort to deal with climate change. This is executive order 14008.

On the foreign side, it put Secretary Kerry in charge of bringing the US back into the Paris Agreement, and that's leading to the COP26 discussions that will occur in about 3 weeks, less than that now, in Glasgow.

And on the domestic side, it established, it recounted the President's policy concerns about climate, talking about how we're now going to be listening to science, we're going to be holding polluters accountable, we're going to be driving the Federal Government to assess, disclose climate pollution and climate-related risk for every sector. We're going to increase the resilience of the US to climate impacts—hang on to that thought. We're going to protect public health, this is all in the executive order. We're going to conserve our lands and waters and biodiversity. We're going to deliver on environmental justice. We're going to spur economic growth. We're going to put innovation in the front row of clean energy, technology, and infrastructure.

How are we going to do that? The President said we're going to create a White House Office Climate Policy; that's my office. It's headed up by Gina McCarthy, the National Climate Advisor. There are 10 of us who are doing this full time, 24/7. I never worked harder in my life, I will comment. But it's good work and it's a pleasure to have the opportunity to do it.

And it established a National Climate Task Force that our office staffs, which is the entire Cabinet of the United States. We have we have Cabinet meetings of this task force every month with enormous amount of activity in between our meetings.

Now on to specifics of that executive order. I'm going to spend a couple minutes to go through this, because it's very important. There's a tendency to think that what matters now is what's in front of the Congress, and that certainly does matter as I'll talk about, but it's amazing what is going on across the government with this whole-government effort, regardless of what happens in the Congress.

The specifics and 14008 said that we're going to use the federal government in a new, aggressive way when it comes to climate. We're going to have the federal government's procurement policies aligned with our climate policy. We're going to push for carbon-free electricity sector by 2035, starting with the Federal Government getting up carbon-free electricity for all of its operations across the board.

We're going to be pushing for renewable energy on the public lands, on offshore waters. If you've been following the offshore wind energy situation, it's unbelievable what we're doing. We're going to have 30 gigawatts of new, clean offshore wind energy off the East Coast of the United States by 2030. We've also opened up the Pacific and the Gulf to wind energy areas, and there's enormous draw and demand for this clean energy, in part because of the progressive states in the Northeast as well as now, the Federal Government.

We are going to limit oil and gas on public lands. The President put a pause on new leasing on public lands. We're protecting the Arctic Wildlife Refuge from oil and gas drilling, and we're doing a complete overhaul of the whole federal oil and gas program. We're not going to be doing any federal funding to subsidize fossil fuels anymore—that's reflected in the budget for fiscal year 2021 and 2022, and now soon, 2023.

We're going to use federal funding to spur clean energy innovation and deployment. Every federal agency has, as of last Thursday, has a new climate action plan that identifies how in their mission area they are going to be dealing with the adaptation and resilience needs now with climate impacts affecting them. I suggest you look at the Department of Defense's energy plan, which you can find from the White House website from last Thursday. It's amazing how they recognize how climate is impacting their mission, and how they're going to deal with it.

And then last week, on Thursday, or rather, it was Tuesday the 12th, we came out with a new policy on climate information products and the part of the challenge of making sure that Americans who are being impacted by climate have the best information about what's affecting them. We had two important reports come in as well as some additional information, which I'll talk about in a minute.

I'll also say that this whole-of-government approach is—so I've been talking a lot about, obviously energy, as part of it, but also as a recognition that conservation is a key part of dealing with the climate situation.

The executive order called for the creation of a—rather, reinforced the President's promise to conserve 30% of the landmass in the waters of the US by 2030. We call it the America the Beautiful Initiative, and we're pushing hard for both working lands and nonworking lands to be protected for their carbon benefits.

We got a climate-smart agriculture and forestry program moving ahead with Secretary Vilsack. I'm happy to be talking about that. A lot of focus on coastal resilience through NOAA and other agencies. We called for a civilian climate corporation to get the youth of America involved in pushing for climate solutions; that's in front of the Congress right now.

Also there's a, to Michele's point, there's a recognition that climate is disproportionately affecting important populations. The executive order recognizes that, embraces that, and says we're going to secure environmental justice and spur economic opportunity. It establishes Environmental Justice Interagency Council for marginalized and overburdened communities that have suffered disproportionately from climate impacts. It also talks about revitalizing energy communities that have been left behind by the transition, recognizing that these are communities with workers who are being displaced. We need to address them, and we need to deal with the legacies around them—the leaking orphan oil and gas wells; the abandoned mines that are continuing to produce methane, etc.; and to help those coal and power plant communities.

