AMERICANS' ATTITUDES ABOUT SCIENCE AND TECHNOLOGY: THE SOCIAL CONTEXT FOR PUBLIC COMMUNICATION

Commissioned Review
in Support of the Alan Leshner Leadership Institute
American Association for the Advancement of Science

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PREFACE

AAAS describes public engagement with science as intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public. Through the Alan I. Leshner Leadership Institute for Public Engagement with Science, AAAS empowers scientists and engineers to practice high-impact public engagement by fostering leaders who advocate for critical dialogue between scientists and the public and lead change to enable their communities, institutions, and others to support public engagement.

This report, with additional work on understanding mechanisms for institutional change, as well as practical experience in public engagement with science, will guide the work of the Leshner Leadership Institute and its Public Engagement Fellows, as well as other programs of the AAAS Center for Public Engagement with Science (Center).

The Center, which manages the Leshner Leadership Institute, offers this paper as a resource for the broader community of public engagement practitioners, researchers, and scientists doing public engagement.

OVERVIEW

In this report we review U.S. public knowledge and attitudes about science and technology, assessing general trends and analyzing specific controversies. Drawing on more than 100 national surveys and peer-reviewed studies, our analysis provides a foundation for critically assessing different communication strategies and for benchmarking the impact of various initiatives. We focus on the following specific questions and topics, emphasizing the broad implications for public communication:

- How are Americans receiving, seeking out, and passing on information about science and technology by way of interpersonal conversations, traditional news outlets, the Internet, and social media? What are the effects of these communication behaviors and choices?

- What is the connection between various forms of scientific knowledge and public attitudes? How do factors such as political ideology or religiosity influence the role that knowledge plays?

- How do Americans view the relationship between science, government, and society? What role do various forms of trust play in shaping public attitudes? How do public views of scientists compare to other influential societal groups?

- How much public support is there for government funding of science? How do Americans view the social impacts of science? What role do views about science and society play in shaping attitudes about specific controversies or debates?

- What role do beliefs about scientific consensus play in shaping perceptions of climate change? How does the public view the severity and immediacy of climate change and what factors influence these views?

- Do Americans believe they can take actions to address climate change, or that society and its leaders are capable of acting in time? How divided are Americans politically on climate change?

- How have public attitudes about food biotechnology evolved over time? What are the public's preferences relative to food labeling?

- What concerns do Americans and parents of young children have about childhood vaccination? Does skepticism of vaccines require nationally focused communication efforts or should such efforts carefully target specific communities?

- In debates over pandemics such as swine flu or Ebola, how has the public responded? What role has the news media and partisan debate played in shaping risk perceptions?

- Are Americans concerned about the risks of antibiotic resistance? Who is considered responsible for addressing the problem? How do public misperceptions about antibiotics influence patient decisions?

PUBLIC DISCUSSION AND MEDIA USE

For adults who have completed their formal education, interpersonal conversations and various forms of media use are the dominant sources of information about science and technology. Research paints a complex picture of how these communication behaviors influence science attitudes and knowledge, suggesting key principles or strategies related to public outreach.

Public Discussion of Science

About a third of Americans say they frequently discuss science-related topics with their friends, family, and co-workers. Research suggests there are many benefits to such conversations. In comparison, discussing politics with like-minded others tends to promote barriers to public engagement.

Asked in 2010 how often science and technology were part of their conversations with family members, 36 percent of Americans said "very often" or "quite often" (BBVA 2012). Other surveys show that discussion of specific issues tends to wax and wane in relation to media attention, major focusing events, and political moments.

For example, in 2008, following a historic spike in media attention to climate change, 40 percent of Americans said they discussed "global warming with family or friends" either often (5%) or occasionally (35%). In the years since, those saying they discussed global warming declined to 25-30 percent of the public (Leiserowitz et al., 2015a).

Extreme weather events also spark public conversations relevant to climate change. In a 2013 survey, among the majority of Americans who said they experienced an extreme weather event over the past year, nearly 80 percent reported discussing the event face-to-face with someone they knew (Leiserowitz et al., 2013).

Studies show that interpersonal conversations about science are closely linked to more effortful processing of the information that people might encounter in the news media, online, or by way of other sources. This greater level of elaboration in turn can lead to a deeper and more sophisticated understanding of a complex issue, along with a greater ability to apply this knowledge when making decisions or offering an opinion (see Eveland and Cooper, 2013).

Research also suggests that discussion of science amplifies concern about problems like climate change. In a study tracking the discussion patterns of a nationally representative sample of Americans across two years, attention to science-related news coverage was found to promote more frequent conversations about science, which in turn helped boost overall

concern about climate change. This heightened concern not only promoted subsequent attention to news coverage of science but also intensified the frequency of science-related conversations, which resulted in even greater levels of worry about climate change (Binder 2010).

Interpersonal conversations are also a key mechanism by which individuals are recruited into taking action to address a problem. For example, two-thirds of Americans say they trust "family and friends" as a source of information about global warming, a proportion higher than any other group except for climate scientists (Leiserowitz et al., 2015b).

Given this level of trust, when the public is asked who could convince them to take action to reduce climate change, rather than naming a political leader, expert, or organization, they are most likely to say a person close to them, including their significant other (27%), child (21%), close friend (17%), parent (11%), or sibling (7%) (Leiserowitz et al., 2013a).

Similarly, if asked by someone they "like and respect," a third or more of Americans say they would sign a petition about global warming, attend a neighborhood meeting to discuss actions to address the problem, or take a pledge to support a candidate that shared their views on the issue (Leiserowitz et al., 2014a).

Studies also suggest that interpersonal discussion in combination with news attention plays an important articulation function relative to public participation, providing individuals with a repertoire of arguments that can be used in conversations, in media comments, and in contacting decision-makers. This articulation function is also likely to boost an individual's willingness to participate in various formal public engagement forums, such as a deliberative meeting, a science cafe, a citizen science project, or science festival (Goidel & Nisbet, 2006).

Research suggests that *talking about science* has many civic benefits, yet other studies show that *discussing politics with like-minded others* can be a key driver of increased polarization on science-related issues.

Discussing politics with ideologically similar others has been shown to boost differences in how liberals and conservatives view issues ranging from stem cell research to biofuels to nanotechnology (see Binder et al., 2009). At the local level, politically like-minded conversations have also been shown to divide opinions in relation to the siting of biological research facilities (Binder et al. 2011).

The Audience for Science News

Studies consistently show a positive correlation between science-related newspaper reading, science documentary TV viewing, and various forms of science-related knowledge (see Su et al., 2015). Yet over the past two decades, the size of the audience for these information-rich news sources continues to decline.

As of 2014, nearly 60 percent of Americans said they were "very interested" in news about medical discoveries, 40 percent indicated a similar level of interest in coverage of new scientific discoveries, and 43 percent were interested in coverage of new inventions and technologies. For comparison, 50 percent said they were very interested in news about local school issues, and 43 percent in coverage of economic and business conditions (NSB 2016).

Yet despite professing a general interest in the topic, far fewer Americans say that they actively follow coverage of science-related subjects. In 2012, 16 percent of the public said they followed news about science and technology "very closely." For comparison, 52 percent said they followed news about the weather closely, 26 percent sports, 21 percent local government, and 17 percent news about politics (NSB 2014).

Among those Americans who follow science-related news, the ways in which they are accessing news is shifting. The main change has been the move away from printed newspapers and television and towards various online and social media sources.

In 2014, 47 percent of Americans reported that the Internet was their primary source of news and information about science and technology, up from 42 percent in 2012 and just 9 percent in 2001. In comparison, 28 percent said television was their primary source of information about science and technology, down from 32 percent in 2012. In terms of other sources, 7 percent named print magazines as their top source, 6 percent print newspapers, and 3 percent radio (NSB 2016).

Of the roughly half of Americans who said they primarily rely on the Internet for information about science and technology, a little more than a third said they turn to a search engine like Google. In terms of other Internet sources, a combined 45 percent said they primarily used either online newspapers (23%), online magazines (15%), or other online news sites (7%). Just 8 percent of Internet information seekers -- or 3 percent of all Americans -- said they rely on a science-focused site as their primary source of information (NSB, 2016).

Younger, higher earning, and better-educated Americans were more likely to say they received most of their information about science and technology by way of the Internet, online newspapers, online magazines, or similar sources. Older and less educated Americans were more likely to rely on television news and print sources (NSB 2016).

Over the past two decades, with the diffusion of cable television, the Internet, social media platforms, and mobile communication devices, there has been an explosion of competing news subjects and entertainment media options for Americans to choose from. As part of this shift, there exists today easier access to quality sources of news about science, health, the environment, and technology than could have even been conceived of five years ago.

In this new online science media ecosystem, highly motivated individuals – who usually hold personal, professional, or strong political affinities for a field of science, an area of

research, or a policy debate such as climate change – can "deep dive" into specific science-related subjects.

These "science publics" consume, contribute, recommend, share, and comment on news and discussion of their preferred topics across media and platforms. They expect high standards and quality for content, and they expect content to be interactive and responsive to their feedback, reposting, forwarding, or commenting (see Fahy & Nisbet, 2011).

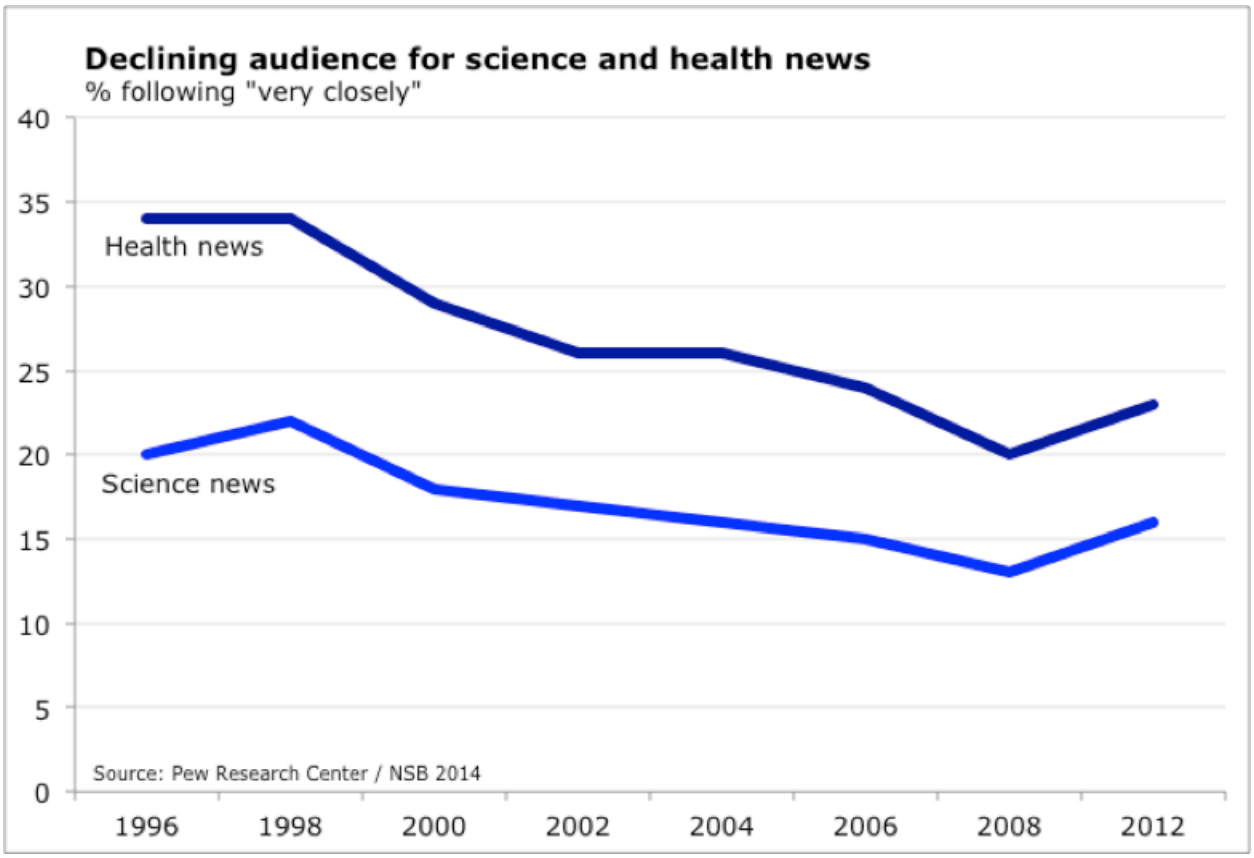
In one of the earliest examples of this type of interactivity around deep sources of content, science-related blogs have provided the opportunity for highly motivated segments of the public to learn about, follow, and discuss science.

Blogs blend the textual depth of online newspapers with the graphical and video capabilities of television, enabling readers to interact in real time with the author of the blog. Posts can also be written quickly and immediately, responding to new events, issues, or debates, bypassing directly the need to convince a journalist to write about the topic or an editor to publish an op-ed.

Yet data on broader public consumption of science-related blogs is limited, and those studies that do exist suggest that blog reading occurs among a small, unique segment of the public who may or may not be drawn to science blogs for discussion of science. Many individuals who seek out science blogs may be seeking discussion of politics related to topics like evolution, atheism, or climate change rather than to learn about science more generally (Su et al., 2014).

When writing a blog, instead of reaching the general public, a scientist may be as likely to reach a journalist or other scientist. A 2009 survey of members of the American Association for the Advancement of Science found that though only 9 percent write a science blog, 42 percent say they read a science blog very often or occasionally (Pew 2009). Other research suggests that journalists often use science blogs as a source for story ideas or to track specialized areas of research (Fahy & Nisbet, 2011).

Science blog writing is likely to be an effective way to reach scientists, funders, decision-makers, and journalists. A recent study, for example demonstrates a direct relationship among news coverage, social media mentions, and a scientist's total citation impact scores (Liang et al., 2014). Members of the scientific community seem to at least intuitively recognize these advantages. In a study of AAAS members examining the range of motivations for writing a science blog, the strongest predictor was a belief that news coverage was important for career advancement (Nisbet & Markowitz, 2015).



Yet when writing a blog or contributing to online publication, research also indicates that scientists should be careful to moderate and screen comment sections. When comment sections display a high level of disagreement or incivility, the comments can have polarizing or confusing effects on readers (Anderson et al., 2012; Anderson et al., 2014).

As the example of science blogs suggests, the availability of information does not mean that members of the broader public will use it. With many easily accessible media choices, citizens can pay almost exclusive attention to entertainment media, or within the news media follow closely only those issues they care most deeply about. This transformation has made it easier for people without a strong interest in health or science-related news to opt out or ignore such coverage all together.

These rapid changes in the media system likely account for a sharp decline across decades in the proportion of the public saying they closely follow health and science news. In comparison to this decline, attention to public affairs coverage tends to wax and wane in relation to major focusing events like war, terrorism, or presidential elections (NSB 2014) (see figure above).

Such barriers to reaching the public require specific strategies that embed discussion about science and technology in places within the media system where less motivated audiences are likely to incidentally discover them.

For example, despite the shift towards online news sources, local TV broadcasts remain the top news source for a majority of Americans, and most say they watch the local news primarily for the weathercast. Given their training, visibility, reach, and trusted status, weathercasters hold the unique ability to describe how local weather conditions such as heat waves, drought, or heavy precipitation may be related to climate change.

Research shows that when people understand that they have personally experienced the effects of climate change, they are more likely to be concerned about the issue and to support a variety of policy actions. In a joint initiative between Climate Central and George Mason University, more than 250 local weathercasters in the U.S. representing 185 stations and 105 media markets have been recruited to include regular "Climate Matters" segments as part of their broadcasts, using easily adopted visuals that are localized to specific audiences (see Placky et al., in press).

For Americans who otherwise rarely, if ever, follow news about science and technology, social media may also provide the opportunity for them to incidentally come across news coverage about science and technology that is recommended by their friends and peers.

With the rapid adoption of Facebook, Twitter, and smart phones, the nature of science-related news consumption among the public is changing, becoming more social, participatory, and incidental (see Brossard 2013).

As of 2015, two-thirds of American adults say they use Facebook and 41 percent say they get news via the platform. In comparison, 17 percent of adults use Twitter and 10 percent say they receive news via the platform. News consumption at both platforms is greatest among 18-29 year-olds, but occurs at significant rates across older segments of the public. Though other platforms like Instagram or Snapchat are popular, these platforms have yet to be used in any measurable way as a news source (Pew 2015a).

Despite their popularity, how Americans find and follow news on Facebook and Twitter is different than other traditional and online news sources. Most people do not go to these platforms seeking out news; rather they “bump into” news items incidentally while using the platforms for other purposes (Pew 2013).

Overall, roughly half of Facebook news consumers and two-thirds of their Twitter counterparts regularly see stories about at least six different topic areas. Among these topics, 47 percent of Facebook news consumers report regularly seeing posts about science and technology and 56 percent of Twitter news consumers report the same (Pew 2015a).

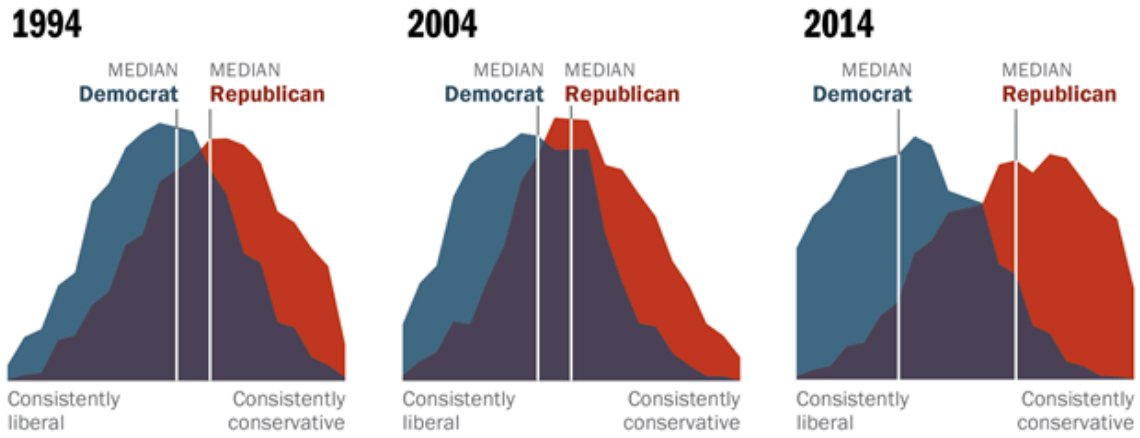
Partisan Publics and Their News Habits

Political news habits also affect public perceptions and knowledge, especially among Americans who are the most ideologically consistent in their political views.

