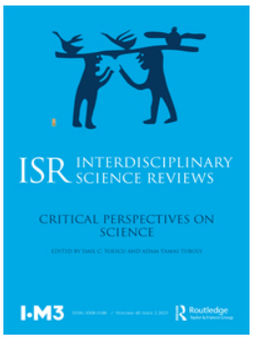

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Public trust in science

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ABSTRACT

It is widely recognized that the public benefits from well-placed trust in science. While expert advice may be wrong at times, nonexperts, on balance, benefit from following scientific experts rather than ignoring them. In short, the public needs science. Numerous professional codes such as the 2017 *European Code of Conduct for Research Integrity*, scientific reports (e.g., American Association of Arts and Science. 2014. Public Trust in Vaccines: Defining a Research Agenda. https://www.amacad.org/sites/ default/files/ publication/downloads/publicTrustVaccines.pdf) and academic scholarship emphasize the importance of public trust in science and recommend a variety of ways to promote it.[1] Less attention, however, is given to the converse relation between science and the public, namely how much science needs the public. This article examines this two-way relationship by considering the role of trust in science, both within scientific communities and between science and the public, where and how public mistrust arises, and what can be done to improve public trust in science.

KEYWORDS

Trust; expertise; public understanding of science; credibility; science and society; public resistance to science; scientific authority; science skepticism

Introduction

Trust is a topic of long-standing interest in philosophy, sociology, and psychology because it is indispensable to the success of nearly every kind of coordinated human activity, from business and politics to sport and scientific research. Trust is also necessary for the successful dissemination of knowledge, practical deliberation, and policy-making that requires the use of more information than we can gather individually and verify ourselves. In short, without trust, we could achieve very few of our goals and we would know very little. It follows that public trust in science and/or scientific institutions is crucially important for science and society.

With such priority placed on public trust in science, considerable resources have been put into surveilling public trust. Public trust indicators are deployed to track public

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[1]The public trust building efforts include science education (especially K-12), ensuring research integrity and legal compliance by scientific institutions, as well as including the public in various areas of scientific governance (e.g. membership on research ethics boards), scientific practice (e.g. citizen science projects), and policy decision making (e.g. mini-publics/citizen juries). The importance of shoring public trust is sometimes seen as reason to avoid certain policies. For example, public trust may be compromised by relaxing protections on human research subjects (Resnik 2011) or mandating vaccines (Tampio 2021). In both cases, ensuring public trust arguably justifies such policy decisions even when the scientific benefit of permissive human subject research or the health benefits of mandating vaccines are compelling.

attitudes on specific issues, in geographic locations, and over time. Numerous national governments commission surveys by market research and public opinion polling companies to measure public attitudes towards science. The earliest national surveys were commissioned by the United States' National Science Foundation, which began publishing biennial *Science Indicator* surveys in 1972. The scope of the *Science Indicators* surveys increased in 1979 to include not just public understanding of science, but also public attitudes toward and willingness to engage with science and technology (Miller 1992). In 1988, the United Kingdom launched its own survey research into scientific understanding and attitudes, *Public Understanding of Science*, in response to a worrisome 1985 Royal Society of London report claiming that low public understanding of science and technology would hinder the nation's economic prosperity in the long run (Royal Society 1985). Both American and British surveys initially examined public *understanding* of science (i.e. science literacy), and later public *attitudes* towards science. They later evolved to measure public *trust* in science, as analysts came to regard this latter measure as better capturing of the public's relationship to science. In Britain, the *Public Understanding of Science* progressed into the current 'gold standard' for measuring public attitudes toward science, including trust, the *Public Attitudes to Science* survey (Office of Science and Technology and the Wellcome Trust 2000; Department of Business, Energy & Industrial Strategy 2020). These surveys and their predecessors have long informed the UK's science communications policies, practices, and scholarship (Smith and Jensen 2016). Public attitudes, especially public trust in science, are now surveyed globally, allowing for cross-country comparison and global indicators (Wellcome Monitor 2019; Gallup 2022). The 2018 *Wellcome Global Monitor* (Wellcome Monitor 2019) surveyed over 140,000 people in over 140 countries on their attitudes towards, and trust in, science.

Since the start of the COVID pandemic in 2020, both national and international survey research into public trust in science have increased in frequency. For example, the *Proof Strategies CanTrust Index* had run annual surveys on Canadian public trust in science since 2016 and increased to biannual surveys (called 'COVID-19 Impact Updates') in 2020 and 2021 (Proof CanTrust Index 2021). The German *Science Barometer* (Wissenschaft im Dialog 2020b) similarly added an extra survey in 2020 focused on coronavirus to the Trust in Science survey that has run annually since 2016. The surge of surveys of public trust were executed in order to inform researchers, policy makers, and science communicators about how pandemic response is being perceived (e.g. Wellcome Monitor 2020), and to anticipate public adherence to public health measures, especially COVID vaccination (e.g. Lazarus et al. 2020; The COVID-19 Consortium for Understanding the Public's Policy Preferences Across States 2020).

Many researchers were interested in the uncharacteristic media visibility and attention that was given to scientists, especially scientific advisors to the government, during the pandemic. The increased publicity resulted in higher public trust in science and scientists at the start of the pandemic compared to pre-pandemic measures (SciDev 2021; Funk 2020; Wellcome Monitor 2020; 3M State of Science Index 2020; Dialog 2020a; Proof Strategies CanTrust Index 2021).[2] This was welcome news, as public trust in science and scientists is widely perceived to be at a low ebb (Tsipursky 2018; Oreskes 2019).

