



Public Meeting of the
President's Council of Advisors on Science and Technology (PCAST)

March 14, 2024

Meeting Minutes

MEETING PARTICIPANTS

PCAST MEMBERS

- | | | |
|------------------------------|--------------------------|-----------------------|
| 1. Frances Arnold, Co-Chair | 11. Sue Desmond-Hellmann | 21. William Press |
| 2. Arati Prabhakar, Co-Chair | 12. Inez Fung | 22. Jennifer Richeson |
| 3. Maria T. Zuber, Co-Chair | 13. Andrea Goldsmith | 23. Vicki Sato |
| 4. Dan E. Arvizu | 14. Laura H. Greene | 24. Lisa Su |
| 5. Dennis Assanis | 15. Paula Hammond | 25. Kathryn Sullivan |
| 6. John Banovetz | 16. Eric Horvitz | 26. Terence Tao |
| 7. Frances Colón | 17. Joe Kiani | 27. Phil Venables |
| 8. Lisa A. Cooper | 18. Jon Levin | 28. Catherine Woteki |
| 9. John O. Dabiri | 19. Steve Pacala | |
| 10. William Dally | 20. Saul Perlmutter | |

PCAST STAFF

1. Lara Campbell, Executive Director
2. Reba Bandyopadhyay, Deputy Executive Director
3. Bich-Thuy (Twee) Sim, Assistant Director for Transformative Medicine and Health Innovation
4. Melissa Edwards, Assistant Deputy Executive Director
5. Kimberly Lawrence, Administrative Specialist

START DATE AND TIME: Thursday, March 24, 2024, 10:05 AM Eastern Time

LOCATION: National Academy of Sciences and Livestreamed via YouTube

WELCOME

PCAST Co-chairs: Frances Arnold, Arati Prabhakar, Maria Zuber

The PCAST co-chairs—Frances Arnold, California Institute of Technology; Arati Prabhakar, Assistant to the President for Science and Technology; and Maria Zuber, Massachusetts Institute of Technology—called the meeting to order. Arnold said that during this meeting PCAST would discuss and consider for approval a report on to the President on PCAST's *Federal Vision for Advancing Nutrition Science in the United States*. She noted that one of the greatest opportunities for the federal government to contribute to the well-being of Americans is by bringing attention to the importance of nutrition, given that diet-related chronic disease is one of our greatest health burdens. Modern living, she said, has brought innumerable benefits, but one downside of the easy access to calories has been an epidemic of chronic disease, which is costly in terms of lost wages, lost health, lost lives, and the enormous burden on the U.S. health system. This burden, she added, has direct costs to well-being that fall especially hard on communities whose access to healthy foods is hindered because of demographic, geographic, cultural, or economic reasons. She then introduced the co-leads of the nutrition working group, Catherine Woteki and Frances Colón.

SESSION: DISCUSSION AND CONSIDERATION FOR APPROVAL OF PCAST'S REPORT TO THE PRESIDENT ON A FEDERAL VISION FOR ADVANCING NUTRITION SCIENCE IN THE UNITED STATES

FRANCES COLÓN

Colón began by noting that the Biden administration is already catalyzing efforts to improve every American's health. In September 2022, the President convened the White House Conference on Hunger, Nutrition, and Health, the first convening of its kind since 1969. On the same day, the Administration released a strategy that set an audacious goal: to end hunger and reduce diet-related disease by 2030 and reduce disparities among the communities that are most affected by hunger and diet-related disease. One of the five pillars of that strategy calls for enhancing nutrition and food security research and for PCAST to work with the Interagency Committee on Human Nutrition Research (ICHNR) to identify scientific opportunities, gaps, and priorities to continue to advance nutrition science, with a particular emphasis on ensuring equitable access to the benefits of research.

PCAST's nutrition working group, said Colón, decided to focus on the health, economic, and social effects of diet-related chronic diseases, including cardiovascular disease, stroke, diabetes, cancer, and obesity, the latter of which increases the risk of developing chronic diseases. During its deliberations, the working group was shocked to realize that the majority of American adults are not healthy and have one or more of these chronic conditions. The burden of these diseases, she said, falls inequitably on people with limited resources, communities of color, and in rural areas, exacerbating health disparities. In addition, the prevalence of chronic diseases increases with increasing food insecurity, another measure of the inequitable burden these communities experience.

Colón said nearly three out of four adults are obese, with obesity being a leading disqualifier for acceptance of potential military recruits. Diet-related chronic disease shortens lifespans, affecting the nation's productivity and competitiveness, and costs the nation over \$500 billion in medical expenses. In comparison, the National Oceanic and Atmospheric Administration recently estimated that climate change and weather disasters cost the nation more than \$165 billion annually. Delaying the age at which

these diseases first develop or preventing them would benefit all Americans, given that the existing scientific evidence shows that an improved diet and exercise can prevent or postpone the onset of diet-related chronic disease. Colón noted that the scientific evidence is under review in the five-year cycle of developing dietary guidelines for Americans. Dietary guidelines inform federal nutrition programs, as well as public and private health promotion, and disease prevention activities.

Colón explained that to develop its report, the working group interviewed representatives from federal agencies with responsibilities for research and for delivering food and health care programs. The working group asked these individuals to identify the biggest evidence gaps and impediments to delivering equitable access to new research findings on diet and health through their programs. This information shaped the working group's recommendations, which were shared with a broad group of stakeholders in a workshop it convened at the White House in November 2023. The workshop's discussions led to further refinements to the recommendations and another round of input from private and public stakeholders.

As a side note, Colón said the large group of federal agencies that provided input to the working group administer some 200 food and nutrition programs, creating challenges to taking a focused approach to reducing diet-related chronic diseases. The fragmentation of federal efforts is a barrier to effective translation of research into concerted program action.