Over the past two decades, as political leaders, activists, and the news media have increasingly packaged almost every major policy debate in terms of clearly defined ideological differences, political party labels have become brand names, each standing for a distinct set of conservative or liberal positions.

Democrats and Republicans More Ideologically Divided than in the Past

Distribution of Democrats and Republicans on a 10-item scale of political values



Source: 2014 Political Polarization in the American Public
Notes: Ideological consistency based on a scale of 10 political values questions (see Appendix A). The blue area in this chart represents the ideological distribution of Democrats; the red area of Republicans. The overlap of these two distributions is shaded purple. Republicans include Republican-leaning independents; Democrats include Democratic-leaning independents (see Appendix B).

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This tendency to frame almost every policy debate in terms of a right-left divide in American politics has made it easy for many members of the public to bundle their opinions across issues in an ideologically consistent direction. Over the past two decades, better-educated, more politically attentive Democrats tend to consistently take a strong liberal position on most issues, and their Republican counterparts tend to take an even stronger conservative position (see Abramowitz, 2010).

A recent analysis by the Pew Research Center estimates that a combined 20 percent of the public can be defined as either consistently liberal or consistently conservative in how they view major policy issues. These Americans play an out-sized role in policy debates since they are the most likely to vote, donate to campaigns, and participate directly in politics (Pew 2014a).

Though consistent liberals and conservatives rely on a diversity of news sources, their patterns of news consumption are significantly different from each other and from more moderate Americans. These patterns have helped intensify polarization across issues, and they present barriers for scientists hoping to effectively communicate with those on the tail ends of the ideological spectrum.

Among consistent conservatives, 47 percent name the right-leaning Fox News as their main source for news about government and politics. In comparison, 50 percent of consistent liberals name the left-leaning New York Times (10%), NPR (13%), MSNBC (12%), or CNN (15%) as their main political news source (Pew 2014a).

Consistent conservatives also tend to *distrust* most news sources with the exception of Fox News, The Wall Street Journal, Rush Limbaugh, and a few other conservative outlets. In contrast, consistent liberals tend to *trust* most news sources, with the exceptions Fox News, Rush Limbaugh, and a handful of other conservative sources (Pew 2014b).

The tendency for the most ideological to engage with like-minded arguments and sources also extends to Facebook. Consistent conservatives (47%) and consistent liberals (32%) are more likely than the typical Facebook user (23%) to say that most of their close friends share their political views. Among consistent liberals, 44 percent say they have blocked or de-friended someone because they disagreed politically with that person. This compares to 31 percent of consistent conservatives and 26 percent of all Facebook users (Pew 2014b).

About half of consistent liberals say that in the past week they received news about politics from Facebook and about 13 percent said the same about Twitter. This compares to 40 percent of consistent conservatives who report the same about Facebook and 5 percent from Twitter (Pew 2014b).

When conservatives and liberals rely on ideologically slanted news sources that reinforce their ideological outlook, such news-consuming behaviors have polarizing effects on opinions about science-related issues. For example, studies show that Fox News serves an influential political function in the climate change debate, sustaining conservative viewers' doubts about climate science even in the face of overwhelming contradictory evidence (Feldman et al., 2014).

These doubts are a key mechanism by which Fox News-viewing conservatives distinguish their political identity from liberals. In turn, the need to sustain core identity beliefs about climate change drives conservative viewers back to Fox News in a reinforcing cycle.

In contrast, given the strong proportion of arguments at MSNBC emphasizing the urgency of climate change, the same studies conclude that heavier viewers of the network, along with other left-leaning and mainstream news sources, are more likely to be concerned about climate change and to support policy action (Feldman et al., 2014).

Other studies suggest that outlets like Fox News and MSNBC have so effectively branded themselves as reliably ideological that if given the choice, their respective partisan audiences will quickly turn to them as preferred sources of information, even for a politically unfamiliar topic such as nanotechnology (Yeo et al., 2015).

Unfortunately, these polarizing effects are not exclusive to cable news. Research shows that strong partisans also differentially interpret political coverage at traditional mainstream news outlets, arriving at opposing conclusions about climate change (Cooper, Nisbet & Elliathorpe, 2015).

Key Takeaways

Public Discussion of Science

- Research on public discussion of science and politics suggests the need for scientists and their partners to systematically invest in communication and media initiatives that foster not just more frequent conversations about science but also interactions that cut across lines of political difference.

- Within their communities, scientists can start by increasing the frequency and diversity of their own everyday, informal conversations with others.

- In this regard, the potential impact of the scientific community should not be underestimated. Though scientists make up only a very small percentage of the professional workforce, 44 percent of Americans say they are personally acquainted with a scientist, and 20 percent say they have a friend who is a scientist (BBVA, 2012).

The Audience for Science News

- The many high-quality sources of news coverage available online are opportunities to engage highly motivated "science publics" who want to "go deep" into interactive content, sharing and commenting on that information with others. Yet in order to reach audiences who do not have a motivation for such content and discussion, “going broad” outreach strategies are needed that take advantage of opportunities to discuss science at outlets like local TV or by way of entertainment media productions (see Nisbet & Scheufele, 2009).

- In an era when the traditional audience for science and public affairs is declining, Facebook and Twitter can serve as important online contexts where scientists and their partners employing a variety of strategies can help the public discover science-related news that they otherwise would have never encountered.

- Social media also enables specific science news stories or topics to "catch on" or go viral, as spirals of attention, recommendations, and meta-commentary can turn the original study, event, debate, or issue into a major political or cultural moment.

Partisan Publics and Their News Habits

- On highly contentious issues like climate change, food biotechnology, and vaccines, scientists and their partners need to plan strategically in order to effectively reach and influence partisan audiences.

- Strong liberals and conservatives are not only difficult to reach by way of the news media; they are also the audiences most likely to reject science-based appeals that contradict their preferred perspective (see Nisbet, Cooper, & Garrett, 2015).

- Scientists and their partners may be wasting resources and potentially reinforcing partisan doubts if they do not first develop a better understanding of how different groups filter or reinterpret science-related information by way of the news media.

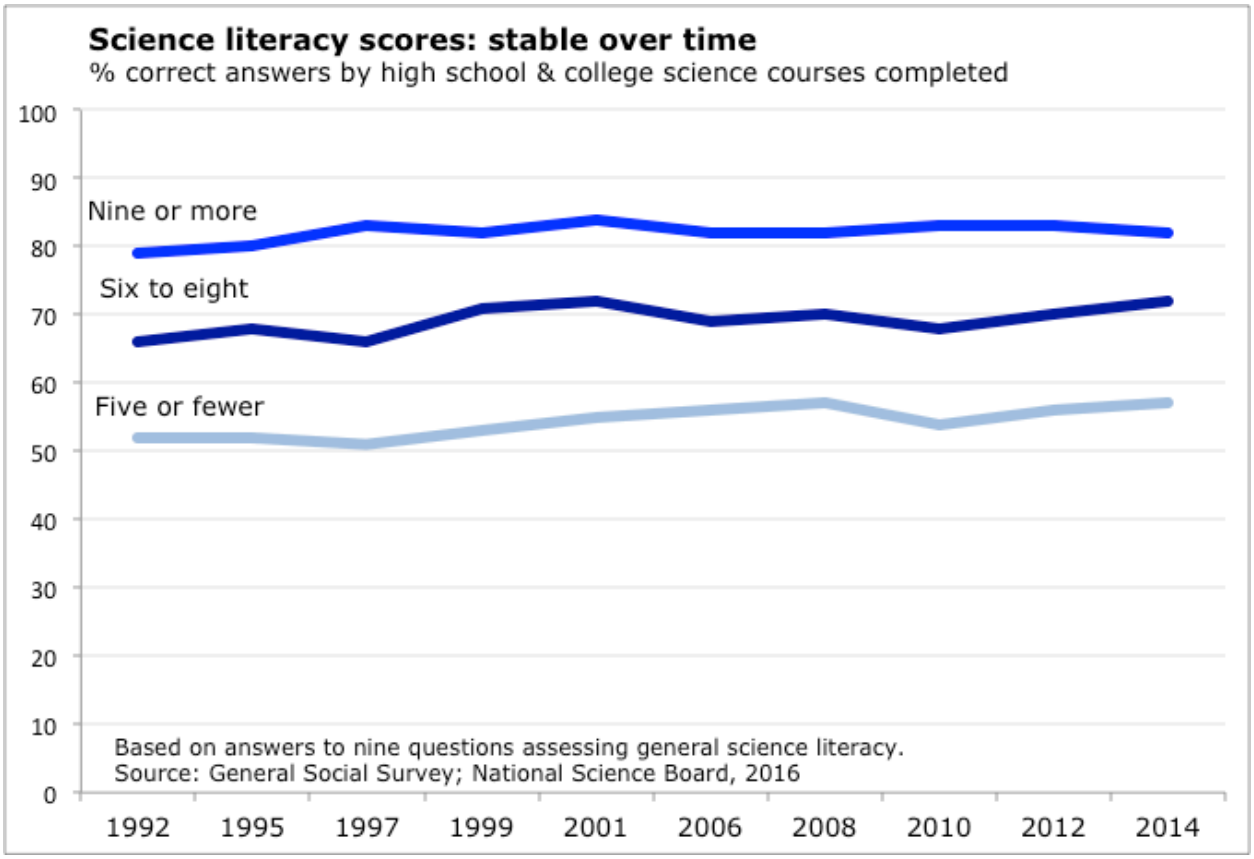
PUBLIC KNOWLEDGE AND ATTITUDES

The scientific community has long had an interest in surveys tracking the public's general understanding and knowledge of science. The assumption has been that a lack of knowledge undermines public support for science as an institution, promotes opposition to action to address problems like climate change, and fosters reservations about scientific advances and emerging technologies.

Acting on this assumption, scientists and their organizations have dedicated ever more resources and activities to boosting science literacy and issue-specific knowledge. Yet the relationship between knowledge and attitudes is far more complex than conventionally perceived and, despite intensive efforts at public education, science literacy has remained relatively stable for several decades. Moreover, evidence suggests that efforts to inform the public via the media and various outreach activities may actually deepen knowledge deficits, rather than reduce them.

Civic Science Literacy

Researchers studying “civic science literacy” assume that knowledge of basic scientific ideas and concepts is essential if individuals are to participate in politics and public affairs, compete in the workplace, and succeed at practical aspects of daily life. Civic science literacy has been measured in regular national surveys by way of two separate but related knowledge constructs.



First is the understanding of factual terms and concepts. These questions are intended to represent a vocabulary of basic scientific constructs sufficient to read opposing views in a newspaper (see Miller 1998; Calvo & Pardo, 2004; Allum et al., 2008).

Examples of questions tapping factual knowledge include true and false questions, such as, “lasers work by focusing sound waves,” “electrons are smaller than atoms,” and “antibiotics kill viruses as well as bacteria.” Multiple-choice questions include, “Does the Earth go around the Sun, or does the Sun go around the Earth?” and “Which travels faster: light or sound?”

In the bi-annual National Science Board surveys, a consistent set of nine such questions has been asked for several decades. Since 2001, the average number of correct answers to the nine questions has ranged from 5.6 to 5.8 responses. Better-educated Americans score higher than their less=educated counterparts. For example, those with a graduate degree tend to answer about 80 percent of the questions correctly, compared with 60 percent among those with a high school education (NSB 2016).

Overall, for several decades, scores on these questions have remained relatively stable over time and are mostly a function of formal education levels, particularly the number of college-level science courses completed (see Figure) (NSB 2016).

Factual knowledge also varies by race. In 2012, white adults answered an average of 6.1 out of nine questions correctly, compared with 4.8 for Hispanics and 4.3 for blacks (Pew 2015b). Men tend to score higher on questions related to the physical sciences, and women score higher on questions related to the biological sciences (NSB 2016).

Questions specific to evolution and the Big Bang are not included in the nine-item index measuring basic factual literacy. Rather than measuring scientific knowledge, these questions tend to measure a commitment to a specific religious tradition or outlook. Many members of the public are aware of the scientifically correct answer to these topics, but if not otherwise prompted to consider the scientific context for the question, they are inclined to answer in terms of their religious views (see Roos, 2014.)

For example, in 2012 when one-half of survey respondents were asked to answer true or false to the statement “human beings, as we know them today, developed from earlier species of animals,” 48 percent answered "true." But among the other half of the survey sample who were asked "*According to the theory of evolution*, human beings, as we know them today, developed from earlier species of animals," 74 percent answered "true." A similar difference in response occurs when a true or false question about the Big Bang is prefaced with "*according to astronomers*, the universe began with a big explosion" (NSB 2014; 16).

Kahan (2015) reports the same process occurring on climate change. In contrast to their responses when posed with a true or false question asking if "the Earth's climate is changing due to human actions," roughly similar proportions of both groups answer "true" when prompted to consider “*according to scientists*, the Earth’s climate is changing due to human actions.”

He argues that because climate change is a heavily polarized issue, asking people whether they believe it is happening, whether it is caused by humans and whether it is a problem to be taken seriously are all, to some degree, asking people which social group(s) they identify with. As a result, people’s responses to these questions do not reflect what people know factually about climate change nor how people interpret and integrate the knowledge that they hold; they instead reflect people’s core partisan or ideological identities.

A second dimension of civic literacy is knowledge of science as a process or mode of inquiry. In this case, the nature of scientific inquiry is defined to be consistent with a Popperian paradigm: Scientific theories are propositions logically connected in a deductive manner, subject to empirical scrutiny, and able to be falsified (Miller et al., 1997). Knowledge of science as a process has been measured in surveys administered by the National Science Board by way of three main types of questions.

In the first set of questions, respondents are asked about the probability that a child or its future sibling will inherit a genetic disease from their parents. In 2014, 66 percent of Americans correctly answered both questions correctly, a response rate that is consistent going back to the 1990s (NSB 2016).

In the second set of questions, respondents are asked about how to test a drug using a controlled experimental design and then asked in an open-ended question the rationale for testing the drug using such as a design. In 2014, 53 percent answered both questions correctly. Measures on this indicator dating to the 1990s may suggest an increase in public understanding but there are odd, non-linear variations across years that also suggest substantial amounts of measurement error (NSB 2016).

In a third type of question, respondents are asked what it means to "study something scientifically." About 26 percent of Americans mentioned correctly that it involved testing a theory using hypotheses, conducting an experiment with a control group, and/or making rigorous and systematic comparisons. This response rate is within the historical range dating back to the 1990s (NSB 2016).

In a recent survey, the Pew Research Center developed a complementary index of 12 questions measuring basic scientific literacy and understanding of science as a process. Out of the 12 questions, the mean score among respondents was 7.9 correct answers. Some 27 percent of respondents answered eight or nine questions correctly, while another 26 percent answered 10 or 11 items correctly. Just 6 percent of respondents received a perfect score (Pew, 2015b).

Those with a college degree or higher averaged more than 9 correct answers, while those with less than a college degree averaged less than 8 correct answers. Consistent with the National Science Board surveys, men scored higher than women by way of higher scores on questions related to the physical sciences, and whites scored higher than either blacks or Latinos (Pew, 2015b).

Public Outreach and Knowledge Gaps

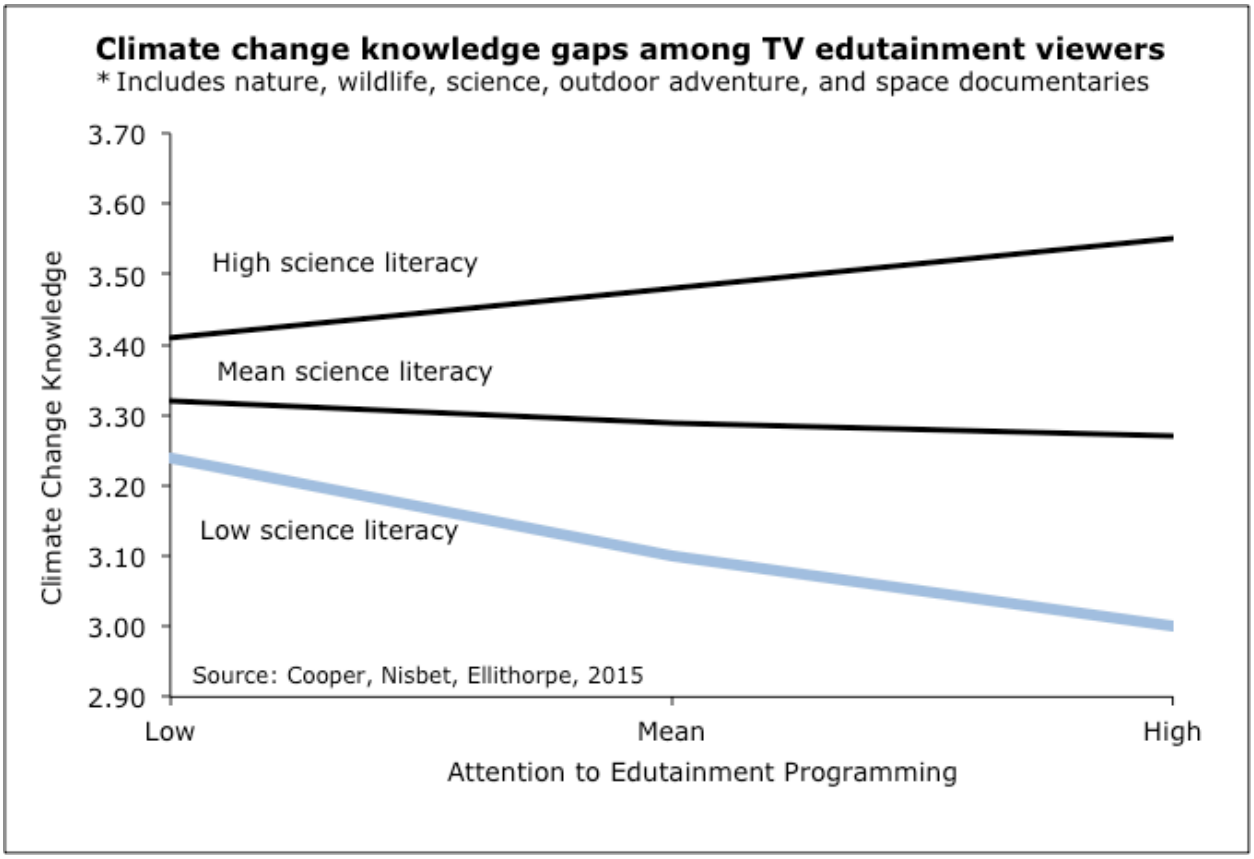
Apart from civic science literacy, researchers have also asked Americans how much they know about specific science-related policy debates. In these surveys, knowledge is assessed directly by way of true or false or multiple-choice questions. Knowledge is also measured indirectly by way of questions that ask respondents to rate their overall level of understanding.