How are we doing all this? It's an amazing across-the-government effort. In the transportation sector—so look at, look first at emissions, then I want to talk about climate impacts. On the emissions side in the transportation sector, we've been working with the auto industry. We have agreements from the auto industry to, by 2030, produce—have half the cars and trucks in the US produced being electric. Amazing. We've increased back the mileage standards. We're pushing for EV, for electric vehicle recharging stations, already in the bipartisan part of the legislation on the bill. There's \$7.5 billion to build half-a-million recharging stations. And we had an announcement about 3 weeks ago about a sustainable aviation fuels initiative to produce 3 billion gallons of sustainable biofuels for aviation by 2030.

In the power sector, we're pushing for offshore wind and other clean energy. In the industrial sector, we're going back with regulations to stop the emissions of methane from the largest source of the super pollutant.

We're also working with the ag sector to get methane emissions down from that sector. In the agricultural sector, climate-smart ag and forestry, we're looking at negative emissions, in particular by taking advantage of carbon sequestration on public lands and other lands.

And then, in the adaptation and resilience space, there has been an enormous amount of attention given to this because of what's happened in the US this year. Everyone's been touched by climate impacts. *The Washington Post* recently did a study showing 1 out of every 3 Americans lives in a county or a state has had a FEMA declaration this year. Two-thirds of Americans have been in an area that's experienced a multiday heatwave event this year.

What have we done? We've established five interagency working groups focused on different climate impacts. We have one on extreme heat; we have one on wildfire; we have one a coastal resilience; we have one on flood impacts; and we have one on drought. These are all organized under my office through the task force that, The National Climate Task Force, and they're set up with the experts from the cross-agencies that have the major equities here. For example, the Extreme Heat Interagency Working Group is headed up by the new office at the Department of Health and Human Services that we set up under executive order 14008 called the Office of Climate Change and Health Equity. They are joined together with EPA, which has traditionally done a lot of work in this area, and NOAA, the third agency that's traditionally done a lot of work in this area.

And you may have noticed that we had an extreme heat fact sheet coming out of the White House about 3 weeks ago that chronicled how a number of agencies are working together to address this crisis. Similarly, on the drought issue that has been an enormous challenge. USDA and DOI are heading up the interagency working group. I'm talking about more of that if there are questions.

Let me close with this, because Michele asked me to talk a little bit about the provisions that are on the Hill right now. We're very excited about both the Bipartisan Framework, Infrastructure Framework, that was passed by the by the Senate in the summer, and it's awaiting final action, and the Reconciliation Bill, which we're—watching the sausage being made as we speak, is not a pretty sight—but when you step back, it's amazing what we potentially will get out of these two pieces of legislation. Enormous, enormous financial support on all of these major areas where we need it in terms of the climate crisis. The Bipartisan Infrastructure Framework, for example, has enormous investments in public transit, in electrifying school buses and transit buses, in the electric vehicle charging stations that I mentioned. We're talking about more than \$10 billion, more like \$20 billion, actually much more than that, in this transportation sector. It's \$15 billion only for EV chargers and electrification of school buses.

In the transmission area, we need better transmission in order to get the clean energy, the new clean energy to the load centers. We have new authority under the bipartisan agreement to give DOE the planning and financial wherewithal to drive new interregional transmission like we've never had before. It also has billions of dollars for grid modernization and for resilience of the of the grid. For methane, we've got \$12 billion plus another \$5 billion for mine reclamation and oil and gas reclamation.

For resilience, I want to close with this, for resilience, we have over \$50 billion in order to help get our forests more healthy, deal with our Western water needs and drought needs around the country, give weatherization—that includes cooling—capabilities to our homes—not just heat and installation anymore, but cooling as well—and we've got huge, tens of billions of dollars in clean energy investments, from hydrogen, to storage, to battery recycling, etc.

The Reconciliation Bill will do more. It will provide more incentives for electric vehicles; it will provide tax incentives for transmission and for solar and wind; it will provide money for the Civilian Climate Corps; it will provide more money for climate-smart ag and forestry; more money for green banks that will enable much more penetration of clean energy in environmental justice communities; and that doesn't even get to the issue everyone's talking about right now, which is the electricity sector.

