

SCIENCE AND THE NEWS:

Trends and Challenges in Science Journalism,
and Best Practices for Maximizing Its Impact

ANALYSIS OF THE RESEARCH LANDSCAPE

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EXECUTIVE SUMMARY

Science journalists – as well as journalism as a whole – are being confronted with new and complicated challenges. Newspapers are closing and shedding jobs; and new profit models focus on consolidation and online platforms. Journalism and journalists are under partisan attack, with labels of “fake news” and “enemies of the people.” However, the twin crises of COVID and climate change have pushed the need for scientific literacy to the forefront, making science journalism as critical as it ever was.

The Howard Hughes Medical Institute (HHMI) is a committed funder of scientific research and education in the U.S. and seeks to understand the impact of science journalism, specifically in terms of systemic change. With HHMI’s support, the USC Annenberg Norman Lear Center’s Media Impact Project has been tasked with identifying best practices (i.e., “what works”) in science journalism, with a focus on the impact of local and regional climate change coverage through the Pulitzer Center’s Connected Coastlines reporting initiative. This report synthesizes existing research in academic publications, gray literature, and expert insights to understand what factors can promote shifts in audience knowledge, attitudes, and behavior. We offer an overview of the role of science journalism and its funding models, and draw from the research and expert interviews to extract best practices for achieving impact.

The Evolving Role of Science Journalism

Historically, science journalists have held privileged positions in society, as gatekeepers who determine what scientific information deserves coverage. It has traditionally relied on the information deficit model – a one-way communication model where information flows from experts to audiences to increase knowledge and potentially change attitudes and behavior.

But as news organizations defund science coverage, the gap is being filled by PR efforts through museums, universities, and other private outlets, creating an over-reliance on press releases. General-assignment reporters cover science topics as often as dedicated science writers, but often lack training to understand and communicate complex science/technology issues.

Also, the transition to digital media requires journalists to master multimedia storytelling and curate science-related news and commentary through their own newsletters, blogs, and social media.

Trends in Science Journalism

The changes to journalism's profit models and their emphasis on profitability have led to several **economic trends** affecting science journalism.

- National coverage has increased at the expense of local issues, and ownership changes have led to rightward shifts in the ideological slant of coverage.
- Topics that require an investment of time or funding are passed over in favor of softer “news you can use,” like consumer health and fitness trends. The rapid-fire pace of a 24-hour news cycle emphasizes shorter pieces and a faster production timeline.
- In climate coverage, major news outlets have given short shrift to climate change-related causes of major weather events, like Hurricane Ida in 2021.

Funding trends in journalism have moved away from traditional print advertising sales and more toward subscription-based models and support from philanthropies/nonprofits, technology companies and government agencies.

- Journalism-focused philanthropy and nonprofit news organizations play a larger role in funding and typically focus on local and exploratory reporting filling the void left by the decline of local news.
- Big Tech, like Google and Facebook, have funded efforts to counter pandemic and climate change misinformation.
- Since 2000, there has been greater effort by government agencies to prioritize science communication through funding from the National Science Foundation and to nonprofit news entities like PBS and NPR.

Cultural/Political trends impact the practice of science journalism.

- Newsrooms lack diversity both in staff and in cited sources. This lack of diversity impacts communities of color and specifically indigenous communities who are disproportionately impacted by climate change and the COVID crisis.
- Science issues – like COVID and climate change – are increasingly at the center of politicized coverage, and conservative outlets are more likely to spread misinformation about both topics. Exacerbating the problem is false balance reporting that highlights “both sides” of an issue rather than underscoring views backed by scientific consensus.

Pandemic-related trends in science journalism are only beginning to be understood.

- Scientific uncertainty is at odds with journalism's need for clear-cut information and recommendations, and journalists increasingly rely on preprint articles that have not yet been peer-reviewed.
- The breaking news cycle increases pressure on news organizations to quickly release information that may not be accurate. Social media also connects audiences directly with

scientists, bypassing journalists entirely.

Digital media trends, in the form of new technologies and social media platforms, give reporters and scientists new avenues to connect with audiences and share information.

- Twitter is the most popular social media platform for health communicators.
- Social media forces science journalists to move away from the one-way information deficit model to a cyclical feedback loop that includes reporters engaging directly with audiences.

Proposed Best Practices

Based on empirically verified research, this report proposes the following best practices for maximizing the impact of science journalism:

Bring science close to home.

- Make scientific findings relevant to a specific local community.

Humanize coverage with personal stories.

- The use of personal stories can facilitate reader engagement.
- But “hero stories” can backfire by framing climate change as a problem an individual can solve.

Balance personal stories with systemic causes and solutions.

- Thematic framing treats problems as a consequence of larger systemic factors and can raise awareness of systemic problems.

Adopt solutions journalism techniques.

- Solutions Journalism focuses on the how-to’s of problem solving, heightening the potential narrative engagement of a story and can be useful in engaging audiences who feel overwhelmed, pessimistic, or defeatist about daunting topics.

Connect science to health outcomes.

- Health framing is one of the best methods to motivate behavior change, especially among conservative and moderate audiences.

Replace scientific jargon with helpful metaphors.

- Refraining from overly complex terminology in favor of concise metaphors can increase understanding of climate change.

Avoid sensationalism.

- Exaggerated science coverage can backfire and lead readers to feel disappointed when overhyped science or technology does not live up to expectations.

Use weight-of-evidence reporting to counter false balance.

- Weight-of-evidence reporting asks journalists to communicate where the bulk of scientific evidence resides, which can help address issues of scientific uncertainty.

Use images strategically.

- A photograph or infographic that illustrates scientific consensus or authority can increase the effectiveness of weight-of-evidence reporting, and can increase reader interest and attention.

Foster diversity in newsrooms and coverage.

- Diversifying newsrooms can improve access to and understanding of how science topics impact underserved communities.

Directions for Future Research

This formative research has helped identify gaps in the existing research on science journalism and its impact. The following two methods could be used in conjunction to determine what journalistic strategies are achieving the best results.

- Content analyses could identify examples and frequency of best practices across different publications and be used to monitor trends over time. A study could be tailored to focus on efforts to address misinformation specifically.
- Survey-based research and impact studies can provide nuanced data on the effectiveness of strategies to engage specific audiences, affecting their knowledge, attitudes and behavior.

INTRODUCTION

Traditional journalism has experienced a collapse in recent years — local newspapers have shuttered, journalists have lost jobs, and news organizations are merging and consolidating to stay afloat and turn a profit. As a result, science journalism is suffering (Barel-Ben et al., 2020; Fahy & Nisbet, 2011; Hayden & Hayden, 2018). Jobs for full-time science writers at major print and online publications have been on the decline for several years (Russell, 2010; Secko et al., 2013; Walker, 2021). Specialty beats — like science and health — are considered more expendable by publishers at both local and regional news outlets (Holton, 2016; Russell, 2010). Meanwhile, the number of important science and related policy developments have increased (Russell, 2010; Secko et al., 2013; Parikh, 2021). The general public has of late been confronted with two major crises — the COVID-19 pandemic and climate change — requiring them to be both science literate and up-to-date on scientific developments (Funk et al., 2017; Ballew et al., 2020; Dunwoody, 2020).

At this moment when the need for quality science information is critical, there has been a hyper-politicization of science reporting and accusations of media organizations as “fake news,” which has degraded public trust in news. One recent poll found that more Americans distrust the media than trust it (Newman, 2021). And while trust in the scientific community remains strong (Ballew et al., 2020; Dunwoody, 2020; Heslop et al., 2021; Imbier, 2021), an extreme politicization of science and science policy in recent years has clouded the debate and divided the American public (Funk et al., 2017; Parikh, 2021). As a leading supporter of scientific research and science education in the United States, the Howard Hughes Medical Institute (HHMI) has developed a number of media partnerships to support high-quality science journalism. These partnerships with media outlets enhance and deepen coverage of science to increase civic science literacy and grow an appreciation for science and for a scientific way of thinking in the general public. HHMI seeks to understand the extent to which their science journalism investments are having an effect on audiences, particularly in terms of systemic change, and how they can maximize and amplify this impact. To this end, HHMI has partnered with the USC Annenberg Norman Lear Center’s Media Impact Project — a nonpartisan research and policy center that studies the social impact of media — to identify best practices (i.e., “what works”) in science journalism, with a focus on what has been most impactful in HHMI’s investments in local and regional climate change coverage through the Pulitzer Center’s Connected Coastlines reporting initiative.

There is relatively little research on best practices for achieving impact through science journalism, including what features of stories are associated with desired outcomes for key target audiences. However, existing research (academic publications and grey literature), along with

expert insights, can shed light on the factors most likely to promote shifts in audience knowledge, attitudes, and behaviors. We address this knowledge gap by reviewing current trends and challenges in journalism, noting opportunities in the digital media ecosystem, and propose a set of evidenced-based best practices for the field of science journalism.

We begin with an overview of the role of science journalism and how it has evolved in the current U.S. media and political landscape. We then identify the economic and social trends that have affected the media industry and presented challenges to the practice of science journalism. Next, we draw from existing research literature — along with conversations with journalists and experts in a series of roundtables and interviews — to extract best practices for addressing these challenges and achieving impact. Finally, we conclude with recommendations for further research, as well as potential opportunities for HHMI and other organizations seeking to maximize the impact of science journalism.