Studies consistently show that across policy debates, the public tends to have very limited knowledge of either the scientific or political issues at stake. Consider, as an example, the debate over stem cell research.

In a 2003 study, respondents were asked three basic true or false questions about the specifics of the policy debate over stem cell research, including whether President George W. Bush in 2001 had allowed unrestricted funding of embryonic stem cell research, whether Congress had passed legislation restricting human cloning, and whether most scientists favored human reproductive cloning. Even after two years of high levels of news attention and political

over the issue, roughly 18 percent answered incorrectly to all three items, and only 44 percent of respondents answered at least two of the items correctly (Nisbet & Goidel, 2007).

Between 2005 and 2010, as stem cell research remained a focus of presidential and Congressional campaigns, less than one in four Americans said they were "very clear" about the differences between stem cells that come from embryos and stem cells that come from adult sources. When Americans were asked in 2005 and 2007 about the types of stem cells that might offer the greatest promise for discovering new treatments, only 14 percent and 22 percent indicated embryonic stem cell research (Nisbet & Becker, 2014).



During this period, even among those survey respondents who said they were either "very interested" or "somewhat interested" in stem cell research, only 54 percent answered correctly that there were two major types of stem cells (adult and embryonic), with 27 percent saying they didn't know. In addition, only 37 percent knew that adult stem cells had been used for many years in the treatment of cancer. Similarly, only 27 percent understood correctly that there were fewer than 100 stem cell lines available for federal funding (Nisbet & Becker, 2014).

Specific to nanotechnology, a 2014 survey study asked respondents a series of five true or false questions about basic elements of nanoscience, expert views on the promise of the technology, and the market availability of nanotech products. Out of the five questions,

respondents answered correctly an average of 2.4 times. In a separate question, on a 10 point scale, respondents were also asked how well informed they thought they were about nanotechnology. Higher scores indicated greater self-knowledge. The average score was 2.8 (Su et al., 2014).

Although the public in the aggregate may score relatively low relative to knowledge about nanotechnology, other research suggests that between 2004 and 2007, as more nanotech products were introduced into the market, knowledge levels about the issue increased substantially among the best educated, while actually declining among the least educated, producing a widening informational gap (Corley and Scheufele, 2010).

This so-called "knowledge gap" effect has been tracked by researchers across issues for several decades. As an emerging scientific issue like nanotechnology or gene editing gains news attention and is the subject of outreach at museums and other venues, segments of the population with higher socioeconomic status tend to acquire knowledge at a faster rate than their lower status counterparts, so that the difference in knowledge between these segments tends to increase rather than decrease (Scheufele, 2013).

The knowledge gap effect has even been observed relative to so-called "going broad" media outreach strategies that are intended to reach audiences who otherwise may never consume science-related coverage. In a 2015 study, more frequent viewing of so-called edutainment programming at National Geographic, Discovery Channel, and the Learning Channel was related to greater climate change-related knowledge, but only among those frequent viewers scoring high on general science literacy (Cooper, Nisbet, & Ellithorpe, 2015).

Scientific Knowledge and Public Attitudes

Despite the assumed importance of science literacy, research suggests only a weak link between knowledge and public attitudes. Knowledge tends to explain a relatively small amount of the variance in opinions, whereas other factors such as ideology, religious beliefs, and trust tend to be much stronger predictors. This is especially true in examining the link between knowledge and attitudes about specific controversial issues, where knowledge may in fact have unexpectedly polarizing effects on opinions.

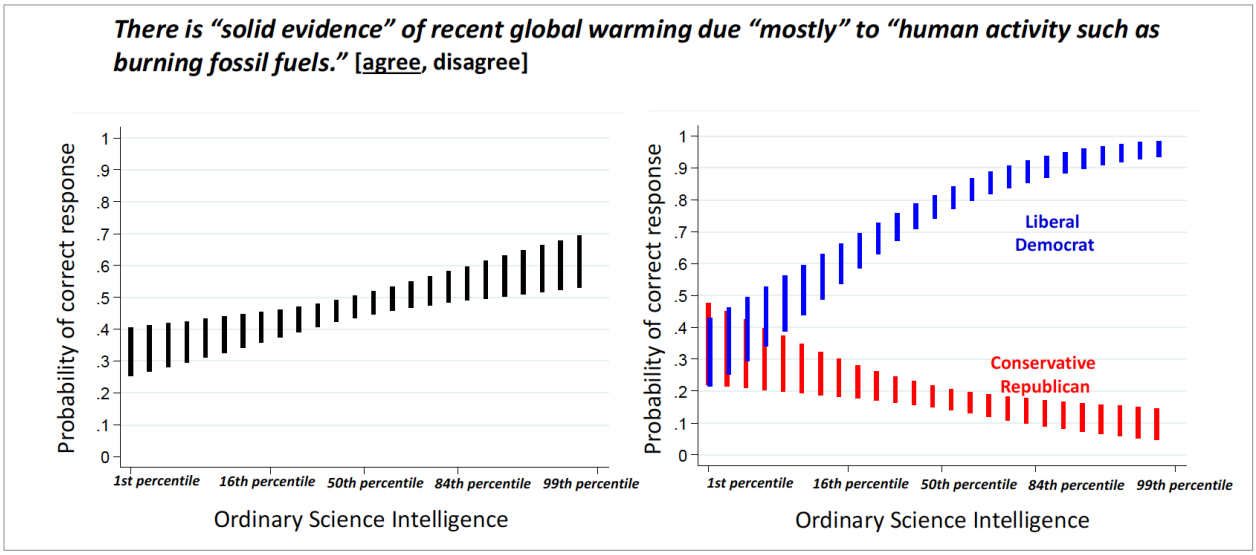
A meta-analysis of nearly 200 surveys conducted in 40 countries revealed that the more general textbook knowledge of science an individual possessed, the more favorable their general attitudes about science. Yet such textbook knowledge had little to no impact on opinions about controversial topics such as genetically modified food. Instead, domain-specific knowledge about genetics and biology predicted more positive views about the technology (Allum et al., 2008).

A recent comprehensive analysis by the Pew Research Center reached similar conclusions. Although basic science knowledge predicted support for government funding of scientific research and the belief that such investments result in societal benefits, it was

unrelated to opinions on highly contested topics such as climate change, vaccines, and natural gas fracking (Pew 2015c).

Other research suggests that greater levels of basic science literacy can have a polarizing impact on attitudes among liberals and conservatives. For example, in comparison to their less knowledgeable counterparts, conservative Republicans scoring high in basic science literacy and numeracy (dubbed in the study as "ordinary science intelligence") are more likely to doubt the human causes of climate change.

Among liberal Democrats, the relationship is the reverse: more science literacy and numeracy predicts acceptance of human-caused climate change. In other words, as science literacy and numeracy increases among liberals and conservatives, the gap in their opinion widens rather than narrows (Kahan et al. 2012; Kahan, 2015) (see Figure).

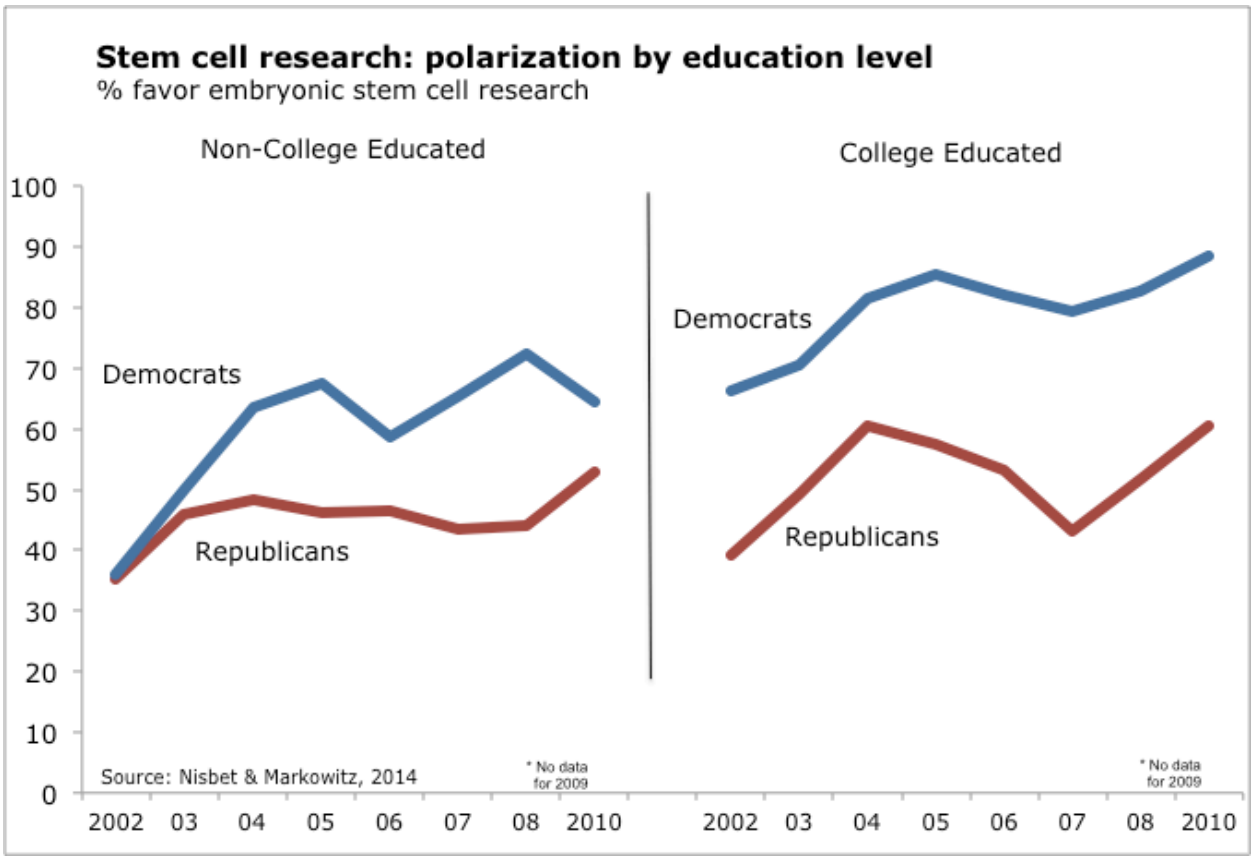


Source: Kahan 2015

A similar relationship between basic science literacy and ideology has been observed relative to support for government funding of scientific research. Liberals and conservatives who score low on science literacy tend to hold equivalent levels of support for science funding. But as science literacy increases, conservatives grow more opposed to funding while liberals grow more supportive (Gauchat, 2015).

The polarizing effects of science knowledge have also been observed in relation to religiosity. In this case, specific to belief in evolution, greater science literacy and numeracy predict doubt among the most religious. But among the less religious, greater levels of science literacy are related to greater levels of belief in evolution (Kahan, 2015). Specific to religiosity, various measures of issue-specific knowledge have been observed as having identical polarizing effects on attitudes about stem cell research (Nisbet, 2005) and nanotechnology (Brossard et al., 2008) respectively.

Researchers differ slightly in the explanations they provide for the role that knowledge and education play relative to polarization across groups. But overall, studies suggest that polarization occurs because individuals with higher levels of education and knowledge tend to be more adept at recognizing politically or religiously congenial arguments, are more attuned to what others like them think about the matter, are more likely to react to these cues in ideologically consistent ways, and tend to be more personally skilled at offering arguments to support and reinforce their pre-existing positions (Haidt, 2012; Kahan et al. 2012).



Consider the role that education played in relation to partisan differences in views about embryonic stem cell research. Following President George W. Bush's controversial 2001 decision to limit Federal funding for research, more politically attentive college-educated partisans were already strongly split in their views on embryonic stem cell research. In the months leading up to the 2004 presidential election, partisan differences were readily made apparent for the broader public by way of campaign messaging and news coverage. Democratic campaign strategists viewed stem cell research as a politically favorable “wedge” issue and employed targeted advertising and other messaging designed to win votes from moderate and weak-identifying Republicans.

Only following the 2004 election did less educated partisans begin to exhibit cleavages in their opinions, but they still showed less separation in their views than their better-educated counterparts. Following the 2009 Obama administration decision to expand funding for research, absent continued partisan conflict over the issue, the gap between Republicans and Democrats narrowed (Nisbet & Markowitz, 2014).

Recently, researchers have developed other measures of public knowledge, focusing instead on fundamental scientific reasoning skills. In this research, respondents are asked 11 survey questions that measure the skills needed to demonstrate competence in evaluating scientific evidence or to "think like a scientist." These questions ask about double blind experiments, causality, confounding variables, construct validity, control groups, ecological validity, history and maturation effects in surveys or experiments, measurement reliability, and response bias.

Respondents on average answered seven of these 11 questions correctly. Individuals who scored higher on the scientific reasoning scale were better educated, more open-minded, and tended to be older. Of interest, scientific reasoning ability was unrelated to either political ideology or religiosity.

After controlling for several confounding factors, higher scores on the scientific reasoning scale consistently predicted acceptance of the scientific consensus on vaccines, genetically modified foods, and human evolution, but not climate change, or the Big Bang. In a skills test, individuals scoring higher on the scientific reasoning scale were also more likely to correctly interpret numerical information regarding the effectiveness and side effects of certain drugs (see Drummond and Fischoff, 2015).

Key Takeaways

Civic Science Literacy

- Among the U.S. adult population, scores relative to civic science literacy have remained stable for decades. In this case, civic science knowledge is strongly predicted by the number of college-level science courses an individual has completed, suggesting the importance of a strong general education curriculum at universities and colleges.

- Although at the individual level, science media use and other forms of informal learning are predictive of science knowledge scores, investment in these resources across decades does not appear to have had a significant impact on the overall population.

Public Outreach and Knowledge Gaps:

- Even in the most high profile science-related debates, it is likely that public knowledge of the specifics of the relevant science or policy details will remain relatively low. To form opinions and judgments, the public is instead likely to rely on views about science

and society, social and political identity, and the frames of reference most readily available by way of trusted news sources and political leaders (see next section).

- Simply making scientific information more widely available via the news media, museums, websites, and social media is likely to deepen knowledge disparities among the public. Over time, the knowledge rich will get richer, while gains in knowledge among the less well off are likely to be minimal. Instead, scientists and their partners need to systematically invest in research and strategies that identify effective outreach efforts for countering such disparities (see Nisbet & Scheufele, 2009).

Scientific Knowledge and Public Attitudes:

- The tendency for the most scientifically sophisticated and knowledgeable Americans to be the most divided on ideologically contested issues like climate change or evolution holds several key implications for newly emerging issues like gene editing. In particular, it is very important for the scientific community and its partners to work to avoid and counter political interpretations that make it easy for the public to interpret such issues through the lens of ideological or religious identity (see Kahan 2012; Nisbet 2014).

- On issues like climate change or evolution where polarization has already occurred, no amount of additional scientific information is likely to alter the views of those inclined to doubt scientific consensus. Instead, the scientific community needs to work with partners who can speak to the background and identity of the disaffected groups involved and who can reframe an issue around commonly held values. On evolution, for example, faith community leaders and religious scientists can speak to the lack of conflict between the teaching of evolution and religious doctrine, emphasizing the importance of evolutionary science to advances in medicine or agriculture (see Labov & Pope, 2008).

- Scientific reasoning skills, above and beyond political identity and other social background factors, appear to be predictive of attitudes consistent with scientific consensus on highly contested issues (though not on climate change). The challenge is that such skills are not easily acquired once formal education ends, leaving the scientific community with few if any effective communication strategies for bolstering this dimension of knowledge among the adult population. Nevertheless the research in the area underscores the importance of teaching such skills as part of the secondary and college-level curriculum to as broad a segment of the student population as possible.

BELIEFS ABOUT SCIENCE, GOVERNMENT, AND SOCIETY

As debates over climate change, biotech advances, vaccines, and nanotechnology continue and as conflicts over other issues emerge, a recurring set of questions is likely to be asked by journalists, policymakers, advocates, and the public.

Relative to other considerations, what role should scientific expertise play in decision-making? Do scientific breakthroughs promote or undermine social progress? Are scientists working in the public interest or on behalf of their own interests? Is research being pursued too cautiously or too quickly? Do scientists respect or cross moral boundaries? Should the government regulate science or the marketplace? Should the government invest in basic research even if there is no immediate direct payoff?

In relation to these questions, research suggests that public feelings of trust, perceptions of expert authority, views about the role of government, and beliefs about science and society are all likely to have a substantial influences on public judgments and decisions.

Public Trust and Cultural Authority

With limited motivation to follow science-related debates closely, in order to form opinions or make decisions about complex questions, the public often relies heavily on how much they trust or defer to the authority of scientists. Above and beyond knowledge, studies show that trust in scientists is one of the strongest predictors not only of general attitudes about science, but also of opinions about contested scientific topics (see Sturgis & Allum, 2004).

Trust involves a relationship between scientists and the public that facilitates ongoing interactions that involving uncertainty and risk-taking about future interactions and outcomes. Trust is considered to have at least three key dimensions including "integrity," the belief that a person or organization is fair and just; "dependability," a belief that an individual or organization will do what they say; and "confidence," a belief that an individual or organization can or will deliver on their promises (see National Academies, 2015).