Have a little step back and take a look at this. It's an amazing—we're on the threshold of potentially amazing additional thrusts of money and policy into the climate arena that's unprecedented. But also keep in mind that, even without that, we have a president completely dedicated to this area doing amazing work.

I went longer than I should have, Michele; I hope you'll forgive me.

Michele Barry: That's okay, David, we'll—everybody's going longer. We're going to try to take a few questions from the audience.

And one question, Kari, do you want to unmute yourself? Go ahead, Kari.

Kari Nadeau, MD, PhD: Quick question, David. Thank you so much; that was really an excellent overview.

My question to you, and I hope you're going to COP26 is, what do you think, from your standpoint or from the Biden administration staff, is the most important focus of COP26?

David Hayes: I think it's a high-level focus that's needed, which is to get the world back on track to make climate a priority. I mean, there will be a number, as you know, Kari, of specific initiatives. There's an initiative to agree to get the major economies green, to cut methane emissions by 30%, by 3030. There's efforts to proliferate the 30 by 30 efforts in terms of conservation and many others. But honestly, I think it's mainly to recognize the obligation, and in the international area, which I work less in as you can tell, to provide the world with the financial backing from the major economies to deal with the crisis that we have abroad. And that's where you've seen a big forward lean by Secretary Kerry and his team and the US.

The issues of climate migration, of the disproportionate impacts on communities that cannot escape the incredible health problems associated with fossil fuel, combustion, are just enormous. We see that here in the US, and it's terrible. As you will know from your work in the Fresno Valley, in the Central Valley in Fresno, etc., the climate, the recognition of the health effects of our current fossil fuel-based economy are tremendous.

Anyways there's so much to do; just getting folks back on track, I think is the main thing.

Linda Fried: Thank you. Thank you so much for this amazing, and inspiring, and highly hopeful work.

I didn't clearly hear the thinking and plans around how to rapidly modernize and invest in a 21st century US public health system that could really be on the ground and at the state and national levels in an integrated way to protect human health. I was wondering what the plans are on that.

David Hayes: We absolutely need, obviously, the public health system is strained. In terms of climate, we've got some folks on this call, including Jonathan and others, who've been preaching for some time, and Michele and many others, and you, I'm sure, about the importance of the climate/health nexus.

It's not been a primary focus. I will tell you that it's one of Gina McCarthy's primary focuses and, as you may know, after she left the NRDC, she was at the Harvard School of Public Health, and is a strong proponent. It's one of the reasons why the President established this new unit at Health and Human Services and recruited some good folks so far.

Unfortunately, because of the budget, sort of, stalemate we've had over on the Hill we don't have the funding yet to fully stand up that unit. They're doing a great job basically borrowing folks from different parts of HHS. But I predict, once we get a real budget through here and we get the several million dollars into that unit, given the President's focus on it, Gina McCarthy's focus on it, Secretary Becerra's focus on it—he's got some very good people, Aresenio Mataka, who was one of his right hands when he was in California, involved, and John Balbus, who many of you may know.

I think we're going to see some real advances there. We're excited because the whole-of-government frame we have around climate provides the room now to bring health into the equation in a way it's never been brought into the equation before.

Jonathan A. Patz: David, that's music to my ears of course, and I just want to thank you. We are so grateful that you're leading this whole-of-government approach. It's just, it is this one of these oh my gosh moments for me that, this is amazing. Thank you so much for this.

Michele Barry: I think there was a comment that you should go on MSNBC, because the Left is cynical. I think that came from David Rosner.

Jonathan A. Patz: David, thank you so much. This is incredible out of the Biden administration and your leadership.

We do need to move on, and based off of your incredible progress, now it's time to turn to next steps and where we go from here. We have two distinguished speakers that are going to take us there. First is Francesca Domenici, who is the Co-Director of the Harvard Data Science Initiative and the Clarence James Gamble Professor of Biostatistics Population and Data Science at the Harvard Chan School of Public Health. She is an expert in causal inference, machine learning, air pollution, and climate change. Dr Domenici will tell us about the future of science predictions, with particular focus on data science and cutting-edge mechanisms to assess vulnerabilities.

And following her, Maureen Lichtveld is the Dean of the Graduate School of Public Health at the University of Pittsburgh. She also serves as Professor of Environmental and Occupational Health and is the Jonas Salk Professor of Population Health. Her environmental health research spans from risk assessment of chemicals in disasters to health disparities in climate change, she will summarize what we've heard all day. Through the three lenses of science, policy, and practice, try to highlight the next steps and key action strategies.