[2]Some of the measured increases in public trust in science during the COVID-19 pandemic were dramatic. An April 2020 survey of Great Britain showed a 19-percentage point increase from a 2015 poll into public interest in having scientists

Yet trend watchers are not satisfied with momentary increases in public trust in science. With knowledge-based and technology-driven societies advancing so rapidly, momentary public trust does not provide the security that science-policy makers and analysts desire. The COVID pandemic might have elicited some momentary increases in public trust in science, but it also underscored the precarity of that trust, as the pandemic has put serious strain on the relationship between science and society. Many early public health 'stars' of the pandemic seemed to buckle under political pressure to provide scientific cover for questionable political choices, thereby undermining the supposed impartiality that scientists were supposed to bring to pandemic policies (Meler 2021; Yong 2021). Other public health officers undermined their credibility by disregarding the very public health measures that they had put in place, for example, breaking lockdown rules in order to travel (Stewart 2020). Soon, political partisanship directed much of public attitudes toward public health measures (in the USA, see Cross 2021). Of course, public health has always been political (Goldberg 2012), and public health units are arms of the government. The public, it seemed, wanted scientists to stand outside of politics and guide pandemic response with science alone. It was disappointing to see public health officers entangled with politics. Public health officials have the difficult task of managing political interests while maintaining scientific integrity. Many of the public-facing scientific advisors were not successful (see, for example, Russell and Russnell 2020).

Writing almost one year into the pandemic, Sudip Parikh, editor of science journals at the *American Academy of Advancement in Science* (AAAS), conveyed an urgent need to build public trust in science to improve life and well-being through the benefits of science (Parikh 2021). While Parikh appreciated the remarkable efficiency of biomedical researchers in sequencing the novel coronavirus and rapidly developing several COVID-19 vaccines, he lamented the disorderly governance, inequitable distribution, and uneven public uptake of those life-saving technologies. He encouraged better shoring of public trust to carry us into the next global crisis. He wrote:

> The cadence of emerging crises and the pace of planet-changing discoveries necessitate permanent elevation of scientific advisers to the front ranks of policymaking as they have only sometimes been during national crises like world wars, and moments of global competition like the space race. At the same time, we need to more fully engage diverse communities with an intentional emphasis on those that have been ignored, marginalized, or harmed by scientific advancement. (Parikh 2021)

Parikh correctly recognizes trust to be the relational glue that binds science and society in advancing social goals.

> One element is absolutely critical to the success of our mission to improve the human condition: trust. It's a foundational element of any relationship, but for the mutual benefit of the scientific enterprise and the people who support it, trust is essential. (Parikh 2021)

For scientific innovation to contribute to achieving social goals, science needs to be trusted by the public.

communicate about their research (Wellcome Monitor 2021; Wellcome Monitor 2016). In the USA and Canada, the number of people who agreed with the view 'I am sceptical of science' dropped by 8% from mid-2019 to late 2020, (3M State of Science Index 2020). The 2020 German science barometer survey showed levels of trust in science and research between 73% in April and 60% in November, compared with 46% in 2019 (Wissenschaft im Dialog 2020a).

The importance of trust in science

What is trust? Trust at both the interpersonal and institutional level is a heavily researched concept in several disciplinary domains: ethics, psychology, sociology, and philosophy of science. There is some convergence on a definition: to have trust is to have confidence in someone or something (Goldenberg 2021). Trust is the disposition upon which this confidence or assurance arises. The main purpose of trust is to facilitate cooperative social interactions, such as friendships, business, family relations, medical care, and education. Those successful interactions depend on shared expectations of behaviour (Whitbeck 1995; Govier 1997), such as keeping promises (Baier 1986). Once trust is established, it resides implicitly in the background, as an unquestioning disposition or attitude towards the trusted source (Baier 1986; Nguyen 2022). In science, discussion about trust usually pertains to *epistemic trust*; to have epistemic trust in someone is to trust them as a reliable source of information (Wilholt 2013).

Trusting others is risky because there is the chance of being misled or harmed. For that reason, trust is and should be administered judiciously; we trust those who we determine to be trust*worthy* (Hardin 2006).[3] Trusting others carries the expectation that they will use skill and sound judgment to take care of something that we deem important, such as our money, children, legal affairs, or secrets (Baier 1986). However, the trustor does not know with certainty that the entrusted person will act as expected. This unavoidable risk places the trusting person in a vulnerable position relative to those they entrust (Baier 1986). Since trust involves risk-taking and vulnerability, it can be easily damaged if the entrusted party does not meet what is expected of them (Baier 1986). As the old saying goes, trust is slow to build but quick to destroy.

To determine whether someone should be trusted, we look for cues regarding their trustworthiness: are they competent in the domain that they are being entrusted? Do they demonstrate the right character to do the task with which they are entrusted conscientiously? For example, trusting a neighbour to babysit your child requires some sort of judgment that the neighbour is competent at childcare provision, and that they have the moral characteristics of a kind and conscientious babysitter. You might draw from past impressions and interactions with the neighbour or trust others' assessments of them.