In one relevant measure of trust, since the early 1970s, the General Social Survey has asked Americans if they have “a great deal of confidence,” “only some confidence,” or “hardly any confidence at all” in the leaders of various major institutions including the scientific community. In 2012, 90 percent of the public expressed either “a great deal of confidence” (41%) or "some confidence" (49%) in leaders of the scientific community. In comparison, since the 1970s, as public confidence in Congress, the presidency, industry, religious institutions, and the news media have plummeted, public faith in the scientific community has remained virtually unchanged (NSB, 2016).

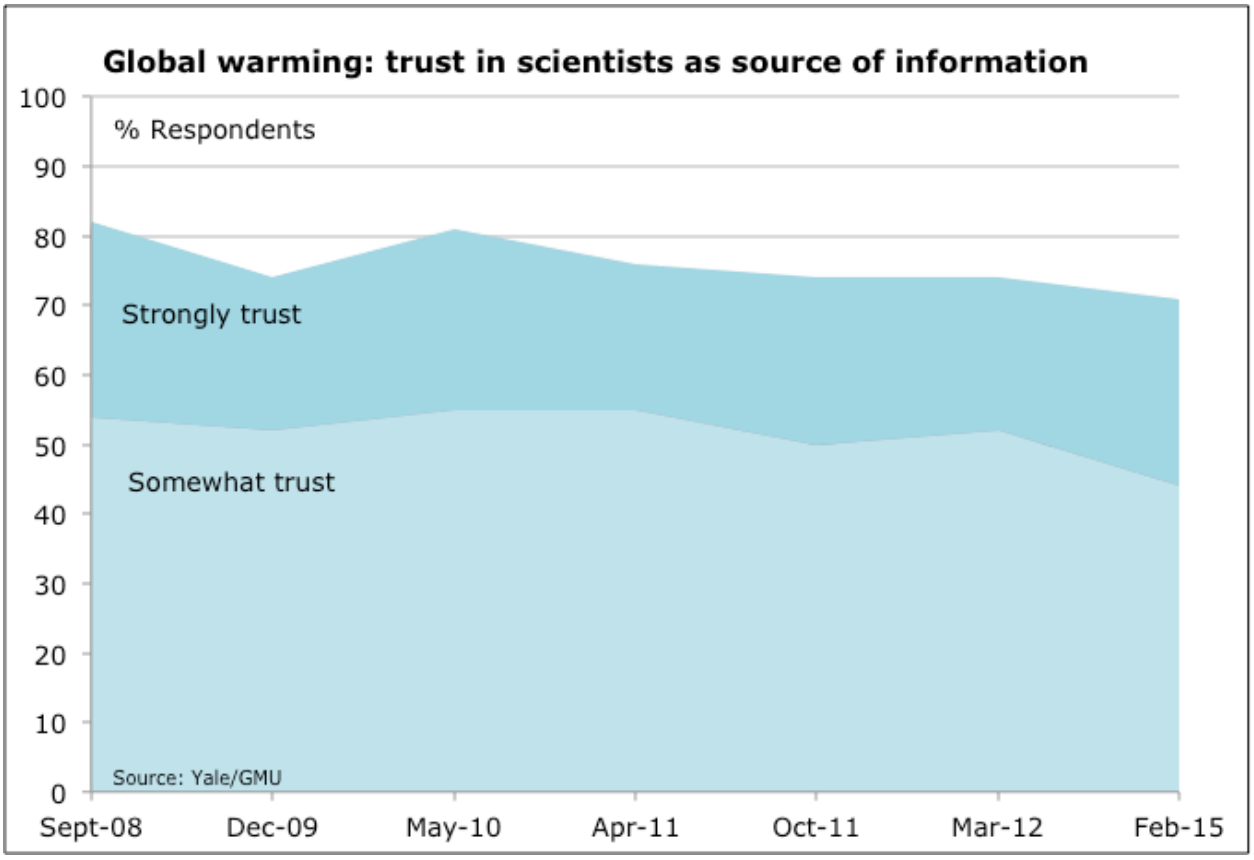
According to statistical analysis of the aggregated General Social Survey data, women, non-whites, and older Americans are the most likely to express lower levels of confidence in the

leadership of the scientific community. Over time, analysis indicates that confidence in the scientific community has also declined among better-educated conservatives, but has remained relatively stable among moderates and liberals (Gauchat, 2012). Yet this decline in confidence in science also mirrors a broader decline in confidence among conservatives relative to most other major institutions.

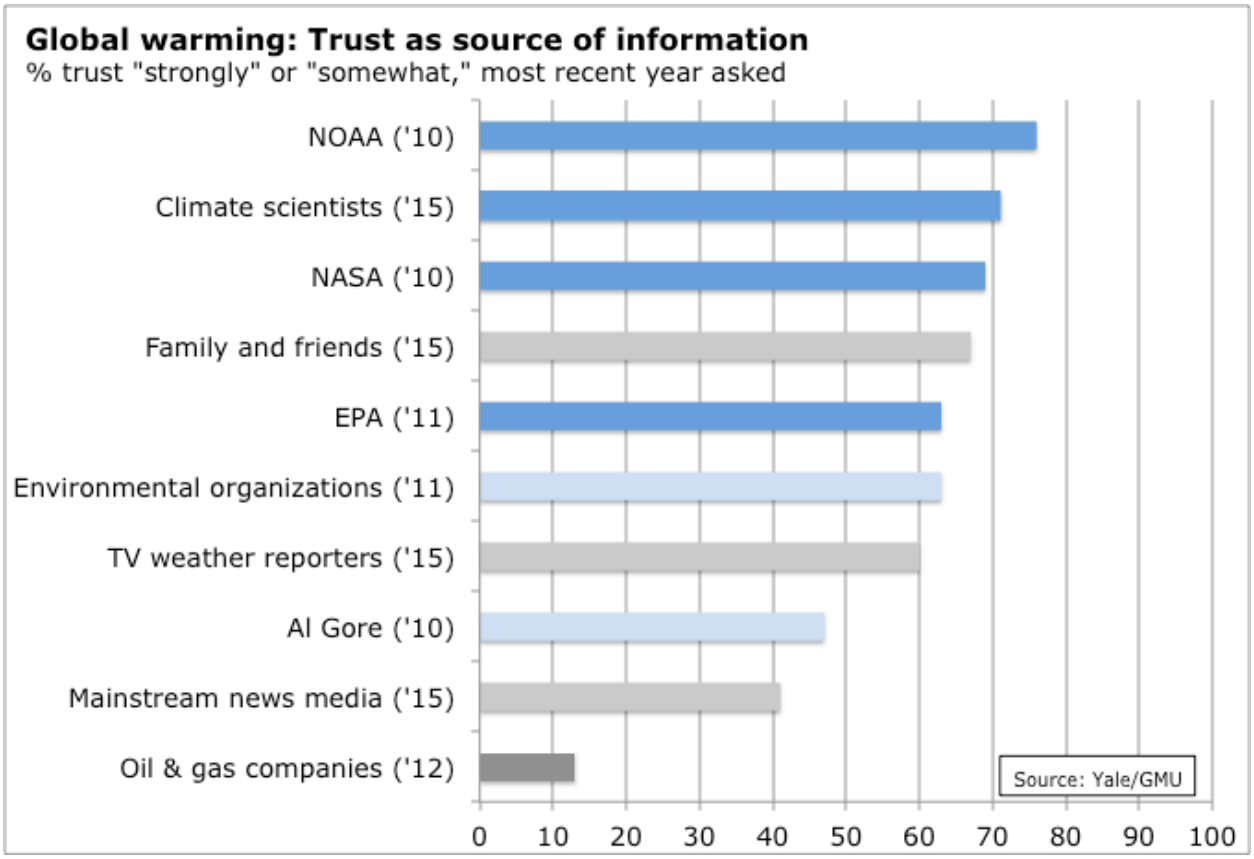
Rather than distrusting the scientific community generally, other research shows that conservatives tend to differentially distrust so-called "impact scientists," researchers such as climate scientists or health scientists who examine the environmental and health impacts of economic development and technology. In contrast, conservatives tend to hold greater trust in so-called "production scientists," researchers such as engineers or chemists producing new technologies and marketable products (McCright and Dunlap, 2010).

Specific to climate change, polling shows that the public holds strong overall trust in scientists as a source of information, though levels of trust have shifted slightly downward in recent years. Yet still, compared to other possible sources of information, scientists and expert government agencies enjoy widespread trust, especially in comparison to the oil and gas industry (see figures next two pages).

In 2004, the National Science Board brought together a team of social scientists to re-examine the organization's biannual surveys on public attitudes about science and technology. The NSF asked the team to redesign the survey to include a new emphasis on what the NSF termed the "cultural authority of science," specifically how the public views the role of scientific expertise in policymaking and societal decisions.



In subsequent 2006 and 2010 surveys, Americans were asked how much influence scientists -- in comparison to elected officials, business leaders, and religious leaders -- should have on policy decisions related to climate change, stem cell research, genetically modified food, and nuclear power. They were also asked how much each group understood the issue and the extent to which they would "support what is best for the country as a whole versus what serves their own narrow interests." Across each topic, scientists in comparison to other groups were believed by the public to have a substantially greater role to play in policy decisions, to have greater levels of expertise, and to be more likely to support what is best for the country (NSB 2012).



Beliefs about Science and Government

Since the 1970s, about 8 out of 10 Americans have either "strongly agreed" or "agreed" that "even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government." Those who are better educated and who score higher in terms of science literacy offer the strongest support for government funding of science (NSB 2016).

In 2014, when asked if the government is spending too much or too little on scientific research, 39 percent said government was spending “too little,” 45 percent said the amount was “about right,” and 10 percent said it was “too much.” In comparison, public support for spending is greater when asked specifically about sectors or topics of which they have greater familiarity or are more easily perceived as having an immediate need.

For example, 75 percent say we should be spending more on education, and about 60 percent say we should be spending more on health, alternative energy sources, and environmental protection respectively. Of interest, public support for increased spending on scientific research (39%) is greater than support for spending on national defense (31%) or space exploration (24%), (NSB, 2016).

The Pew Research Center has asked several questions that tap other dimensions of public beliefs about science and government. In 2014, more than 70 percent of Americans said that government investments in basic scientific research pay off in the long run rather than not being worth it. A similar proportion said the same about investments specific to engineering and technology.

Overall, Hispanics, those with a college degree, and those who scored higher on science literacy were all more likely to agree that both scientific research and investments in engineering and technology pay off in the long term. Relative to partisanship, about 80 percent of Democrats agreed with the two statements compared to 70 percent of Independents and 60 percent of Republicans (Pew, 2015c).

A strong majority of Americans (61%) similarly believe that government funding is essential for scientific progress compared to 34 percent who say that private investment would be enough to ensure progress even without government investment. In this case, blacks and those with a graduate degree are more likely to believe that government funding is essential. In terms of partisan differences, when asked this way the gaps are wider than in the previous question. About 80 percent of Democrats believe that funding is essential compared to 60 percent of Independents and 50 percent of Republicans (Pew, 2015c).

Beliefs about Science and Society

Researchers studying public attitudes about science and technology have identified two dominant mental models that members of the public rely on to generate opinions about specific scientific advances and to form judgments about policy options (see Miller 1998; Nisbet & Goidel, 2007; Nisbet & Markowitz, 2014).

In comparison to factual or procedural knowledge, mental models provide a deeper cognitive architecture, defining core concepts about how society works. In doing so, mental models provide easy-to-use cognitive shortcuts for reaching an opinion about a complex issue such as nanotechnology, gene editing, or stem cell research, serving as a basis for inference, and operating as a mechanism for storing and retrieving information from memory.

The first mental model, “scientific optimism,” is an attitude construct representing respect for the intentions of scientists, a sense that science and technology provide useful results and products for society, and the assumption that future benefits from science and technology are likely. Across national surveys, this mental model has been measured using an index of items that ask respondents to agree or disagree with statements such as "because of science and technology, there will be more opportunities for the next generations," and "science and technology are making our lives healthier, easier, and more comfortable (See Miller et al., 1997).

The second mental model, “scientific reservations,” is an attitude construct reflecting public concerns about the speed of change in modern life and a sense that science and

technology pose conflicts with traditional values or belief systems. Across national surveys, this mental model has been measured by asking Americans to agree or disagree with an index of questions such as, "On balance, the benefits of scientific research have outweighed the harmful results," and, "We depend too much on science and not enough on feelings and faith" (See Miller et al., 1997).

In the U.S. context, the two mental models tend to be negatively correlated with one another. Thus “science optimists,” who hold a strong belief in the promise of science and technology, are generally less likely to have concerns about negative impacts. In contrast, “science pessimists,” who have strong reservations, are less likely to acknowledge the benefits of science and technology to society.

Studies also show that some individuals hold both mental models strongly and concurrently, perhaps reflecting among this “conflicted” group a more nuanced and complex consideration of the role of science and technology in society. Additionally, some people may score low in both schema, which suggests that this “disengaged” group may lack a strong mental model for how science and technology might generally impact their lives and society more broadly. In the absence of clear guiding schema about science, such individuals may be more apt to rely on other heuristics such as partisanship or ideology when asked to make judgments about unfamiliar scientific issues or technologies (see Nisbet & Markowitz, 2014).

A 2014 study analyzed data collected from eight national surveys administered between 2002 and 2010, segmenting the public by way of their relevant question responses into scientific optimists, scientific pessimists, the conflicted, and the disengaged. Each segment was then examined for unique characteristics in terms of social background and political outlook. Their specific attitudes about stem cell research were also compared (see Nisbet & Markowitz, 2014).

- *Scientific Optimists*. Representing about a third of the public, scientific optimists are disproportionately white, and have the highest incomes and highest average educational level with 40 percent holding at least a four-year college degree. They tend to split almost evenly by partisan identity though trend slightly more Democrat. In terms of ideology, they are the most moderate in their outlook and almost all believe that abortion should be legal. Specific to self-rated knowledge, among the four segments, they tend to consider themselves the best informed about science and medicine. Among this group, about 75 percent said they favored embryonic stem cell research.

- *Scientific Pessimists*. About a quarter of the public, scientific pessimists tend to be the least well-educated with 78 percent lacking a four-year college degree. They tend to earn the lowest incomes with 40 percent earning less than $35,000 a year. This group also has the highest proportion of non-whites (26%) and the highest proportion of women (55%). Scientific Pessimists split evenly relative to partisan identity but tend to be disproportionately either moderate (37%) or conservative (46%) in their ideological outlook. Among this group, roughly one in four believes that abortion should be illegal no

matter the circumstance. Interestingly, this group also tends to view themselves as the least informed about science and medicine. Among this group, about half said they favored embryonic stem cell research.

- *The Conflicted*. About a quarter of the public, the Conflicted are similar to Scientific Pessimists in terms of education, gender, and income. They are also the oldest of the four segments. The Conflicted on the whole are slightly more likely to identify as a Democrat but are also more moderate and conservative in their political outlook. More than eight out of 10 believe that abortion should be legal. Despite lower levels of education, they tend to rate themselves relatively high in terms of knowledge about science and medicine. Among this group, about 58 percent said they favored embryonic stem cell research.

- *The Disengaged***.** About 15 percent of the public, the Disengaged are higher income earners and roughly 30% have at least a four-year degree. These individuals tend to lean Democrat or Independent and lean moderate in their ideological outlook. They have a similar level of support for abortion as the Conflicted. In comparison to Scientific Optimists, a distinguishing trait is their lower levels of self-rated knowledge about science and medicine. Given that this group lacks a well-developed mental model for the social implications of science and considers themselves less informed, it is likely that the Disengaged are therefore more reliant on their partisanship or ideology to guide their judgments. Among this group, about 60 percent said they favored embryonic stem cell research.

Key Takeaways

Public Trust and Cultural Authority

- Even on highly contested issues, scientists continue to enjoy a rich bounty of perceptual capital. In comparison to political, religious, or business leaders, scientists are perceived by the public as having the greatest level of expertise relative to several major policy debates, are believed to have a greater role to play in policy decisions, and are viewed as the most impartial.

- When controversies occur, the challenge for scientists and their partners is to understand how to use this capital to effectively inform science-related decisions (see Nisbet & Scheufele, 2009).

Beliefs about Science and Government

- As budget battles continue to define Congressional politics, the public holds a strong latent belief in the need for the government to fund both basic scientific research and technological innovation.

- Yet the challenge in making appeals to the public for support will be in gaining public attention for what are typically highly technical, less visible budgetary battles. Although strong majorities of the public support government funding for science, relative to other issues and priorities, it will be difficult to mobilize broader public pressure and demand for such funding.

- Instead, as the example of the late 1990s doubling of the NIH budget by Congressional Republicans makes clear, such political battles will be driven by framing strategies that emphasize the relevance of research to international competitiveness and social progress; specific personal appeals made to key Congressional members; and the mobilization of a coalition of special interest groups and their constituencies (see Dresser, 1999; Best, 2012; Hegde, 2015).

Beliefs about Science and Society

- In science-related policy debates, if scientists and their institutions in their outreach focus exclusively on the potential for partisan and ideological differences they may be distracted by relatively simplistic left-versus-right distinctions that will vary considerably in relation to media attention and specific policy proposals.

- In comparison to partisan and ideological identity, mental models about science and society are likely to be more stable over time, less volatile, and have greater predictive power in assessing public opinion and perceptions across issues.

- Profiling and segmenting the public in terms of their beliefs about science and society can allow scientists and their partners to tailor their communication activities to the unique concerns of each group (see Nisbet & Markowitz, 2014).

PUBLIC ATTITUDES ABOUT CLIMATE CHANGE

Researchers have identified numerous psychological and social processes that shape how individuals learn about and form opinions about climate change. Many of these mechanisms act as barriers to public participation by inhibiting perceptions of climate change as an important, real, and serious problem that requires action (Gifford, 2011).