THE EVOLVING ROLE OF SCIENCE JOURNALISM

Science journalists held a privileged position for decades, and served as the “principal arbiters” of what science information earns coverage and how (Trench, 2008). Science journalists were historically considered gatekeepers and knowledge brokers, which gave them prestige and enhanced the authority of scientists they used as sources (Fahy & Nisbet, 2011; Gesualdo et al., 2020). In addition, journalists also historically played a role in guiding attention to specific issues and framing the public debate (Gesualdo et al., 2020). Science reporting traditionally relied on a communication model — also known as the information deficit model — that involves transmission of information from knowledgeable sources (scientists) to the general public (Fahy & Nisbet, 2011). In roundtable discussions facilitated by the Pulitzer Center and in stakeholder interviews conducted concurrently with this literature review, science journalists largely indicated that they subscribe to this model, asserting that their primary goals are to “inform audiences” or to “raise awareness” of science issues (HHMI & Pulitzer Center, 2021).¹

In the U.S., the public is most likely to get their science news from incidental exposure to general news sources that cover a range of different topics (Barel-Ben et al., 2020; Funk et al., 2017; Anderson et al., 2021). In one Pew Research survey prior to the COVID-19 pandemic, the public believed that specialty sources — documentaries, science magazines and science and technology museums — were more likely than the news media to get science facts right (Funk et al., 2017). Cutbacks at news organizations, particularly newspapers, have brought a decline in the number of jobs for science journalists and in the amount of weekly science sections. (Russell, 2010; Holton, 2016; Walker, 2021). And the gap created as news media organizations deprioritize science coverage (Russell, 2010) is being filled by scientists, museums, universities, and other private outlets that communicate to the public through public relations efforts (Barel-Ben et al., 2020; Fahy & Nisbet, 2011). Journalists subsequently over-rely on press materials crafted by these institutions to share the organizations’ scientific findings (Sanza et al., 2019; Trench, 2008). As a result, these press releases tend to drive the agenda and content of news agencies (Boumans, 2018). Schwartz et al. (2012) found that one-third of health news stories relied solely or largely on

¹ On April 6, 2021, the Howard Hughes Medical Institute (HHMI) and the Pulitzer Center invited a number of Connected Coastline (CC) grantees, as well as related scientists, experts, and staff (including members of the USC Annenberg Norman Lear Center) to participate in two roundtable discussions about their work on CC projects in relation to the field of science journalism. Questions were open-ended and topics included the impact of HHMI and the Pulitzer Center’s grantmaking, challenges and opportunities in climate change reporting, and ways to engage readers and communities in science journalism.

press releases. Scientific findings synthesized by public relations offices are frequently hypersensationalized (Patillo, 2019; Sumner et al., 2016). Sumner et al. (2016) found that subtle exaggerations of findings in press releases also frequently appeared in the corresponding news stories. Wetts (2020) further found that press releases discouraging action on climate change were twice as likely to be referenced by major U.S. newspapers, compared to those supporting climate action. Press releases on climate topics from big business were more likely to be cited than those from science organizations, like universities and observatories (Wetts, 2020).

Science stories are just as likely to be covered by general-assignment reporters as full-time science writers, and science coverage is increasingly appearing in coverage of other issues, like education, politics, and business (Russell, 2010). Because of this, half of published science stories are written by reporters who have not been trained to understand the complexities of science and technology nor their social ramifications (Russell, 2010). As news media has transitioned to online platforms, journalists across coverage fields are required to master multimedia storytelling and newsgathering, including writing, editing, infographic design, and video and audio production. In addition to their traditional role as conveyors of information, this new “science media ecosystem” (Fahy & Nisbet, 2011, p. 781) asks journalists to curate science-related news and commentary through their own newsletters, blogs, and social media. Fahy and Nisbet call this a “plurality of roles” (p. 790), in which journalists wear multiple hats, as a reporter, teacher, agenda-setter, and public intellectual.

TRENDS IN SCIENCE JOURNALISM

Economic Trends

Systemic changes to news media's revenue streams have led to several economic trends that have impacted journalism as a whole, and science journalism specifically. Smaller news outlets have merged with larger ones, and media behemoths have consolidated ownership (Benson, 2018; Russell, 2010). These structural shifts have led to increased coverage of national issues at the expense of local ones, and in some cases, ownership changes have led to significant rightward shifts in the ideological slant of coverage as well as decreases in readership and viewership (Martin & McCrain, 2019). Marketplace competition and an emphasis on profitability mean that journalists are often expected to produce more copy in less time (Sumner et al., 2016). The economic impact on staffing means that a larger proportion of science journalists are freelance (Borshelt, 2016; Holton, 2016; Fahy & Nisbet, 2011; Sanza et al., 2019). A 2016 analysis of membership of the National Association of Science Writers (NASW) found staff writers for journalism outlets comprised the smallest portion of NASW membership, outnumbered by freelance writers and public information officers (Borshelt, 2016).

Many complicated scientific issues that require an investment of time in investigative reporting are left unreported in favor of soft “news you can use” (Russell, 2010), including consumer health and fitness trends, and features on fad diets and exercise machines (Humus, 2019; Russell, 2010). Online outlets can tend towards “clickbait” to garner both engagement and attention, but these shareable pieces of content can also oversimplify information (Amend & Secko, 2012; Humus, 2019; Dunwoody, 2020). Science news outlets, with an eye towards attracting and cultivating new audiences, may downplay alienating content and filter science coverage through commercial interests (Molek-Kozakowska, 2018).

The 24-hour breaking news cycle has been adopted by most major news outlets and provides a constant feed of news stories to audiences (Thomas, 2021). This immediate need for new content puts an emphasis on timeliness at the expense of investigative, long-term coverage (Brown, 2014, Thomas, 2021). With this rapid pace of production, news outlets lean toward shorter pieces about concrete events, rather than thematic stories that delve into complicated issues (Dunwoody, 2020). Tight schedules and staff cuts, including to fact-checking enterprises, impact both the depth and accuracy of coverage (Barel-Ben et al., 2020; Dunwoody, 2020). Major outlets like the

New York Times have cut their copy desk, and in many cases, fact-checking jobs have shifted to freelance or disappeared. In one 2018 survey (Borel et al., 2018), only 34% of media outlets employed fact-checkers for their science coverage, and of them only 13% had a science degree.

Critics have been particularly harsh on media coverage of the climate crisis, particularly for drawing inadequate connections between natural disasters and climate change in quick-turnaround news stories (Allsop, 2020; Atkin, 2018; Atkin, 2020; Hassol et al., 2016). During one week in September 2020 (Allsop, 2020), ABC, NBC, and CBS collectively ran 46 segments on California's historically intense forest fire season, yet only seven mentioned climate change. Similarly, the six largest television networks in the U.S. (ABC, CBS, CNN, Fox, NBC and MSNBC) ran 774 stories about Hurricane Ida in August 2021, but less than 4% mentioned climate change (Hertsgaard, 2021). The 2018 landmark U.N. Intergovernmental Panel on Climate Change (IPCC) report was covered by only 22 of the 50 largest U.S. newspapers (MacDonald, 2018). Overall, the number of articles connecting climate change to natural disasters in most mainstream newspapers peaked in 2019 before dropping the following year (Atkin, 2020). Nisbet (2019) contends that national TV news and cable news networks with a focus on breaking political news, personality conflicts and horserace election coverage continue to give little airtime to climate change.

Funding Trends

Trends in journalism funding have significant implications for the practice and sustainability of science reporting. Traditionally, journalism has been funded through the sale of print advertisements — a business model that dates back to the late 1800s. However, this business model has come under threat in the 21st century, as audiences and advertisers progressively move online, where digital ad sales bring in significantly less revenue than traditional print advertising (Pickard, 2014). This is particularly true for science reporting, which is relatively less popular with advertisers, compared to business, consumer technology, and entertainment news sections. As a result, science writing is not typically a profitable endeavor for many commercial news organizations (Brown, 2014). Journalistic outlets also compete for audience attention within a fragmented digital media landscape in which social media and e-commerce sites increasingly dominate audience attention and online advertising sales (Adgate, 2021; Ingram, 2018).

The viability of other commercial models, such as online news subscriptions, remains in contention, with only a few elite publications (e.g. the *New York Times*, *The Washington Post*) achieving sustainability via digital reader subscriptions, thus far (Chyi & Ng, 2020; Luo, 2020; Olsen et al., 2021; Pickard, 2014). However, in 2020, for the first time in over 50 years, U.S. newspapers generated more revenue from the sale of subscriptions and individual issues than from advertising (Barthel, 2021). This reflects both the steep decline of advertising sales and the

growing power of news readers over advertisers to influence news coverage (Mir, 2021; Olsen et al., 2021). Whether subscription-based models of journalism can offset sharp advertising losses in the future remains to be seen, and the implications of the growing power shift from advertisers to audiences are not yet fully understood (Mir, 2021; Olsen et al., 2021). Some scholars believe the push towards digital subscription-based journalism models will exacerbate the information gap among audiences who are willing or able to pay for their news versus those who will not or cannot (Luo, 2020; Olsen et al., 2021). In fact, one report found that only 16% of people in the U.S. pay for digital news, and those readers are more likely to have college degrees and higher incomes relative to non-subscribers (Luo, 2020).

Philanthropy and Nonprofits

The declining advertising revenues combined with media consolidations, staff cutbacks, and other economic trends outlined above have opened the door for journalism-focused philanthropy and nonprofit news to provide ongoing fiscal support and alternative funding models. Brown (2014) characterizes evolving business models for science journalism, in particular, as undergoing a period of great “experimentation” (p. 832). Identified experimental sites include science blogging networks, as well as nonprofit, foundation-funded, private investment-based, and crowdfunded investigative and longform science reporting. Philanthropy now plays a larger role in funding journalism, relative to the past, particularly for local and investigative news, and in exploring alternative business models that can help sustain journalism (Armour-Jones, 2019). Journalism philanthropy has quadrupled since 2009 with 300 funders providing \$69 million in grants to more than 300 U.S. news-related organizations that year. In 2017, over 1,200 funders gave a total of \$255 million to 925 organizations (Armour-Jones, 2019).

Nonprofit newsrooms, which are primarily supported by philanthropic funding and individual donations and typically focus on local and exploratory reporting, continue to fill the void left by the decline of local news (Benson, 2018; Miller, 2021; Schallom, 2021). The most prominent, and well-funded, nonprofit news organizations include the Center for Public Integrity, ProPublica, Center for Investigative Reporting, the Pulitzer Center (funded by HHMI), and the climate-focused Grist (Nisbet et al., 2018). On the philanthropic side, the top five U.S. funders of national news nonprofits from 2010 to 2015 were the Ford Foundation, The John D. & Catherine T. MacArthur Foundation, Omidyar Network Fund, the Knight Foundation, and the Kendeda Fund (Nisbet et al., 2018). A number of investigative journalism nonprofits experienced a significant “Trump bump” in funding following the 2016 elections, as both foundations and individual donors responded to Trump’s attacks on the press with increased fiscal support (Nisbet et al., 2018). Stakeholder and journalist Tony Bartelme shared that *The Post & Courier* recently started a nonprofit branch to fundraise for their reporting, consisting of an investigative reporting unit and a climate change

fund. These funds are designed to supplement traditional news revenue streams from subscriptions and advertising (Jauriqui & Weinstein, 2021).

