Using Narrative and Data to Communicate the Value of Science: Proceedings of a Workshop—in Brief

DETAILS

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Proceedings of a Workshop

IN BRIEF

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How should we convey science—both its findings and its value to society—to the many members of the public who lack either scientific training or intense interest in scientific progress? This proceedings in brief summarizes a workshop held in October 2016 by the Committee on Science, Engineering, Medicine, and Public Policy to explore ways of better presenting science—both specific findings and the processes of discovering and confirming—to the public.

The workshop was one of a series of workshops sponsored by the National Science Foundation's Science of Science and Innovation Policy program that were designed to identify upcoming challenges and contribute to the development of a research agenda. The program funds "scientometric" research: that is, efforts to develop models, analytical tools, data, and metrics that can be applied in the science policy decision-making process and that concern the use and allocation of scarce scientific resources. This workshop was designed to explore how this research could be communicated most effectively to policy makers and the public.

According to the workshop's charge, "An ad hoc committee will convene a public workshop to explore how two important streams in science communication might be combined to create an effective format for illustrating how scientific research contributes to important social goals such as a more productive economy, better public health, a more sustainable environment, and enhanced national security. The two streams are narrative and improved scientometrics. The goal of the workshop is to bring together science communications scholars, writers and editors, scientometricians, and scientific researchers to discuss ways to develop data-enriched narratives that communicate to the public and policy makers in an engaging and rigorous way the work of basic research. Participants will also discuss the varied ways in which research provides the foundation for products, services, and activities that are of broad benefit to humanity."

In addition to exploring new approaches to scientometrics and methods of integrating narrative with accurate scientific information, speakers examined the current state of public opinion about science, scientists, and a variety of science-based issues, which forms a baseline for presenting ideas and information. They also discussed the methods that communication research has found to be effective in presenting and integrating information about science. Following welcoming remarks by planning committee Chairman Richard Zare, the workshop consisted of five sections, each composed of one or two expert presentations, followed by questions. The day ended with a brief period of general discussion. The segments were:

- "How Do We Assess the Quality and Value of Science?" presented by Diana Hicks of Georgia Tech University, which compared two methods, one scientometric and one narrative, of assessing the quality and effectiveness of research.
- "What Do We Know About Public Attitudes toward and Knowledge about Scientific Research?" presented by Chris Volpe of Science Counts and Cary Funk of Pew Research Center, which discussed research on the public's opinions about science, scientists, and several issues involving science.
- "Overview of How the Public and Policy Makers Form Their Opinions and What We Have Learned about How to Influence Them," presented by Kathleen Hall Jamieson, director of the Public Policy Program at the University of Pennsylvania's Annenberg School, which examined the Zika virus emergency as a case in point of communication about science.
- "Case Studies of How the Public and Policy Makers Respond to Communications Efforts on Specific Topics," presented by Talia Stroud of the University of Texas and Ed Maibach of George Mason University, which describe effective and ineffective ways of communicating with the public about two divisive issues, vaccination and climate change.

- "How Can Narrative Be Used Effectively to Explain Complex Subjects in an Engaging Way?" presented by Lee Gutkind of Arizona State University and editor of *Creative Non-Fiction magazine*, Laura Helmuth, science editor of the *Washington Post*, which describe techniques of constructing narratives that convey information about science.

Richard Zare noted that for many people in the scientific world, "if they can't count it, it doesn't count." COSEMPUP director Kevin Finneran added "Policy makers and the public. . .don't think like data analysts and generally do not connect with the charts and data that scientists use to communicate their results, instead find them confusing and alienating. People everywhere respond to narrative, often known more simply as storytelling, and it appears to hold promise for explaining science—both its findings and its role in society—in a way that wide publics not only understand but relate to."

1. Quantitative evaluation should support qualitative, expert assessment
2. Measure performance against the research missions of the institution, group, or researcher
3. Protect excellence in locally relevant research
4. Keep data collection and analytical processes open, transparent, and simple
5. Allow those evaluated to verify data and analysis
6. Account for variation by field in publication and citation practices
7. Base assessment of individual researchers on qualitative judgement of their portfolio
8. Avoid misplaced concreteness and false precision
9. Recognize the systemic effects of assessment and indicators
10. Scrutinize indicators regularly and update them

Figure 1 The 10 Principles of the Leiden Manifesto.
Source: "Bibliometrics: Leiden Manifesto for Research Metrics," *Nature*, April 22, 2015.

SESSION 1: HOW DO WE ASSESS THE QUALITY AND VALUE OF SCIENCE?

Diana Hicks explored the approaches used by scientomectricians to measure the value of science by discussing two different evaluation methods, one that uses data alone and one that combines data with brief, structured narrative accounts.

Reform of scientometrics is necessary because recent decades have seen "a growing amount of bad practice around the world, with badly constructed metrics of scientific merit becoming increasingly prevalent and influential," she said. Reasons for this trend include the ever more "widespread use of national systems of university research evaluation, on which a part of the funding of the university is based."

The focus on using single numerical metrics has intensified since the 1980s. In those days, "a few of us experts would buy the CD roms from Web of Science or Thomson Reuters and do analysis largely at the country level." Since then, however, proliferation of different metrics and greater obsession with the numbers has now made it possible to measure all the way down to individuals and journals and papers and groups. "So we got into a situation really of metrics overload," Hicks said.

To help scientists who were being bombarded with poor metrics to fight back, Hicks and colleagues Paul Wouters, Ludo Waltman, Sarah de Rijke, and Ismael Rafols wrote an article that proposed a set of standards that they call The Leiden Manifesto for research metrics. (See Figure 1, The 10 Principles of the Leiden Manifesto.) Published in Nature in 2015 and thus far translated into 11 additional languages, their article is also the basis for a video that Hicks showed to the group and that is available at the website http://www.leidenmanifesto.org/.

The Leiden Manifesto identifies two important elements that should play significant roles in assessing the quality of research, expert judgment and clarity about the goal of a piece of research, Hicks continued. Both of these can help to protect locally relevant research and studies published in local languages from being devalued in favor of publication in English. Assessment methods should also recognize differences in publication and citation practices among fields, which can severely skew ratings based only on indicators such as number of citations. Percentile position within a field provides a much more accurate indicator than an absolute number. Judging a researcher's standing by reading and assessing his or her work gives the full picture, whereas a single number such as the H-index (which is a commonly used measure of a researcher's supposed productivity and impact) gives a one-dimensional view, Hicks said. She added that impact factors are customarily calculated to three decimal places in order to avoid ties, but added that the "false precision" of these numbers can create misleading comparisons. Furthermore, because each type of indicator creates particular incentives, using a suite of indicators protects against gaming the system far better than does any single indicator. In addition, indicators need to be updated regularly to reflect changing conditions and practices. "Abiding by these principles, decision making about science can be based on high-quality processes informed by the highest quality data," she said.