Further depressing motivation to engage with climate change, many Americans perceive, correctly, that the worst consequences of the problem will accrue to other people living far away both in time and social distance. Because people strongly discount events that are psychologically distant, such perceptions generally act to decrease risk perceptions and feelings of urgency (Trope, Liberman, & Wakslak, 2007).

Moreover, because climate change is often talked about as a distant, abstract, probabilistic, and scientific phenomenon, people lack naturally strong emotional reactions to

the issue (Weber, 2006). Research in the behavioral sciences emphasizes the critical role that such emotional processes play in shaping both our short- and long-term decision-making.

Climate change also involves many different types of uncertainty relative to its ultimate consequences, timing of events, and severity of outcomes. In turn, uncertainty tends to promote the belief that individuals do not hold personal responsibility to respond, since people are generally predisposed to be overly optimistic about their chances of avoiding climate change risks (Weinstein, 1980).

As a result, many individuals are likely to interpret information about climate change in ways that allow them to maintain a positive outlook on life. When people do recognize the severity of the threats posed by climate change, they are likely to respond either by denying those consequences or else by feeling helpless to respond (Norgaard, 2011).

Apart from these general social and cognitive processes, studies over the past decade have found that public perceptions vary by age, gender, race, education, and income level. The strongest and most consistent predictor of perceptions tends to be political ideology and worldview.

Over time and across groups, studies have also shown that public opinion shifts in relation to economic conditions, weather-related events, news coverage, and political messages, though researchers disagree on which of these factors have the strongest or most predictive influence (see Shao et al., 2014 and Scruggs & Benegal, 2012).

Perceptions of Climate Change and Scientific Consensus

Surveys of climate scientists and comprehensive reviews of thousands of peer-reviewed studies confirm the same basic fact: at least 97 percent of climate scientists say that human-caused climate change is happening (see Doran and Zimmerman, 2009; Anderegg et al, 2010; Cook et al., 2013).

In comparison, multiple survey studies show that about 60 to 75 percent of U.S. adults believe that climate change is occurring, a level of belief that has remained relatively stable for the past decade.

When asked to identify the core cause(s) of climate change, between 40-50 percent of the U.S. adult population state that it is primarily human caused; these numbers have fluctuated somewhat from year to year, but public opinion in 2015 looks similar to where it was in 2007.

One likely factor limiting public acceptance of human-caused climate change is that surveys find that only one out of 10 Americans correctly estimate agreement on the matter among climate scientists as greater than 90 percent. Thirty percent say they don't know or can't answer the question (Leiserowitz et al. 2014b).

Public beliefs about expert consensus have been measured in a variety of ways, yet each question wording leads to similar results: Many Americans do not believe there is widespread agreement among scientists that climate change is occurring or that it is human caused.

Since 1997, Gallup has asked the American public to rate the accuracy of a series of statements about scientific agreement. In 1997, 48 percent of Americans rated as most accurate, " Most scientists believe that global warming is occurring." In 2015, 62 percent of Americans said the same.

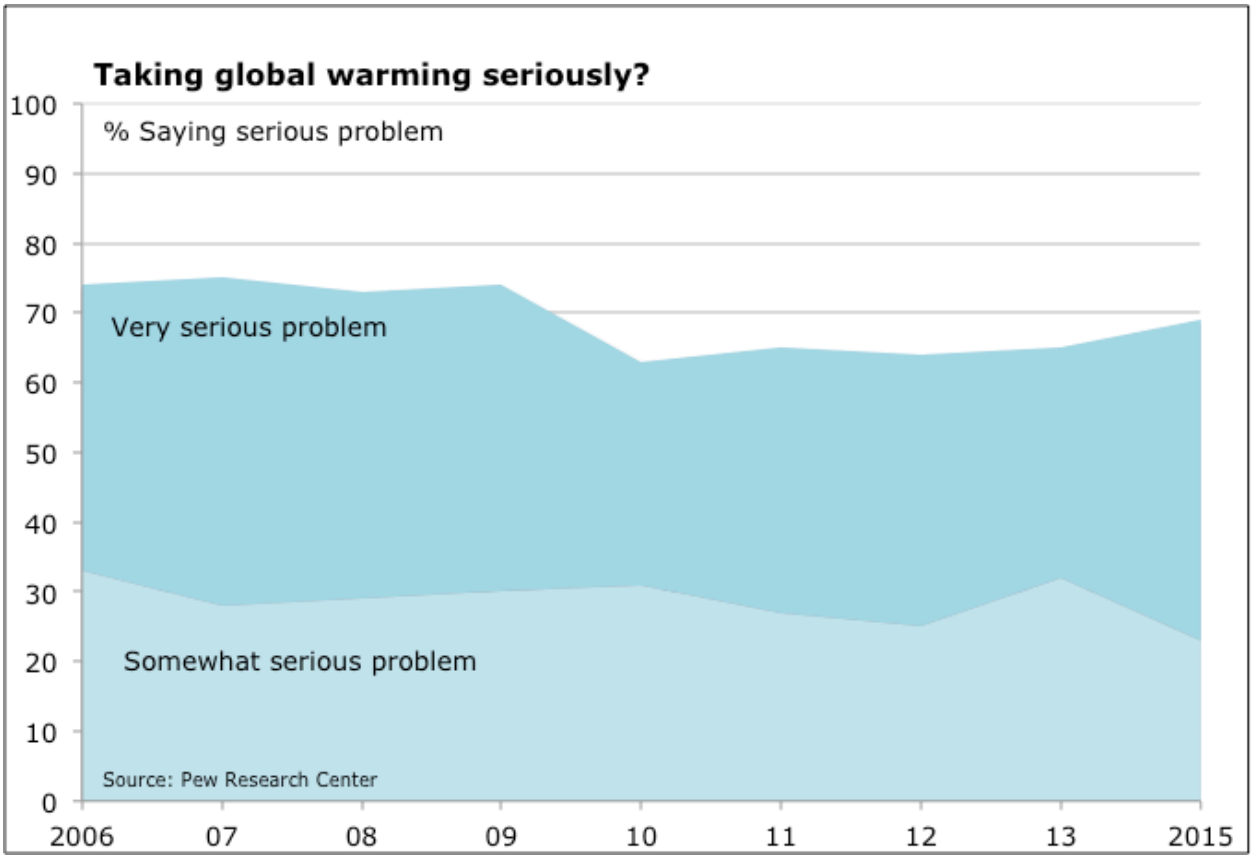
As simple as it might sound, studies indicate that perceptions of scientific consensus on climate change serve as a key "gateway belief," influencing other beliefs about the issue, which in turn, shape support for policy action. To evaluate strategies for correcting perceptions of expert consensus, in carefully designed online experiments, van der Linden and his colleagues (2014) tested the effects of different variations on the same message: "97% of climate scientists have concluded that human-caused climate change is happening."

Across each of their experimental conditions, boosting awareness of scientific consensus increased beliefs that climate change is happening, that it is human caused, and that it is a worrisome problem. These shifts in beliefs in turn increased subjects' support for policy action, with some of the biggest increases observed among Republicans, who tend to be more dismissive of the issue (van der Linden et al. 2015).

Shifting Perceptions of Severity and Immediacy

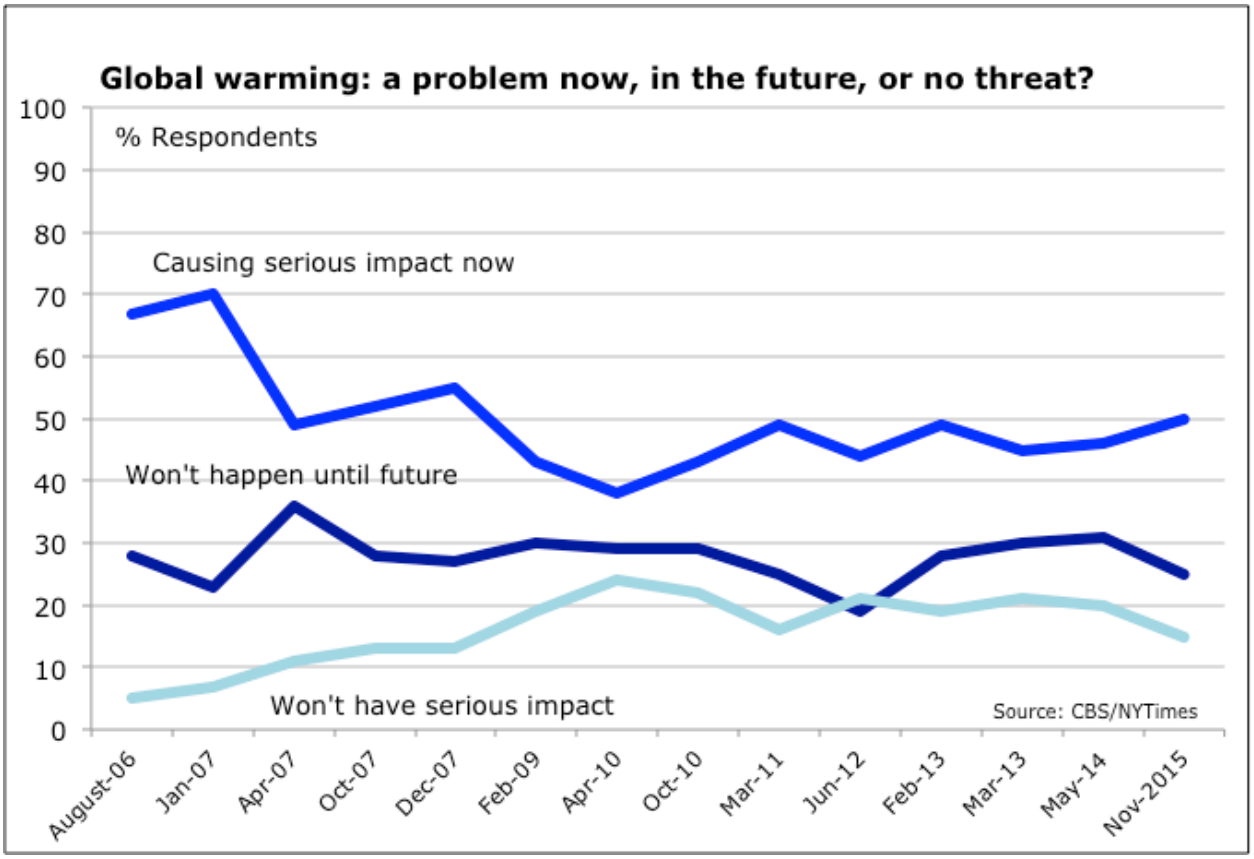
Many Americans tend to discount the seriousness of climate change or believe that the impacts of climate change are far off in the future, if they will occur ever at all. These perceptions tend to shift in relation to economic conditions, political events, and weather trends and vary by the social and political background of an individual.

For example, over the past decade, the Pew Research Center has asked Americans to rate the perceived severity of global warming. In 2006 and 2007, 75 percent of Americans said that global warming was either a very serious (41%) or somewhat serious (33%) problem. In the years since, the combined proportion saying the same has ranged between 63 and 69 percent of Americans. Interestingly, between 2010 and 2013, about a third of the public said that global warming was a very serious problem. In 2015, this proportion jumped to 46 percent (see Figure).



Similarly, over the past decade, the Gallup Organization has asked Americans to rate the perceived immediacy of global warming as a threat. Surveys have asked Americans if global warming "is an environmental problem that is causing a serious impact now, or do you think the impact of global warming won't happen until sometime in the future, or do you think global warming won't have a serious impact at all?"

. In 2006 and early 2007, 70 percent of Americans said that global warming was causing a serious impact now. Yet by April 2007, as the economy began to falter, the proportion saying the same had dropped to 49 percent. In the years since, the proportion believing that global warming is having serious impact now has ranged between 38 and 50 percent. During this same period, the proportion saying the impact of global warming won't happen until sometime in the future has ranged from 25 to 31 percent. Finally, those saying global warming won't have a serious impact rose from 5 percent in 2006 to a high of 24 percent in 2010, declining to 15 percent in 2015.



A tendency to discount the severity and immediacy of climate change partly explains why climate change is a relatively low political priority for Americans. The Pew Research Center has annually asked the public to rank what they believe to be “top priorities” for the president and Congress. In this case, dealing with global warming consistently ranks towards the bottom of the list whereas the environment and energy respectively rank as mid-tier concerns. For at least a decade the economy, jobs, terrorism, and war have dominated the public's top priorities, and this holds true for both Republicans and Democrats (Pew 2015d).

Shifting perceptions of the severity and immediacy of climate change along with its relatively low ranking as a political priority all relate to what social psychologists describe as the public's “finite pool of worry” (Weber, 2006). As one perceived risk gains societal attention, other risks often are bumped from concern. Perhaps no other issues have the ability to swamp public worry to a greater extent than the performance of the economy and the threat of terrorism.

Unlike the diffuse, creeping nature of climate change, the economy and terrorism for many Americans provide daily and powerful reminders of their vulnerability.

A 2010 study investigated directly the linkages between the economic recession that hit the U.S. in 2007 and the subsequent downturn in climate change concern. Analyzing Google

search trends, the authors discovered that in states with higher unemployment rates, given a limited pool of worry, individuals were much less likely to search for information about global warming. Turning to national survey data, after controlling for demographics, they found that individuals living in states with higher unemployment rates were appreciably less concerned and more dismissive of climate change (Kahn & Kotchen, 2011).

Comparing public opinion trends to a variety of real world indicators, a second study evaluated whether the decline in public belief in climate change between 2008 and 2011 could be attributed to economic conditions, the weather, and/or the influence of skeptical voices in the news media. Among the factors, the drop in the unemployment rate was the strongest predictor of changes in public opinion, followed by a modest influence for extreme cold weather. No significant aggregate influence for media coverage was found (Scruggs & Benegal, 2012).

A more recent study conducted a similar analysis of the individual-level and contextual-level factors shaping the perceived severity of global warming and the immediacy of the threat, extending the analysis across a decade's worth of aggregated polling data (Shao et al, 2014).

In terms of individual level factors, consistent with other studies, women, the better educated, and those who earn lower incomes were each more likely to score higher relative to perceived severity and immediacy of climate change.

Yet the strongest predictors of risk perceptions were political partisanship and ideology. In comparison to Democrats and liberals, Republicans and conservatives were substantially more likely to dismiss the severity and immediacy of climate change. As in other studies, these differences between left-leaning and right-leaning individuals were greatest among the better educated.

In terms of contextual-level factors, surprisingly the study did not find evidence that economic conditions -- measured as unemployment at the county level-- were related to the perceived severity or immediacy of climate change. Instead, summer temperature trends and to a lesser extent fall precipitation patterns were each predictive of risk perceptions. Specifically, those living in areas that had experienced especially hot summers and wet autumns were more likely to view climate change as a very serious problem that was already posing risks to society (Shao et al, 2014).

Recent surveys by the Yale/George Mason team are consistent with the conclusion that weather patterns are influencing Americans' perceptions of climate change. Consider that 57 percent of the public in 2014 believe that “global warming is affecting weather in the United States.” Alternatively, when asked how much global warming is affecting weather, 39 percent indicated “a lot.” Similarly, when asked, “how strongly do you agree or disagree with the following statement: Global warming is affecting the weather in the United States,” close to two-thirds of the public indicated “strongly agree” or “somewhat agree.”

Feelings of Efficacy and Public Participation

Low levels of personal and political efficacy are also major barriers to public engagement with climate change and to building support for policy action. Many Americans do not believe they personally can take effective actions to address climate change or that society and its leaders are capable of acting in time.

Consider that between 2008 and 2014, a majority of Americans believed that “humans could reduce global warming, but it is unclear at this point whether we will do what is needed." While the trends indicate this response is decreasing among the public -- 51 percent in 2008 down to 42 percent in 2014 -- a stable percentage of respondents across years hold less than optimistic views of our collective ability to respond to the problem. Between 2011 and 2014, nearly 25 percent of study respondents agreed that “humans could reduce global warming, but people are not willing to change their behavior, so we aren’t going to" (Leiserowitz et al., 2014a).

Such feelings of inefficacy are promoted when the public is told that there is little that can be done to stop the worst outcomes of climate change, a message that can be heard from both sides on the issue. Alternatively, news coverage and communication campaigns that emphasize the dire risks of climate change without a similar emphasis on direct actions that can be taken to address those risks are likely to backfire by boosting fear and reducing hope, which in turn can promote feelings of inefficacy and doubt (Feldman & Hart, 2015; O'Neill & Nicholson-Cole, 2009).

Similarly, when individuals lack trust in existing political leaders or institutions to have either the capacity or will to respond effectively to climate change, personal motivation to engage with the issue is dampened, since research shows that feelings of reciprocal sacrifice are important motivators of participation (Feldman & Hart, 2015).

Unfortunately, much news coverage of climate change separates reporting of impacts and risks from efficacy enhancing messages that feature specific forms of action. Reviewing network television coverage of the issue, Hart and Feldman (2014) found that impacts and possible solutions to climate change are rarely discussed in the same broadcast.

In a follow up experimental study using a nationally representative sample of adults, Feldman and Hart (2015) provided subjects with contrasting messages about climate change that varied in the amount of efficacy-enhancing information. Specifically, respondents read a news article that warned in the headline of "severe impacts of climate change on the horizon." Apart from scientific information about the nature of the threat, those in the control condition were provided with no other details about how the public or government were taking action to address the threat.

In contrast, in the experimental condition, subjects were exposed to different types of efficacy-related information including details on how citizens were turning out to a government

agency-sponsored public meeting to provide input or, alternatively, how the government agency was taking into account public comments in planning actions to address the threat.

The efficacy-inducing messages promoted greater feelings of hope about climate change and reduced feelings of fear. In turn, feelings of hope were predictive among subjects of intentions to become active politically and civically on climate change. These findings spanned ideology, demonstrating similar effects among liberals, moderates, and conservatives (Feldman & Hart, 2015).

Political Polarization and Audience Segmentation

Recent studies suggest that climate change has become the single most politically polarized issue in American politics. The gap in concern about climate change among strong liberals and strong conservatives is greater than gun control, abortion, social security, health care, immigration, and several other divisive political issues (see Guber, 2012).

As previously reviewed, multiple studies have convincingly demonstrated that as science literacy and numeracy increase, partisan and ideological polarization in relation to climate change *also* increases, contrary to the traditional and widely held assumption that greater knowledge reduces differences among groups.