Large philanthropic funders represent a sizable revenue source for science reporting efforts. According to data from Foundation Maps for Media Funding (n.d.),² the five largest U.S.-based funders of science and environmental journalism from 2009 to the present are the Ford Foundation, The Robert Wood Johnson Foundation, The William and Flora Hewlett Foundation, Kavli Foundation, and the Bill & Melinda Gates Foundation.³ Among all environmental media grants, climate change is the most common area of focus, followed by conservation, ocean-related efforts, and wildlife coverage (Armour-Jones, 2020).

Technology Companies

In recent years, technology companies have increasingly funded journalism to a greater extent than even most philanthropies (Rashidian, 2020). Big Tech companies, like Google and Facebook, are now some of the largest funders of journalism in the world (Ingram, 2018). Their science journalism efforts tend to focus on combating pandemic and climate change misinformation. Examples include the Google News Initiative's \$11 million investment to support the global ecosystem fighting COVID-19 misinformation (Scire, 2021), the Facebook Journalism Project (FJP)'s \$2 million in funding to support coronavirus reporting efforts by North American local newsrooms' (FJP, 2020), and an additional \$1 million in FJP grants for organizations working to combat climate change misinformation in the U.S. and abroad (FJP, 2021).

Google and Facebook's investments go far beyond science journalism, with a focus on the news industry as a whole. Since 2018, the two companies have committed \$1.8 billion dollars to journalism internationally, including direct support to local newsrooms, advertising purchases for news outlets, journalist training and fellowship programs, funding for journalism schools, fact-checking efforts and more (Rashidian, 2020).⁴ In comparison, the U.S.-focused Knight Foundation, a major journalism funder, provides an average of \$118 million in grants per year. Craig Newmark Philanthropies, also U.S.-focused, has donated \$170 million to journalism since 2016, and the Bill & Melinda Gates Foundation has invested an estimated \$250 million in journalism projects around

² Foundation Maps for Media Funding is a data visualization platform hosted by Candid in partnership with Media Impact Funders, with additional support from the Bill & Melinda Gates Foundation and the Wyncote Foundation. <https://candid.org/use-our-data/about-our-data/data-sources?fceref=pg>

³ For descriptions of these funders' three largest grants in science and environmental journalism, please see [Appendix A](#).

⁴ For descriptions of Google and Facebook's funding commitments in response to COVID-19, please see "[Appendix: Funding Breakdown](#)" in Rashidian (2020). Some journalists note that these two companies are notoriously vague about the details of their journalism funding, often sharing general project announcements without the full details of their financial spending or grant recipients (Coster, 2021; Rashidian, 2020).

the world (Rashidian, 2020). With this funding come concerns about conflicts of interest between technology giants and the news media, especially as news sites, social media platforms and search engines are direct competitors for advertising sales. And these tech platforms are taking the winning share of the digital advertising market (Ingram, 2018). Some critics worry that this funding relationship between journalism and Big Tech may further damage news business models and potentially influence journalistic coverage of these companies and the tech philanthropists providing funding (Ingram, 2018; Schwab, 2020).

Government Funding

Government funding also plays an important role in supporting science journalism. Traditionally, the federal government has underwritten a large amount of basic scientific research and technological advancements (Michelson, 2020). However, between 2000 and 2010, there was a significant push to include science communication priorities in government funding (de Semir, 2010). The Corporation for Public Broadcasting, for instance, supports public media, including science stories on NPR and PBS, which also receive funding from foundations and individual donors. Notably, government grants only make up a small portion of PBS's and NPR's total budgets (approximately 14% and 1%, respectively), with the majority of funding coming from foundations, businesses, and audience contributions (Luo, 2020; NPR, 2021; Sikka, 2018). Another significant source of government funding comes from efforts to advance science communication through the National Science Foundation (NSF). Examples of some of the largest science journalism investments by NSF include nearly \$6 million since 2010 for Climate Matters, a reporting initiative that helps journalists and meteorologists report on climate change impacts in their local communities (Climate Matters, 2021), a \$20 million grant in 2012 to Emory University to support their Chemistry Communications program that trains scientists on best practices in communicating science to the public via blogs, science animations, and science journalism, and a \$6 million ecological research grant in 2011 to study climate change in the Arctic, which incorporates funding for journalism field courses (NSF, 2021).

Awards and Fellowships

There are also specific science journalism organizations that offer awards and fellowships to individual science reporters. These grants are given to science journalists at different stages of their careers, and range anywhere from \$1,000 to \$100,000. Some notable award-granting organizations include the National Geographic Grants Program, Council for the Advancement of Science Writing, World Federation of Science Journalists, The Science Fund for Investigative Reporting, and the AAAS Kavli Science Journalism Awards.⁵

⁵ For a complete list of awards, please see [Appendix B](#).

Cultural and Political Trends

While economic trends are unquestionably important in understanding the practice of journalism, there are other cultural and political influences that challenge the news media industry, and science journalism specifically. We identified several influences that impact both the practice of journalism and the content that is created: lack of diversity, politicization and polarization, and pandemic-related trends.

Lack of Diversity

People of color make up 40% of the U.S. population, yet account for only 23% of newsroom employees (Grieco, 2018). Half of newsroom staff are white men, compared with about a third of the overall workforce. And Latinx, Black, and Asian women make up less than 5% of newsroom staff at print and online news publications (Abaddy, 2017; Merrefield, 2020). On science and environmental beats, 58% of journalists are men (Women's Media Center, 2021). Among NASW members, the majority (63%) identify as female and 82% of members are white (NASW, 2020).

This lack of diversity extends beyond journalism personnel to the sources reflected in news stories (Olmstead, 2017; Sanza et al., 2019). In a recent analysis of 15 years of science stories from the publication *Nature*, Davidson and Greene (2021) found that male experts are quoted more than twice as often (69%) as women. This trend has seen slight improvement, as similar studies in 2005 found 87% of experts sourced in *Nature* were men (Davidson & Greene, 2021). Sanza et al. (2019) suggest this lack of diversity results from a reliance on experts from top-tier science institutions who also tend to be white and male. Western media tends to rely on European and North American academic institutions (Sanza et al., 2019). Shifting focus to international expert sources could increase public understanding of the global nature of science research and the global impacts of science-related issues like climate change (Sanza et al., 2019). Indigenous communities also suffer disproportionately from the impacts of climate change, but their experiences have been poorly represented in media as they tend to be portrayed as victims (Callison, 2017; Laduzinsky, 2019). Callison adds that traditional Indigenous knowledge systems (also known as Traditional Ecological Knowledge or TEK) passed down over generations provide a historical and location-specific view of climate change as well as recommendations and opportunities for adaptation. Participants in the Pulitzer roundtable discussions made a distinction between local versus TEK⁶ knowledge, the latter of which is often overlooked by the scientific community (HHMI & Pulitzer Center, 2021). Many indigenous communities want to be involved in collaborative scientific research and reporting efforts, as they bring valuable

⁶ Local knowledge comes from living in one region for many years versus traditional knowledge, which stems from multiple generations of indigenous cultural knowledge based on living on the land.

traditional knowledge of the ecosystems, and are directly impacted by ongoing climate changes via food insecurity and displacement. One participant cautioned that researchers and science journalists should not make assumptions about the various needs of indigenous communities, and instead should carefully strive to listen and co-create knowledge, as indigenous people are the ones most directly experiencing these climate impacts. Another participant shared how working closely with both indigenous and local knowledge holders lent “authenticity” to their CC reporting, and helped them identify changes in the land that would have otherwise gone unnoticed (HHMI & Pulitzer Center, 2021).

Politicization and Polarization of Science Journalism

Though a tense relationship between science and politics has always existed, the COVID-19 pandemic and the climate crisis have brought this dynamic to the fore (Nisbet & Fahy, 2015; Russell, 2010). In what Nisbet & Fahy (2015) call an “ideologically divided media culture” (p. 224), scientists and science organizations are increasingly at the center of politicized coverage. Heated political interchanges reduce opportunities for nuanced discussion about innovative approaches to respond to either science crisis (Nisbet & Fahy, 2015). Hart et al. (2020) found that U.S. news coverage of the COVID-19 pandemic from March to May 2020 was highly politicized, tended to emphasize the opinions of politicians over scientists, and may have contributed to the public’s polarized attitudes on the health crisis. Another study of international news coverage suggested the pandemic is still largely covered in mainstream media from a political angle, with the voices of politicians taking precedence over scientists (Mellado et al., 2021).

Journalistic methods themselves can further contribute to ideological polarization. Mindful of being accused of bias, journalists sometimes adhere to the tenet of “objectivity” by presenting “both sides” of a scientific issue (Hart et al., 2020; Schechter, 2016). Also known as “factionalism” or the “norm of balance,” science and policy issues are introduced as a battle between dueling experts at two extremes. However, giving weight to minority viewpoints can present a false impression of balance (Brainard, 2009; Hart et al., 2020; Russell, 2010; Schechter, 2016). For example, though there is scientific consensus that climate change is human-caused and vaccines are not linked to autism, the news media still gives space to climate deniers and anti-vaxxers (Brüggemann, 2017; Guenther & Weber, 2019; Petersen et al., 2019), elevating unsupported viewpoints through falsely balanced coverage. Although most experts are critical of false balance, 72% of a global sample of news consumers said it was better to give the same amount of time to all sides (Newman, 2021); younger respondents were more aware of the hazards of false equivalency.

Journalists have begun to place less emphasis on “balanced” reporting, instead highlighting views that are backed by scientific consensus (Brüggemann & Engesser, 2017; Fahy & Nisbet, 2011). A

recent content analysis of the *New York Times*, *Washington Post* and *USA Today* (McAllister et al., 2021) found less amplification of outlier beliefs that contradict scientific agreement. In one analysis of climate change coverage, Brüggemann and Engesser (2017) found that climate change deniers have almost disappeared from stories in major news outlets. Contrarians (defined as those who are skeptical about climate change's causes, the severity of its impact, or strategies to mediate the impact) are still mentioned or quoted nearly 20% of the time, but primarily within the context of dismissing their opinions on climate change. Multiple studies have noted news outlets are shifting away from descriptive reporting, in which facts and quotes are simply relayed to audiences, towards interpretive reporting, which requires science journalists to sort through speculations, explanations and evaluations (Brüggemann & Engesser, 2017; Fahy & Nisbet, 2011).