Turning from the Leiden Manifesto, Hicks next introduced a system used in the United Kingdom that employs narratives to assess the impact of research. Under the Research Excellence Framework, which is used to evaluate university research output and then distribute part of the central funding to the universities based on the results, universities submit case studies, i.e., narratives describing societal impact, Hicks explained. In 2014, 154 universities participated, submitting nearly 7,000 case studies covering a wide range of fields and disciplines (see Figure 2).

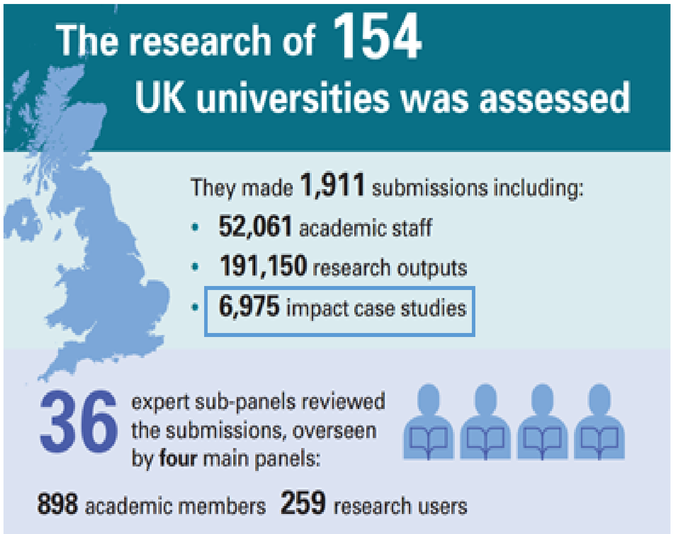

Figure 2 Scope of the United Kingdom Research Excellence Framework impact case studies.
Source: Available at http://www.ref.ac.uk/media/ref/content/pub/REF%20brief%20Guide%202014.pdf.
Reprinted by permission of Higher Education Funding Council for England.

This very rule-bound exercise requires that case studies not exceed 4 pages or 1,350 words and discuss impacts occurring between 2008 and 2013 based on research in the prior 20 years. Five hundred words may be devoted to describing the research, 750 words may be devoted to describing its impact, and the remainder to indicating references. The case studies must include evidence for what they are claiming.

Judged by panels of experts, the narratives revealed a wonderful cornucopia of productive activities happening at universities, a great reach and breadth and rich and sophisticated research ecology, and varied missions, all of which make the point that the government needs to keep funding research at this very high level so that more of this could be produced, Hicks said. Beyond that, the narratives illustrated numerous instances of unexpected results from research, which provide additional support for the argument for basic research. The rules did cause some problems, however. The 20-year timeframe proved just too short for the mathematicians, physicists, and classicists, and in some cases, the research and the evidence for impact were very far apart and there were a lot of intermediaries and a winding path to impact.

This narrative technique nonetheless has considerable power, as indicated by examples Hicks presented, researchers at the University of Nottingham's Children's Brain Tumor Research Center used a case study to describe how they were able to remedy the "unacceptably long delay between the first symptom onset and diagnosis of brain tumors in children, which occurred because [of] multiple referrals," she said. The researchers developed guidelines for diagnosing brain tumors in children, including symptom clusters for various ages and also created a card showing the clusters, which was widely disseminated to pediatricians and general practitioners. National Health Service data showed that the time from symptom onset to brain tumor diagnosis was reduced from 14 weeks to 7 weeks after the cards were introduced.

In a second example, Hicks described how researchers at Imperial College showed how they found that polio immunity thresholds vary among populations around the world. This finding helped the Polio Global Eradication Initiative improve its strategy to eliminate the disease. In a third example, Hicks described philosophers at the University of Essex using a case study to show how beneficence, which is a principle underpinning medical care, functions in decision making about patients unable to make care decisions for themselves. Findings from studies of the Court of Protection, which adjudicates disputes in this area, have had influence on framing the guidelines for patient care. A final case, from Glasgow, involved research that resulted in guidelines and software that aid ambulance personnel in determining whether patients need emergency care from specialist cardiology units. Used by the London Ambulance Service, these tools improved the survival rate of patients with cardiac arrest. The Research Excellence Framework is state of the art right now for establishing impact from research, Hicks said. Many universities publish their cases on their websites to inform the public about the impact of their research.

Hicks concluded that "we'd like to think that our little *Nature* paper is trying to raise the state of the art in the application of metrics to evaluating the scholarly impact of research, and the state of the art in evaluating societal impact is really these narratives, evidenced, structured, well written, and providing a resource for the universities themselves to talk to society about the benefits that they're producing."

SESSION 2: WHAT DO WE KNOW ABOUT PUBLIC ATTITUDES TOWARD AND KNOWLEDGE ABOUT SCIENTIFIC RESEARCH?

In this session, Chris Volpe, executive director of Science Counts, reported on recent survey data collected in cooperation with Research!America and some of the professional societies. In addition, Cary Funk of the Pew Research Center spoke about a series of polls conducted in cooperation with the American Association for the Advancement of Science (AAAS) that examines demographic details of age, education, and political party, and how opinions differ across a number of specific topics such as climate change and genetic engineering.

Volpe described his organization as a new nonprofit devoted to bringing people to the table concerning science and said he would be presenting the results of a project called "Raising Voices for Science," which studied Americans' attitudes toward science. First, people generally like science a lot. This refers, however, to science in the abstract. The minute you get down to particular topics there are certainly issues that polarize opinion. Research over the years consistently shows, however, that people respond very favorably to the word "science"—and that's good news.

The bad news, however, Volpe continued, as shown by a study of public opinion about the federal budget done in 2011-2015, is that when people are asked which programs should be cut to reduce the deficit, science was at the top. "So they like science, but it's the first thing to get tossed out the window if you have to cut something," he said. Significantly, the category of science excluded medical research, which people were much less likely to want to cut. Asked to describe the benefit of science, people almost always mentioned medical research and its ability to cure disease—an answer explained by the ease of relating emotionally. When people are asked for non-medical benefits, "that's where you get chin scratching," Volpe said. "So that's the bad news."