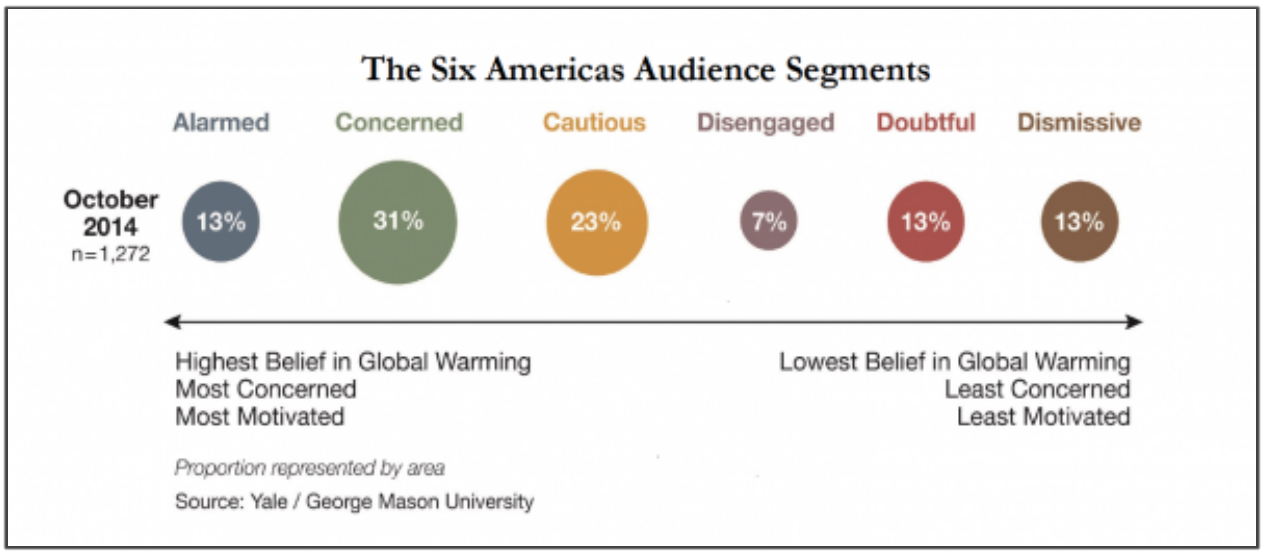
Yet the focus on polarized differences among strong liberals and conservatives can lead to a false binary view, defining public opinion exclusively in terms of left-wing believers and right-wing deniers. Such a focus, however, can distract from the broad range of public views in between these two tail end perspectives.

In this regard, research suggests that rather than a problem of public denial; the communication challenge in the United States is more accurately viewed in terms of overcoming public ambivalence.

In this case, over the past half-decade, audience segmentation research on the "Six Americas of Global Warming" has helped shift focus to why a greater diversity of different segments of the public accept or reject certain arguments, risks, and dimensions of the climate debate.

Analyzing nationally representative U.S. survey data, this research has identified six distinct interpretative communities on climate change, profiling their demographic characteristics, risk perceptions, affective reactions, levels of trust, forms of knowledge, political and personal behaviors, and media use patterns (Maibach et al., 2011).

The sizes of these six segments have shifted slightly across years and include the Alarmed (approx. 15 percent of the adult population), the Concerned (30 percent), the Cautious (20 percent), the Disengaged (7 percent), the Doubtful (13 percent), and the Dismissive (13 percent) (see Figure).



These audience segments range along a continuum of knowledge, attitudes, and behavior from the Alarmed, who accept climate change as a problem, are concerned, and are looking for opportunities to take personal and political action, to the Dismissive, who reject the reality of climate change and strongly oppose action.

Individuals in the four middle segments are far less certain and consistent in their views about climate change, more ambivalent about the risks and relative importance of the issue, and disengaged personally and politically.

In terms of public engagement and communication, the challenge is to identify which messages, opinion-leaders, and communication channels best enable and help members of each segment accurately understand and perceive the relevance of climate change, the personal choices and policy options available, the common interests they share with others, and how they can collaborate on solutions (see Maibach, Roser-Renouf, & Leiserowitz, 2008).

One major success to come out of the Six Americas project has been a recognizable shift in how many climate advocacy groups think about public engagement, recognizing that no single approach to climate communication will be successful across all six segments.

However, a Six Americas segmentation strategy may be challenging to use in practice because the method is based on responses to questions about climate change, rather than identifying people by their underlying core motives, identities, or values as is standard in the marketing world and in election campaigns.

As a result, the typology is less helpful in identifying *why* an individual believes what he or she believes as well as what might motivate a shift from, say, the Cautious segment to the

Alarmed segment. Still, the general idea of segmenting the public in a way that can inform public engagement activities is a worthwhile one, and other researchers and groups are employing approaches.

Key Takeaways

Perceptions of Climate Change and Scientific Consensus

- In engaging the public, a first step for scientists and their partners is to invest in strategies that make more salient and readily available messages emphasizing that "97% of climate scientists have concluded that human-caused climate change is happening." The AAAS "What We Know" campaign is an example.

Shifting Perceptions of Severity and Immediacy

- The physical, temporal, and social distance that many Americans feel relative to climate change poses a challenge for greater public engagement and suggests the need for innovative approaches that help individuals identify personally relevant and relatable aspects of the issue.

- The public's limited capacity to worry about issues that don't directly (and obviously) affect their day-to-day well being means their mental and emotional "space" for climate change is limited. Scientists and their partners can potentially get around this issue by focusing on the environmental, public health, and economic benefits that come from taking action on climate change, thus moving the problem from the "something to worry about" list in people's minds to the "something that can make things better" list.

- Risk perceptions of climate change vary not only by individual level factors such as education or ideology, but also in relation to macro conditions related to the economy, news coverage, political debate, and the weather.

- Research indicates that as publics in different regions of the country experience particularly hot summers and wetter than usual autumns, these weather and climate-related trends serve as cognitive short cuts for reaching judgments about climate change.

- Direct, local level experience with climate change suggests that scientists and their partners need to invest in communication and outreach efforts that are regionally and locally focused and that connect weather-related events with long-term climate-change-related trends and their short- and long-term impacts.

- In terms of elevating climate change as a political priority, research suggests that asking Americans what will be the most serious issue in the future if nothing is done to stop it

led many respondents to switch their thoughts from the economy or terrorism to consider climate change as a top priority (see Yeager et al., 2011).

- Somewhat paradoxically, this research suggests as a strategy encouraging people to think explicitly about the future, rather than the present.

- In experiments, simply asking people to reflect upon how they want to be remembered by future generations can lead them to engage in more "helping behavior" in the present, particularly when it comes to protecting the environment.

- Whether deciding to make a charitable donation to environmental organizations or choosing environmentally friendly products over cheaper but more damaging ones, people who first consider their future legacies consistently make decisions that leave them looking environmentally conscious (and more virtuous) in the future (see Zaval, Markowitz & Weber, 2015).

Feelings of Efficacy and Public Participation

- Regardless of how effectively the causes and risks of climate change are explained or who the messenger is, effective public engagement strategies must convey a sense that the issue can successfully be addressed. This can include details on how people are getting involved and taking action, how their activities are recognized by decision-makers, and how decision-makers themselves are taking action. Communication strategies that promote feelings of efficacy are critical for generating and ensuring long-term public engagement and participation.

- Focusing on regional and local adaptation and mitigation successes is one strategy for supporting and building efficacy-related beliefs. Highlighting successful local adaptation efforts in particular may do much to build efficacy.

Partisanship, Ideology, and Audience Segmentation

- Few Americans strongly deny climate change, intensely resisting arguments on behalf of the problem's reality and urgency. Instead, most Americans can be placed on a continuum of indifference. Some are concerned, but do not know what can be done, or consider other issues to be a higher priority. Others have seldom if ever thought about the topic. Still others are not outright dismissive, but hold their doubts.

- The goal of communication should not be to change the minds of those who strongly deny climate change, but to engage those Americans who are ambivalent about the topic, using communication strategies and dialogue to frame climate change in ways that are more personally and socially relevant and to focus on solutions that cut across lines of difference. An example includes talking about climate change as a public health problem and the benefits to public health if action is taken. Similarly, many Americans

are likely to support actions related energy efficiency or cheaper solar power chiefly for economic reasons, rather than their environmental benefits.

- The Six Americas audience segmentation reports offer rich demographic background on each of the audience groups, helping scientists anticipate and envision the types of audiences they are trying to reach. The Six Americas research team has also developed a 15-item questionnaire that can be deployed at events or forums like science centers that can provide more predictive assessments of audiences.

PUBLIC ATTITUDES ABOUT FOOD BIOTECHNOLOGY

Genetically modified (GM) crops have been planted in the U.S. since the early 1990s, but it was not until a decade later that pollsters and researchers began to examine related forms of public knowledge and attitudes. These early analyses were motivated in part by controversy over the technology in Europe, campaigns by advocacy groups to ban the technology or to require food labeling, and a correlated rise in news attention.

During this period, looking across survey findings, researchers concluded that Americans were still unaware of most GM food products, lacked basic knowledge of the science or policy specifics involved, and had yet to form strong opinions about the issue. Yet, there was also some evidence that Americans had grown more cautious in their outlook on the technology (see Shanahan, Scheufele, & Lee, 2001; Hallman et al., 2004).

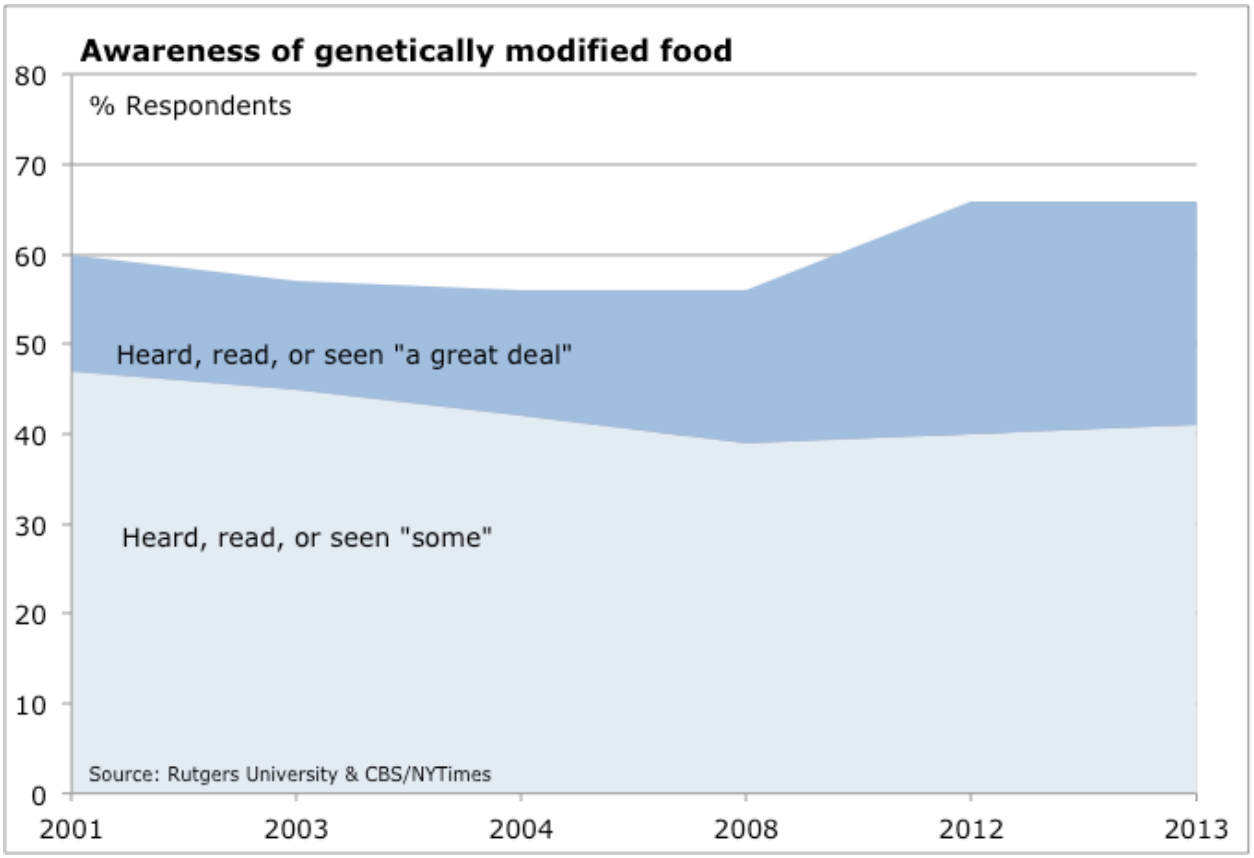
An emerging segment of consumers were also already actively seeking GM-free food choices. Analyzing national survey data collected in 2003, researchers profiled respondents by their ranking of more than 25 different desired attributes in the food that they consumed. The subset of consumers who said that they preferred GM-free food also preferred that their food be organic, vegetarian, natural, locally produced, not processed, and without artificial colors or flavors (Bellows, Alcaraz, and Hallman, 2010).

In 2012 and 2013, the labeling of GM food re-emerged as a hotly debated political issue. In successive years, California and Washington state residents considered and eventually voted down proposals to label GM food products. In both ballot measure battles, each side spent tens of millions of dollars to influence voters, generating national media attention to the controversy.

Overall, more than 20 states have considered bills or other measures to label GM food, though only Vermont so far has passed labeling requirements. In 2016, responding to legislative uncertainty on labeling across states, Campbell Soup Company announced that it would be the first major food company to voluntarily label its products as containing GM ingredients.

Public Awareness of GM Food

Since the early 2000s, some evidence suggests that overall public awareness of GM food has increased. For example, in 2012 and 2013, when a CBS/New York Times survey asked how much they had read, heard, or seen about genetically modified food, a quarter of Americans said they had heard a "great deal." This compares to 17 percent in 2008 and 13 percent during the early 2000s.



Yet other surveys suggest public awareness and attention to the issue remain remarkably low. For at least a decade, the great majority of processed foods sold in grocery stores have contained ingredients from GM crops. But when asked in 2013 about the matter, only 44 percent of Americans said they were aware of such foods, and only 26 percent believed that they had ever eaten any food with GM ingredients.

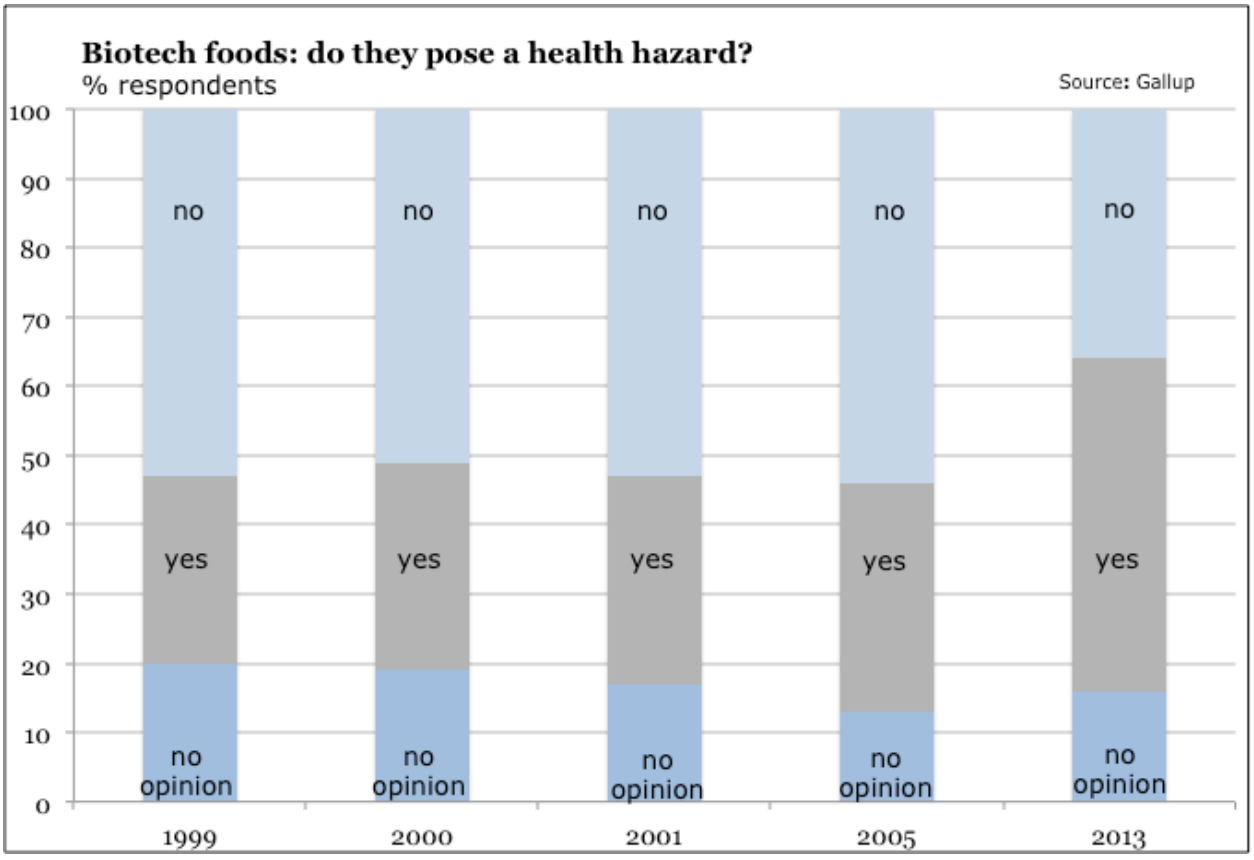
In 2013, 54 percent of Americans admitted they knew very little or nothing at all about GM foods, and 25 percent said they had never heard of them. Even among those who said they were aware of GM food, a majority mistakenly believed that GM tomatoes, wheat, and chicken products were currently being sold in supermarkets (Hallman, Cuite, & Morin, 2013).