With regard to the two major science stories of 2020 — COVID-19 and climate change — public opinion was starkly divided along party lines, and scholars debated whether journalism increased this partisanship (Hart et al., 2020; Motta et al., 2021). Hertsgaard (2021) and Newman (2021) noted that major trusted news outlets like Fox News, MSNBC, and CNN share responsibility for shaping audience opinions. Conservative media outlets, for example, were more likely to spread misinformation about the pandemic, and viewers of these outlets were more likely to be misinformed about the disease (Motta et al., 2021). Fox News had the lowest amount of coverage of COVID-19, and pandemic-related social media content posted by Fox News lagged behind other news outlets (Calvillo et al., 2020). In 2020, the more an audience member relied on Fox News, the less vulnerable they felt to COVID-19 and the more likely they were to believe that the pandemic is a hoax or the result of a conspiracy (Calvillo et al., 2020; Ye et al., 2020). Furthermore, another study found that Fox News viewership is associated with the decreased likelihood that audiences accept human-induced climate change (Bolin & Hamilton, 2018). Americans who rely most on Trump for COVID-19 news are among the least likely to be vaccinated (Jurkowitz & Mitchell, 2021).

Journalists who participated in the Pulitzer roundtable discussions and our stakeholder interviewees also took issue with how the media often frame climate change as a polarized issue, emphasizing that there is more public consensus on the topic than is reflected in current media coverage (HHMI & Pulitzer Center, 2021; Jauriqui & Weinstein, 2021). According to Nisbet & Fahy (2015), media discourse “specializes in provoking moral outrage, spreading partial truths about opponents, promoting dire forecasts of doom, and exaggerating the evidence in support of their preferred positions” (p. 224). Some scholars believe journalism relies on conflict and uncertainty to generate controversy, novelty and interest around contentious science topics like climate change and vaccines (Bolsen & Shapiro, 2018; Guenther & Weber, 2019). This is despite a recent survey finding that journalists covering climate change strongly agreed with the scientific consensus on the issue (Brüggemann, 2017).

Pandemic-Related Trends

The COVID-19 pandemic has changed the landscape of science journalism, though its full impact is only now beginning to be understood. The pandemic has brought to the forefront the relationship of science to many aspects of society, from business to education to public health and policy. It has also altered the practice of journalism in multiple ways. These changes include challenges associated with reporting on scientific uncertainty during a public health crisis and the increasingly rapid flow of information via the breaking news cycle and social media.

Challenges of Communicating Scientific Uncertainty

The pandemic has put in stark relief the challenges of communicating uncertainty when scientific knowledge is evolving at breakneck speeds. Uncertainty is intrinsic to both the process and outcomes of science; Janssen et al. (2021) explain, “Scientific research does not only reduce uncertainties, but inevitably also produces uncertainty [. . .] While science works to find answers to open research questions, it also reveals unresolved matters that motivate further research. Thus, uncertainty can be seen as a driving force of science” (Janssen et al., 2021, p. 603). Furthermore, all scientific knowledge is inherently uncertain, as scientific claims are only supported by the best currently accepted evidence, which is always open to refutation (Janssen et al., 2021). Because many personal and policy-based decisions rely on tentative, uncertain, or evolving scientific findings, the communication of uncertainty is critical to all stakeholders involved in the scientific enterprise, including scientists, journalists, politicians, and the general public (Peters & Dunwoody, 2016).

Even prior to the pandemic, scholars identified meaningful differences in how scientists and journalists communicated scientific uncertainty (Guenther & Weber, 2019). Scientific language tends to be complex, while journalistic language is simpler and asserts greater certainty. Guenther and Weber (2019) suggest journalists are likely responding to the perception that audiences want clear-cut information and recommendations, which is reflected in newsroom norms and practices. Additionally, some journalists may not understand complex principles of scientific evidence and uncertainty. Despite journalists’ tendency to present scientific findings with greater certainty than scientists do (Guenther et al. 2019), the representation of scientific uncertainty in journalism is highly context-specific (Peters & Dunwoody, 2016). Perpetuated by false balance coverage, journalists may overemphasize uncertainty in reporting on climate change or vaccines to create controversy and newsworthiness, (Guenther & Weber, 2019). The inclusion of scientific uncertainty may also be influenced by the political and cultural context; evidence from prior public health crises suggests the media may fail to mention the uncertainty of scientific findings while reporting on a crisis (Fleerackers et al., 2021).

One way that scientific uncertainty has manifested during the pandemic is in the increased reliance on preprint science papers. Preprint articles are preliminary manuscripts posted on online servers prior to academic publication in order to facilitate the prompt sharing of potentially critical research; however, they are marked by a high degree of scientific uncertainty due to the fact that the methodology has not yet been peer-reviewed, so the conclusions being drawn are not necessarily fully supported by the evidence (Fleerackers et al., 2021). Journalists and audiences have come to seek out more preprint science papers during the pandemic, on popular preprint server sites, like BioRxiv and medRxiv (Fleerackers et al., 2021; Yan, 2020). Because these sites publish articles that have not yet undergone rigorous peer-review they risk misleading people who may not have the science literacy required to interpret complex findings or who misunderstand the nature of scientific uncertainty (Yan, 2020). One study of COVID-related preprints covered by media outlets found that 40% of the articles studied did not characterize preprint research as uncertain in any way (Fleerackers et al., 2021). Of the news stories that did mention scientific uncertainty, the majority only included a single disclaimer that the research was not peer-reviewed, rather than more comprehensive explanations of how the research is preliminary or needs further verification. Fleerackers et al. (2021) identify a problem in citing COVID-19-related preprints as “research” rather than identifying them as “preprints,” which gives them too much credibility (Fleerackers et al., 2021). Prominent examples of erroneous preprint research being picked up by news media prior to retraction include contested claims about the effectiveness of hydroxychloroquine in reducing COVID-19 fatalities and ivermectin to treat coronavirus patients (Teixeira da Silva, 2020). While studies were later withdrawn from preprint servers, they helped spread dangerous misinformation about the use of both drugs to treat COVID-19, most notably promoted by former President Trump (Lewis, 2021) and popular podcaster Joe Rogan (Romo, 2021).

Breaking News Pressure, Social Media, and Misinformation

The challenges of communicating uncertainty during the pandemic are exacerbated by the breaking news cycle, which provides both opportunities and challenges with the fast-paced spread of knowledge and (mis)information via news and social media. Firstly, the pandemic has increased pressure on both scientists and journalists to break news and report findings rapidly (Hanage & Lipsitch, 2020). As audiences demand immediate information during a crisis, journalists may be incentivized to “accept lower standards,” as the pressure to break news may outweigh the value of accurate reporting (Hanage & Lipsitch, 2020). Many journalists report leaving their careers entirely, due to the pace of an accelerated breaking news cycle driven by the pandemic (Guaglione, 2021).

Secondly, as the pressure to rapidly communicate findings intensifies, more scientists are bypassing journalists to communicate with the public directly, especially via social media. Since the onset of the COVID-19 pandemic, scientists have taken to Twitter⁷ to discuss the pandemic and share important health and science-related information (Konig & Breves, 2021;⁸ Massaro et al., 2021). The voices of scientists are especially notable within the context of a highly politicized global health crisis. In one German experiment, participants perceived a fictional scientist on Twitter as possessing more expertise than a politician when sharing COVID-19 health advice (Koning & Breves, 2021). This effect was replicated in another German experiment in which scientists were perceived as more trustworthy than politicians when publishing an article in support of mandatory mask-wearing (Janssen et al., 2021). These findings are consistent with U.S.-based surveys demonstrating relatively strong trust in scientists (Funk et al., 2020; Heslop et al., 2021; Imbier, 2021), doctors, and infectious disease experts during the pandemic (Ballew et al., 2020). These experimental effects, coupled with widespread trust in scientists in public opinion polls (as compared to relative distrust in the media and politicians) point to the critical role scientists play in communicating science to the public. For science journalists, this may mean relying more on the trusted voices of scientists in future news coverage, despite the fact that current mainstream media coverage still reports the pandemic from a largely political angle (Hart et al., 2020; Mellado et al., 2021)

During the pandemic, science journalists also report using Twitter to source story ideas (Makri, 2021) — a reversal of the norm of news cycles driving social media commentary (Fischer & Walsh, 2020). Nonetheless, Twitter has been called a “double-edged sword of rapid scientific communication” during COVID-19 (Pollett & Rivers, 2020, p. 2185) as the fast-paced spread of information can increase scientific awareness, but also promote misleading scientific information or falsehoods. For instance, Twitter facilitated the sharing of the complete genome sequence of coronavirus to the global science community within 10 days of the reported outbreak; the dissemination of further genomic analyses on Twitter confirmed that the virus was capable of human-to-human transmission and that it had been circulating within the U.S. for weeks (a finding which was picked up by mainstream media outlets) — both examples of the positive power of Twitter to rapidly disseminate critical information within the scientific community and beyond (Pollett & Rivers, 2020). However, Twitter has also been instrumental in circulating misinformation

⁷ This is a trend that predates the coronavirus crisis, as the uptake of online media has provided scientists with more opportunities to communicate with the public directly (Peters et al., 2014). However, scholars suggest that the phenomenon of scientists communicating on Twitter has grown during the pandemic (Konig & Breves, 2021; Massaro et al., 2021).

⁸ Konig & Breves (2021) cite the Twitter accounts of prominent politicians and scientists in both Germany and the United States to establish this trend. These include [Alex Azar](#) (former Secretary of the U.S. Department of Health & Human Services), [Jens Spahn](#) (former German Federal Minister of Health), [Lauren Gardner](#) (Civil and Systems Engineering Professor at John Hopkins University), and [Christian Drosten](#) (German virologist).

and disinformation about the pandemic. For example, Twitter helped disseminate a study that suggested that COVID-19 originated from snakes — an unsupported claim that was picked up by mainstream news media and led to the spread of misinformation (Pollett & Rivers, 2020). Another preprint paper suggested that COVID-19 had “uncanny” genetic similarities with HIV, which was soon withdrawn from the bioRxiv server, following an uproar from numerous scientists. But not before it was adopted by conspiracy theorists on Twitter who asserted that it was evidence of the Chinese government manufacturing the virus for population control (Majumder & Mandl, 2020; Yan, 2020). The rapid spread of COVID-19 misinformation on Twitter and other social media platforms has been well-documented as an “infodemic” (World Health Organization, 2020), with some claims being based on erroneous science (Teixeira da Silva, 2020) and others being fabricated entirely (Stein et al., 2021).