"From our results," Volpe continued, "the public does not differentiate among science, technology, engineering, mathematics; it's all the same bucket. We have done a wonderful job in promoting STEM and convincing people that it's all the same stuff," and the results of this study cover all four areas.

The study examined the "emotional lens" through which people view science to see "what message platforms, what themes resonate. . .and what don't" with different segments of the public, because in thinking about science, "there is no such thing as the public [in the sense of an] amorphous blob." A word association test that asked people to rate 15 words associated with science as either positive, neutral, or negative showed that those viewed most positively were aspirational: discovery, invention, and technology. The least positive, unfortunately, were those like investment, federal, and public, which are used a lot, especially in Washington, DC, when communicating to the public and trying to justify and rationalize investment in science and technology.

Summarizing the study's nine major findings from the study, Volpe noted that;

- The public likes science and trusts scientists.
- People do not understand the pivotal role of the federal government in funding science. In fact, "the general public has no idea how science is funded, they have no idea how the government plays a role in that as well." Asked what would happen if the federal government stopped funding science, half the respondents said that industry and philanthropists would replace the federal contribution, a quarter were unsure, and only a quarter worried that total funding would decline. As revealed in a number of questions, Volpe explained, the general perception is that government plays a role in funding science and performing science—an ancillary role, not the central role—and that most research is done by the private sector, by corporations to put products on a shelf.
- Ideologically, people feel that both government and the private sector have a role to play in science.
- The public can be divided into four segments along a spectrum of willingness to engage in the issue of supporting science. Using the metaphor of an automobile, the most engaged, whom Volpe termed the drivers, constituted 17 percent of the population. Older, whiter, more likely to own their homes, more liberal and more educated than the others, and likelier to live in the Northeast and the West Coast, they are also much likelier to vote. Two intermediate groups, called the front seaters, representing 19 percent, and the back seaters, with 52 percent, were somewhat less likely to vote, somewhat less educated, and most represented in the South and Southwest. The group termed disengaged, constituting 12 percent were by far the least likely to vote and also younger, more likely to belong to minority groups, and least likely to be homeowners.
- Americans are quite open to altering their position on federal funding for science in a favorable direction if given information about the benefits of research.
- There is a vocal minority of Americans who are against science across the board, but they constitute only a few percent of the population. For Americans generally, "science is hope. That is the brand." Americans "see science as a means. . .to usher in a better tomorrow Getting into details may dispel that romantic view. But science is hope, those two are synonymous."
- Such branding is "incredibly important," Volpe added, noting that "Harley Davidson does not sell motorcycles, they sell freedom. That's why you never see a Harley Davidson commercial of someone stuck in traffic in Manhattan, or on a winter day. It's a beautiful day, hair in the air, someone riding behind you. Coca-Cola sells refreshment. Apple until recently sold irreverence." When the message is consistent that science is hope, "we're going to get results."
- It is important to talk about science in terms of benefits. "This is sales 101, you always talk benefits, not features, and we as scientists sometimes have a difficulty doing that."
- Engaging people depends on presenting arguments in the right order. Beginning with data, charts, and economic arguments has proven ineffective. People respond favorably, however, when they "hear a dream, when they want to hear how you're going to make something better for a person, for a community, for the country. And then after that, after you have that engagement, that's where some other data may fit in to support that argument in favor of research."

Funk explained that she would also be presenting recent research on the public's views and understanding of science and scientists from the Pew Research Center. Looking at science as a general enterprise, the public holds mostly favorable attitudes, but the consensus breaks up and assessments become more mixed once attention turns to particular issues and the changes that science and technology may bring, she said. Beyond that, the key factors underlying people's views also tend to vary, with many individuals and professional societies in the scientific community rethinking how to engage with policy makers and with the public. Some of the data spur concern among many in the science community, even though the public does continue to have positive views about the scientific enterprise generally.

When asked about science's effect on society, for example, two-thirds of Americans called it "mostly positive," with only 4 percent calling it "mostly negative." Consistent with Volpe's findings, Funk said that several Pew surveys confirmed that "the dominant link here is with medicine and health." People also recognize other benefits for society, "but medicine and health tend to dominate public thinking," especially new treatments. Reinforcing Volpe's observation that "science is hope," Funk noted "a strong public expectation for continued innovation" from science and technology. For example. . ."roughly two-thirds of Americans expect that we will find a cure for most forms of cancer within 50 years [and] nearly half of Americans think we're going to eliminate almost all birth defects through gene editing" during that period as well.

Innovation means change, however, and the optimistic and positive view co-exists with mixed feelings and concerns about what changes will mean for society. Potential innovations aimed at enhancing human health though editing genes to reduce disease risk in babies, implanting chips in the brain to improve cognitive abilities, or using synthetic blood to enhance physical ability inspire more worry than enthusiasm. Most respondents expect more negative than positive effects and nearly three quarters of Americans expect gene editing, brain chip implants, and synthetic blood substitutes to be used before we fully understand the effects. Those wishing to communicate with the public about science therefore need to remember that the experience of science in people's lives is often fluid, it's changing over time, and it's bringing a wide range of changes to people's lives. Distinguishing between the public's opinion of science as a whole and opinion about the large variety of particular scientific topics and issues is therefore important.

Opinion also differs sharply on a number of issues between the general public and those more knowledgeable about science, such as members of the American Association for the Advancement of Science (AAAS). A 51 percentage point gap, for example, separates those two groups on whether genetically modified foods are safe to eat, with 88 percent of AAAS members thinking they are but only 37 percent of U.S. adults generally agreeing. Other important gaps include whether animals should be used in research (47 percent of the general public and 89 percent of AAAS members agreeing); whether humans have evolved over time (65 percent of the public and 98 percent of AAAS members agreeing), and whether humans are mainly responsible for climate change (50 percent of the general public and 87 percent of AAAS members agreeing).

Analysis of public attitudes over 22 issues revealed no single factor that explains public attitudes across a wide-ranging set of topics. Sometimes political factors are key, sometimes it's education in science knowledge, sometimes it's religion, sometimes it's something else altogether (see Figure 3).