Thank you. Francesca, take it away.

Francesca Dominici: Thank you.

First of all, fasten your seat belt, both because I'm going to go very fast but also because I'm going to tell you where the science is going and project in the future.

I also think that my talk is also linked to Linda Fried's comment about how do we modernize US public health system. Something that I know for a fact that, by interacting with Gina McCarthy, that's something that she would be highly receptive to.

I'm just going to give you immediately my key points. One is, of course I'm coming from a world of data scientists—I'm a data scientist—I do think that we now have a wealth of information from satellite data science, atmospheric chemistry, machine learning. They're really allowing us, both at the domestic level

and the global level, to pinpoint and estimate exposure to climate change–related exposures, such as wildfire, and droughts, and heatwave with an unprecedented precision.

But also we have advanced methodology that allows us to link and assess causal link between exposure to climate change and how outcome, including the most vulnerable population—just so I point it out, this week the Nobel Prize winner in economics, among them is Guido Imbens, talking about causal inference for natural experiment—this is really the area that we're talking about here.

And then we have been seeing emerging evidence of a link between air pollution and wildfires and COVID that really allow us to think about an additional sense of urgency.

Critical point that the many of you know. Climate change and air pollution share the same sources, so attacking air pollution and the fossil fuel emissions is actually a very effective way to targeting our greenhouse gases emission.

We have learned now, in the context of the Clean Air Act, that with amount of data, with data science and by providing evidence on link between air pollution exposure and health, had led to policy change and had led, indeed, to breathing cleaner air.

The other good news is that, as we know, the WHO very recently, a few weeks ago, had revised their quality standards, getting from $10 \mu\text{g}/\text{m}^3$ to $5 \mu\text{g}/\text{m}^3$. Basically, that said that effort to cut pollution by reducing fossil fuel use would provide a double benefit in both improving public health conditions and in bringing down climate coordinate emissions.

I am a big advocate for building national and global data platform that will allow us to assess exposure to climate change, and it will allow us to quantify the impact of climate change, and will allow us to pinpoint who are the most vulnerable. So as we are thinking about how to regulate greenhouse gas admission, at the same time we can protect the most vulnerable population.

And so we have now across, actually there is a final work in the United States, it is a consortium that I am a member together with the Melbourne School of Public Health, with Yale University, with Boston University, and of course I'm from the Harvard T.H. Chan School of Public Health, where we are putting together national data platform that will allow us to assimilate exposure to wildfires, to drought, to tropical cyclone, to heatwaves, to link to health data from the Medicare and Medicaid Services as well as national cohorts and be able to quantify on a national and also global scale the impact of climate change. We can estimate exposure to temperature, extreme and in a temperature variability with the level of accuracy actually much, much higher than the county, up to 3 km per kilometers resolution.

We already know a lot about the health impacts from heatwaves, of which I'm not going to go through here again. We are, and this is work led by my colleague at the Melbourne School of Public Health, have an opportunity to estimate and quantify the exposure to tropical cyclone and linking to hospitalization rate. There is work on wildfires that is actually telling us that in the future, we are moving from 57 million of people that have been exposed to wildfires for sure, up to 82 million between 2046 and 2051.

I also want to point out emerging work from my team. We are linking exposure to wildfire exposure, to COVID, that these are linking directly to the wildfire that we had last year with COVID. There is a national platform, well a platform specifically for the state of the source of the first wildfires, where similarly, as we have been monitoring COVID, we can also start monitoring COVID-19 cases that's directly and

causally attributable to excess PM2.5 and during the wildfire days. This is a publicly available, and you can find this platform. This is really the additional monitoring and surveillance that we can do.

We also know, and this is adding additional level of urgency, that exposing population to fine particulate matter, air pollution but also to NO₂, is making the health outcome of the pandemic worse and has increased the mortality rate for people that have been tested positive for COVID.

We have estimated that in all of North America, for example, 14% of the number of deaths for COVID are indeed attributable to fossil fuel–related emission; the number for Europe is 13%, in East Asia it's 15%, and North Americans, as I said, 14%.