Some news organizations have responded to the proliferation of COVID-19 misinformation by temporarily lowering their online paywalls for coronavirus coverage to share accurate, up-to-date science and health reporting more broadly (Luo, 2020). Many others have increased their fact-checking efforts (Dunwoody, 2020; Siwakoti et al., 2021). However, fact-checkers have been profoundly challenged during this period due to uncertain and constantly evolving scientific understanding of the virus (Holan, 2021; Siwakoti et al., 2021). Because scientific findings emerge at a slower pace than breaking news cycles, fact-checkers must become comfortable with the uncertainty inherent in the scientific process (Holan, 2021). Prominent reversals by scientists and politicians concerning masking recommendations and COVID lab leak theories are prime examples of the challenges journalists face, especially as they try to explain important policy decisions that rely on uncertain or contested scientific findings (Janssen et al., 2021; Leonhardt, 2021; Thacker, 2021).

Digital Media Trends

Though the field of journalism, and science reporting, has its share of challenges, digital technologies and social media platforms are giving reporters new avenues to share information, connect directly with the public and blur the lines between journalists, scientists, and audiences in the news production process.

Scholars refer to this as the age of “digital reporting” as journalists continue their coverage on science stories through traditional media outlets while they simultaneously publish through blogs, email newsletters, and social media sites (Fahy & Nisbet, 2011; Mueller-Herbst et al., 2020; Trench, 2008). The decline in newspapers, magazines and broadcast outlets has been met with an increase in niche online science publications, including *Mother Nature Network*, *ClimateWire*, and *Grist* (Brainard, 2009).

Journalists have taken to social media to create new forms of storytelling through sharable short videos, Instagram stories, and podcasts (Sanza et al., 2019). Facebook and Twitter in particular have become significant channels for the dissemination of scientific information (Mueller-Herbst et al., 2020). Mueller-Herbst et al. (2020) found that use of Facebook was significantly associated with awareness of scientific research; the researchers identified a positive relationship between a user's awareness of science issues, the length of their social media sessions, and the heterogeneity of their network (friends with different levels of education, interests, politics, and diversity in racial and ethnic makeup).

In 2020, Twitter was the social media platform most used for communication by health experts (Kullar et al., 2020). Twitter enables scientists to easily communicate with members of the scientific community, journalists, advocates, and the public at-large. Walter et al. (2019) found that scientists on Twitter reach out directly to journalists through direct messages, rather than waiting for journalists to contact them. In addition, scientists adjust their tone depending on the audience, communicating negative emotions while tweeting directly at journalists, the public and politicians, highlighting certainty when addressing politicians, and using more neutral language when conversing directly with other scientists. Walter et al. suggest scientists are duplicating the negativity and drama portrayed in news media when they interact with journalists and public figures. Another study by Walter et al. (2017) analyzed scientists' Twitter usage at the 2015 United Nations Climate Change Conference and noted that scientists live-tweeting the conference filled the role traditionally held by journalists. Unlike journalists, however, scientists were more inclined to advocate for certain policies, which Walter et al. identify as a new "hybrid science communication" model (p. 586), where scientists fulfill roles that are attributed to both journalism and advocacy. Côté and Darling (2018)⁹ studied ecologists and evolutionary biologists on Twitter, finding those with more than a thousand followers better able to reach non-scientific audiences (especially governmental agencies and elected officials). Heavily-tweeted articles from medical journals are more likely to be cited in scientific research, giving scientists greater ability to disseminate their own work and increase its impact within academia (Eysenbach, 2011).

Journalism, and science journalism in particular, is moving away from the one-way information deficit model in which journalists filter scientific information and relay it directly to the public. The emerging approach is more of a cyclical feedback loop that includes reporters and newsrooms engaging with audiences, who then provide feedback to reporters and newsrooms (Fahy & Nisbet, 2011; Thoreson, 2018). As this happens, journalists, scientists and the public collaborate, and journalism becomes more participatory (Fahy & Nisbet, 2011; Thoreson, 2018; Weingart et al.,

⁹ Côté & Darling's (2018) sample of 450 scientist accounts on Twitter was drawn from a list of ecology and evolutionary biology researchers compiled by [J. Byrnes](#).

2021). The aim of this collaboration may be to deliberate an issue, define a problem, collect and analyze data, or co-create new knowledge (Fahy & Nisbet, 2011).

Conclusion

In this review, we have identified a number of economic, cultural, and political trends in science journalism (and journalism in general), which have been exacerbated by the COVID-19 pandemic and advances in digital media that have rendered the information deficit model obsolete. Each of these trends presents challenges and opportunities for science journalists and organizations that support the enterprise. In the remainder of this report, we seek to address these challenges by proposing a set of best practices — strategic communication recommendations for maximizing the impact of science journalism in the current information economy. These best practices are drawn from a combination of insights gleaned from roundtables and interviews with journalists and experts, along with empirical evidence primarily from the framing literature.

BEST PRACTICES FOR IMPACTFUL SCIENCE JOURNALISM

Journalists and experts have proposed numerous “best practices” for science journalism based on their professional experience or anecdotal evidence of impact (Society of Professional Journalists, 2014). Many of these amount to broad statements about the field, or recommendations that are already widely practiced within and beyond science journalism (e.g., Opportunity Agenda, 2016). For example, the American Association for the Advancement of Science (2021) has collected a list of tips for scientists and journalists such as “ask to repeat something if they’re not satisfied with their answer” and “ask about the intended audience for the piece.” One popular article about “What Constitutes Good Science Journalism” offers the following advice: “A good science journalist is one who can write in ways that transcend the ivory towers built around the sciences by using the ‘public idiom’ and ‘oral translation.’” (Shanker et al., 2021). Another popular piece tells science journalists to “State the source of the story — e.g. interview, conference, journal article, a survey from a charity or trade body, etc. — ideally with enough information for readers to look it up or a web link” (SMC, 2021).

In our review of the literature, we found no existing, empirically supported best practices *specific to science journalism*. However, research from related fields like informal science education and general journalism, and particularly the framing literature, can be synthesized into a set of emerging best practices for impactful science journalism, which further empirical research could help to substantiate. For example, drawing upon work by the National Research Council (Bell et al., 2009), Rowan et al. (2017) identified six broad best practices for informal science education: (1) engage audiences’ emotions and interests; (2) have learners generate and use scientific content; (3) focus on the scientific method; (4) show that science is not an established set of facts but a process of knowledge construction; (5) teach science in informal settings where learners actively and participate, using scientific language and tools; and (6) encourage people to enjoy contributing to science.

Defining Best Practices

In the context of journalism, “best practices” for achieving impact can mean different things depending on the impact objectives. *Proximate* impact objectives might include increasing news circulation or making stories attractive to audiences, while *ultimate* objectives might include

deepening scientific literacy or inspiring readers to change their behavior (Meier, 2018; Powers & Curry, 2019). Each of these objectives can be understood as an effort to *inform* or *engage* audiences. “Informing” means making scientific knowledge easily understandable and accessible. “Engaging” in this context means making stories interesting and attractive to audiences, and high levels of engagement may lead to deeper impact, including behavior change (Braddock & Dillard, 2016; Morris et al., 2019; Johnson, 2012).

For the purpose of this review, we prioritize best practices that are empirically verified, though not — in most cases — in the context of science journalism. Further, to facilitate future empirical research on science journalism best practices, we focus on content-related features of journalism that have traditionally been the purview of framing research (McLeod et al., 2021).¹⁰ Accordingly, the majority of the research literature that informs our best practices curation is drawn from this field.

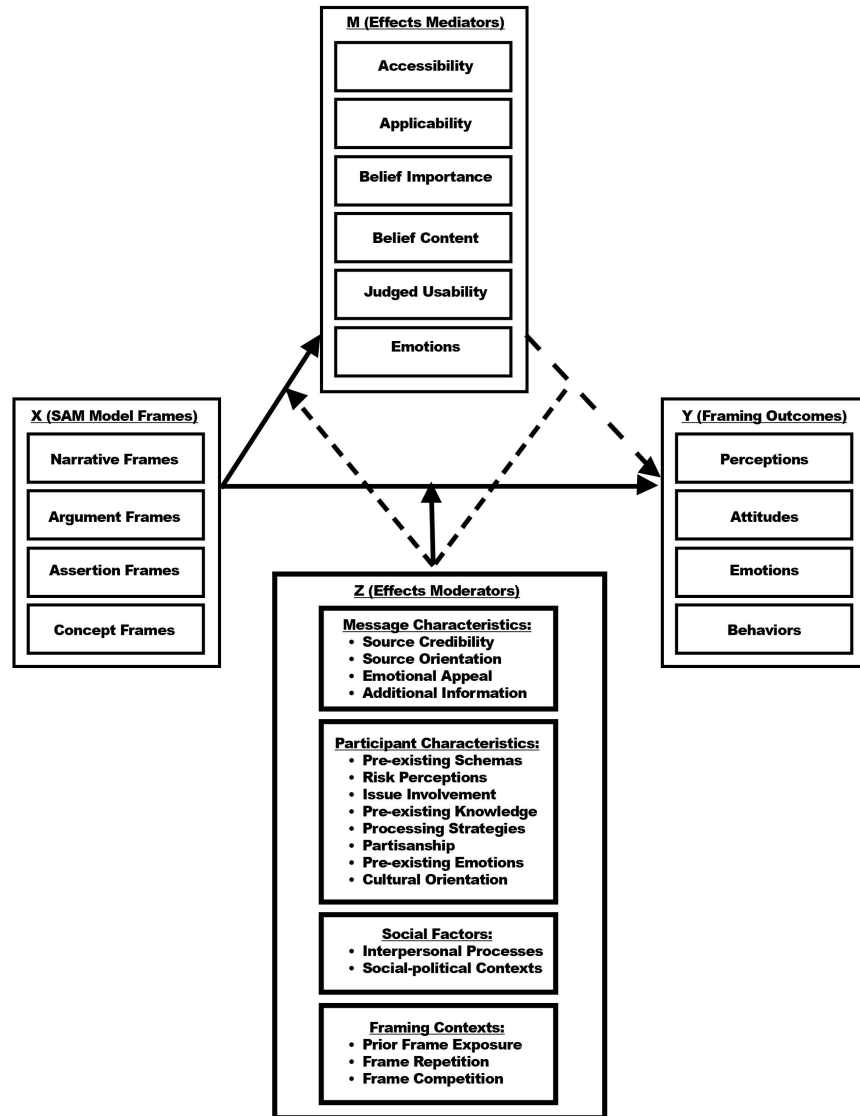
Decades of framing research indicate that few “frames” — features of content or form — work equally well on all audiences (McLeod et al., 2021). When general effects are found in framing studies, they tend to be quite modest. Rather, the most effective frames depend on the subject matter and the characteristics of the target audience (Chong & Druckman, 2007). For example, political conservatives tend to dislike science journalism that criticizes science skeptics, whereas liberals prefer reporting that discredits false science (Heslop et al., 2021). Climate communication scholar Anthony Leiserowitz has remarked, “Not knowing your audience is like throwing darts at a dartboard with the lights off” (Shepherd, 2016, para. 2). To address this need, Leiserowitz and his colleagues at the Yale Project on Climate Change and the George Mason University Center for Climate Change Communication have identified six segments of Americans who respond differently to distinct messaging strategies (2009).