CATHERINE WOTEKI

Woteki said the working group identified several scientific gaps, with the most significant being an insufficient focus on chronic disease prevention in federally sponsored research programs which further affects disparities in outcomes. Diet is the leading modifiable risk factor for death and disability in the United States, but only the National Institutes of Health focuses on reducing these exposures. Additional gaps include:

- Lack of implementation science—research with the explicit purpose of informing the decision-making needs of population health and nutrition programs—limits the effectiveness of program interventions.
- Need for improved and innovative methodologies for capturing information on dietary habits.
- Limited prioritization of equity considerations in research framework.
- Limited infrastructure to collect data on subpopulations at all life stages to inform, develop, and evaluate comprehensive prevention programs.
- Homogeneity of the scientific workforce limits ability to partner with communities to provide equitable access to the benefits of research.
- Unrealized and restricted private sector research engagement leads to missed opportunities, for example, to gather information on consumer habits and practical implementation considerations.
- Need to expand research in precision nutrition to consider multiple synergistic interactions, such as the interactions of diet with genetics, microbiome, environmental exposures, and socioeconomic factors.
- Insufficient authority and resources for ICHNR limits federal coordination efforts, a factor in the 2021 expiration of the federal research plan for nutrition research.

Woteki said the need to address these gaps led to the working group's first recommendation, which calls for taking rapid actions to fill gaps hindering equitable access to the benefits of nutrition research. The four specific actions in this recommendation are:

1. The Department of Health and Human Services (HHS)/Centers for Disease Control and Prevention (CDC) and the U.S. Department of Agriculture (USDA), working with state, local and territorial public health entities, should strengthen national nutritional surveillance programs to provide greater understanding of the dietary intake, nutritional, and health status of sociodemographic subgroups.
2. Federal agencies should prioritize equity in nutrition research; the ICHNR should develop guidelines for review of research programs for equity considerations and support agencies in their efforts to identify, share, and adopt leading practices.
3. HHS/CDC and USDA, in consultation with the Department of Defense (DoD) and Veterans Administration (VA), should design a cross-agency program to diversify the nutrition science and dietetics workforce, building on widespread education and training resources in multiple departments that are not currently harmonized.
4. ICHNR should develop and submit a budget request to the Office of Management and Budget for fiscal year 2026 for a coordinated research program in implementation science.

Regarding the second recommended action, Woteki noted that the National Institutes of Health (NIH) has taken steps to examine its research programs and develop a research framework for equity, and its experience can help to inform the actions of other science agencies that are conducting and sponsoring nutrition research. She added that the nutrition science and dietetics workforce is among the least diverse in the sciences, limiting the agencies' ability to partner with communities in the design of research and to test interventions and to deliver the benefits of research to individuals and communities.

Woteki said the working group's second recommendation is to fortify the scientific evidence base for future public and private sector actions to combat diet-related diseases through a coordinated and sustained federal interagency effort, led by the Secretaries of HHS and USDA, whose agencies sponsor the majority of human nutrition research. This recommendation includes three specific actions:

1. Develop and launch a sustained public-private sector campaign to optimize implementation of science-based recommendations, beginning with the *2025 Dietary Guidelines for Americans*.
2. In consultation with private sector entities, propose innovative ways to engage the private sector and remove barriers to integration of public and private data and research on diet and health.
3. Develop a 5-year (2025 to 2030) nutrition research roadmap, building on the framework in the ICHNR 2016 to 2021 roadmap.

In conclusion, said Woteki, preventing diet-related chronic diseases should be a primary goal for the United States. She added that the scope of the necessary work requires:

- Supporting high priority research to understand the unfolding and changing nature of the problem.

- Developing effective evidence-based solutions for federal agencies and private sector implementation.
- Equitable implementation of federal food and health programs.
- Assessing and reporting on progress and emerging issues to the President and Congress.
- Coordinating agency efforts to develop, implement, and adapt strategies.
- Engaging and challenging the private sector and individuals to take steps within their purview.
- Seeking Congressional support to fund these programs and ultimately deliver benefits to the nation.

Woteki said the U.S. Global Change Research Program provides a useful model for assembling the vast scientific evidence and focusing coordinated efforts to reduce the burden of diet-related chronic diseases. She added that the working group wanted to acknowledge the excellent work ICHNR does that provides the groundwork for coordinating research on diet-related chronic illnesses. At the same time, ICHNR would require additional authorities, resources, and dedicated staff to effectively transfer and translate research into disease prevention efforts at the scale required to have the needed impact. Woteki concluded her comments by thanking the working group's ICHNR colleagues for their help and guidance.

After the working group co-leads' presentation, discussion among PCAST members followed.

ZUBER MODERATED THE Q&A AND DISCUSSION BETWEEN PCAST MEMBERS AND COLÓN AND WOTEKI

Zuber opened the discussion by commenting that the private sector has a huge role to play in this effort given that a large part of health nutrition is having access to healthy foods. But more than new policies, there is a need for incentives for the private sector to both locate and to stock their stores with healthy foods. Woteki said she agrees with that point and that some recent incentives have provided benefits in that area. One example is the FDA's labeling requirement regarding trans fats that produced a dramatic decrease in the trans fat content of food. She added that when the nation has made progress on diet-related diseases it has been because of private sector actions based on science produced by federal agencies. Identifying those incentives and putting them in place is key.

Saul Perlmutter asked if it is easy or difficult to close the loop in terms of showing the economic benefits resulting from interventions, such as reduced health care expenditures or economic growth. Woteki replied that the Nutrition Monitoring and Related Research Act, which lapsed more than a decade ago, required regular reporting to Congress on nutrition-related health issues. Since then, there has not been the opportunity to assemble that information to produce high-level visibility regarding progress and emerging problems. This is why the working group noted the need for regular reporting that includes data that would enable determining economic benefits.