Politics, for example, is pivotal concerning climate change, with consistent and growing disagreement between Democrats and Republicans about whether human activity is causing the planet to warm (see Figure 4).

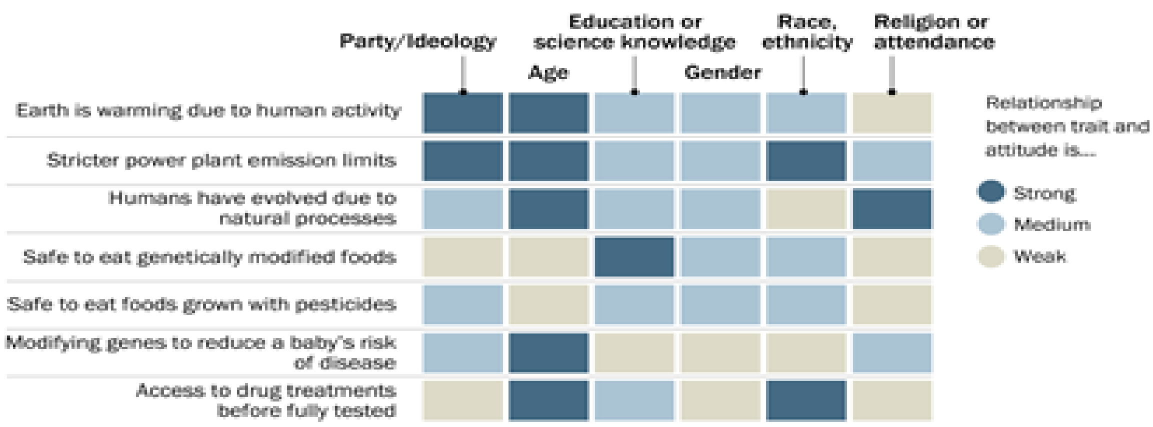

Figure 3 Wide mix of factors influencing public views on science-related issues.
Source: Pew Research Center survey of U.S. adults August 15-25, 2014.
Note: Chart shows relative strength and significance of each factor or set of factors.

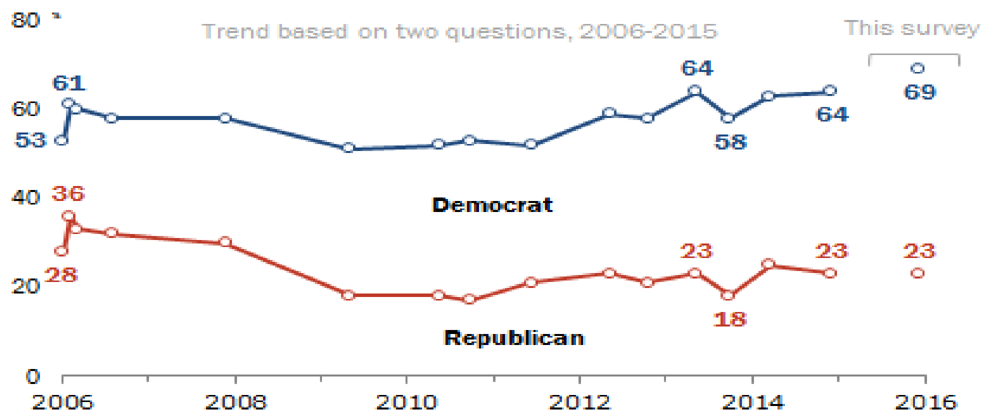

Figure 4 A decade of political division over climate change.
Source: Pew Research Center surveys of U.S. adults 2008 through May 10–June 8, 2016. The Politics of "Climate."
Note: Republicans and Democrats include independents and other non-partisans who "lean" toward the parties. Respondents, who do not lean toward a political party, those saying "don't know," and other responses are not shown.

The public has a skeptical view of climate scientists, Funk continued. Only a third of Americans believe that scientists have a good understanding of whether climate change is happening, 28 percent believe that scientists understand the causes of global climate change very well, and 19 percent believe that scientists understand very well the best ways to address it. Fifty-five percent of liberal Democrats believe that almost all climate scientists agree that human activity is causing climate change and an additional 23 percent believe that the majority of climate scientists agree, while the comparable figures for conservative Republicans are 16 percent and 34 percent. For U.S. adults at large, the figures are 27 percent and 35 percent. As to whether climate scientists are trustworthy sources on climate change, 78 percent of adults say they trust them "a lot" or "some." Other sources trail them, with the news media at 43 percent, the energy industry at 41 percent, and public officials at 32 percent. Trust of sources is also "strongly polarized along political lines," with 70 percent of liberal Democrats but only 15 percent of conservative Republicans trusting climate scientists.

Opinion about climate scientists' motives also differs by politics, with 55 percent of liberal Democrats but only percent of conservative Republicans believing that the best available evidence influences research conclusions. More than half of conservative Republicans, but 16 percent and 11 percent of liberal Democrats, believe that career advancement or the scientist's political views are influential most of the time. Nonetheless, opinion on whether scientists should play a major role in climate policy is less divided, with 92 percent of liberal Democrats and 86 percent of conservative Democrats believing they should play at least some role.

Some other scientific issues are also polarized, but not by political identity, Funk continued. Republicans and Democrats agree (88 percent and 87 percent, respectively) that childhood vaccines are safe, but generations differ. Whereas 91 percent of those over 65 believe they are safe, and only 5 percent believing they are not, the comparable figures for people between 18 and 28 are 77 percent and 15 percent. Belief that foods grown with pesticides are unsafe has also been growing in recent decades, with gender and scientific knowledge playing large roles. Sixty percent of men are likely to believe them unsafe, whereas 38 percent believe them safe. The respective figures for women are 78 percent and 18 percent. Similar percentages divide people with more scientific knowledge, who are less likely to believe foods grown with pesticides unsafe, from people with less scientific knowledge. Nonetheless, "the influence of science literacy on people's attitudes about science issues tends to vary," Funk noted. "There are issues where it has a strong direct effect, and lots more where it does not."

Overall, confidence that scientists act in the public interest is high, with medical scientists ranking second only to the military among a range of professions, and scientists generally ranking third. This suggests that "deep political divides and skepticism that we saw when looking at climate scientists is primarily focused on climate scientists, and not really about scientists in general."