In science, a colleague may be entrusted due to their experience and professional status, as well as their moral standing as a reliable colleague that reports information honestly (Hardwig 1991; Whitbeck 1995; Whyte and Crease 2010). Against the popular understanding that science is rigorous by being *wary* of trust—rather than listen to authority, examine the evidence for yourself! – sociologists of science have detailed the numerous relations of trust that operate implicitly in laboratory settings and field stations, collaborative research projects, and journal clubs (e.g. Shapin and Schaffer 1985). In these group settings, each participant relies on the others to do their piece of the collective effort competently and to report their findings honestly. There is no one person providing comprehensive oversight by rechecking all calculations, replicating

[3]There may be crisis situations where trust must be given more freely, for example, trusting an emergency room doctor to execute life-saving treatment. Alternatively, the crisis situation might shift assignments of trust from the individual physician to the institution as a whole, where trust in the Emergency Room or hospital infrastructure is sufficient to warrant accepting care. I thank an anonymous reviewer for suggesting this alternative reading.

all parts of the experiment, and so on; the background of trusting professional relationships rationalizes this practice. Science as we know it could not happen without these background relationships of trust.

The role of trust is more obvious and explicit in the relationship between science and the public than it is within science communities. When members of the public, as well as politicians and policymakers, seek advice and guidance from scientific experts, they put their trust in the authority of science. The public will trust advice and information from scientific experts if the individual, group, or the institutions the scientists represent are perceived as (i) epistemically competent, i.e. they are in a position to know, (ii) morally reliable, i.e. they are disposed to tell the truth, *and* (iii) they work in the public interest. That last criterion adds social consideration to the epistemic and moral considerations already laid out. Does the expert or expert institution engage in scientific research and practice aimed at improving public life and welfare, or do they serve power interests (corporate or governmental) or strive for personal gain (money, prestige)? When assessing scientific claims to be trustworthy, the public characteristically brings all three considerations – epistemic, moral, and social – to bear on the claimant, that is, the scientific expert or institution making the scientific claims. Whereas members of the public presumably do not have the expertise to assess the content of the scientific claims themselves, they do possess (imperfect) metacognitive awareness to assess the speaker of those claims, including scientific experts. Does the speaker or institution seem trustworthy? Members of the public assess *who to believe* as a heuristic for *what to believe*. These character assessments (as trustworthy or not) determine the extent to which the public trusts science.

These assessments of trustworthiness can happen at the individual or group level. For example, an individual can evaluate the trustworthiness of their city's Chief Public Health Officer based on their credentials and prior public health directives; a social group or creed (i.e. evangelists, naturopaths) may stake out an accepting or critical stance towards individuals and collectives (i.e. scientific experts as a whole or a scientific agency like the Center for Disease Control and Prevention (CDC) or the European Medical Association (EMA). Public trust in science, then, determines the extent to which the public will follow public health advice (not only during a pandemic), accept new technologies such as gene therapies and nanotechnologies (Resnik 2009), and support any other scientific and technology applications for which the risks and benefits are not fully understood (Frewer 2001).

This method of evaluating character instead of content is, in some sense, a 'shorthand' for non-experts lacking the insider knowledge to assess the content of the expert claims. Indeed, if we did have that insider information, we would not need expert advice. Yet it is still appropriate to assess the moral and social characteristics of scientific experts and scientific institutions because of the values that accompany scientific claims. Expert judgments made by scientists are never merely scientific; they include moral judgments about what risks are worth taking and how potential and expected harms should trade off against potential or anticipated social benefits (Douglas 2009). The public need some confidence that the scientists have the right values shaping their pronouncements, that is, values that are commensurable to one's own. Value differences invite fierce public debate regarding scientific claims about climate change and pandemic response, for example, as well as strong disagreements over who are the 'real' experts, i.e. those with

the legitimate authority to pronounce on the subject. Trust is the measure for which the public will accept and (likely) follow scientific advice.

Why do some members of the public mistrust science?

Because there is too much for anyone to know for themselves, we rely on experts to inform most of our decisions. How should I plan financially for retirement? Should I vaccinate my children? Should I take an umbrella with me this morning? The previous discussion has highlighted how *warranted* trust in science (that is, trust in trustworthy science and scientists) is beneficial for members of the public. The difficulty lies in knowing when trust is well placed. It makes sense for non-experts to rely on expert advice. Experts are more likely to be correct than non-experts are. Yet the frequent rally of frustrated science communicators beseeching the public to '*trust science!*' ignores the risk and vulnerability associated with trusting. The public must decide to follow or ignore scientific advice under imperfect conditions that include gaps in scientific information and understanding, and historical knowledge that science and scientific findings are not always trustworthy. For example, recent scandals in the biotech sector, such as Vioxx (Nesi 2008), the opioid crisis (Meier 2018), and the medical device scandal (International Consortium of Investigative Journalists 2018), are routinely cited by vaccine hesitators as reason not to trust both pediatric vaccines (Goldenberg 2021) and COVID vaccines (Griffith, Marani, and Monkman 2021; Palamenghi et al. 2020). These scandals, then, are damaging to the fragile trust between scientific institutions and the public. Furthermore, little change to scientific governance has been put in place to rebuild that trust, for example, enacting reform of the very industry-research-regulatory relationships that permitted these breathtaking cases of corporate malfeasance, scientific malpractice, and regulatory inaction to happen.