Perceptions of GM Food Risks

Despite knowing very little about the issue, multiple surveys indicate that the public has grown more skeptical of GM foods. In a 2013 Gallup survey, when asked if they believed that foods that have been produced using biotechnology pose a serious health hazard to consumers, 48 percent said yes. This marked an increase of 15 points since 2005 and 21 points compared to 1999. Those saying no registered at just 36 percent, a decline of 18 points from previous years.

Between 2012 and 2013, according to CBS News/New York Times polls, the proportion of the public saying that they were either very or somewhat concerned about GM food increased from 63 percent to 75 percent. If asked directly, those Americans saying they were worried or concerned about the issue increased from about 60 percent in 2001 to 75 percent in 2013 (Runge et al., in press).

In 2013, 50 percent of Americans disagreed with the statement "I think it is safe for me to eat genetically modified food." A majority also said they would pay more for food that was not genetically modified. More than 60 percent said they would be upset if GM food were served in a restaurant without their knowing it (Hallman et al., 2013).



In 2012 and 2013, among those survey respondents who said they were concerned about GM food, worries that the food could cause cancer, allergies, or health problems were cited as the primary concern, followed by safety/toxicity, and environmental problems (Runge et al., in press).

In a 2014 Pew Research Center analysis, only 37 percent of Americans said that genetically modified foods were safe to eat compared to 57 percent who said they were unsafe. Whites, women, political Independents, those with lower levels of education, and those scoring lower in terms of science literacy were all statistically more likely to say that GM foods were unsafe to eat.

Yet the strongest predictor of health fears was uncertainty about expert opinion. Those individuals who falsely believed that scientists did not have a clear understanding of the health effects of GM foods were significantly more likely to believe that GM food was unsafe.

In this case, only 28 percent of the public said that scientists had a clear understanding of the health effects compared to 67 percent who believed scientists do not. Women, whites, and older Americans were all significantly more likely to say that scientists do not understand the health effects (Pew, 2015c).

In terms of specific foods, more than 70 percent of Americans in 2012 and 2013 said they were unwilling to eat genetically modified fish, and nearly two-thirds said the same about genetically modified meat. Opposition to eating GM fruits, vegetables, or grains was lower with about 50 percent saying they would not eat these foods (Runge et al., *in press*).

Public Preferences on Labeling

Relative to the debate over labeling, in a 2014 survey, 50 percent of Americans said they "always" or "sometimes" looked for labels specific to GM food when shopping. About three in 10 said they "never" looked for labels. In this case, women and blacks were significantly more likely to report that they looked for labels (Pew 2015c).

In 2013, asked somewhat differently, 81 percent of the public said that it was either "very important" or "somewhat important" to know whether a product contains genetically modified food (Hallman et al, 2013). Since 2001, when asked directly if GM food should be labeled, other surveys show that about 90 percent of Americans have consistently said "yes" (Runge et al., in press).

Yet the public's preferences on labeling appear to be weakly held. In a 2013 survey, when respondents were asked in an unprompted way “What information would you like to see on food labels that is not already on there?" only 7 percent said GM food labeling. Moreover, only one in four Americans knew that federal regulations do not currently require such labels (Hallman et al., 2013).

Key Takeaways

- For many scientists, the controversy over GM food has raised concerns that the public is misled about the technology's applications, risks, and benefits. Many fear that the public has strongly turned against GM food, that trust in science has been damaged in the process, and that a public backlash might restrict the direction of research (see NAS 2015 for discussion).

- Survey evidence suggests that in correlation to increased news attention and political controversy, the public has grown more fearful of GM foods, with a majority of Americans believing that they are unsafe. The public, if asked directly, say they overwhelmingly support the labeling of GM food.

- Yet on closer examination, research indicates that these opinions are weakly held, anchored in little to no actual awareness or understanding of the issue. In comparison, there is a relatively small segment of activists and consumers who are intensely opposed to GM food and who are willing to share their concerns with others. It is the voice of this relatively small group of Americans that has prompted responses from elected officials, regulators, and food companies. In the face of this intense opposition, effectively engaging the broader public, who have yet to form solid opinions on the matter, becomes all the more important.

- For the general public to form an opinion about GM food, analysis shows that they lean heavily on their estimate of how well scientists understand the health risks of the technology**.** In this case, only about a quarter of Americans say that scientists understand the risks (Pew, 2014).

- Apart from judgments of expert consensus, the broader public are also likely to rely on their trust in government agencies, food companies, and restaurants to guarantee the safety of the food that they eat (see Lang & Hallman, 2005). Over the past decade, survey trends show that there has been a decline in public trust in each of these institutions and groups. This decline follows a series of high profile food safety controversies, all of them unrelated to GM food (see Runge et al., 2013).

- As a consequence, scientists and their partners need to focus their communication and outreach efforts on emphasizing the strong level of expert agreement about the safety of GM food and on bolstering public trust in how food safety more generally is ensured by government, food companies, and restaurants.

- The framing of GM food also matters. Past surveys show that when asked about GM food in the context of specific applications that result in health or economic benefits to consumers, the public responds with strong levels of support for the application. Even the terms used to refer to the issue matter. The public tends to react more negatively to

the labels "genetic engineering" and "genetic modification" and more positively to the term "biotechnology" (see Hallman et al., 2002).

- These findings suggest that more research is needed specific to how scientists and their partners can effectively frame conversations about high-tech crops and food biotechnology with different segments of the public and stakeholders.

- With the emergence of gene-editing techniques and the genetic modification of livestock and fish, public concerns are likely to increase relative to the environmental risks of these technologies and their impacts on animal welfare. More research is needed to anticipate shifting public perceptions and to develop public outreach strategies.

PUBLIC ATTITUDES ABOUT CHILDHOOD VACCINATION

Over the past four decades in the United States, high rates of childhood vaccination and immunization have led to dramatic declines in cases of polio, measles, mumps, and rubella (MMR), chickenpox, and other diseases. Vaccination has been so successful that parents aged 45 and younger have little to no comprehension of how pervasive and deadly some of these diseases were as recently as the 1960s. In the past decade, vaccination recommendations have been updated and expanded to include all children six months to 18 years of age, and new vaccines to protect against rotavirus and meningitis have been added to the routine schedule (Kennedy, Basket & Sheedy, 2011).

Yet over the same decade, many health providers and scientists have come to believe that the general public has grown more skeptical and dismissive of the safety of vaccines and their essential public health benefits. Such concerns cite high rates of vaccine non-compliance in specific communities and numerous high profile books and media accounts which have sowed doubt about vaccine safety. Also cited are celebrities and parent activists who have linked vaccines to autism, raised fears over allegedly dangerous mercury levels in vaccines, or rejected the need for HPV vaccination among girls.

At a national population level, according to the 2014 National Immunization Survey conducted by the Centers for Disease Control and Prevention (CDC), vaccination levels for most recommended vaccines among 19- to 35-month-old infants were at or above the established herd immunity goal of 90 percent. Fewer than 1 percent of infants nationwide were completely unvaccinated.

These statistics suggest that rather than focus on national-level public attitudes about vaccines, it may be more important to focus on the concerns that specific communities and social networks of parents may have about vaccines and to tailor communication and outreach to those concerns. Moreover, rather than think about parents in terms of simplistic vaccine

denial versus acceptance, parents should more accurately be understood in terms of a continuum of concerns and beliefs.

General Public Opinion

During the 30 thirty days of 2015, the CDC reported a record 102 cases of measles across 14 states. Most of these cases were related to a highly publicized outbreak of measles among those who had visited Disneyland in California. The outbreak and linkages to the vaccination debate received considerable news attention. At the time, 25 percent of Americans said they were following news of the outbreak and debate "very closely" (Pew 2015e).

In the same 2015 survey, 83 percent of Americans said that vaccines for diseases such as measles, mumps, and rubella are safe for healthy children compared to n percent who said they were not safe and 7 percent who said they did not know. According to a regression analysis, whites (87%) were more likely than non-whites (76%) to say that such vaccines were safe. Those age 50 and older (90%) were also more likely than those age 18 to 29 (77%) to say that vaccines were safe (Pew 2015c).

Interestingly, among the 80 percent of Americans who reported paying at least some attention to news coverage of the measles outbreak, nearly nine out of 10 said that vaccines were safe. In comparison, among the 19 percent who said they had not paid attention to the outbreak, only two-thirds said the same. There were no meaningful differences in perceived safety by political partisanship (Pew 2015b).

In 2009 and 2014, the Pew Research Center also asked if parents should be allowed to decide not to vaccinate their children or if all children should be required to be vaccinated. Across the two surveys, those saying that all children should be required to be vaccinated was 68 percent and 69 percent respectively. In comparison, 28 percent and 30 percent said that parents should be allowed to decide (Pew 2015a).

On this topic, regression analysis showed that age was the strongest predictor of attitudes with younger Americans more likely to support parental choice. Specifically, 41 percent of 18-29 year olds and 35 percent of 30-49 year olds said that parents should have a choice about vaccination. This compared to 23 percent of 50-64 year olds and 20 percent among those 65 and older (Pew 2015a). These differences may be due in part to the greater proportion of younger adults who believe that vaccines are unsafe. More research on this topic is needed.

Analysis also showed that Republicans were more likely than Democrats to say that parents should be allowed to decide whether to vaccinate their children. Moreover, these partisan differences appear to have emerged only in the years since 2009.

These differences are likely in part due to the propensity among right-leaning Americans to reject government mandates more generally. The differences also likely relate to debates over the HPV vaccine which, was framed by some conservatives as enabling sexual promiscuity.

HPV vaccination was the subject of controversy across several state legislatures, as well as being discussed during the 2011 Republican presidential primary debates and covered within the political and opinion press (Fowler & Gollust, 2015; Kahan, 2013; Abiola, Colgrove & Mello, 2013). For example, in 2011, 30 percent of Americans said they had heard "a lot" about "Republican candidates debating mandatory vaccination for young girls against a sexually transmitted virus" (Pew 2011).

Risk Perceptions of Parents

More relevant to the vaccination debate may be the opinions of parents with young children. In this case, a carefully designed 2010 nationally representative survey of parents provides several key insights.

More than 80 percent of parents with children under age six said that they had either already vaccinated their children and another 11 percent said they planned to vaccinate their kids with all recommended vaccines. Only 5 percent intended to vaccinate their children with some, but not all vaccines. Just 2 percent said their kids would receive none of the recommended vaccines (Kennedy et al., 2011).

A high rate of compliance with vaccination, however, does mot mean that parents are not worried about the subject. Indeed, only 23 percent of parents said that they had no concerns about childhood vaccines. Top concerns mentioned by parents included that it would be painful for children to receive so many shots (38% of parents); that children were receiving too many shots in one doctor's visit (36%); that children are getting too many vaccines during the first two years of life (34%); that vaccines might cause fevers (32%); that vaccines may cause learning disabilities such as autism (30%); and that the ingredients in vaccines are unsafe (26%).

Among those parents who said their child would receive some but not all vaccinations, the concerns most likely to be cited were that children get too many vaccines, that vaccines may cause learning disabilities and autism, and that vaccines are given to children to prevent diseases that are not serious (Kennedy et al., 2011).

Twenty four percent of parents said they had sought "a lot" of information before vaccinating their children, and 36 percent said they had sought "some." Among the three most important sources that parents said helped them make decisions about vaccination, 85 percent mentioned health professionals, 46 percent named family members, and 22 percent friends. Specific to expert sources, 28 percent named the American Academy of Pediatrics and 26 percent the Centers for Disease Control (Kennedy et al., 2011).

Parents were less likely to say that they turn to the Internet for information: 24 percent mentioned the Internet as a top three information source. Interestingly, fewer than 5 percent named traditional news outlets like newspapers, magazines, or television. As the authors of the study concluded, "these results suggest that the Internet probably supplements, but does not replace, direct communication with a health care provider or other trusted individual." In this case, more than 80 percent of parents said that they trusted the vaccine advice of their health care provider (Kennedy et al., 2011).

Other studies have focused on specific states or regions, examining the specific socio-demographic correlates of those schools or districts with high rates of parents opting their students out of vaccination, citing personal beliefs (the so-called personal-belief exemption.)

Community-based Engagement

Many researchers have warned that raising the national profile of childhood vaccination, even if emphasizing the benefits of vaccination, could set off a backfire effect, elevating awareness of the issue among parents in a way that magnifies concerns. Instead, a more effective strategy likely involves specific targeting within communities, regions, and school districts that have high rates of non-vaccination, tailoring communication efforts to the unique local dynamics and context.

For example, in California, between 2007 and 2013, the percentage of exemptions statewide increased from 1 percent to 3 percent, but some suburban pockets of the state are reported to have exemption rates close to 50 percent. Specific to measles vaccinations, more than a quarter of schools in California are estimated to have immunization rates below the target herd immunity rate of 92-94 percent (Yang et al., 2016).

In California, belief exemptions are most likely to occur in communities of so-called "white privilege," defined by their economic affluence and their disproportionately white populations. Within these communities, non-vaccination rates also tend to be highest among smaller private and charter schools. Studies have found similar correlates of non-exemption rates within the Midwest region (Yang et al., 2016).

Key Takeaways

- At the national level, younger Americans and non-whites tend to be slightly more likely to believe that vaccines are not safe. Younger adults along with Republicans are also more likely to say that parents should have the right to decide if their child should be vaccinated.

- The recent controversy and media attention to the outbreak of measles cases in 2015 at Disneyland may, however, be raising the profile of vaccination as a national concern, sensitizing parents to the importance of the issue. In this case, the challenge from a communication standpoint is to be able to engage and reach those parents within a

specific community who may be anxious about vaccine risks but are not yet decisive in their opposition to vaccinating their child.

- Still, statistics show that childhood vaccination is not a national level problem, nor should it be a focus of national level outreach and engagement. Engaging in national campaigns could backfire, triggering undue alarm and controversy over the subject by exposing parents to conflicting cues and false information.

- Instead, communities with high rates of non-vaccination need to be specifically studied, identifying the range of parent concerns and beliefs that are correlated with the decision not to vaccinate.

- In these studies, to inform community specific engagement strategies, parents should also be asked about their trusted sources of information on the topic. Different forms of message testing, design, and targeting could also be conducted.

- Absent this level of research and coordination with the expert community, efforts to communicate with and engage parents risk being ineffective or, worse, may backfire.

PUBLIC ATTITUDES ABOUT INFECTIOUS DISEASE EPIDEMICS

In contrast to childhood vaccination, debates over infectious disease epidemics require investment in national-level public outreach and engagement efforts. Recent controversies over swine flu and Ebola are also perhaps unique among science-related debates in that they have developed into national news stories in a matter of weeks, eclipsing or crowding out most other issues. Though these issues require long-term efforts at public engagement, their dynamics also require federal authorities and experts to respond rapidly to evolving events, often in the context of high levels of uncertainty and strong partisan conflict.

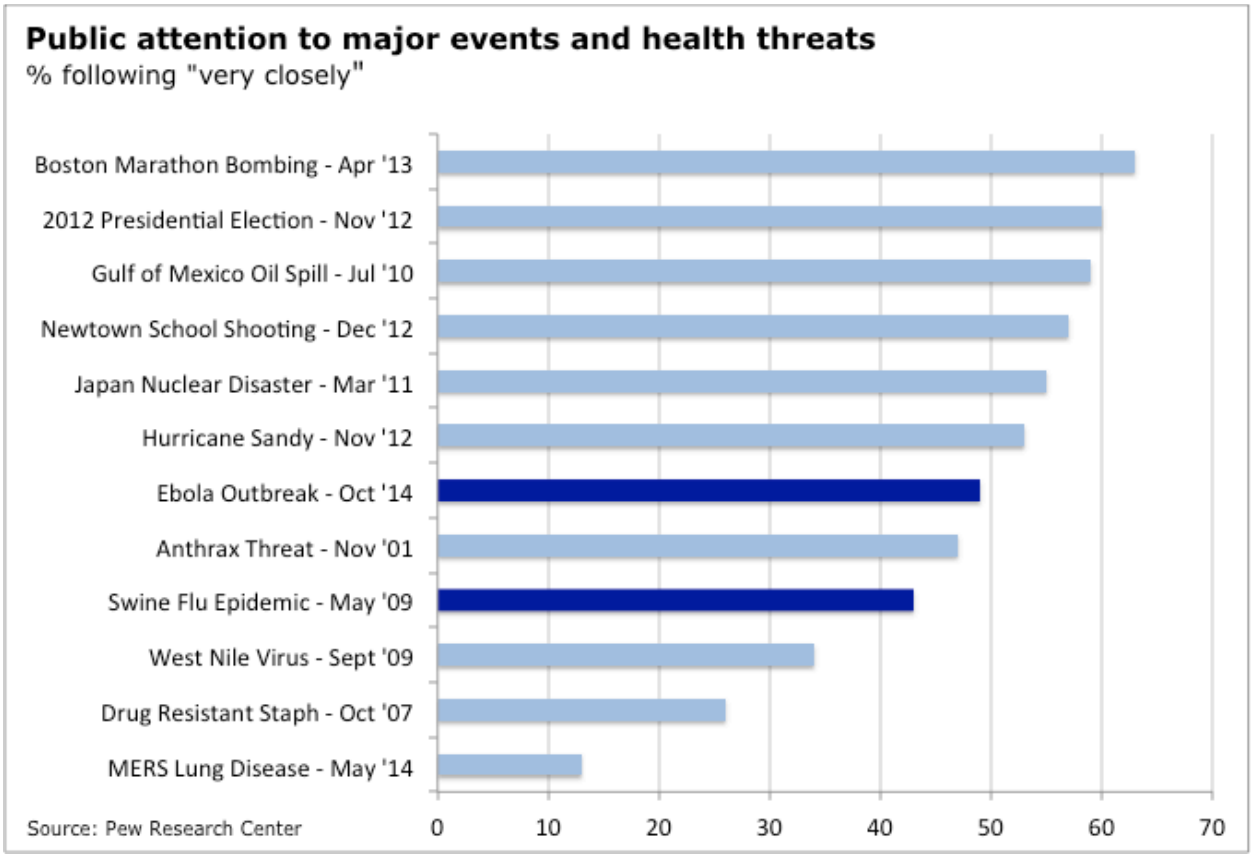
The Swine Flu Pandemic, 2009-10

In spring 2009, the first cases of swine flu (otherwise known as influenza A H1N1) were reported in Mexico with other cases soon identified in the U.S. and around the world. By June 2009, the World Health Organization (WHO) announced that the swine flu outbreak was the first worldwide pandemic in 40 years. Two dimensions of swine flu were particularly alarming to experts and the public. First, the strain resembled the 1918 Spanish flu, which had resulted in 40-100 million fatalities worldwide. Second, swine flu affected the young and healthy, rather than just the elderly and infirm (Klemm, Das, & Hartmann, 2014).