Clearly, "people's views about science differ, and what underlies them differs depending on the particular science topic we're talking about," Funk added. "Some science issues raise strong ethical concerns. We saw that a decade ago with embryonic stem cell research; we're likely to see that again with gene editing. Food issues are dividing the public in other ways altogether, neither religious nor political." Funk concluded that in communicating the value of science to a broader audience, "we probably need to be very nimble in order to reach common ground, because the fault lines of concern for people are so varied across the spectrum of science issues."

SESSION 3: OVERVIEW OF HOW THE PUBLIC AND POLICY MAKERS FORM THEIR OPINIONS AND WHAT WE HAVE LEARNED ABOUT HOW TO INFLUENCE THEM

To examine means of effectively communicating both science—the specific findings about a particular issue—and about science—the processes that scientists use to reach conclusions—to the public and policy makers, Kathleen Hall Jamieson chose the case of the Zika virus and the threat it poses to the United States. A key issue, she began, is determining if and when people, both the public and policy makers, are "susceptible to communication. . . .We know there are times in which people are. . .more likely to absorb information, and more likely to be influenced," she said. Scientists therefore need to be ready in those circumstances to tell them not just the science itself but about science in general.

Zika is an example of just such a circumstance because it is highly emotional and involves a new health threat to the United States, in addition to a familiar pest, the mosquito, and a serious risk to babies. In this kind of situation, the public and policy makers have the same concerns, Jamieson said. For months surveys by the Annenberg Public Policy Center have been tracking public awareness of the virus, its potential consequences for pregnant women and babies, and the possible means of reducing risk, such as spraying, practicing safe sex, and introducing a transgenic or genetically modified mosquito that would reduce the ability of offspring to reproduce.

"We know that when you've got high levels of existing attention and a credible source able to capitalize on the attention, at a time when people need to make decisions for which they will be held accountable, susceptibility to communication is high, and Zika meets each of those conditions. Policy makers need to decide on remedies, and individuals need to decide what actions they will take," Jamieson added.

Senator Marco Rubio [R-Florida], for example, stated that ordinarily he does not favor federal funding of things. But he wants funding for Florida, he wants the Congress to state responsibilities to increase the Centers for Disease Control and Prevention (CDC) funding for vaccinating, for its vaccination research, and for its distribution of Zika prevention kits. This has resulted in "conditions under which you're likely to be able to talk to the policy makers, and they're likely to pay attention, [so] now we have a susceptible audience in which we can communicate not just science but about science," Jamieson said.

With 60 percent of people in the United States—about 200 million people—living in areas that have the *aedes aegiypti* mosquito, which carries the Zika virus, the public is paying attention. Surveys show that 73 to 80 percent know that pregnant women infected with Zika are more likely to deliver a baby with an unusually small head and brain. Even before scientists had the confidence to say that the virus is related to microencephaly, the media were showing "graphic telegraphic visuals" highlighting affected children and mosquitos. "Every communication scholar knows [that this] would increase public knowledge quickly," because juxtaposed images "invite a causal inference, and news juxtaposed those images," Jamieson added.

Beyond having widespread public knowledge and concern, the nation also has a credible source because the CDC enjoys high credibility, "up there with NASA and with the military, [and] with the Supreme Court, [which are at] the top of that list." Jamieson noted that "When science speaks through that voice, science gets the extra credibility of not being a polarizing voice. It's not saying climate scientists today told you about Zika, or GMO scientists told you about Zika, it's the CDC. And so you have credible spokespersons coming into national media carrying a message." Jamieson continued, given this opportunity, "the message that they need to carry is not simply about the science but about the scientific process by which we know and we learn, because that's ultimately how we're going to shape attitudes" not only about the Zika virus but about science generally.

Jamieson next mentioned three important policy decisions that need to be made about dealing with Zika. First was President Obama's request for $1.9 billion in emergency funding, which was delayed when extraneous issues were inserted into the legislation; ultimately $1.1 billion was funded. Second, the decision about whether to use available pesticides was complicated because some desired to insert the issue of deregulation for chemicals that many consider hazardous. Therefore, "polarized politics is getting in the way of government appropriating money to solve the problem that is being visualized in the form of these terribly damaged babies." The third decision is whether to try to reduce the virus's spread by releasing mosquitos that have been genetically engineered to be unable to reproduce, a trial that the Food and Drug Administration has approved. In this last case, involving genetic modification, the choice of language—for example, "genetically modified" versus "genetically engineered"—can play a crucial role in acceptance or rejection. "You can engage in language that automatically polarizes, or you can open a window for people to hear you, and [though] the polarization may happen, but at least they've heard you before" that, Jamieson said.

Once the conditions are right for communicating science and about science, Jamieson continued, communications must be accurate and use accessible, precise language. The threat should be described, for example, as "mosquito-borne, sexually transmitted Zika virus." The public very clearly learned "mosquito borne," but "sexually transmitted has taken longer," and a "20 point gap in that knowledge" persists because CDC did not use "sexually transmitted" or call the virus a new STD. Had this language been used, the press would have "conventionalized" it at the outset. It's also necessary, Jamieson said, to call the infectious agent "Zika virus" rather than "Zika," in order to communicate the difference between bacterial and viral diseases and explain why there is no cure, why antibiotics won't work, and therefore why a vaccine is needed.

A further important communication issue is explaining why scientists did not immediately confirm a causal connection between the virus and microcephaly, even though the media had already implied that it existed. According to Jamieson, "When [the] voice of science speaking through the CDC [explains the process of confirming the connection], it is explaining that science doesn't just rush to say association equals causality; science is careful, science has testing mechanisms There are ways that you rule out causes and. . .ways that you rule in the possibility of causes. And when you have enough of these [factors] saying the same thing, the CDC will be comfortable saying it's causal." Such communication conveys the voice of science not as a partisan voice that rushes to judgment or says whatever is convenient to say in the moment, but rather that carefully looks at available evidence through a method that has rules that everyone accepts. This teaches how scientists reason and enhances respect for the scientific process.

Building such respect, Jamieson added, can help avoid damage like that caused when a bogus—and now totally discredited—scientific article launched a longstanding controversy by using fraudulent evidence to suggest that vaccinating children with the measles, mumps, and rubella (MMR) vaccine causes autism. Through the choice of effective and precise language, the discussion of genetically engineered mosquitos in the fight against the Zika virus could also offer an opportunity to educate about science rather than provoke controversy. Everybody has taken a position on GMOs for whatever legitimate or illegitimate concern, Jamieson said. But talking about genetic engineering could spread understanding of different kinds of gene manipulations because engineering the mosquito differs from engineering of food crops, especially as it is intended to minimize the likelihood that the mosquito will produce offspring that can reproduce.