Low trust in science is also the product of historic and contemporary experiences of abuse and injustices (Goldenberg 2021). Early in the COVID pandemic, communities of colour in industrialized nations polled far less likely to accept a COVID vaccine when it became available despite these communities having suffered far greater rates of infection, morbidity, and mortality than non-racialized communities (Kricorian and Turner 2021). This phenomenon is attributable to pre-existing fraught relationships between racialized communities and healthcare institutions, where medical racism often results in suboptimal care (Dryden and Nnorom 2021). For example, poor pain management is widely experienced by Black and Hispanic Americans due to racist assumptions about high pain thresholds and drug-seeking behaviour (Goyal et al. 2015; Hoffman et al. 2016; Wyatt 2013). Beyond health care, science has long been misused to justify racist discrimination (Tucker 2007; Saini 2019; Gould 1996). Much like financial conflicts of interest in scientific research, there has been inadequate movement by scientific institutions to rectify low trust by racialized communities. In medical and public health training programs, anti-racism education has not been sufficiently prioritized despite general agreement of its importance (de Shazo, Hoesley, and Vickers 2021; Hess, Palermo, and Muller 2020; Tiako et al. 2021). Same with efforts to increase representation in the fields by active recruitment and retention of trainees and faculty from underrepresented groups (Ajayi, Rodriguez, and de Jesus Perez 2021). Numerous studies show that representation in healthcare settings matters to patients,

who associate racial and gender concordance between patient and physician with better healthcare (Street et al. 2008).

> The physician-patient relationship is strengthened when patients see themselves as similar to their physicians in personal beliefs, values, and communication. Perceived personal similarity is associated with higher ratings of trust, satisfaction, and intention to adhere. (Street et al. 2008)

Lack of diversity and representation in the healthcare workforce contributes to health disparities in underrepresented patient populations (Smedley, Stith, and Nelson 2003). Building public trust involves building both diverse scientific research communities and a diverse healthcare workforce. While medical and public health schools widely acknowledge the importance of diversity and inclusion, their actions do not match intent. Equity-seeking healthcare and public health professionals recently called on the Canadian public health sector to 'walk the walk' on equity, diversity, and inclusion (Shahi, Karachiwalla, and Grewal 2019).

To insist, as some science communicators do, that science is still trustworthy overall places too great a burden on the public to assess each case for themselves (Contessa 2022). The demand is too great and most of our cognitive tools are too limited to fully disentangle each of our risk profiles vis-à-vis the scientific-industrial complex. It should be little wonder that most worried parents empowered to 'do the research and decide for yourself' often end up more vaccine hesitant than before (Seigal 2020). The abundance of information available online can be overwhelming and frequently mixed in with misinformation and propaganda; trade secrets are protected; experts disagree. Online information network bubbles, motivated reasoning, and group identity allegiances make it extremely unlikely that any one of us can accomplish unbiased and thorough research on politically charged science policy issues like vaccination. Unwarranted public mistrust of science, then, is not likely to be resolved by fact checking and myth-busting (see, for example, AFP Fact Check 2022; International Fact-Checking Network 2022) communications targeting individuals' information assimilation.

The group identities and allegiances that have formed around both trust and distrust in science point to a social account of knowledge rather than an individual one. Cultural cognition research details how (and why) we tend to believe what our group believes (Kahan 2012). It also points to social solutions being necessary to counter unwarranted public mistrust of science. The public's concerns about financial conflicts of interest in biotechnology mentioned earlier do not occur because industry and academic research cannot work in harmony and achieve publicly acceptable goals like better and more equitable health care. Rather the public's dissatisfaction lies in how these partnerships have resulted in a social environment of poorly incentivized science (what Contessa (2022) calls a 'degraded socio-epistemic infrastructure') that prioritizes profits over improved health and welfare.[4] The harms and injustices experienced by racialized people and communities in relation to science, public health, and health care point to broader systemic

[4]This type of research environment has resulted in instances of poorly executed research and publication bias, as well as the '10-90 gap'. The 10/90 gap is the term adopted by the Global Forum for Health Research to describe the finding by the Commission on Health Research for Development in 1990 that less than 10% of global funding for health research is spent on diseases that afflict people in the Global South, where 90% of the world's population resides and over 90% of all preventable deaths worldwide occur (Vidyasagar 2006). This health equity problem is largely attributed to a skewed incentive scheme to that values market returns over global health impact (Health Impact Fund ND).

problems in scientific governance and scientific practice that require structural solutions. Public mistrust in science can be alleviated by addressing those problematic social relationships that keep people from confidently trusting science and scientific advice. Inaction by those with power and influence to acknowledge the problems (e.g. Shaywitz and Stossell 2009) and fix them (e.g. Rosenbaum 2015) is self-serving. Biomedical industries, academic medicine leadership, medical journals, and policy makers benefit from current industry-academic arrangements. Without strong leadership, scientific and medical racism can continue. Yet public disaffection[5] is ultimately harmful for the epistemic and social aims of science.

The fulfilment of many scientific aims hinge on positive public relations. Science strives to create universally applicable knowledge, and this knowledge is universal only insofar as it is accepted by various stakeholders. Research institutes rely on stable relations with the outside, at minimum to ensure access to public research funds and to enjoy little interference with their work. When that minimal level of public trust is in place, science can operate smoothly. This is the case for more esoteric areas of science that do not receive much public attention or concern.