Paula Hammond asked Woteki and Colón to elaborate on ideas that might involve engaging with educational institutions such as community colleges and how the recommendations might affect that engagement. Colón replied that a concern of the stakeholders at the November workshop was that the workforce should represent the communities it serves because that affects how community members receive and access information and use it to make decisions for their families. However, because requirements for careers as dietitians and nutritionists have increased to a master's degree, these careers are now inaccessible for many members of the community. Another concern the workshop participants

voiced regarded whether the field could use other models for reimbursing the costs of conducting nutrition studies and obtaining training for these careers at community colleges.

Woteki noted the fragmentation of training opportunities; the USDA has relationships with land grant universities and historically Black colleges and universities, but little interaction with the programs that HHS has been launching or the dietician training opportunities that the VA and DoD offer. The working group found there are few undergraduate and graduate programs in nutrition and dietetics. She noted that nutrition rarely gets mentioned in elementary and secondary school science classes even though that would be an opportunity to help students improve their family's health.

Arati Prabhakar asked what changed when the new regulations on trans fats went into effect and whether it changed eating behaviors because companies now had to report this information or because consumers stopped buying products with trans fats. Woteki replied this is an example of a silent intervention. Partially hydrogenated vegetable oils were cheap and had been incorporated in a wide variety of foods. However, after FDA, using its labeling authority, instituted the labeling requirement, companies reformulated their products and removed the trans fats, which meant the public did not have to change its eating behavior to reduce or eliminate trans fats in their diet. FDA has used this same approach to partner with the private sector to get companies to make health-promoting changes from which consumers then benefit.

Prabhakar then asked for another example of an action that has worked. Woteki said that before the obesity epidemic accelerating in the 1970s and 1980s, widespread educational programs about heart health led to changes in individual eating behavior that reduced the prevalence of cardiovascular disease and cardiovascular disease risk factors. Specifically, HHS informed the public to switch from butter to corn oil when preparing food, with the American Heart Association amplifying that message. However, the obesity epidemic negated this advance.

Dan Arvizu, a member of the working group, commented on how profound the implementation gap is and how challenging it is to implement an intervention so that there is public uptake and positive societal effects. He asked Woteki and Colón to discuss how technologies, such as artificial intelligence, could help provide a better understanding of human behavior that would inform future work.

Lisa Cooper, a working group member, provided an example of an intervention that works. Research has shown that people with high blood pressure need to follow the Dietary Strategies to Stop Hypertension (DASH) guidelines and eat more fruits, vegetables, nuts, and beans. However, getting people to follow the DASH diet requires understanding the ability of individuals to purchase fruits and vegetables and what they eat in order to provide them with advice on how to change their diet according to their tastes and preferences. A project in which she participated recruited community health workers to go to people's homes and talk to them about what they eat, how they shop, and how the food in their kitchen cabinets did or did not fit the DASH diet. There, the community health workers, who did not have a degree in dietetics or nutrition, could serve as a coach on how to eat healthier and purchase healthier options.

Frances Arnold asked how the field can acquire the fundamental data the first recommendation calls for other than by looking at what people purchase in the supermarket. Woteki replied that traditionally, the federal government uses surveys, and particularly the National Health and Nutrition Examination Survey, to acquire that type of information. This survey uses a combination of interviews asking people to recall

what they ate over the past 24 hours and physical exams that collect an individual's blood pressure, blood sample, height, weight, health history, and program participation. The working group recommendation calls for expanding the survey beyond the current 5000-person sample size to enable more granular analysis at the level of subpopulations and life stages, such as infancy and during pregnancy. The idea is to launch an expanded campaign in 2025 based on the scientific review for the upcoming Dietary Guidelines for America.

Woteki agreed with Prabhakar's statement that behavior change requires effective delivery of an intervention. In that regard, the federal government has the opportunity to make a concerted effort over multiple years to implement the working group's recommendations. One place to start would be to use federal cafeterias to launch a long-term campaign to improve the health of federal employees and to work with the private sector to disseminate interventions to the wider public.

Eric Horvitz said he appreciated the equity-centric lens the working group took throughout its report, the material it contains on exposure to healthy food marketing and nutrition education across different demographics, and the call for research on behavioral economics. He asked Woteki and Colón to clarify federal government powers regarding its ability to regulate communication, food marketing, and messaging at the retail level. Woteki replied there are several existing authorities the federal government can use, such as FDA's authority regarding nutrition labeling for packaged foods. The question is whether FDA can use this authority to incentivize companies to change the composition of their products. FDA also has authority to regulate messages on health claims, such as "this product builds strong bones" or is "this product reduces your risk of heart disease." She noted that there is a high bar regarding the scientific evidence needed to make such claims, and that such messaging can help the public distinguish between products that are "heart healthy," for example, and those that are not. The Federal Communications Commission also has authority to regulate marketing claims more generally.

Arvizu asked if the federal government could require packaging to include negative messages in the same way that cigarette packages must state risks from smoking. Arnold noted and Woteki agreed that companies will claim they simply deliver food people want, so implementation science must work at the level of influencing individual choices.

Terence Tao asked about the potential role of setting concrete goals to focus national efforts such as identifying specific metrics the nation should meet by a certain date regarding diet-related diseases. Woteki responded HHS has set goals for health promotion and disease prevention, such as increasing fruit and vegetable intake by a specific amount each year, but the working group believes nutrition-related goals need work.