The question of why there is no cure for Zika also offers an opportunity to emphasize the value of basic research and also of vaccination. That, in turn, offers the opportunity to explain what scientists mean when they say something is safe. "They mean there is some risk with everything, but that relatively this has lower risk [and] it creates more benefit than it does harm across populations," said Jamieson. This implies the need for research, and ultimately, she said, that means we have to fund scientists.

In short, Jamieson concluded, "The bottom line is we have the opportunity with Zika to tell people about science in ways that will ground their inferences about science in other kinds of controversies preemptively at the same time as we talk the specifics of this individual case."

A major worry, Jamieson added in answer to a question, is the perception that scientists are partisan, because in the climate debates we've had that allegation, and in the GMO debates we've had that allegation. What I am most interested in is making sure that every communication. . .shows that scientists are human, but that the method underlying this has protections in place to guard against human bias."

SESSION 4: CASE STUDIES OF HOW THE PUBLIC AND POLICY MAKERS RESPOND TO COMMUNICATION EFFORTS ON SPECIFIC TOPICS

Talia Stroud of the University of Texas and Edward Maibach of George Mason University each spoke of the issues involved in specific communication campaigns. Stroud showed how the structure of a narrative influences its ability to convey scientific concepts accurately. Maibach discussed the complex dynamics of opinions on climate change. Stroud began her presentation on communicating about MMR vaccination by noting that research into communicating about vaccination done with Kathleen Hall Jamieson suggests three general points that she would examine in more detail and specificity. They are:

- Language really matters, and it matters in the context of vaccination as it does in the context of Zika.
- Metaphors really matter.
- Generalizable science can be successfully integrated into narratives.

A statement on the CDC website illustrates the first point, the importance of the exact words chosen to convey a message. "In 2000, the United States declared that measles was eliminated from this country." What does this say to a parent on the fence about whether to vaccinate a child against measles? CBS News tried to clarify the situation by stating that "measles still poses threat to the United States despite being eliminated"—a clarification that only adds to the confusion. How can a disease that has been eliminated still be a threat?

The answer lies in the obscure fact that CDC draws a distinction between "elimination" and "eradication," with only the latter meaning "the permanent reduction to zero of the worldwide incidence of infection caused by a specific agent." Elimination, "which means reduction to zero in a defined area, implies that the disease still exists in other areas and therefore can still pose a threat. Distinctions like this, which may have scientifically meaningful components aren't so meaningful to a parent trying to make decision about vaccination." In fact, Stroud called them "incomprehensible precision" because the excessive exactness keeps non-experts from understanding them.

Something similar happens with metaphors, such as "herd" versus "community immunity." The overall concept is that "there's some probability that someone in the population is sick, and the rate of vaccination within that population is what determines whether or not other people are catching the disease." Herd, however, implies an undifferentiated mass of individuals and "seems to convey that each person has an equal probability of coming into contact with every other person in the population, when, in fact, we know that's not correct. We don't live in a herd in that way."

In daily life, people come into contact with only selected segments of the overall population, and the particular community or communities they interact with will affect their risk of contracting a particular disease.

In a community where many people are vaccinated, an unvaccinated person who is sick and contagious has a low probability of infecting others. In a different community with a smaller proportion of vaccinated people—a pediatric waiting room, for example, where some of those present are babies below a year of age and thus too young to be vaccinated—the odds of the disease spreading are much higher.

The case of a baby who catches measles from an unvaccinated older child is in fact the example Stroud used to illustrate her third principle, the possibility of integrating generalizable science into effective narrative. Accomplishing this successfully is tricky because such a narrative must be both "transportive" and "informative." "A narrative that transports can be powerful." Transportation is the experience of "being swayed and carried along with the story." But she also noted an important caveat. A narrative often presents only a single case of a particular individual and therefore people may not generalize what they learn from it to a broader population. This makes narrative a complicated technique to use when trying to inform the public about issues like vaccination because accurate data must speak to broader scientific generalizations without reducing the transportive power of the narrative. Can we embed information within a narrative to indicate to people this is not just a single case, that this is something that's broader, thereby influencing the way that they think about the probability of their own likelihood of getting measles or of their chances of having negative consequences from getting a vaccination?

The narrative of the anti-vaccination community—accounts of previously normal children becoming autistic after receiving vaccinations—is incredibly powerful, she said. Countering this requires coming up with another narrative that effectively rebuts what this narrative is telling us. One narrative cited by the CDC website is the account by a mother, Megan Campbell, whose unvaccinated baby became gravely ill and was hospitalized after catching measles in a pediatric waiting room from an older child whose parents had chosen not to vaccinate him for measles.

Research shows that exactly how such a story is integrated with factual information strongly influences the effect it has on the audience and the lessons they draw, Stroud said. She cited 2014 research by Brendan Nyhan and collaborators showing that embedding narrative vignettes into a factual report may lead to false impressions because the stories may be more influential than the facts. For example, an article that used a condensed version of the Campbell story along with other vignettes and factual information about the relative rarity of adverse effects from the vaccination actually produced a boomerang effect and caused people to believe that the MMR vaccine "is more likely to cause serious side effects. . .exactly the opposite of what CDC was attempting to convey."

Stroud's research found, however, that it was possible to tweak the structure of the Campbell story to "make it do the work that we wanted it to do" and convey the importance of vaccinating children to maintain community immunity. This was accomplished by recalibrating risk by integrating generalizable science into the narrative. "So instead of having people focus on what's the risk associated with getting an MMR, let's get them to think more about what's the risk associated with getting the measles." The revised narrative presented the Campbell case as a freestanding story, included more detail, and added the information that some people, including babies younger than a year, cannot be vaccinated and are therefore vulnerable to measles; that measles is highly contagious; and can be very serious, even life-threatening. The narrative illustrates how Campbell's baby breathed the same waiting-room air as the sick, unvaccinated older child for only perhaps 30 seconds.

This fact is one of the elements of the revised account used to "enhance narrative transport," which, in turn, reduces counter argument against the story's intended message. Other methods include making characters identifiable. The baby in the Campbell story became "Timmy," a fictitious name chosen, as the story acknowledges, to protect his privacy. In addition, specific physical descriptions showed that the baby required an IV that it took four nurses one hour to get it into the screaming child, and that the nurses hugged once they had succeeded. An additional method of increasing transport is adding suspense, accomplished by not revealing whether Timmy survived until the end of the story.