In a recent review of framing research, McLeod et al. identify several audience-related factors that influence the effectiveness of science and health journalism (Figure 1). These include pre-existing values and opinions (Shen, 2004a), personal proximity to the subject matter (Gallagher & Updegraff, 2012; Yun et al., 2008), preexisting knowledge of the topic (Peters et al., 2011), and cognitive processing strategies (Steward et al., 2003; Umphrey, 2003). They also include group-level variables like cultural orientation (Yu & Shen, 2013) and political context (Bolsen et al., 2014). Depending on these audience variables, different framing strategies may be more or less effective (e.g., focusing on the benefits of getting vaccinated vs. the costs of not getting

¹⁰ The definition of the “frame” has been contested since Goffman (1974) suggested framing studies as a direction for research in the social sciences. An often-cited paper by Robert Entman (1993) noted the lack of consensus regarding framing definitions in 1993. McLeod et al. (2021) noted recently, “there is no simple answer to the question of, ‘What is the frame?’” (p.14). Essentially, any study that measures the effect of a formal or content decision on readers can be considered a framing effect study.

vaccinated). Other framing choices, like attributing individual responsibility for problems (Gross & D'Ambrosio, 2004) or accentuating ethical implications (Shen, 2004b), work better for some audiences than others.

Figure 1. Components of the Framing Effects Process (McLeod et al., 2021).



Proposed Best Practices

Based on our review of the academic literature — along with expert opinion drawn from a series of roundtables (HHMI & Pulitzer Center, 2021) and interviews (Jauriqui & Weinstein, 2021) we conducted with journalists and science communication experts — we propose 10 best practices for maximizing the impact of science journalism:

1. **Bring science close to home**
2. **Humanize coverage with personal stories**
3. **Balance personal stories with systemic causes and solutions**
4. **Adopt solutions journalism techniques**
5. **Connect science to health outcomes**
6. **Replace less scientific jargon with metaphors**
7. **Avoid sensationalism**
8. **Use weight-of-evidence reporting to counter false balance**
9. **Use images strategically**
10. **Foster diversity in newsrooms and coverage**

The effectiveness of any of these strategies depends upon the characteristics of the audience of interest. Thus, above all, journalists and stakeholders should **consider the motives and needs of their particular audience**. In other words, these best practices should be treated as tools that science journalists and other stakeholders can use to inform their broader strategy, rather than universal rules. They are also most applicable to science journalism topics that have clear social stakes and ramifications, such as climate change and COVID-19.¹¹

1. Bring Science Close to Home.

In our roundtables and interviews with journalists and science communication experts, a recurring recommendation was to make scientific findings relevant to a specific local community (HHMI & Pulitzer Center, 2021; Jauriqui & Weinstein, 2021), as people tend to care more about issues that feel closer both geographically and in time. The importance of localizing science coverage is also supported by research. In a study of editorials and news stories (Donnelly, 2005), participants were more likely to understand and remember locally applicable information more than information that had more distant relevance. Similarly, Maiorescu-Murphy et al. (2012) found that

¹¹ Several of the identified best practices are specifically intended for journalistic coverage of social issues. For example, Solutions Journalism (SJ) was designed specifically for social issues reporting. Moreover, most of the available evidence is related to topics such as health, climate change, or COVID-19.

articles about local issues were perceived as more credible and more likely to generate additional views of the same newspaper.

The effectiveness of localization depends upon the audience of interest and the subject matter. For example, when it comes to climate change, some readers may actually have more concern about psychologically *distant* people and places (Leiserowitz, 2005; Spence & Pidgeon, 2010). Brügger et al. (2016) similarly found that reducing psychological distance in relation to climate change did not increase the reader's willingness to respond to the climate challenge. Some research (Rickard et al., 2016) suggests conservatives may respond better to stories about people who are affected in the distant future but are geographically close (e.g., a New Yorker reflecting on life in the year 2066), while liberals may respond better to stories about people who are further away geographically, but closer in time (e.g., a person in a foreign country reflecting on their life now).

Several roundtable participants and interviewees emphasized that talking about the current impacts of climate change is critical to engaging audiences to take action, since much of climate change coverage is presented as forward-looking projections regarding future events. This future-focus can obscure the climate challenges that people are facing in the present and move conversations away from the need for adaptation.

2. Humanize Coverage with Personal Stories.

Like bringing science close to home, the use of personal stories is an established journalistic tool for engaging audiences (Zillman & Brosius, 2000; Brosius & Bathelt, 1994). Health journalists commonly illustrate science-related concepts and information with personal narratives (Hinnant et al., 2013). Dahlstrom and Rosenthal (2018) found that stories about individuals are able to persuade people about the existence of climate change, even more than they may realize. Indeed, the fictional disaster film *The Day After Tomorrow*, which is told from the perspective of a handful of main characters, was shown to foster concern about climate change and intentions to take meaningful action (Leiserowitz, 2004). While this film is not science journalism, Kaplan and Dahlstrom (2017) note that science education can benefit from the use of storytelling techniques, since readers are more receptive to scientific information when they are mentally transported into a story and identify with its characters.

While humanizing the impacts of climate change can facilitate reader engagement, “hero narratives” that frame climate change as an individual problem run the risk of backfiring, by making a systemic problem appear to be a matter of individual agency (Solnit, 2019). Several of our interviewees noted that these narratives can divert public attention away from the real problem and effective solutions. As environmental journalist Chip Giller noted, reporters should

try not to “deify individuals and create this cult of the hero. So much social change and social destruction come from systems and institutions and organizations” (Jauriqui & Weinstein, 2021).

3. Balance Personal Stories with Systemic Causes and Solutions.

As noted above, narratives that focus on individual heroes can be counterproductive. However, *thematic frames* that situate “public issues in some more general or abstract context” (Iyengar, 1991, p. 14) can raise awareness around systemic problems. One study (Hart, 2011) found that a thematic frame produced more support for government action than an *episodic frame* that focused on a case study — in this case, a story about an individual polar bear who was affected by climate change. A more recent study (Boukes, 2021) found that people who read thematically-framed stories were more likely to blame politicians for economic problems, and this effect was particularly pronounced among conservative audiences.

In the context of health communication, episodic framing has been shown to hinder empathy for people with obesity (Major, 2009), while thematic framing promotes support for changes in policy as well as personal health practices (Coleman et al., 2011). Health reporting that describes systemic problems but also acknowledges individual agency may be particularly effective at generating empathy for people with obesity and support for systemic changes (Niederdeppe et al., 2015). Our own research (Rosenthal, 2021) found this sort of “hybrid” frames — combining personal and systemic causes (in this case, related to COVID-19) — was more effective at shifting responsibility toward government and promoting support for equity-based policies than thematic framing alone. Further, hybrid narratives that included a systemic solution generated the most policy support, whereas stories with an individual-level solution backfired relative to no solution at all.

Roundtable participant and *The News & Observer* editor Robyn Tomlin noted that scaling up to talk about systemic issues often requires the reader to first identify with the article. She said that “individual pieces [can] collectively tell a larger story, [but that’s hindered] if people don’t recognize themselves in the story. When they start to see themselves, they see the systemic issue as something they want to solve” (HHMI & Pulitzer Center, 2021).

4. Adopt Solutions Journalism Techniques.

“Solutions Journalism” (SJ) could be an especially useful method for science journalists to engage audiences who may feel overwhelmed, pessimistic, or defeatist when reading about daunting problems such as climate change. The Solutions Journalism Network (2017) defines SJ as focusing “not just on what may be working, but how and why it appears to be working, or alternatively, why it may be stumbling.” It typically manifests as investigative or explanatory journalism, which

includes descriptions of efforts to address problems. SJ stories often focus on the how-to's of problem solving, positioning problems as mysteries to be solved, effectively heightening the potential narrative engagement in the story (Solutions Journalism Network, 2017). Though it is frequently misunderstood as advocating for particular solutions, the University of Texas, Austin's Center for Media Engagement suggests that an effective SJ article should include five key pieces of information (Murray & Stroud, 2019a, p. 2):

Problem: The causes and symptoms of the issue

Solution: The replicable ideas tied to solving the problem

Implementation: The how-to details of putting the solution into action

Results: The progress, data-based or anecdotal, that has been made in working toward a solution

Insights: The teachable, big-picture lessons that can be learned beyond one particular solution or situation

There is a growing body of SJ articles in popular news outlets. Between 2010 and 2021, *The New York Times* (n.d.) has published 600 SJ-oriented pieces as part of its weekly “Fixes” column.¹² When reporting on the failures of modern recycling practices, an article in *The Guardian* highlighted new AI sorting machines, chemical recycling, and other technological innovations that could make recycling more efficient (Franklin-Wallis, 2019).¹³ The article also spotlighted relevant legislation, praised taxes on under-recycled products, and showcased companies that sell durable and reusable products (Franklin-Wallis, 2019; Min, 2019).¹⁴ A recent SJ article in Canada's investigative newspaper *The Narwhal* focused on the daunting prospect of economic transition away from fossil fuel jobs, but also highlighted individuals who creatively moved into the renewable energy sector (Riley, 2019).¹⁵

Not all reporting that includes discussion of solutions is SJ. In an effort to more clearly delineate what it is and is not, the Solutions Journalism Network (2016) describes six different types of journalism that address solutions but nonetheless miss the mark:

1. **Hero Worship** stories celebrate an individual without digging into the qualities of their problem-solving methods.