In policy-relevant science, that is, science aimed at improving human, animal, and environmental health and welfare, there are more elaborate ties to the public. Practical goals like improving public health or promoting environmental welfare require scientific claims to be accepted by stakeholders outside of their specialized scientific communities (Scheman 2001; Wilholt 2009; Whyte and Crease 2010). Policy-relevant science can only provide those public benefits if its scientists and institutions are regarded as trustworthy by members of the public. Conversely, low levels of public trust in science impede such efforts when expert advice is ignored or refused. Even routine scientific practice can be misinterpreted, for example, suspicion often arises upon changes in scientific understanding and directives. The self-correcting nature of science—surely a virtue of science and critical thinking—is often interpreted uncharitably by a sceptical public as evidence of poorly executed science (Barash 2015).

To illustrate, public health science can only improve population health if the public largely accepts and follows its recommendations. Health recommendations and consensus statements bank on the public's trust in these institutions' conscientious and honest efforts to inform and protect. Earning and maintaining the public trust is therefore crucial for fulfilling the goals of public health. Offering the best science and the most carefully considered action directives are not enough. The science must be trustworthy but also trusted by all public health stakeholders. Persistent vaccine hesitancy indicates an institutional failure to engender public trust. This warrants self-reflection by public health institutions and agencies about their own public trust building practices.

How can public trust be improved?

The extent to which public trust improves when sources of mistrust are addressed or removed is two-fold. First, removing sources of potential and actual bias improves

[5]Social science research shows that the public are extremely uncomfortable with the current social arrangement between industry and health research and practice (Hargreaves, Lewis, and Speers 2003; Lenzer 2004; Narayanan and Mathew 2019).

science, thereby giving the public less reason to worry about being misled or harmed. Second, addressing public concern shows scientific bodies to be responsive to public interests, thereby demonstrating moral and social aspects of trustworthiness (discussed earlier). Inserting the public into science – whether in citizen science fieldwork opportunities, townhall meetings, participation in scientific governance, and mini-publics to deliberate on science policy – is known to improve public trust by involving and familiarizing the public with science (see nn. 1). Less appreciated is the extent to which public participation benefits science itself, by bringing in local or experiential knowledge that may improve scientific understanding and refine the values and expectations shaping the research and/or intervention (Douglas 2005). For example, farmers, hunters, and fishers have experiential knowledge of local ecology that is valuable for environmental and conservation research (e.g. Batumike et al. 2022).

Insofar as public trust improves adherence to scientific directives,[6] and science strives to contribute to social goals like improved health and welfare, science needs to be trusted by the public. Science will be trusted by the public to the extent that it is perceived to be executed rigorously, reported honestly, and working in the public interest. Just as the public needs science in order to make good choices, science needs the public too.

That many members of the public hear competing claims on politically charged scientific issues and do not know who to believe, and many members of socially marginalized groups trust their peers and online sources more than mainstream science, and others find meaning in conspiratorial theories that elevate and amplify the historic and present harms done by, or in the name of, science tells us that the relationship between science and the public needs more work. Rather than point to flaws in individual reasoning, attention must be directed to the social structures and social institutions that fail to build and maintain the public trust needed for confronting many of our greatest societal challenges.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributor

Maya J. Goldenberg is Professor of Philosophy, researching the fundamental epistemic question, 'How do we know what to believe?' in health care. She has addressed this question in the pressing context of evidence-based medicine, the decision-making framework that relies on clinical trial evidence (especially randomized controlled trials) to inform individual patient care. Recently, she has broadened her research into the science-values complex to investigate vaccine hesitancy as illustrative of poor public trust in scientific institutions, published in a book, *Vaccine Hesitancy: Public Trust, Expertise, and the War on Science* (University of Pittsburgh Press, 2021).

[6]For public trust and adherence to public health measures enacted during the COVID pandemic, see Devine et al. (2021) and Goldberg et al. (2020).

References

AFP Fact Check. 2022. *Busting Coronavirus Myths*. Fact Check. https://factcheck.afp.com/busting-coronavirus-myths.

Ajayi, Antonette A., Fatima Rodriguez, and Vinicio de Jesus Perez. 2021. "Prioritizing Equity and Diversity in Academic Medicine: Faculty Recruitment and Retention." *JAMA Health Forum* 2 (9): e212426.

Baier, Anette. 1986. "Trust and Anti-Trust." *Ethics* 96: 231–260.

Barash, David. 2015. "Science Needs the Freedom to Constantly Change Its Mind." *Aeon*. October 27. https://aeon.co/essays/science-needs-the-freedom-to-constantly-change-its-mind

Batumike, Rodrigue, Franklin Bulonvu, Gérard Imani, Desiré Akonkwa, Aimable Gahigi, Julia A. Klein, Rob Marchant, and Aida Cuni-Sanchez. 2022. "Climate Change and Hunter-Gatherers in Montane Eastern DR Congo." *Climate and Development* 14 (5): 431–442.

Contessa, Gabriel. 2022. "It Takes a Village to Trust Science: Towards a (Thoroughly) Social Approach to Social Trust in Science." *Erkenntnis*. doi:10.1007/s10670-021-00485-8

Cross, Ryan. 2021. "Will Public Trust in Science Survive the Pandemic?" *Chemical and Engineering News*. January 25. https://cen.acs.org/policy/global-health/Will-public-trust-in-science-survive-the-pandemic/99/i3

Department of Business, Energy & Industrial Strategy. 2020. *Public Attitudes to Science 2019. Main Report*. BEIS Research Paper Number 2020/012. July 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/905466/public-attitudes-to-science-2019.pdf.

deShazo, Richard D., Craig J. Hoesley, and Selwyn M. Vickers. 2021. "Ending Racial Bias in American Medicine: A Call for Help from the AMA, NMA, AAMC, and the Rest of Us." *American Journal of Medicine* 134 (5): 565–568.