Telling the story in chronological order also helped increase impact, as does avoiding gaps in the narrative flow that encourage questions. "In the version used in the Nyhan article," Stroud explained, "it's not until the very end that you learn that Megan's baby was exposed to a boy in the waiting room, and you don't actually learn that that boy was unvaccinated because of his parents' choice, and that the reason that Timmy was not vaccinated is because he was under the recommended age. So we, in our revised narrative, incorporated these key details so that you can follow the flow of the narrative. Timmy wasn't vaccinated for very good reasons. This other child was unvaccinated because his parents elected not to vaccinate him. This is why Timmy contracted the measles." People reading the revised account came away really powerfully understanding the idea of community immunity, of what needs to happen in order for children like Timmy to be protected. This version of the story, furthermore, does not boomerang.

It also shows that "integrating generalizable science did not undercut transportation" and that "it is possible to include these generalizable scientific details within the narrative without interrupting transportation." In fact, "transportation does mediate these effects." People read the narrative, they're swayed by the story, and as a consequence, they recognize more of the information from the narrative and they begin to adopt beliefs more in keeping with what we know from science.

Maibach began his presentation on communicating about climate change by stating a basic principle derived from communication science: "The human mind deals best with simple, clear information." Therefore, research shows that public education and information "campaigns that work almost always comport to this simple clear formula: Simple, clear messages, repeated often by a variety of trusted voices."

These facts create a communication paradox, however: "the less we say, the more we're heard." It therefore follows that "if we want to be effective in sharing what we know, we have to put a lot of thought into saying only what is most important to say." Beyond simplicity, repetition is really important. It's the mother of learning, it's the mother of liking, and it is exactly why we need to be extremely cautious about repeating myths. "Every time we repeat a myth, even if to debunk it, we have the unintended consequence of simply reinforcing the myth that we're trying to debunk." Maibach noted that, as has been previously mentioned, members of the scientific community are still privileged to be very trusted, even though sometimes scientists behave in ways that undermine their standing as trusted figures. "When we come off as aloof, when we come off as overbearing and arrogant, non-responsive, not listening, unsympathetic, we tend to erode an audience's trust in us." Beyond that, "for a variety of historical reasons, climate scientists are suffering from slightly eroded trust among some Americans and for reasons that I think were largely preventable. To what degree we can earn that trust back remains to be seen, but we're certainly working on doing exactly that." In general, most people trust above all those close to them. "Horizontal communication, peer to peer, is ultimately the most trusted and the most influential."Emphasizing the importance of simple, clear messages, Maibach noted the importance of understanding the objective the communication is intended to achieve when trying to choose the most effective message. This makes it possible "to use communication science to find the information that has the most value in terms of helping us achieve those objectives."

Regarding climate science, he said, he and his colleagues at George Mason University agree that the objective is to influence attitudes and behaviors so that "members of the public feel that we should be responding at the societal level. . . .We think it's appropriate for people to support a range of different policies that are consistent with their values." Research has also identified a small number of beliefs very strongly associated with attitudes and behaviors that favor taking action on climate change. These beliefs are "that climate change is real, that it is human-caused, that it is bad or serious, for people, not just plants, penguins, and polar bears, and that it is solvable, essentially, that there is hope."Also, research has shown, the most fundamental belief underlying a willingness to take action is that scientists agree. . .that human-caused climate change is happening. A widely held myth on the other hand holds that there isn't an expert consensus on climate change. This is the single most prominent talking point of the opponents of climate action in America, and it implies that it would be premature to take societal action that could harm our economy, which is bad for all of us. So the most prudent response would be to invest in more research.

This argument was spread by "a very disciplined, very intelligent strategic communication campaign to sow the seeds of doubt," Maibach said, adding that it has been highly effective. It goes after the belief in a scientific consensus, because climate change is a complicated scientific issue. Most of us are not all that interested in learning the science. Instead, people defer to experts as their "heuristic for decision making." Believing that expert opinion is divided therefore constitutes permission for us not to engage with the issue, he said. Because 97 percent of climate scientists in fact agree, however, using that number is important because the public generally believes that it is lower.

In fact, the five main beliefs about climate change—It's real. It's us (human-caused). It's serious (for people). It's solvable. Experts agree on it—are pretty simple, clear messages in and of themselves—"5 ideas in 10 words. It's hard to be more precise and concise than that," Maibach said. Many people, however, see the threat as distant—distant in time (it's a future problem), distant in space (it's a sub-Saharan African problem, not an Appalachian problem), and distant in species (it's a planet's problem, not a people problem). However, people don't want to hear about the threats, the risks, he continued. There's a profound risk burnout in America. If, however, messaging "pivot[s] immediately to the solutions, to the reasons for hope, we tend to be able to earn people's attention long enough for them to listen to the entire story, the entire narrative if it's offered in a narrative format."

Trusted voices that can convey this message include physicians, who can explain how it can affect their patients and how many are already seeing effects, Maibach added. Another trusted group is TV weathercasters, whom viewers see as familiar figures. Working with weathercasters such as Jim Gandy, chief meteorologist for the CBS station in Columbia, South Carolina, as well as with over 100 others, Maibach has developed ways that they can incorporate information about climate change into their broadcasts. "They can, for example, explain the fact that the weather we are experiencing today is symptomatic of a long-term trend: If you don't like this thing we're experiencing today, you've got to understand, we're seeing more of it today already than we did in the past and we are very likely to see even more of it going forward."

Another example of a trusted and authentic spokesman is former six-term U.S. Representative Bob Inglis, a conservative Republican who "lost his primary in 2010 [for] two reasons: one, he refused to pander by saying that the president is not an American and therefore he is not our legitimate resident. And two, he refused to pander by saying climate change is a hoax."

When Inglis's eldest son turned 18, he told his father that he "could earn his vote if and only if he cleaned up his act on the environment." As a member of the House of Representatives science committee, Inglis traveled to Antarctica to consult with scientists working there and came home convinced that climate change was real. After losing his seat, he joined Maibach's center and is now working as a "completely authentic thought-leading conservative" to spread the five beliefs and advocate a free-market approach to a solution and has won the JFK Profile in Courage award for his efforts. "It's wonderful to see how a messenger who is completely different than me takes these key beliefs and makes them completely authentic to him," Maibach observed.