¹² <https://www.nytimes.com/column/fixes>

¹³ <https://www.theguardian.com/environment/2019/aug/17/plastic-recycling-myth-what-really-happens-your-rubbish>

¹⁴ <https://www.cbsnews.com/news/terracycle-loop-zero-waste-products-procter-gamble-nestle-household-brands-expanding/>

¹⁵ <https://thenarwhal.ca/after-oil-and-gas-meet-alberta-workers-making-the-switch-to-solar/>

2. **Silver Bullet** stories often focus on a piece of technology or simply money, suggesting that one approach will fix everything.
3. **Favor for a Friend** stories celebrate a single entity's efforts, with no caveats, resembling a press release.
4. **Think Tank** stories propose solutions that do not yet exist.
5. **Afterthought** stories tack on a meager discussion of solutions after focusing entirely on problems.
6. **Instant Activist** stories suggest that providing some support for a cause (like a small donation) will solve the problem.

One qualitative study found that Solutions Journalism Network reporters “rely heavily on anecdotal evidence” when measuring impact on readers’ actions (Powers & Curry, 2019, p. 2253. See Rani, 2016 for example of anecdotal impact evidence). The study also notes that reporters at SJN partner organizations are largely “unaware of efforts at their news organization to measure impact” (Powers & Curry, 2019, p. 2253).

Empirical research on the effectiveness of SJ has been on the rise, however. Lough and McIntyre (2021) reviewed 27 SJ studies published in peer-reviewed journals since 2011. A seminal study conducted by UT Austin and the Solutions Journalism Network (Curry & Hammonds, 2014) found readers spent more time reading SJ articles than non-SJ articles, had greater self-efficacy and optimism when doing so, and were more likely to donate to relevant causes afterward. Another study (Murray & Stroud, 2019a) found that articles with all five SJ components increased reader knowledge and curiosity, induced positive feelings, heightened intentions to act, and raised impressions of article quality. Those who read SJ stories and were more transported into the narrative were more likely to trust and agree with what they read compared to non-SJ stories (Thier et al., 2019). Some studies, however, question the effectiveness of SJ with regard to motivating behavior change. McIntyre (2019) found that SJ did not influence reader behavior or intentions, even as it made them more confident about potential solutions. Similarly, Meier (2018) found no indication that SJ readers were more likely to take positive action than non-SJ readers. However, SJ readers felt more cheerful and less depressed after reading SJ news.

Some interviewees and roundtable participants indicated familiarity with and use of SJ, noting that the inclusion of solutions in news articles can help move away from the “doom and gloom” narrative of climate change towards stories of hope and resilience (HHMI & Pulitzer Center, 2021; Jauriqui & Weinstein, 2021). One roundtable participant characterized SJ as a form of “accountability journalism [because] describing a solution that has been implemented in one place allows readers to go back to their own elected officials and ask about specific, proven policy solutions” (HHMI & Pulitzer Center, 2021).

5. Connect Science to Health Outcomes.

To overcome polarization among audience members, experts recommend relating scientific findings to *health* as a shared concern among the general public (Maibach et al., 2010). Petrovic et al. (2014) advocate for further research on health frames, since “personal perception of risk, which is likely to be linked to health, is one of the strongest motivators of behavioral change” (p. 245). Indeed, a recent study found the use of health frames increased participants’ intentions to vaccinate, more so than highlighting the economic costs (e.g., shutdowns) associated with non-vaccination (Motta et al., 2021).

Health frames may also be useful for topics that might not seem immediately relevant to health. For instance, in our roundtables on climate journalism, journalist Sammy Fretwell pointed out that “people really want to know how this changing climate is going to affect them personally, and there’s nothing more personal than health” (HHMI & Pulitzer Center, 2021). Similarly, Geoff Scott noted that “people are concerned about their health. They exercise, they diet, they watch the things they eat and drink, and everything else. And so, the more we can focus on health issues... that is clearly the way to make [climate journalism] personal to people.” One study (Myers et al., 2012) found a news article highlighting the health risks of climate change was particularly effective for reaching conservative and moderate audiences among the “Six Americas” segments (Leiserowitz et al., 2009). Health frames are also particularly influential among audiences who have health concerns (Kreslake et al., 2016).

6. Replace Scientific Jargon with Metaphors.

Limiting the use of scientific jargon is an established and accepted best practice for making science journalism accessible to a general audience. Recent research shows that overly complex scientific terminology hinders climate education (de Bruin et al., 2021). In a *Physics Today* article, Somerville and Hassol (2011) provide a list of science terms to avoid when communicating with a general audience; they recommend trying concise metaphors instead. Along these lines, The FrameWorks Institute found that some climate metaphors (e.g., “osteoporosis of the sea”) are more effective for increasing knowledge than others (Bales et al., 2015). Both roundtable participants and interviewees reiterated the need to translate scientific findings into accessible language for lay people, and highlighted metaphors used by science journalists as a “valuable tool [for building] powerful bridges” between scientists and the public (HHMI & Pulitzer Center, 2021; Jauriqui & Weinstein, 2021).

As with many of these strategies, the effectiveness of science metaphors may depend on the audience, however. For example, a 2011 study (Schuldt et al.) found that conservatives are more

likely to believe that “climate change” — rather than global warming — is taking place.¹⁶ Some research suggests, however, that framing conservation in terms of environmental “purity” can promote pro-environmental attitudes among conservatives (Feinberg & Willer, 2013).

7. Avoid Sensationalism.

Scientists and journalists alike bristle at reporting that oversimplifies, spins, or hypes scientific findings.¹⁷ For example, ecologist and roundtable participant Merritt Turetsky cautioned against sensationalized science headlines: “My huge plea to the media is [to] please ensure that there is oversight over the headline editor. I often find so much diligence and care in articles can get sideswiped by a clickbait tagline” (HHMI & Pulitzer Center, 2021). Researchers have found considerable exaggeration and bias in a number of science journalism sub-fields including stem cell research (Mason & Manzotti, 2009), neuroimaging (Caulfield et al., 2010), nanotechnology (Maynard, 2007), and genetics (Evans et al., 2011).

The potential costs of such sensationalized reporting are numerous. Shuchman and Wilkes (1997) suggest that unfounded hype has caused some patients to stop using their hypertension medication. Some propose people might experience disappointment when overhyped science fails to live up to their expectations (Brown, 2003), and that this disappointment can ultimately reduce public trust in science and scientists (Weingart, 2017). However, the effects of sensationalism of science on public knowledge and attitudes are under-researched. In 2013, Master and Resnick reported that they were unable to find any “published empirical papers supporting a causal relationship between hype, public trust, and public enthusiasm/support” (p. 322). Thus, the harmful effects of sensationalized science on the public remain plausible and intuitive, but largely speculative.

8. Use Weight-of-Evidence Reporting to Counter False Balance.

In a media environment in which any scientific uncertainty can be exploited to foment distrust in science, journalists should avoid *false balance* reporting that gives equal weight to scientists and science-deniers (Brüggemann & Engesser, 2017; Guenther & Weber, 2019; Petersen et al., 2019). Researchers have repeatedly shown that audiences who read falsely-balanced reporting on vaccines — such as reporting that includes a quote from a biologist alongside a quote from a vaccine skeptic — perceive less scientific consensus and certainty regarding the debunked

¹⁶ A more recent study was unable to replicate this effect (Soutter & Möttus, 2020).

¹⁷ In 2016, HBO’s *Last Week Tonight with John Oliver* aired a segment on the ways in which science journalism misleads the public about science. As of this writing, the segment has earned over 17 million views on YouTube: <https://youtu.be/oRnq1NpHdmw>

vaccine-autism link (Dixon & Clarke, 2013; Dixon et al., 2015; Clarke et al., 2015). There has also been extensive research on false balance in the context of climate change (Oreskes & Conway, 2011; Lewandowsky, 2021). Along similar lines, stories about disagreement within the scientific community have been shown to reduce trust in scientists (Ophir & Jamieson, 2021). In our stakeholder interviews, experts and journalists agreed that they were seeing less *false balance* coverage of climate change in recent years, a welcome development given their warnings of the dangers of giving a platform to climate deniers (Jauriqui & Weinstein, 2021).

One strategy that has been proposed for navigating the challenges of scientific uncertainty while avoiding giving false impressions of balance is “weight-of-evidence” reporting. This approach asks journalists to “find out where the bulk of evidence and expert thought lies on the truth continuum and then communicate that to audiences” (Dunwoody, 2005, para. 14). Weight-of-evidence information can lessen the misleading effects of false balance (Clarke et al., 2015; Dixon et al., 2015). Kohl et al. (2016) found that weight-of-evidence reporting helps audience members navigate competing scientific claims by allowing them to recognize where the majority of evidence resides. They suggest journalists should consider the amount of text or airtime they dedicate to competing scientific claims in a manner that is proportional to their scientific validity (Kohl et al., 2016).

However, the helpfulness of weight-of-evidence reporting might not be as strong when qualitative, imprecise terms are used, such as noting that an expert “represented the minority viewpoint (one of the few who disagrees)” (Kortenkamp & Basten, 2015). Further, one study (Koehler, 2016) found that highlighting two opposing viewpoints on a topic can distort readers’ impressions of scientific findings, even when readers are presented with accurate information about the state of scientific consensus on the topic. That is, the weight-of-evidence did not make up for the false impression of balance. Nonetheless, weight-of-evidence reporting could be a useful strategy for addressing concerns around scientific uncertainty, particularly in contexts in which scientific knowledge is rapidly evolving, such as a global pandemic.

9. Use Images Strategically.

Showing pictures of scientists to indicate scientific consensus or authority has been shown to enhance the effects of weight-of-evidence reporting (Dixon et al., 2015). In fact, using images strategically is a key best practice for journalists in a variety of contexts. For example, loss-framed messages about recycling — those that focus on the costs of not recycling, rather than the benefits of recycling — have been found to be effective, but only when paired with infographics showing the harms of not recycling (Huang et al., 2019). One study (McIntyre et al., 2018) found that in the context of SJ, a photograph illustrating a solution made readers feel positive about the topic, but a neutral photograph actually made readers more interested in the story and more

likely to take action on the issue. Journalists frequently report that audiences are engaged by articles with photos of interview subjects. For example, Hinnant et al. (2013) noted “[Readers] love to hear about other people with their same problem, and the photos draw you in a lot more than some kind of drawing or abstract diagram.” Further, the Center for Media Engagement found that news articles advertised with photographs generated more clicks than those with illustrated graphics, among both conservatives and liberals (Murray & Stroud, 2019b). Roundtable participants and interviewees likewise emphasized the importance of visual elements of reporting and communicating climate change to readers via photojournalism (HHMI & Pulitzer Center, 2021; Jauriqui & Weinstein, 2021).