Devine, Daniel, Jennifer Gaskell, Will Jennings, and Gerry Stoker. 2021. "Trust and the Coronavirus Pandemic: What are the Consequences of and for Trust? An Early Review of the Literature." *Political Studies Review* 19 (2): 274–285.

Dialog, Wissenschaft Im. 2020a. *Science Barometer* 2020. https://www.wissenschaft-im-dialog.de/fileadmin/user_upload/Projekte/Wissenschaftsbarometer/Bilder/Wissenschaftsbarometer_2020/English/2020_WiBa_EN_Brochure.pdf.

Dialog, Wissenschaft Im. 2020b. "Science Barometer Special Edition on Corona." https://www.wissenschaft-im-dialog.de/en/our-projects/science-barometer/science-barometer-special-edition-on-corona/.

Douglas, Heather. 2005. "Inserting the Public Into Science." In *Democratization of Expertise? Exploring Novel Forms of Scientific Advice in Political Decision-Making*, edited by S. Masen, and P. Weingart, 153–169. Amsterdam: Springer.

Douglas, Heather. 2009. *Science, Policy, and the Value-Free Ideal*. Pittsburgh: University of Pittsburgh Press.

Dryden, OmiSoore, and Onye Nnorom. 2021. "Time to Dismantle Systemic Anti-Black Racism in Medicine in Canada." *Canadian Medical Association Journal CMAJ* 193 (2): E55–E57. doi:10.1503/cmaj.201579. January 11

Frewer, Lynn J. 2001. "Environmental Risk, Public Trust and Perceived Exclusion from Risk Management." In *Environmental Risks: Perception, Evaluation and Management*, edited by G. Böm, J. Nerb, T. McDaniels, and H. Spada, 221–248. Bingley: Emerald Group Publishing Limited.

Funk, Carly. 2020. *Science and Scientists Held in High Esteem Across Global Publics*. Pew Research Center. September 29. https://www.pewresearch.org/science/2020/09/29/science-and-scientists-held-in-high-esteem-across-global-publics/.

Gallup. 2022. *Wellcome Measures Trust in Science When It Matters Most*. Gallup.com. https://www.gallup.com/analytics/327173/wellcome-success-story.aspx.

Goldberg, Daniel. 2012. "Against the Very Idea of Politicization of the Politicization of Public Health Policy." *American Journal of Public Health* 102 (1): 44–49.

Goldberg, Matthew H., Abel Gustafson, Edward W. Maibach, Matthew T. Ballew, et al. 2020. "Mask-Wearing Increased After a Government Recommendation: A Natural Experiment in the U.S. During the COVID-19 Pandemic." *Frontiers in Communication* 5 (Article 44). June 17. https://www.frontiersin.org/articles/10.3389fcomm.2020.00044/full

Goldenberg, Maya J. 2021. *Vaccine Hesitancy: Public Trust, Expertise, and the War on Science*. Pittsburgh, PA: University of Pittsburgh Press.

Gould, Stephen Jay. 1996. *The Mismeasure of Man*. Revised edition New York: WW Norton.

Govier, Trudy. 1997. *Social Trust and Human Communities*. Montreal: McGill-Queen's University Press.

Goyal, Monika K., Nathan Kupperman, Sean D. Cleary, Stephen J. Teach, and James M. Chamberlain. 2015. "Racial Disparities in Pain Management of Children with Appendicitis in Emergency Departments." *JAMA Pediatrics* 169 (11): 996–1002.

Griffith, Janessa, Husayn Marani, and Helen Monkman. 2021. "COVID-19 Vaccine Hesitancy in Canada: Content Analysis of Tweets Using the Theoretical Domains Framework." *Journal of Medical Internet Research* 23 (4): e26874.

Hardin, Russell. 2006. *Trust*. Cambridge: Polity Press.

Hardwig, John. 1991. "The Role of Trust in Knowledge." *Journal of Philosophy* 88 (12): 693–708.

Hargreaves, Ian, Justin Lewis, and Tammy Speers. 2003. *Towards a Better Map: Science, the Public, and the Media*. London: Economic and Social Research Council.

Health Impact Fund. ND. "The Health Impact Fund." https://healthimpactfund.org/en/.

Hess, Leona, Ann-Gel Palermo, and David Muller. 2020. "Addressing Harmful Bias and Eliminating Discrimination in Health Professions Learning Environments." *Academic Medicine* 95 (12S): S44–S50.

Hoffman, Kelly M., Sophie Trawalter, Jordan R. Axt, and M. Norman Oliver. 2016. "Racial Bias in Pain Assessment and Treatment Recommendations, and False Beliefs About Biological Differences Between Blacks and Whites." *PNAS Proceedings of the National Academies of Science* 113 (16): 4296–4301.

International Consortium of Investigative Journalists. 2018. Medical Devices Harm Patients Worldwide as Governments Fail on Safety. *ICIJ*. November 25. https://www.icij.org/investigations/implant-files/medical-devices-harm-patients-worldwide-as-governments-fail-on-safety/.