SESSION 5: HOW CAN NARRATIVE BE USED EFFECTIVELY TO EXPLAIN COMPLEX SUBJECTS IN AN ENGAGING WAY?

Lee Gutkind, author of several popular books, writing professor at Arizona State University, professor and founding editor of *Creative Non-Fiction* magazine, has been conducting NSF-funded training programs to teach young scientists, engineers, and science journalists to write data-rich narratives. Laura Helmuth, the science editor of the *Washington Post* who has also worked at *Science*, *Smithsonian*, *Slate*, and *National Geographic*, joined him to comment on the lessons of conveying science to popular audiences.

Introduced by Finneran as "the godfather of. . .narrative nonfiction," Gutkind said that he has taught the techniques of narrative or creative nonfiction to a range of experts in various fields. Creative nonfiction, he explained, is the term most widely used in the writing world for the approach of using structural and other techniques from storytelling, fiction, and film, such as scenes, dialogue, characters, and description, to create true stories that you tell in order to communicate valid information. Gutkind has devoted much of his career to teaching these techniques because it is "really hard to tell a good story and to communicate information at the same time."

Also called narrative nonfiction, literary nonfiction, long-form nonfiction, this approach is "the fasted growing genre in the publishing world," responsible for numerous books that have appeared in the *New York Times* bestseller list. Writers use it not only to write about science, but also law, medicine, history, and other subjects. Gutkind offered three examples of well-known books belonging to the genre: *Walden*, Henry David Thoreau's description of his life in the Massachusetts woods; *Down and Out in Paris and London*, George Orwell's account of living and working among the poor during the Great Depression; and the more recent *The Immortal Life of Henrietta Lacks*, Rebecca Skloot's account of the HeLa cells widely used in cancer research and the woman from whom they were derived. The elements of creative nonfiction have existed in writing throughout a long and important history about all kinds of different subjects, but the form has grown rapidly in prominence in recent decades.

Conveying information through story can have tremendous power. Gutkind asked if those who have sat through the workshop remember all the incredible research the speakers presented. Though filled with facts, they will probably forget a great many of them, he predicted. But, he added, "you will never forget the story" that Maibach told about Bob Inglis and how his son "made him study the environment and do the right thing."

To convey a point effectively, he continued, "first you have to get people interested in the point. . .interested in what you think." So "what is the point?" is not the issue that the writer faces, but "what is the story that will lead to the point?"

The building blocks of creative nonfiction are scenes and little stories that are carefully assembled and structured, Gutkind continued. To illustrate, he showed a familiar use of scene, the opening sequence of an episode of the TV show "Law and Order," which follows the program's invariable structure of an opening vignette showing the discovery of the crime that will be the program's subject, followed by a second scene in which the detectives arrive at the place the crime took place. Then come one or more commercials, comparable to the information that writers use as segments in a creative nonfiction piece. Next comes a scene at the precinct headquarters as the detectives discuss the crime with their lieutenant and begin the investigation, followed by a series of alternative scenes and commercials as the story progresses. "Scenes plunge you into the story," Gutkind said. The reader's interest is aroused and nourished because, in a well-constructed story, "there is always something at stake" as the protagonist faces challenges. This method "is the best way we can make an impact and we can communicate our ideas and those really important data and information to the largest audience possible."

Laura Helmuth spoke next. "At all these different publications," she said, "my job is to help people get their stories straight. . . .Basically, what Lee said is right. The best way to get people to pay attention to what you are doing is to tell stories, to have interesting characters, to use metaphors, to use imagery, to translate something that can be sort of intimidating to people who have no science background, who didn't necessarily wake up in the morning thinking they are interested in science, to make them interested." To do so, "We use all the manipulative tricks of fiction." Charles Sims of Princeton University commented that he sees some danger in formalizing this and popularizing this approach: that people become resistant to being manipulated. A colleague of his, for example, criticized the character-centered "long stories in the *New York Times*," saying "he feels. . .he has to kind of dismiss all that part of the article because he feels it is trying to hook him in and get him to not think critically about the information he is being given." Helmuth agreed that these techniques are indeed manipulative, but called the critique "very sophisticated—most people don't notice it." Movies are "ridiculously emotionally manipulative, and yet we still enjoy" them, she added. If you are looking for just straight information, graphs are better, data are better, but few people are just seeking information. "The issue is that journalism, [although] we like to think of it as. . .having an educational and world improvement mission is also entertainment [and] has to compete with other forms of entertainment and other forms of attention grabbing."

The real skill and challenge of narrative nonfiction, Gutkind said, "is to be able to be so manipulative that the person doesn't know it is happening." Storytelling has ancient roots in human life, and "information was always transmitted through stories," National Academy of Engineering president Dan Mote observed. Helmuth agreed that stories have very great power that can also be used for ill. In fact, "one of the problems with the anti-vaccine movement is that they are so good at telling stories about these poor children who were fine until they were two, and then they got vaccinated, and now look at them."

"It would be really interesting," University of Wisconsin biologist Judith Kimble commented, "for our students to try to write exactly the same material in two different ways, one being the sort of standard scientific publication and then another the narrative, and just have them go through that exercise and see how their synapses were firing differently in writing those two different ways."

"It also might be interesting," she continued, "to have a journal in which your publications could come out in a narrative form instead of our standard incredibly dry form, and see if anybody would be able to believe it, because I think we are trained to be really dry so people will believe us."

DISCLAIMER: This Proceedings of a Workshop—in Brief has been prepared by Beryl Benderly as a factual summary of what occurred at the workshop. The planning committee's role was limited to planning and convening the workshop. The views contained in this Proceedings of a Workshop—in Brief are those of individual workshop participants and do not necessarily represent the views of all workshop participants, the planning committee, or the National Academies of Sciences, Engineering, and Medicine.

PLANNING COMMITTEE ON USING NARRATIVE AND DATA TO COMMUNICATE THE VALUE OF SCIENCE: A WORKSHOP: Richard Zare (Chair), Stanford University; Paul Citron, Medtronic, Inc. [Retired]; David Daniel, The University of Texas System; Judith Kimble, University of Wisconsin-Madison; Alan Leshner, American Association for the Advancement of Science; Michael Witherell, Lawrence Berkeley National Laboratory; Staff: Kevin Finneran, Study Director.

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