I'm going to really quickly conclude with my last two slides. One is the steps needed to mitigate climate change in the future are substantially the same as those needed to reduce the burden of death and disability due to air pollution in the present. So cut back on both nonburning fossil fuel and biomass, and I really hope that in the US we will follow the leadership of the WHO and lower the national interquility standard for fine particular matter.

In the meantime, I am a strong advocate that machine learning and data science allow us to measure exposure to this climate change–related disaster to pinpoint with incredible amount of precision susceptibility and vulnerability. So then when we try to allocate, and we aim to allocate billions of dollars for policy, we know who is going to benefit the most and we know which policy will matter the most.

And again, I think, remind us, this week with the Nobel Prize in Economics that we don't invent has been teaching us that, through natural experiment, we can indeed assess causality. in context of climate change or exposure, we are often dealing with natural disasters. So we can really learn and borrow this mentality to really think about causal attribution.

My own perspective on looking ahead. We need data. We need data; we have data; we just have to get ourselves organized to be able to integrate, harmonize, and provide access to these data, both and the US level and at the global level. We have the expertise; we have the technology; we have the ability to maintain privacy; and I think, in my own opinion, is that they will really allow us to better understand the distribution of effects on these disadvantaged portions of the population.

Thank you.

Jonathan A. Patz: Francesca, thank you so much. That's a lot to chew on. Really, really valuable information.

Maureen, you have the, you're next.

Maureen Lichtveld: Wow, how to summarize this in a few minutes? We're very thankful for everyone who participated.

My task is to summarize this through three lenses: science, policy, and practice. The absolute bottom line for us in the area of science, is that we are responsible for making science, make climate and health

science, work for those most vulnerable. Across all presentations every single presenter talked about issues of equity and issues of vulnerability.

Paul Schramm and Jonathan Patz pointed out equity and social vulnerability. Kari and Phil pointed out the amount of pollution that wildfires bring—so much more—and that climate change and wildfires actually have a reciprocal relationship. Elvis Paul brought up the impact of drought, again, on the most vulnerable populations that particularly focused on mental health and identified drought as one of the areas where we don't have enough data. David Hayes, I couldn't write quick enough on his comments, but what's most striking, David, and I'll talk a little bit about policy in a minute, is the approach of it to be the whole government; just like in the past we did the whole system when we addressed disasters. And then, just now, Dominici mandating that we focus on data platforms that go far beyond how data and include weather data and others, so that we have a transdisciplinary platform to be able to look into the future.

Now, policy. We've heard that modeling from Kari and from Francesca, that modeling can inform policy and that policy, in turn, can impact people, especially those most vulnerable. We heard specifically from David that a climate focus must include science, must include resilience, must include protecting public health and a special emphasis on environmental justice, must include identifying those risks and dealing both with emissions and with adaptation. He also indicated that, beyond just seeing it's a resilience, there's money; there are funds around it for forest, for water preservation, for clean energy.

And then in the area of practice, Paul Schramm brought us back to where it really matters: vulnerable communities and CDC surveillance efforts in multiple cities. Kari again emphasized why vulnerable populations are such an emphasis that we can't ignore. And Elvis brought up that nature-based solutions actually help us address more resilience, adaptation, and mitigation measures.

Further on the practice side, Francesca really pointed out the need for transdisciplinary data for action.

Our effort today doesn't stand alone. It was preceded by just Friday, a workshop a summit convened by the Consortium of University of Global Health that looked at climate and held it through three lenses: energy, transportation, agriculture; green financing; and policy implementations. And there, again, there were some very provocative issues such as revisiting whether cheap food is really cheap. It might be cheap for humans but definitely not cheap for the ecosystem. The focus on local, where the action is, and protecting one special aspect of vulnerable populations, and those are our Indigenous brothers and sisters.

Preceding that was a conference focused on small-island nations in the Caribbean, where the impact of climate is particularly cumulative, building on persistent health disparities, environmental health disasters, and natural disasters. And then of course, coming up, it was our own conference tomorrow, you've heard from president it's all about, and then in March and early April on the CUGH Annual Conference on healthy people, healthy planet, and social justice.

I couldn't really, and thank you Linda Fried, to pay attention to the floor of the house, and the floor of the house in public health is our public health infrastructure, where we have several of us emphasizing the need for a new workforce, a climate and health workforce where we work with accrediting bodies in medicine and public health and other health professionals to require that our future health

professionals our current health professionals do something about the relationship between climate and health, and that local partnerships, also those that are not so traditional, really matter.