International Fact-Checking Network. 2022. Fighting the Infodemic: The #CoronaVirusFacts Alliance. *Poynter Institute*. https://www.poynter.org/coronavirusfactsalliance/.

Kahan, Dan, et al. 2012. "Cultural Cognition as a Conception of the Cultural Theory of Risk." In *Handbook of Risk Theory: Epistemology, Decision Theory, Ethics and Social Implications of Risk*, edited by Sabine Roeser, 725–760. Springer Netherlands: Amsterdam.

Kricorian, Katherine, and Karin Turner. 2021. "COVID-19 Vaccine Acceptance and Beliefs among Black and Hispanic Americans." *PLoS ONE* 16 (8): e0256122.

Lazarus, Jeffrey V., Scott C. Ratzan, Adam Palayew, Lawrence O. Gostin, Heidi J. Larson, et al. 2020. "A Global Survey of Potential Acceptance of a COVID-19 Vaccine." *Nature Medicine* 27: 225–228. https://www.nature.com/articles/s41591-020-1124-9.

Lenzer, Jeannie. 2004. "Scandals Have Eroded US Public's Confidence in Drug Industry." *British Medical Journal* 329: 247.

3M State of Science Index. 2020. 2020 *Global Report*. https://multimedia.3 m.com/mws/media/1898512O/3m-sosi-2020-pandemic-pulse-global-report-pdf.pdf.

Meier, Barry. 2018. "Origins of an Epidemic: Purdue Pharma Knew Its Opioids Were Widely Abused." *New York Times*. May 29. https://www.nytimes.com/2018/05/29/health/purdue-opioids-oxycontin.html

Meler, Bryan. 2021. "It's a Minefield': How Public Trust in Canada's Top Doctors Is Undermined by Politics Amid the COVID-19 Pandemic." *Yahoo News Canada*. March 11. https://ca.news.yahoo.com/covid19-canada-trust-doctors-politicans-cmohs-120047289.html.

Miller, Jon D. 1992. "Toward a Scientific Understanding of the Public Understanding of Science and Technology." *Public Understanding of Science* 1 (1): 23–26.

Narayanan, Arjan, and Aju Mathew. 2019. Why India's Pharma Industry Needs to Act Now to Win Back the Trust It Lost. *The Wire*. September 8. https://thewire.in/health/why-indias-pharma-industry-needs-to-act-now-to-win-back-the-trust-it-lost

Nesi, Tom. 2008. *Poison Pill: The Untold Story of the Vioxx Drug Scandal*. New York: St. Martin's Press.

Nguyen, C. Thi. 2022. "Trust as an Unquestioning Attitude." In *Oxford Studies in Epistemology Volume 7*, edited by Tamar Szabó Gendler, John Hawthorne, and Julianne Chung, 214–244. Oxford: Oxford University Press.

Office of Science and Technology and the Wellcome Trust. 2000. *Science and the Public: A Review of Science Communication and Public Attitudes to Science in Britain. A Joint Report by the Office of Science and Technology and the Wellcome Trust*. October 2000, London.

Oreskes, Naomi. 2019. *Why Trust Science?* Princeton, NJ: Princeton University Books.

Palamenghi, Lorenzo, Serena Barello, Stephania Boccia, and Guendalina Graffigna. 2020. "Mistrust in Biomedical Research and Vaccine Hesitancy: The Forefront Challenge in the Battle Against COVID-19 in Italy." *European Journal of Epidemiology* 35 (8): 785–788.

Parikh, Sudip. 2021. "Why We Must Rebuild Trust in Science." *Pew Trend Magazine*, February 9. https://www.pewtrusts.org/en/trend/archive/winter-2021/why-we-must-rebuild-trust-in-science

Proof CanTrust Index. 2021. "The Proof Strategies 2021 CanTrust Index." *Proof Strategies*. https://getproof.com/what-we-do/cantrust/?utm_source = getproof&utm_medium = newsrelease&utm_campaign = 21q1_cantrust

Resnik, David B. 2009. *Playing Politics with Science: Balancing Scientific Independence and Government Oversight*. New York: Oxford University Press.

Resnik, David B. 2011. "Scientific Research and the Public Trust." *Science and Engineering Ethics* 17 (3): 399–409.

Rosenbaum, Lisa. 2015. "Beyond Moral Outrage – Weighing the Trade-Offs of COI Regulation." *New England Journal of Medicine* 372: 2064–2068.

The COVID-19 Consortium for Understanding the Public's Policy Preferences Across States. 2020. *The State of the Nation. A 50-State COVID-19 Survey Report #13: Public Trust in Institutions and Vaccine Acceptance*. http://www.kateto.net/covid19/COVID19%20CONSORTIUM%20REPORT%2013%20TRUST%20SEP%202020.pdf.

The Royal Society. 1985. *The Public Understanding of Science. Report of a Royal Society ad hoc Group Endorsed by the Council of the Royal Society*. London: Royal Society. http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/1985/10700.pdf

Russell, Jennie, and Charles Russnell. 2020. "Secret Recordings Reveal Political Directives, Tension Over Alberta's Pandemic Response." *CBC News*. Nov 26. https://www.cbc.ca/news/canada/edmonton/alberta-covid-19-response-tension-recordings-1.5814877.