Lara Campbell asked Woteki to talk more about some of the specific research areas upon which the report recommends expanding, such as precision nutrition. Woteki replied that precision nutrition is a priority in the biomedical research community and is a focal point for NIH's current strategic plan for nutrition research. It is also underlying the direction of research that USDA and other agencies are funding. The underlying concept is that individuals vary in their nutritional requirements and in their response to the food they eat as determined by their genetic inheritance, environmental exposures, and subpopulation variability. For example, people of Asian ancestry have a higher prevalence of salt-sensitive hypertension, while people of Northern European ancestry are unusual in that they maintain high levels of lactase in their adult years and can continue digesting milk products without experiencing digestive discomfort.

Precision nutrition aims to identify those types of characteristics to improve dietary guidance for specific subpopulations, and perhaps lead to providing that information on food labels.

Jennifer Richeson asked if the recommendations included mention of addressing food insecurity, given that food insecurity is a strong predictor of diet-related health risks. Woteki said the recommendations do not tackle the question of how to address food insecurity, but the report does note that connection. William Dally noted that there is implementation research around food insecurity as it relates to screening for negative social determinants of health in the health care setting and then connecting people with services to address food insecurity.

Dally remarked that the chief challenge is to modify people's behavior, and he asked if the working group considered economic incentives to accomplish that change. For example, a sugary soft drink surcharge could be directed to a broccoli credit to discourage unhealthy eating and encourage healthy eating. Woteki replied that behavioral economics falls within the area of conducting research to determine what interventions in that realm will work. She agreed that financial incentives will likely have an important role in changing consumer behavior.

With the discussion concluded, PCAST voted unanimously to accept the report.

PUBLIC COMMENT

Two minutes of public comments were provided.

CLOSING COMMENTS

Arnold adjourned the public meeting.

SESSION ADJOURNED: 11:11 AM Eastern Time

MEETING RESUMED: Thursday, March 14, 2024, 1:00 PM Eastern Time

ADDITIONAL PARTICIPANTS

UK PRIME MINISTER'S COUNCIL FOR SCIENCE AND TECHNOLOGY (CST) MEMBERS

- | | | |
|----------------------------|--------------------|--------------------|
| 1. John Browne, Co-Chair | 8. Ottoline Leyser | 15. Brooke Rogers |
| 2. Angela McLean, Co-Chair | 9. Max Lu | 16. Adrian Smith |
| 3. Julia Black | 10. Jim McDonald | 17. Paul Stein |
| 4. Muffy Calder | 11. Fiona Murray | 18. Nicholas Stern |
| 5. Suranga Chandratillake | 12. Paul Newman | 19. Paul Stewart |
| 6. Jim Hall | 13. Carol Propper | |
| 7. Saul Klein | 14. Keith Ridgway | |

Invited Speakers (in order of presentation)

1. Derek Cummings, Professor and Emerging Pathogens Institute Associate Director for Education and Graduate Programs at the University of Florida
2. Judith Green, Professor of Sociology and Director of the Wellcome Centre for Cultures and Environmental Health at the University of Exeter
3. Sarah Kapnick, Chief Scientist at the National Oceanic and Atmospheric Administration (NOAA)
4. Nick Pidgeon, Professor of Environmental Psychology and Director of the Understanding Risk Research Group at Cardiff University

WELCOME

PCAST Co-chairs: Frances Arnold, Arati Prabhakar, Maria Zuber

The PCAST co-chairs—Frances Arnold, California Institute of Technology; Arati Prabhakar, Assistant to the President for Science and Technology; and Maria Zuber, Massachusetts Institute of Technology—called the meeting to order. Prabhakar welcomed colleagues from the UK Prime Minister's Council for Science and Technology (CST) and said that international collaboration, and in particular the long-standing partnership between the United States and the United Kingdom, is critical for addressing the vast challenges and taking advantage of the research opportunities that lie ahead. In June 2021, she noted, the United States and the United Kingdom issued a joint statement committing to closer coordination between PCAST and CST. This statement accompanied the Atlantic Charter, a broader set of science and technology collaborations aimed at tackling global challenges. The United States and the United Kingdom reaffirmed their commitment to close collaboration in science and technology in the June 2023 Atlantic Declaration for a Twenty-First Century U.S.-UK Economic Partnership.

CST Co-chairs: John Browne and Angela McLean

CST Co-chairs—John Browne, founder and chairman of BeyondNetZero, and Angela McLean, Government Chief Scientific Adviser—thanked the PCAST and CST members for the work they put into preparing for this meeting. Browne added there are substantial collaborations between the United States and the

United Kingdom occurring every day. This meeting, however, represents an important symbolic and substantive moment to reinforce the fact that creating solutions requires working even more deeply together.

SESSION: GLOBAL CHALLENGES

Steve Pacala and Brooke Rogers introduced the session. Pacala said humanity faces a constellation of threats all of which have the capacity, with a high degree of certainty, to inflict large and accelerating damages. These threats require global actions to prevent, adapt to, and mitigate them, but today's global institutions are probably not adequate to do so. This meeting, he said, will focus on three of those challenges—climate change, emerging pandemics, and emerging antibiotic resistance—and their interactions with one another. The interactions that this joint PCAST-CST meeting is focusing on are not those tied directly to one another—that deforestation leads to zoonotic events and pandemics as well as climate change, for example—but the more difficult to understand and potentially more dangerous indirect interactions that arise from systemic, system-level feedbacks. An example of system-level feedback might be a heat event that triggers food shortages, which leads to conflict and an increase in refugees from violence, and subsequently a pandemic resulting from a zoonotic event and the combined stresses that overwhelm institutions on a continental or global scale. That these system-level interactions are murky and difficult to understand makes them more dangerous given it is difficult to prepare for something that is poorly understood. Rogers then introduced the four speakers.