10. Foster Diversity in Newsrooms and Coverage.

Some of our interviewees suggested that increasing diversity of newsrooms can lead to better access to and understanding of underserved communities (Jauriqui & Weinstein, 2020). In recent decades, social scientists and philosophers have convincingly argued that knowledge, communication, research, and education are more robust when produced by diverse voices (Harding, 2009). In short, more diverse perspectives in the newsroom means fewer blind spots (Steiner, 2018). Willman (2020) notes that when newsrooms lack diversity, the organization’s world view becomes “unnecessarily narrow” and the “richness of life in the non-white population” is missed by white gatekeepers. Advocates suggest a more racially diverse reporting staff is more likely to identify news topics and cultural sensitivity concerns that their white colleagues might otherwise miss (Nishikawa et al., 2009). More diverse news staff can also make science journalism more accessible to a wide audience (Childers, 2020).

Fostering diversity has become an industry priority within the past five to ten years (Benton, 2021). The American Press Institute (n.d.) notes that diversity in the newsroom “is a business imperative...Readers pay attention to the content that speaks to or serves their identity.” Editors might consider alternative pipelines for recruiting diverse talent. For example, *Blavity News* recruits writers for their op-ed sections from the communities they serve, and Outlier Media works with the community to determine the newsroom’s agenda (Childers, 2020). Undergraduate and graduate degrees, which can run upwards of \$100,000, can be a barrier to entry for lower-income aspiring journalists. On-the-job training and alternative certification programs following a Teach for America model can offer a different path for journalists to enter the profession (Benton, 2021).

The theme of diversity also came up repeatedly in the roundtables and stakeholder interviews. Interviewees emphasized the importance of prioritizing diversity in all aspects of reporting, not just newsrooms, but also sources and subjects including subjects (Jauriqui & Weinstein, 2021). Including diverse sources as journalistic subjects is associated with stronger knowledge production and more receptive audiences as consumers demand coverage that reflects their

experiences and communities (Childers, 2020). Our roundtable participants highlighted the need to purposefully include indigenous voices in climate change science and reporting efforts, as their traditional knowledge of ecosystems is valuable to scientific endeavors. They also stressed that climate change journalism and research should be grounded in the communities most directly affected, since BIPOC communities are disproportionately vulnerable to climate impacts (HHMI & Pulitzer Center, 2021; Jauriqui & Weinstein, 2021).

DIRECTIONS FOR FUTURE RESEARCH

The best practices proposed above are supported by the experience of journalists and experts, as well as some empirical evidence, particularly in the area of SJ. However, there is a need for additional data to determine how frequently they are implemented, their effectiveness in the specific context of science journalism, and with diverse audiences. Powers and Curry (2019) suggest that “developing tools to measure journalism's social outcomes should be considered a priority for the field” (p.2253). In this section, we recommend potential research avenues to address these gaps through content analysis, as well as audience segmentation and impact research.

Content Analysis

Content analysis would enable measurement of the extent to which the identified best practices are represented in actual science reporting, and tracking changes in their implementation over time. In the next phase of our evaluation of Connected Coastlines reporting, we will aim to operationalize the 10 identified best practices and measure their usage in all Connected Coastlines stories. Future content analysis research might address the following questions:

- ***Beyond Connected Coastlines.*** How does the use of the identified best practices vary across different publications and audiences, according to factors such as newsroom size, national/regional/local focus, and the political and sociodemographic makeup of reporters and readers? To what extent does science journalism reporting use other strategies not discussed here, such as narrative elements, visualization, or appeals to shared values?
- ***Monitoring Trends Over Time.*** Longitudinal content analysis would allow tracking of changes in content and formal features (e.g., jargon, sensationalized language, infographics, and photos), and monitor whether science journalists are increasingly incorporating the identified best practices into their work.
- ***Combating Misinformation.*** What evidence-based strategies, techniques, and tools are science journalists using to combat misinformation? How frequently are these strategies employed and in what contexts (e.g., what outlets, what topics)?

Audience Segmentation and Impact Research

Audience research can help to elucidate the links between content-related best practices and their impact on the real-world knowledge, attitudes, and behavior of diverse audiences. With the exception of emerging evidence for SJ, there is scant research specifically on the impact of science journalism that employs the identified best practices. Survey-based impact studies could examine the role of the identified best practices — as well as others — and the mechanisms through which they operate. Further, the effectiveness of any strategy depends upon the audience. Thus, audience data is crucial not only for commercial purposes but also for developing and targeting effective strategies for social impact. Survey-based research would provide nuanced audience data that can inform audience segmentation and marketing efforts more generally. Potential avenues for audience research include:

- **Audience Segmentation.** What are the defining features of various audiences for science journalism, including those who are distrustful of media or scientific expertise? What demographic and psychographic variables distinguish these audiences from one another? From what media sources do they receive their scientific information?
- **Impact of Identified Best Practices.** What is the impact of the identified best practices (e.g., SJ, weight-of-evidence reporting, use of multimedia) on the knowledge, attitudes, and behavior of the various audiences? Are there contextual variables beyond the audience (e.g., online vs. print) that inform the effectiveness of different practices?
- **Mechanisms.** What are the psychological mechanisms through which the most effective best practices achieve their impact? Do they work by facilitating long-term engagement in a narrative story arc? By fostering identification through the humanization of subjects (e.g., those most affected by climate change)? By reducing psychological distance? By cultivating trust and reducing psychological reactance?
- **Scientists Communicating Directly with the Public.** How do audiences respond to the increased visibility of scientists in the public eye (e.g. on social media and in advocacy and social movements)? What factors are associated with trust in scientists versus trust in science journalists?
- **Combating Misinformation.** What is the impact of specific strategies, techniques, and tools for combating misinformation and disinformation in science journalism? Through what mechanisms do these strategies operate (e.g., increasing trust in scientists, reducing counterarguing), and how effective are these strategies with the most difficult to reach audiences?

- ***Integrated Data Sources.*** Audience survey data can be connected with content analysis and web analytics data to address questions such as what stories had the greatest impact on what audiences, and by virtue of what strategies or best practices? Do some best practices outweigh others in a real-world context? What best practices are associated with direct measures of behavior — such as time spent on a page, reading other stories by the same author, and subscriptions — and for whom?

POTENTIAL PRIORITIES FOR HHMI

As this report has demonstrated, there is a great deal of work to be done validating which science journalism practices lead to the strongest knowledge, attitudinal and behavioral outcomes among various audiences. It is abundantly clear that there is no one-size-fits-all answer, given the profound ideological, demographic and psychographic divides that define this country. In addition to a highly heterogeneous audience for science reporting, the media ecosystem is more complex than ever, which provides both opportunities and challenges to an organization trying to connect audiences to accurate scientific information that can affect how they live their lives. Relatively "narrow" channels can be used to reach niche audiences, for whom specific strategies can be deployed to increase engagement and positive outcomes. Broader channels reach larger audiences, but smaller now than before the rise of digital media. They still attract very diverse audiences, for whom a generic engagement strategy is difficult to develop. Consequently, for an organization like HHMI, which funds various types of local and national science journalism, information about the composition of audiences for these various outlets is crucial to the development of strategies for effective science reporting.

We were surprised to discover so little empirical research on best practices in science journalism, but we found enough work in adjacent fields to propose a research agenda for developing, deploying and evaluating a wide variety of methods and approaches. Among the lowest hanging fruit is SJ, which has undergone empirical research, though not explicitly focused on science topics. This could be a particularly promising approach for HHMI and science journalism because it reflects the practice of scientists themselves, who identify key problems and develop solutions based on the best evidence available. Studies have demonstrated higher engagement for SJ, including greater likelihood of reading more stories about the topic, and more loyalty to the news outlet. This is welcome news to outlets that are working hard to increase engagement and subscriptions. However, there is a lot of misunderstanding among journalists about what SJ entails, and so it would be important to increase understanding of SJ through journalist workshops, training and mentoring programs, potentially in partnership with the Solutions Journalism Network.

With Tangled Bank Studios, HHMI has already demonstrated its commitment to engaging broad public audiences in science through compelling storytelling. Instead of simply focusing on transmitting scientific knowledge, the studio has emphasized the importance of emotional

engagement in science and increasing its appeal for the general public through inspiring stories — many of which humanize scientists. With its media partnerships portfolio, we see a strategic opportunity to focus on the power of storytelling as well. Humanizing science journalism by focusing on intriguing characters and the inherent drama of the scientific enterprise is a promising strategy for achieving impact. Twenty years of research at the Lear Center has demonstrated strong correlations between the experience of "transportation" (or immersion) into a story and positive shifts in knowledge, attitudes and beliefs (e.g., Murphy et al., 2011). Further, through mechanisms such as fellowship programs, HHMI can increase the diversity of the voices telling those stories, and enrich the ecosystem of science journalism as a whole. Diversifying the storytellers, doubling down on the use of storytelling tools, and measuring the impact of those efforts is a natural extension of the studio's work, which itself deserves comprehensive impact assessments. Regardless of the best practices that HHMI chooses to embrace, the organization can make better decisions about future investments by evaluating the social impact of the work it has funded in the past.

Journalism is in crisis, but it needs more than a handout from philanthropists hoping to serve their own missions by providing funding to beloved institutions in economic jeopardy. More than money, journalism needs tools to survive. Fortunately, the kinds of methods and tools that are used for achieving social impact — the ultimate goal of HHMI's media funding — are also well-suited for the news industry's goals: attracting audiences and achieving economic stability. Both goals — social and commercial — depend on engaged audiences, who keep coming back for more content. Whether those readers can be monetized through subscriptions or advertising, their desire to return again and again to a particular outlet is directly related to their level of engagement in its content, and engagement is a prerequisite for social impact. If HHMI can partner with journalistic institutions to help them increase not only coverage of critical science topics but also audience engagement with that coverage, HHMI will not simply be serving its core mission, but also helping journalism to survive and thrive.

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