In 2010, at the end of the outbreak, the CDC had linked swine flu to an estimated 12,000 U.S. deaths, 270,000 hospitalizations, and 60.8 million infected individuals. For comparison, the CDC estimates that U.S. deaths from the seasonal flu between 1976 and 2007 ranged annually from a low of 3,000 to a high of about 49,000 people.

At the outset of the pandemic, in May 2009, surveys indicated that swine flu had come to dominate Americans' attention, as 43 percent of Americans said they were following the story "very closely" and 39 percent named it as the story they were following "most closely." In comparison, 22 percent said they were following most closely the economy and 11 percent the auto bailout. In all, swine flu registered as one of the most followed news stories of the year. At the time, it was also the most followed story about infectious disease in history, topping SARS, West Nile Virus, and mad cow disease, though it would soon be eclipsed in 2014 by attention to the Ebola virus (Pew, 2009).

The level of public attention to swine flu was not surprising given that an estimated 31 percent of total news coverage across media outlets was devoted to the virus. No other issue came close. Even the still faltering economy only captured 10 percent of total news coverage. Specific to swine flu, local TV news, cable TV news, and the Internet were the most cited sources of information by the public (Pew, 2009).



Public attention to swine flu ebbed during the summer months, though it still remained substantial during this period as 25-30 percent of Americans said they were following the issue "very closely" (Pew, 2009b). Across the summer months, a subsequent statistical analysis of survey data showed that for most demographic groups, worry about swine flu increased. The increase in worry was greatest among women, those over 65 years old, and those with large

families, defined as six or more children. Worry declined among blacks and Hispanics, but still remained relatively high (Mesch, Schwirian, & Kolobov, 2013).

Those who said they had actively followed news of swine flu somewhat predictably remained worried about the issue across the summer months of 2009, but so did those who said they were neither interested in the topic nor were following it closely. For this latter group, information about the threat likely spread by way of interpersonal conversations and by way of incidental exposure on social media and elsewhere (Mesch et al., 2013).

In October 2009, the proportion of Americans saying they followed the swine flu issue "very closely" spiked again to 38 percent, as news coverage focused on the public availability of a swine flu vaccine (Pew 2009b). But efforts to offer the vaccine to the public soon became controversial, leading many individuals to forgo vaccinations (Steinhauer, 2009).

The same month, surveys showed that the public was also split over whether or not the news media had exaggerated the danger. In this case, 46 percent said that news reports were presenting swine flu's danger about right, compared to 43 percent who said that the news media were overstating the danger and just 7 percent who said the press was understating the threat (Pew 2009).

There were also strong partisan differences in perceptions. More than half of Republicans (54%) said news reports were overstating swine flu's danger, compared with 42 percent of independents and just 35% of Democrats. Similar differences appeared by age and education. Half of those younger than 40 believed the danger was overstated compared to 29 percent of those 65 and older. College graduates (51%) were also more likely to say that the threat was exaggerated compared to those with less education (Pew 2009).

Similar differences existed relative to an individual's willingness to receive the vaccine and in their trust in the government's ability to handle the threat. In October 2009, less than half of Americans (47%) said that they would get the swine flu vaccine if it were made available to them; an identical percentage said they would not get the vaccine. Democrats (60%) more so than Republicans (41%) said they were likely to get the vaccine (Pew 2009).

In terms of confidence in the government's ability to deal with swine flu, 64 percent said they were very (17%) or somewhat (47%) confident in the government's ability to deal with the problem. Yet in this case, 75 percent of Democrats said they were confident compared to 62 percent of Independents and 51 percent of Republicans (Pew 2009b).

Subsequent statistical analysis showed that after controlling for a number of confounding variables, those following news coverage of the issue were more likely to say they would get the vaccine than those not following media reports. Whites were also less likely than blacks to say that they would be willing to get the vaccine (Mesch & Schwirian, 2015).

Specific to partisanship, after controlling for a variety of factors, Republicans and Independents were also less willing to take the vaccine, but the effects of partisanship dropped out once controlling for trust in the government's ability to handle the issue. This suggests that trust and confidence in government played a key role in decisions to seek out vaccination (Mesch & Schwirian, 2015).

Examining trust in government more closely, after controlling for other factors, Republicans, Independents, higher income earners, and those who did not follow news coverage of the issue were all less likely to believe that the government could handle the swine flu problem. In contrast, Democrats, lower wage earners, and those who said they followed media reports were more confident in government's ability to manage the threat (Mesch & Schwirian, 2015).

The Ebola Outbreak (2013-14)

In December 2013, the first Ebola epidemic in history broke out in West Africa. By mid-2014 the epidemic had dramatically intensified. From July 2014 to October 2014, monthly reported cases in Guinea and Sierra Leone increased from 500 in each country to a peak of nearly 3,000.

In August 2014, the WHO declared a "public health emergency of international concern." The next month, the WHO called the Ebola epidemic the most "severe acute public health emergency seen in modern times." By January 2016, when the WHO declared the epidemic officially over, there had been more than 28,000 reported cases in West Africa and 11,300 confirmed deaths.

In the U.S., there was a total of four confirmed cases and one related death. On September 30, 2014, the U.S. declared its first confirmed case and fatality from Ebola in an individual who had recently traveled from Liberia. Despite assurances from medical authorities that the patient had been treated using the strictest safety protocols, two American nurses who had contact with the patient became infected, though each would eventually recover. In late October, a U.S. doctor who treated Ebola patients in West Africa tested positive upon returning to New York City. He also survived.

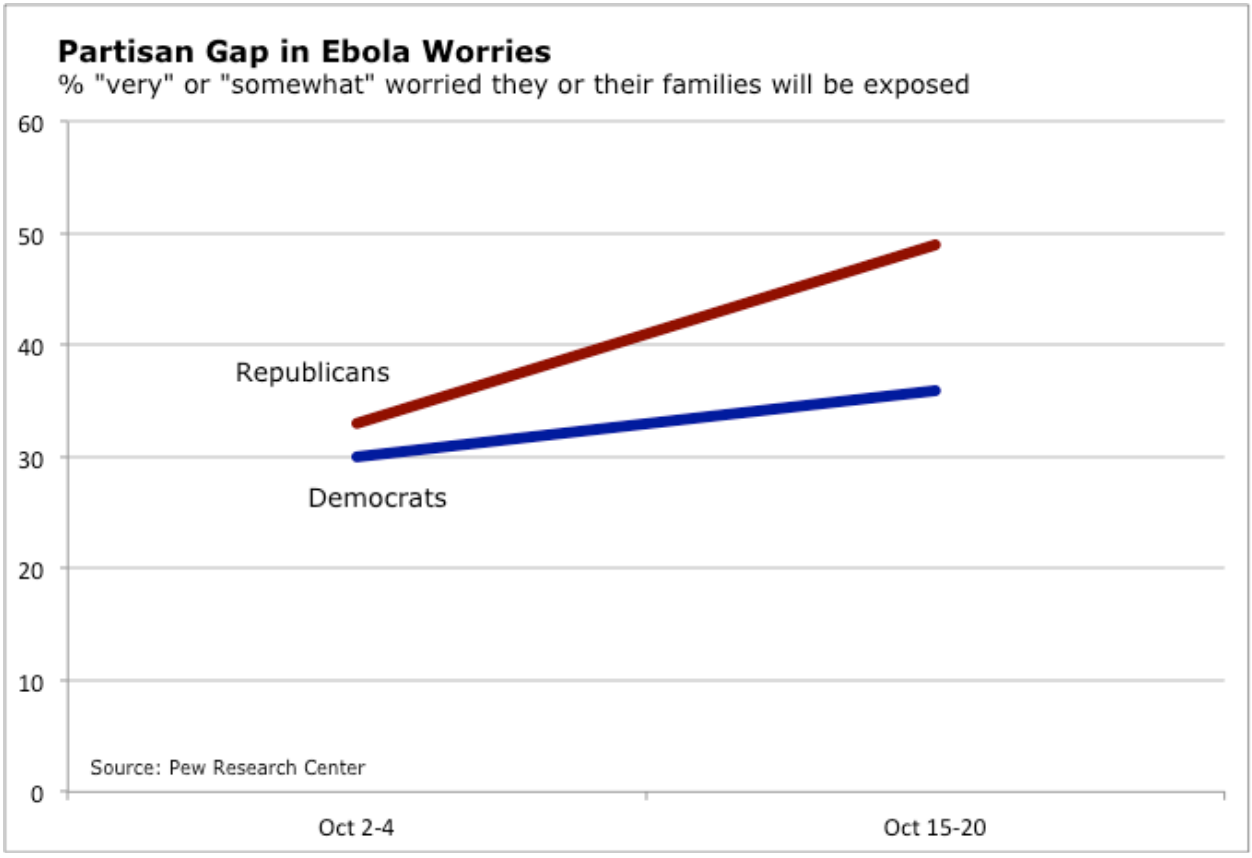
The timing of these cases and the peak of the crisis in Africa coincided with the 2014 U.S. midterm elections, which not only helped turn Ebola into the most talked about topic in the news media, but also framed responsibility for the handling of the issue in strongly partisan terms.

In October 2014, about half (49%) of Americans said they were following news about Ebola "very closely." Over the previous two years, only the Boston Marathon bombing (63%), the 2012 election (60%), the Newtown shooting (57%) and Hurricane Sandy (53%) generated greater levels of public attention. Overall, nearly eight of 10 Americans said they had heard "a lot" about Ebola (see Figure Above) (Pew 2014c).

In early October, 32 percent of Americans said they were very or somewhat worried about Ebola. Two weeks later, worry had spread to 41 percent of the public. At the start of the month, Americans regardless of partisan identity expressed similar levels of worry. But two weeks later, worry among self-identified Republicans had grown from 33 percent to 49 percent, while worry among self-identified Democrats had shifted more modestly from 30 percent to 36 percent (see Figure below) (Pew 2014c).

In terms of other demographic differences, by mid-October, women (48%) were more likely to say that they were worried than men (34%). Minorities and individuals with less education also expressed greater levels of worry than their counterparts among whites and the better educated (Pew, 2014c).

In mid October 2014, at the peak of concern, a review of polls shows that about half of the public (45%) said they were either very or somewhat worried that they or their family would become sick with Ebola. Fears of infection subsequently declined as no other U.S. cases were reported. Yet by November 2014, Americans ranked Ebola as the third most urgent health problem facing the country, just below cost and access to health care and ahead of cancer and heart disease which combined to account for nearly half of all U.S. deaths annually (SteelFisher, Blendon, & Narayani, 2015).



A review of polling evidence suggests several key factors that led to a public fear over Ebola that was substantially out of proportion to the actual nature of the threat.

First, surveys indicate that false beliefs about Ebola were widespread. For example, Ebola is not airborne and is not contagious until someone shows symptoms. Yet 85 percent of Americans believed that if sneezed or coughed on by a symptomatic individual, a person is either very likely or somewhat likely to get Ebola. Similarly, 77 percent of Americans said they could contract the virus by touching surfaces that had been in contact with someone with Ebola, and 48 percent said that a person could transmit Ebola before showing symptoms (SteelFisher et al., 2015).

A second factor was the saturation nature of news coverage particularly on network TV and cable news. By one tally, CNN, NBC, and CBS aired nearly 1,000 evening news segments about Ebola between mid-October and early November. The personalization of coverage around the two American nurses and one doctor who were infected with Ebola at the expense of more contextual, thematic coverage likely helped intensify public concern (see Steelfisher et al., 2015).

News and commentary on cable news, talk radio, and elsewhere also framed the U.S. government's response to Ebola in strongly political and partisan terms, making it easy for Republicans and others who disliked the Obama administration to discount reassurances from health officials that there was little need to worry.

The third factor was public confidence in government. Although 57 percent of the public said they had a great deal or fair amount of confidence in the government to prevent an Ebola outbreak, there were predictably strong partisan differences in opinion. By mid-October, 67 percent of Democrats said they had confidence in the government compared to only 41 percent of Republicans who said the same (Pew 2014c; see also SteelFisher et al., 2015).

Key Takeaways

- The cases of swine flu and Ebola demonstrate that future epidemics are likely to quickly dominate the news agenda and thereby become a major object of public worry. Public health officials and the expert community will need to prepare in advance of an outbreak, implementing previously established media and public outreach protocols.

- In the context of epidemics like Swine flue or Ebola, strong levels of public worry will occur during an era when public trust and confidence in government and the news media are at a historic low. In the case of swine flu, those who expressed lower levels of confidence in government were significantly less likely to say that they were willing to be vaccinated.

- Not only are overall levels of trust in government low, but such perceptions are likely to also have a partisan basis. In the case of swine flu, with a Democratic president in office,

Republicans were differentially less trusting of the government's ability to handle the threat. As a consequence, Republicans were less willing to get vaccinated.

- In the future when a Republican is in office and a similar epidemic threat occurs, Democrats are likely to express lower levels of trust in government than they did during the Obama years, which may lead to lower levels of vaccination.

- To counter over-dramatic, politically framed national news coverage, public health officials and the expert community need to invest in local and regional outreach strategies that can effectively reach the public outside of these national channels. This includes building and cultivating networks of relationships with local media and community opinion-leaders, which can be activated quickly (see SteelFisher et al., 2015).

- To counter likely partisan attacks on a future administration, public health officials and the expert community should cultivate strong relationships with leaders across the political spectrum and with respected non-partisan voices such as military and faith-based leaders who can speak knowledgeably and confidently about epidemic risks (see Steel, Fischer et al., 2015).

ANTIBIOTIC RESISTANCE

Antibiotic resistance is linked to 10 million deaths globally each year and if unabated is projected to cost the global economy $100 trillion by 2050. Much of the problem is driven by the over-use of antibiotics by people and the use of antibiotics to grow livestock (McCullough et al, 2016).

Analysis of pharmacy and hospital drug sales indicates that between 2000 and 2010, global human consumption of antibiotics increased by 36 percent with the middle income countries of Brazil, Russia, India, China, and South Africa accounting for three quarters of this increase. Overall, India, China, and the U.S. are the largest consumers of antibiotics, though by a wide margin, Americans are the highest per capita consumers (Van Boeckel et al., 2015a).

Between 2010 and 2030, the global consumption of livestock antibiotics is estimated to increase by 67 percent. In Brazil, Russia, India, China, and South Africa, as these middle-income countries shift to large-scale intensive farming practices, the increase in antibiotics over the same period is expected to be 99 percent (Van Boeckel et al., 2015b).

Despite the pervasive use of antibiotics and growing problems, research on public awareness, knowledge, and attitudes about antibiotic resistance is limited, as is research on communication and engagement strategies. In the few surveys and qualitative studies conducted across countries, subjects had little to no substantive knowledge of the issue, expressed anxiety about the problem when asked, did not perceive antibiotic resistance as personally relevant, and tended to distance themselves from any responsibility for the

problem. Few perceived a link between their personal use of antibiotics, risks to themselves, or the broader societal problem. Instead, blame focused on the need for action from doctors, hospitals, and government. Subjects also tended to believe optimistically that science would find a solution to the problem through the discovery of new antibiotics (McCullough et al., 2016; Wiklund et al., 2015).

More than 70 percent of Americans with a respiratory infection visiting a primary care doctor receive antibiotics. However, research shows that antibiotics provide only minor benefits in treating such infections. Yet 50 percent of patients visiting a doctor expect to be treated with an antibiotic (McCullough et al., 2016). This disconnect between science, knowledge, and patient expectations has led some scientists to argue that public health campaigns need to focus on bolstering public understanding of antibiotics.

They cite national survey findings that only about half of Americans correctly know that antibiotics only kill bacteria and not viruses, a proportion that has remained relatively stable for more than a decade. Misperceptions are greatest among the least well-educated and lower-income Americans (NSB 2016; Hwang et al., 2015).

There is some evidence that false impressions about the use and effectiveness of antibiotics does link to patient decisions. Consider that in one recent national survey, Hispanic consumers were more likely to believe that when they get sick antibiotics can prevent more serious illness (40% of Hispanics versus 17% of general public) and that antibiotics can help them get better more quickly (48% versus 25%).

When asked what they expected of their doctor when they visited them for a cold, 41 percent of Hispanics said an antibiotic compared to 26 percent of all consumers who said the same. Hispanics were also more likely to obtain antibiotics from other sources than a doctor including leftover antibiotics from a prior illness (25% versus 9%); neighborhood grocery store (23% versus 5%); or from a family member or friend (17% versus 6%) (Hwang et al., 2015.

Key Takeaways

- As news attention increases to the problem of antibiotic resistance, public knowledge of the proper use of antibiotics is likely to grow. But in this case, knowledge gains are likely to differentially occur among the better educated and well off (see earlier discussion related to the knowledge gap.) To reach lower income Americans, campaigns and outreach efforts will need to engage specialized media such as Spanish-language outlets and entertainment programming, as well as work through interpersonal networks and opinion leaders.

- Knowledge, however, is likely to play an important but limited role. Other aspects of communication related to framing also matter. In this case, Americans still do not see antibiotic resistance as a personally relevant problem that poses risks to their health or that is a function of their own choices as a health consumer. They also believe that science is

likely to find a solution in the form of new antibiotics and, as of yet, do not see the need for major changes in health care practice and policy. In this case, elevating public concern over antibiotic resistance will likely be a necessary condition for driving change within the health care system and among health care providers.

- Overall, much more research is needed on how a diversity of Americans understand the risks of antibiotic resistance, the information sources they rely on and trust, and the opinion leaders and frames of reference that are likely to influence their judgments and decisions. More research is also needed on how the public understands the use of antibiotics in livestock agriculture and the relationship to their food choices and policy preferences.

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