DEREK CUMMINGS, UNIVERSITY OF FLORIDA

Cummings discussed the interaction between emerging pathogens and climate change with a focus on dengue, a mosquito-borne pathogen infecting about 100 million people annually, as an example of the challenges to respond to human infectious disease threats and pandemics. The public health community, he said, worries that a mosquito-borne virus will cause the next pandemic, as seen with the Zika and chikungunya viruses over the past decade.

The prevalence of dengue in the Western Hemisphere increased significantly in the 1980s, said Cummings, and the experience of controlling dengue can provide important lessons pertaining to the challenge of responding to future pathogens. Over the next 60 years, dengue will spread from its current distribution in southeastern United States into the Midwest and up the Atlantic coast, with parts of southern Europe projected to be more conducive to transmission. Climate change's more significant effect will be to intensify transmission in regions where dengue is already present. Climate change, particularly changes in temperature and rainfall, will alter how effectively the virus transmits between mosquitos and humans.

Today, said Cummings, a record number of dengue cases are occurring in Brazil, other parts of South America, and across Southeast Asia because of enhanced climate variability and El Niño events. This is analogous to the effect that warming oceans have on increasing the frequency and intensity of hurricanes and the intensification of societal disruptions. Cummings noted that dengue has the potential to have substantial swings in case numbers from season to season that can be up to 30 times as great from one year to the next. This creates incredible stresses on health systems, where wards meant for treating other diseases must become dengue wards. Thus, dengue can have a broad impact on health systems that extends to other conditions.

Cummings said these dengue outbreaks present an opportunity to prepare for pandemics of newly emerged pathogens by building expertise and competencies and testing strategies and systems. It is also a clear opportunity to build trust with the public. Mistrust can be a barrier to responding effectively to pandemics, as seen with the SARS-CoV-2 pandemic. Dengue and other mosquito-borne pathogens disproportionately affect people with few resources, making it imperative to engage low-resource communities, build trust, and develop the capacity to respond to large outbreaks or novel pandemics. One way to do that is by responding to a community's needs year in and year out. Cummings noted that informal, low-resource communities that arise on the fringes of cities provide a focal point for infectious diseases, increasing transmission intensity, further marginalizing these communities, and creating a reinforcing cycle of poverty and disease transmission.

The Zika pandemic, said Cummings, illuminated a blind spot in the response to a pandemic—the ability to detect the burden these pathogens create. The Zika pandemic occurred with little notice of the widespread transmission in Brazil and other South American countries until cases of microcephaly started appearing seven to nine months after the big outbreaks. In one region in Brazil, Zika virus infected 70 percent of the population in five months, with most cases being mildly symptomatic or asymptomatic. Serologic analysis to reconstruct the outbreak showed it to be one of the largest infectious disease outbreaks in intensity, space, and time in recent human history, yet systems were not set up to detect the outbreak and characterize it.

JUDITH GREEN, UNIVERSITY OF EXETER

Green focused on the role of knowledge about and from the public in developing an appropriate national response to a global pandemic. She noted that “the public” is not just an aggregation of individuals in a particular national population, but rather complex, diverse, plural entities that deserve a more sophisticated way of thinking about them in the context of global health challenges and pandemic planning. For example, the threat of an avian influenza pandemic in 2004 triggered a call from the World Health Organization for an international response that contained the outbreak to Southeast Asia using a response that was oriented primarily to protect the global north. In one at-risk country, Zambia, international programs aimed to contain an outbreak largely through measures such as trade bans or improving biosecurity, but these measures were largely inappropriate. Based on their experience containing the outbreak in Asia, international responders identified small-scale and backyard poultry producers as the major biosecurity risk in Zambia, even though Zambian backyard farmers were far less likely to interact with wet markets and the mixed farming systems typical in Southeast Asia.

In addition, said Green, international planning for the avian influenza epidemic did not account for Zambia's trade and development priorities that emphasized cattle rather than poultry production, limiting the resources available to plan for and react to an outbreak of avian influenza. This shows the difficulty in protecting at-risk countries where the interventions do not align with immediate priorities. Another confounding factor was the gaps in knowledge transfer between ministries at the national level that led to hard-to-enforce trade bans in a country with a porous border and limited veterinary expertise to manage livestock movements across national borders.

Green said this is not an example of policy failure, but one illustrating the importance and difficulty of making an international, coordinated response that at a national level pulls in the right kind of knowledge in the right places to craft the most effective responses. The knowledge to do so existed. National trade

and development experts knew about export needs, small-scale farmers knew about how they interact with markets and manage their livestock, and veterinarians were aware of their limited capacity. However, this is the type of knowledge that does not get mobilized in the right time and at the right place to craft an appropriate response.

It is easy, said Green, to identify the information needed to act after the fact, but harder to think ahead and maximize a system's ability to mobilize the right kind of knowledge at the right time and in the right place. One common thread that comes from retrospective analyses is that knowledge from publics and about publics—both how individuals and publics of various kinds operate as a system in a complex manner—is missing from planning activities.

Green said the COVID-19 pandemic is a good example of how knowledge from and about different publics was systematically ignored in some public health messages. Here, public health treated publics as an empty vessel where people knew nothing and were waiting for expert guidance to educate them. In addition, publics in many countries in Europe and the Americas were positioned as a national public that needed defending. Even when not positioned as passive entities, publics were assumed to be ignorant of or resistant to new knowledge, easily duped by fake news on social media, and needing strong, clear, unambiguous messages. However, faced with rapidly evolving and uncertain scientific knowledge, the UK public was engaged in an adaptive process of working out how to live with a virus that was not well understood by experts or publics. Communities were sharing information with each other on how to manage infection risks from shopping, for example, and how to make a homemade mask. They were also developing resilience through active community organization. While this reaction was known, work to map public expertise did not occur and that knowledge was not mobilized in real time.