Saini, Angela. 2019. *Superior: The Return of Race Science*. New York: Penguin Random House.

Scheman, Naomi. 2001. "Epistemology Resuscitated: Objectivity as Trustworthiness." In *Engendering Rationalities*, edited by Nancy Tuana, and Sandra Morgen, 23–52. Albany: State University of New York Press.

SciDev. 2021. *Trust in Scientists on the Rise Worldwide*. SciDev.net. November 29. https://www.scidev.net/global/data-visualisation/trust-in-scientists-on-the-rise-worldwide/

Seigal, Ethan. 2020. "You Must Not 'Do Your Own Research' When It Comes to Science." *Forbes*, July 30. https://www.forbes.com/sites/startswithabang/2020/07/30/you-must-not-do-your-own-research-when-it-comes-to-science/?sh = 90a723d535ea

Shahi, Ankur, Karachiwalla Fareenm and Nagma Grewal. 2019. "Walking the Walk: The Case for Internal Equity, Diversity, and Inclusion Work Within the Canadian Public Health Sector." *Health Equity* 3 (1): 183–185.

Shapin, Steven, and Simon Schaffer. 1985. *Leviathan and the Air Pump: Hobbes, Boyle and the Experimental Life*. Princeton, NJ: Princeton University Press.

Shaywitz, David A. and Thomas P. Stossell. 2009. "It's Time to Fight the 'PharmaScolds'." *Wall Street Journal*, April 8. https://www.wsj.com/articles/SB123914780537299005

Smedley, Brian D., Adrienne Y. Stith, and Alan R. Nelson, eds. 2003. *Institute of Medicine, Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care, Board on Health Sciences Policy. Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care*. Washington: National Academies Press.

Smith, Benjamin A., and Eric Jensen. 2016. "Critical Review of the United Kingdom's 'Gold Standard' Survey of Public Attitudes to Science." *Public Understanding of Science* 25 (2): 154–170.

Stewart, Heather. 2020. "Neil Ferguson: UK coronavirus adviser resigns after breaking lockdown rules." https://www.theguardian.com/uk-news/2020/may/05/uk-coronavirus-adviser-prof-neil-ferguson-resigns-after-breaking-lockdown-rules.

Street, Richard L., Kimberley J. O'Malley, Lisa A. Cooper, and Paul Haidet. 2008. "Understanding Concordance in Patient-Physician Relationships: Personal and Ethnic Dimensions of Shared Identity." *Annals of Family Medicine* 6 (3): 198–205.

Tampio, Nicholas. 2021. "Vaccine Mandates Will Backfire. People Will Resist Even More." *The Washington Post*, July 31. https://www.washingtonpost.com/outlook/2021/07/31/biden-mandate-covid-vaccine-hesitancy/111

Tiako, Nguemeni, Max Jordan, Eugenia C. South, and Victor Ray. 2021. "Medical Schools as Racialized Organizations: A Primer." *Annals of Internal Medicine* 174 (8): 1143–1144.

Tsipursky, Gleb. 2018. *(Dis)Trust in Science*. Scientific American blog. July 5. https://blogs.scientificamerican.com/observations/dis-trust-in-science/.

Tucker, William H. 2007. *The Funding of Scientific Racism: Wickliffe Draper and the Pioneer Fund*. Chicago: University of Illinois Press.

Vidyasagar, Dharmapuri. 2006. "Global Notes: The 10/90 gap Disparities in Global Health Research." *Journal of Perinatology* 26: 55–56.

Wellcome Monitor. 2016. *Wellcome Trust Monitor Report Wave 3 Tracking Public Views on Science and Biomedical Research.* https://cms.wellcome.org/sites/default/files/monitor-wave3-full-wellcome-apr16.pdf.

Wellcome Monitor. 2019. *Wellcome Global Monitor 2018.* https://wellcome.org/reports/wellcome-global-monitor/2018.

Wellcome Monitor. 2020. *Wellcome Global Monitor. How Covid-19 Affected People's Lives and their Views About Science.* https://cms.wellcome.org/sites/default/files/2021-11/Wellcome-Global-Monitor-Covid.pdf.

Wellcome Monitor. 2021. *Wellcome Monitor 2020: How the British Public Engage with Health Research.* https://cms.wellcome.org/sites/default/files/2021-02/wellcome-monitor-2020-public-engagement_0.pdf.

Whitbeck, Caroline. 1995. "Truth and Trustworthiness in Research." *Science and Engineering Ethics* 1: 403–416.

Whyte, Kyle Powys, and Robert Crease. 2010. "Trust, Expertise, and the Philosophy of Science." *Synthese* 177: 411–425.

Wilholt, Torsten. 2009. "Bias and Values in Scientific Research." *Studies in History and Philosophy of Science* 40 (1): 92–101.

Wilholt, Torsten. 2013. "Epistemic Trust in Science." *British Journal of Philosophy of Science* 64 (2): 233–253.

Wyatt, Ronald. 2013. "Pain and Ethnicity." *Virtual Mentor: American Medical Association Journal of Ethics* 15 (5): 449–454. https://journalofethics.ama-assn.org/article/pain-and-ethnicity/2013-05.

Yong, Ed. 2021. "How Public Health Took Part in Its Own Downfall." *The Atlantic*. October 23. https://www.theatlantic.com/health/archive/2021/10/how-public-health-took-part-its-own-downfall/620457/