SARAH KAPNICK, NOAA

Kapnick said climate change triggered by increases in atmospheric concentrations of greenhouse gases is increasing the frequency and intensity of extreme weather events and natural disasters such as intense heat waves, coastal flooding, rainfall events, severe drought, and heightened wildfires. While typically these are treated as isolated events, they are connected and the resulting risks are more than the sum of the risks from individual events. The fifth U.S. National Climate Assessment identified compound events in 2020 and 2021, such as the timing of extreme heat, drought, and fire events in the U.S. West and multiple destructive tropical cyclones along the U.S. East coast, all superimposed on the COVID-19 pandemic. Though one can think of each event individually, they are not independent of one another. Moreover, these occurrences are changing, compounding their impact on a society built for a climate that no longer exists. She added that people are having a hard time conceptualizing what it is like to have compound events.

While extreme weather and climate events attract the public's attention, said Kapnick, there are also slower environmental shifts associated with climate change that also create important risks. For example, Valley Fever is expanding across the United States from its limited range in the U.S. Southwest. By the end of the century, projections show it spreading all the way to the Canadian border as the climate warms, soils dry out, and the fungus that causes Valley Fever finds more hospitable places to thrive. In another example, increasing carbon dioxide levels in the ocean are affecting biogeochemical cycles, particularly those associated with plankton, but the net effects and downstream impacts on the marine food web or even the oxygen content of the atmosphere are unclear.

Kapnick said in both of these examples, the ability to characterize and manage the associated risks is predicated on the robustness of monitoring systems and the veracity of models that can assemble information and provide insights into what is happening between observation gaps and forecast changes over the coming hours to decades. There is good news, though. Modeling and projections of future climate conditions have improved dramatically over the last few decades as an understanding of the climate system and its responses has improved. Even in simulations with uncertainty, such as how ice sheets will respond to global warming, researchers have developed scenarios that can assist in planning for the future. NOAA has built a website where people can access information to understand what the future holds.

Pivoting to a discussion on challenges, Kapnick said that the first challenge is that while there is an abundance of information about the future climate, the nation struggles to infuse this information to many local-scale decisions that affect land use, infrastructure, housing, public health, and natural resources. More community-scale engagement is needed to help planners and community leaders identify where they can access great climate information and use it to inform decision making. NOAA has been working with communities in the U.S. Virgin Islands on hurricane preparedness, in Phoenix on extreme heat, and in Honolulu on resilience plans for cities, but these efforts need to be scaled for all nations.

A second challenge, said Kapnick, is addressing the limited understanding of economic exposure and vulnerability. Ongoing research is focusing on translating physical climate risk into economic terms, and while it is possible to demonstrate that the effects of climate change are costly, most studies only look at individual parts of the economy. Key questions such as, 'how will climate change affect spending over a 10-year period?', 'how the effects of climate change will ripple through labor, insurance, and credit markets?', or 'how will industries reallocate resources or change regions in which they operate following extreme events or in anticipation of climate change?', remain unanswered.

Kapnick's third challenge relates to the inequities in society that come into play for individual groups that are most exposed and vulnerable to climate effects. In many cities across the United States and the world, people with the lowest incomes are more likely to live in the warmest parts of a city with less shade and vegetation to offset heat extremes. NOAA is mapping these locations and working with community managers to reduce these adverse effects. This is one example of where there is a need to understand where there are vulnerabilities associated with climate change and how to respond to reduce that vulnerability.

Kapnick asked whether enough is being done and if resources are being directed appropriately. Until recently, less than five percent of public and private resources were directed toward adaptation, though that figure has increased recently to between five and ten percent of total global finance. She argued that while mitigation is important for addressing long-term climate change, the world needs to start managing adaptation. Extreme events are here and having significant financial and societal effects. Adaptation, she said, requires a multi-scale approach heavily weighted toward local scales. Adaptation involves an economic equation for which many terms are not well known, and will force the nation and the world to confront deep societal inequities.

NICK PIDGEON, CARDIFF UNIVERSITY

Pidgeon said when thinking about the interactions between the risks the world faces today, it is important to not lose sight of their commonalities. One commonality is the human element, and human factors often contribute to risks and bad outcomes in complex ways. The International Risk Governance Council (IRGC) calls this systemic risk. Because major disasters have complex conditions leading to the disaster, there is a need to focus on socio-technical resilience and environmental and engineering resilience. For example, while the space shuttle Challenger disaster resulted from a combination of factors on launch day, the real causes were production failures, a failure to understand the risk over time, and a poor safety culture at the National Aeronautics and Space Administration.

How people perceive risk matters, said Pidgeon. People use a range of factors to appraise risk, including benefit and cost, trust in others, equity issues, and the values and narratives of everyday life. In addition, risk perceptions can change quickly, either through social amplification or risk attenuation. These changes in perception can have real consequences. For example, in autumn 2013, a virulent fungal disease that was far down the list of the UK Biosecurity Risk Registry suddenly had the Environment Minister asking why they were reading newspaper accounts that a fearsome new pathogen was about to decimate the nation's ash trees. Pidgeon and his colleagues examined why this issue went from nothing to a big national controversy within a month, and it was clear that the threat to a key national symbol—the ash trees—combined with a lurking, invisible killer over which there was little control, fueled the flames of the controversy.

Pidgeon explained that many risks, whether biosecurity, climate change, or industrial hazards, have layers of uncertainty. Sociologist David Collingridge coined the term “dilemma of control” to explain how to deal with this uncertainty. Early in large, complex technology projects, when there is still the opportunity to steer a project to address possible risks, uncertainties and ignorance about possible consequences abound. When such consequences become clear, it may be too late to adjust course since policies, supply chains, and technologies are already set in place, making them difficult, expensive, and time consuming to change. The solution to this dilemma, in the face of uncertainty, is to put a premium on reversible decision options, monitor for emergency issues and hazards through ongoing learning, and have flexible organizational norms that can prepare a project to change course as it proceeds; which IRGC calls “resilience through adaptability.”

One issue, said Pidgeon, is that society does not always learn and remember lessons from prior incidents, and so preventable disasters still occur. There is an argument that there are facets of globalization that have generated great economic wealth and social benefit around the world and at the same time are making hazards recur in ways that happened in the past. Digitalization that decouples physical processes and human decision-making processes, externalization of responsibility and safety, new and opaque modes of financialization, standardization, and self-regulation all have implications for how to govern risks for all hazards, he added, in closing.

ROGERS AND PACALA MODERATED THE Q&A AND DISCUSSION BETWEEN PCAST MEMBERS AND CUMMINGS, GREEN, KAPNICK, AND PIDGEON.

Pacala asked Pidgeon if there any precedents for how to build adaptability into the global institutions that will have to manage global threats, given that global institutions are often pulled in many directions

simultaneously. Pidgeon could not provide an example of adaptability by a global institution, but there are precedents of large, complex institutions that have grappled with this problem. In the United States, the High-Reliability Organizations Program which looked at very large systems such as aircraft carriers and air traffic control, is one example, and researchers in Europe have tried to think through the dimensions of what a good safety culture would be.

Pidgeon said the lesson from these and other examples is that adaptability requires good monitoring systems within the organization and internal flexibility that overrides the standard controls and systems of operation when somebody spots something they think is a hazard in the making. The U.S. military, normally a hierarchical organization, has a norm in place that allows anyone with a junior rating to stop operations immediately if they see something amiss on an aircraft carrier flight desk. This type of flexibility, a part of the operating culture, is one factor that makes an aircraft carrier a high-reliability organization.

Kapnick said from NOAA's perspective, the only way to develop a plan to reduce exposures and execute as an event unfolds is to have an early warning system. Observations are critical for an early warning system to identify an event when it is starting to occur, which can enable early deployment of mitigating factors. A critical stage occurs after an event when it is important to gather information and use it to plan how to reduce vulnerabilities and build resilience.

Cummings commented that because of the urgency of responding to an event, there is often a devaluation of flexible surveillance that is not targeted towards creating a specific intervention to implement in the short term. This limits the collection of information that could prove useful later. He suggested developing a global serum observatory to produce generalizable, analytical, and logistical frameworks to observe what is going on in populations before, during, and after a pandemic that enables certain populations to make adaptable and flexible decisions.

Horvitz asked if it is possible to compute qualitatively or quantitatively and propagate measures and models of uncertainty that would carry into visualizations that do not look at specific point estimates. Cummings replied that with spatial information, it is important to quantify and communicate uncertainty and to recognize the potential to misunderstand the system. Green commented that the scientific community is not good at communicating uncertainty to the public and as a result, overstating the certainty of science usually leads to dysfunctional outcomes. Pidgeon added that communicating well-structured risk issues is rather straightforward, but more ill-structured problems with deeper uncertainties require having two-way conversations with people. Here, the challenge is not about presenting and explaining the science but to understand how the science plays into people's pre-existing knowledge. An important part of communicating in the face of uncertainty is to provide people with steps they can take to protect themselves regardless of that uncertainty.

Kapnick noted that the climate change field is developing better approaches for characterizing uncertainty, though the problem becomes more challenging when trying to determine how uncertainty affects social impacts. NOAA, for example, has been studying whether it would save more lives to extend tornado forecasting out to an hour or to ensure that people are accessing the forecasts. NOAA's finding was that ensuring access had a bigger effect on reducing deaths than extending the time.

McLean asked Kapnick if there is a way to determine if nations are spending their climate change funds correctly. Kapnick replied that the balance between mitigation and adaptation affects whether money is being spent appropriately. Early research shows that every \$1 spent on resilience and adaptation produces \$6 in savings from outcomes. The issue is that the amount of money spent on mitigation affects how much adaptation is required given that the amount of mitigation that occurs changes climate trajectory. She said the science of determining how much to spend on adaptation in the context of mitigation is a new and active area of research.

Tao asked the panelists to address the trade-off between the speed of responding to a pandemic and the quality of the response, given that responding hastily can lead to poor policy decisions that will have to be reversed later, while waiting too long to deploy a high-quality response may make it too late to contain the pandemic. Cummings said the answer is tied to the treatment and communication of uncertainty. Fast responses often run afoul and need to be changed later when communication about decisions and uncertainty is poorly done. Improving communication can help mitigate the risk of making quick decisions without the benefit of good information.

Green said the challenge with this question is that the counterfactual never occurs, that is, there is no information about what would happen with no pandemic response. What would be useful is to have better methods for determining the relationship between planning and spending decisions and outcomes.

Kathryn Sullivan, who served on aircraft carriers during her time in the Navy, said the flexibility Pidgeon described is a result of a carefully inculcated culture of situational awareness and situational authority to act that is simple for everyone, from an admiral to a sailor with the lowest rating, to understand. A similar culture exists at NASA Mission Control. She wondered how that type of operational culture could be brought into more complex sociopolitical structures and communities that are planning and responding to disasters. Pidgeon replied that how the Navy's culture developed is an interesting anthropological question that research can address. Until 25 years or so ago, a universal culture of situational awareness did not exist in the aviation industry. Even when airlines started to develop such a culture, primarily through training, one issue was that the flight attendants did not feel they had a safety role and that if they had, certain failures might have been avoided because the crew in the back of the aircraft sees things that pilots need to know. This has led to new approaches to training that brings the flight deck and cabin crews together to inculcate situational awareness. He acknowledged this approach would be difficult to implement at a political level.

Andrea Goldsmith asked the panelists to identify mechanisms they have found that either work or are missing from their collaborations in research and crisis response. Kapnick said she sees research occurring organically between scientists, but the difficulty is finding people internationally to work with as a crisis unfolds, which is where engagements at the leadership level are helpful. Building those relationships takes time and requires developing trust between partners over the long term.

Julia Black said it is expensive to prepare for something that might not happen, leading to the challenge of accessing funds from the capital markets and getting political buy-in to develop redundancy in a system. Stress testing, scenario analysis, and reverse stress testing—determining how big a crisis has to be to break a system—can help address this challenge by demonstrating that redundant capacity is necessary to avoid a disaster. She wondered about the extent that scenario analysis is being done, either at a national or global level. Kapnick said she is seeing reverse stress testing being done more often for climate

resilience discussions, particularly regarding the built environment. Reverse stress testing can identify many risk factors beyond those that are obvious.

Cummings said in the public health sphere, there are pathogen-caused outbreaks every year that can inform stress testing and reverse stress testing activities. The responses to those outbreaks provide an opportunity to evaluate various mechanisms in less dire circumstances, such as a seasonal influenza outbreak, that would be deployed when the risks are much greater. What is needed, he said, is more empirical work on how the public evaluates and responds to different possible outcomes without having experienced them. Green added that it is important to understand how different actors and nations might prioritize different outcomes.

Arati Prabhakar asked the panelists to discuss their favorite example of how learnings are translating into new institutional capacities that should improve response to a particular crisis. Pidgeon noted a phenomenon called the atrophy of vigilance, where people, institutions, and nations forget lessons learned through experience. For example, he worked with a major airline that was struggling to learn from its incident report given they could not use the formal risk-and-uncertainty matrix provided by aviation authorities designed for high-frequency, highly catastrophic events that do not happen in aviation. It turns out assessors were learning by looking at the number of safety barriers breached during an incident and trying to work out what had gone wrong in that incident. He said there are opportunities to establish retrospective learning systems for natural hazards and pandemics. The key is having good information to power such learning systems.

Kapnick said something that is going well is the response to the realization that large heat waves are a problem in places without much experience with heat waves. To address this issue, NOAA and the Centers for Disease Control and Prevention created the National Integrated Heat Health Information System to develop and provide actionable, science-based information that can be used to protect people from heat. Going forward, she sees an increased need for coordination on resilience, though the issue here is determining what type of resilience is needed in the context of the appetite for risk of an exposure.

Cummings said there were many triumphs during the COVID-19 pandemic, including the rapidity with which vaccines and therapeutics were produced. These successes resulted from scientific advances coupled with the ability of the regulatory and scientific frameworks to evaluate interventions rapidly. He would like to see better surveillance frameworks established that can provide the next level of understanding systemic interventions, such as how different societies respond to pandemic threats and how effective those responses are.

Green said one thing that worked well in the UK's response to the pandemic was its implementation and rollout of its vaccine program. This involved both a high-level health system response and mobilization of a significant public response in terms of the number of volunteers who worked at vaccine centers. To her, this was a good example of when communication hits the right level of evoking commonality between publics and trust. She noted the biggest challenge in her mind is to repair the loss of trust the public has in science.

SESSION: ANNOUNCEMENT OF A JOINT STATEMENT

Rogers introduced the co-leads of the PCAST and CST Joint Committee, Jonathan Levin and Vicki Sato from PCAST and Jim Hall from CST. Levin explained that at the conclusion of the public meeting, PCAST and CST would release a joint statement addressed to President Joe Biden and Prime Minister Rishi Sunak that will outline PCAST and CST's shared views on priority issues for science and technology and areas for future collaboration between both councils and between countries. He noted the statement would be posted on the PCAST and CST websites.

Hall commented that the interactions between PCAST and CST are the tip of the iceberg regarding the scientific and technological interaction between the United States and United Kingdom. The joint statement, he explained, will say that PCAST and CST are committed to the importance of scientific evidence in addressing these challenges and to the opportunities which technology bring to addressing them. He noted that the day's discussions have illuminated the fact that while there is much to learn about addressing risk and resilience, he is optimistic that responsible innovation will help address some of the critical challenges the panelists raised, improve human well-being, and lead to greater prosperity.

CLOSING COMMENTS

Browne said he had four takeaways from the discussion. First, it is imperative to focus on fairness and incorporate the global south with the global north with regard to adaptation. Second is the realization that implementing large-scale responses will only work with a deep understanding of local consequences. Third, it is imperative to engage with communities and do a better job of communicating risks with a balanced view, though striking the right balance is difficult. Fourth, it is important to work on permanently learning lessons from the past. In his experience, it takes far less than a generation to forget lessons and reinvent them.

Maria Zuber thanked the speakers for their insightful presentations and the council members for their thoughtful discussions. To her, the session highlighted the real challenges facing the United States, United Kingdom, and the rest of the world. She then thanked the PCAST-CST Joint Committee for organizing the session and drafting the statement and reminded the participants that the leaders of the United States and United Kingdom asked for the two councils to get together because they see these challenges and realize how important science and technology are for solving them. Clearly, she said, the world will be better off facing these challenges together rather than separately.

PUBLIC MEETING ADJOURNED: 2:45 PM Eastern Time

In the preparatory sessions that were not webcast, PCAST subcommittees provided administrative updates on the status of each working group. PCAST staff provided updates on upcoming meeting dates and members discussed possible locations for an in-person meeting outside of DC. I hereby certify that, to the best of my knowledge, the foregoing minutes are accurate and complete.

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