Humanities & Social Sciences Communications

ARTICLE

https://doi.org/10.1057/s41599-022-01058-y OPEN

Legacy media as inhibitors and drivers of public reservations against science: global survey evidence on the link between media use and anti-science attitudes

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Public resentment toward scientific institutions, scholars, and their expertise challenges the status of science in society in many countries worldwide. It is thus essential to examine the global prevalence of such resentment—and the potential of legacy media to temper it, thanks to their ability to cultivate positive views of science, educate citizens, and connect publics to scientific discourse. However, existing research has mostly surveyed Western populations, focused on pro-science rather than anti-science views, rarely studied the role of media use, and often ignored country characteristics that may interact with media use. This secondary analysis addresses these caveats, drawing on the 2017–2020 wave of the World Values Survey ($N = 70{,}867$ in 49 countries) and three relevant country-level indicators (freedom of the press, populism, uncertainty avoidance). Findings indicate that anti-science attitudes vary substantially across countries and are more prevalent in many Latin American nations. Results of Bayesian multilevel regressions show that frequent use of newspapers, TV, and radio indeed alleviates anti-science attitudes in some countries—but fosters them in others, particularly in those where populist rhetoric is more prevalent in public discourse, potentially because such rhetoric often challenges science and academic expertise. These findings call for further comparative research on global reservations against science and reflections about their repercussions on the science-society nexus.

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Introduction

Across the world, science has been challenged by public reservations against it—such as preference of faith over academic expertise, moral resentment toward scientists, or disinterest in scientific knowledge (Rutjens et al., 2022). These reservations can undermine the capacity of science to effectively provide reliable knowledge for informed everyday decisions, policymaking processes, and societal discourses (Mehta et al., 2020). Public resentment toward science thus curbs its potential to help individuals and societies cope with daily challenges as well as severe environmental, health, and economic crises like climate change or the COVID-19 pandemic (Luna et al., 2021). For example, such resentment has been shown to reduce people's knowledge (Allum et al., 2008), compliance with government policies (Merkley and Loewen, 2021), or confidence in vaccination (Sturgis et al., 2021), and increase support for political movements and candidates that are skeptical of experts (Motta, 2018). Anti-science attitudes therefore pose a challenge to education, well-being, and democracy.

Public opinion researchers and science communication scholars have thus examined the prevalence of anti-science attitudes in large-scale, nationally representative population surveys, and sought ways to reduce these attitudes. On the one hand, findings suggest that reservations against science are often *more widespread* within certain sociodemographic and attitudinal milieus, e.g., in older, lower educated, more religious, or politically conservative subpopulations (Chan, 2018; Noy and O'Brien, 2019; Rutjens et al., 2022).

On the other hand, multiple surveys indicate that anti-science attitudes tend to be *less widespread* among people who frequently use newspapers, TV, or radio to inform themselves about current matters in general or scientific topics in particular (Anderson et al., 2012; Besley and Shanahan, 2005; Cacciatore et al., 2018; Dudo et al., 2011; Liu and Priest, 2009). These media, which are often termed "legacy media" (Fawzi and Krämer, 2021, p. 3293), seem to alleviate anti-science sentiment under certain conditions and to some degree—presumably because they often feature positive depictions of science, emphasize its problem-solving capacity, ascribe epistemic authority to scientists, and cultivate public understanding of the scientific research process (Brondi et al., 2021; Hilgard and Jamieson, 2017; Lee and Scheufele, 2006; Nisbet et al., 2002). More generally, legacy media can be conceived as mediators at the science-society nexus, i.e., as institutions that convey public trust in science (Schäfer, 2016). Frequent use of newspapers, TV, or radio could thus be assumed to trigger favorable orientations toward science—and temper reservations against it (see Diehl et al., 2021; Huber et al., 2019; Schäfer, 2016).

Processes like these have been conceptualized against the backdrop of concepts like framing (Brossard and Nisbet, 2007) or cultivation (Nisbet et al., 2002), which suggest that people's appreciation for science is a long-term outcome of exposure to positive media portrayals of scientists in newspaper, TV, and radio reporting, for example. Further scholarship theorized that effects like these differ across media channels, people, and countries, as they depend on individual habits, skills, or pre-existing attitudes, and on the characteristics of local media systems, political contexts, or cultural conditions (Boomgaarden and Song, 2019; Valkenburg and Peter, 2013).

However, research on the prevalence of anti-science attitudes and the ability of legacy media to affect these attitudes has several limitations (see Guenther and Joubert, 2017; Massarani, 2015; Metag and Schäfer, 2018). First, it has usually examined only single countries (e.g., Hmielowski et al., 2014) and thus barely provides insights as to how prevalence and media effects compare across nations. Second, research which does include multiple countries has investigated almost exclusively Western, educated, industrialized, rich, and democratic (WEIRD) societies (e.g., Lübke, 2021; Yan et al., 2021), although certain non-WEIRD countries provide specific conditions for anti-science sentiments (Bauer et al., 2019) and exhibit distinctive media systems (Hallin and Mancini, 2011). Third, studies which do compare WEIRD and non-WEIRD societies have often examined attitudes toward specific science-related topics rather than attitudes toward science in general (Diehl et al., 2021; Franzen and Meyer, 2010; Hornsey et al., 2018a, 2018b), even if these attitudes were shown to vary across topics (Rutjens et al., 2022). Fourth, comparative surveys on public views of science in general have mostly focused on pro-science views such as trust, confidence, or faith (Evans, 2014; Gil de Zúñiga et al., 2019; Kim et al., 2014; Price and Peterson, 2016; Sturgis et al., 2021; Wellcome Trust, 2019). Yet favorable and unfavorable orientations toward any kind of object cannot necessarily be conceived as polar opposites, because they may often have different qualities, antecedents, and implications, and may rather be understood as "alternative social realities" (Lewicki et al., 1998, p. 445; see also van de Walle and Six, 2014). Therefore, findings on pro-science attitudes may not apply to anti-science attitudes. Fifth, cross-cultural surveys that do investigate unfavorable science attitudes specifically have not included media use variables (Chan, 2018; Crettaz von Roten, 2019; Noy and O'Brien, 2019; Rutjens et al., 2022).

Many existing surveys nevertheless provide useful suggestions for the present study. Some are instructive because they show that individual-level attitudes toward science are moderated by country-level factors (Allum et al., 2008). However, these surveys have not considered factors related to media use but focused on socioeconomic indicators such as the GDP or the Gini coefficient (O'Brien and Noy, 2018; Sturgis et al., 2021). Others are helpful because they suggest links between legacy media use and *political* attitudes (Boomgaarden and Song, 2019) or between *social* media use and trust in science (Huber et al., 2019).

Yet overall, scholarship is inconclusive in at least two ways: First, it offers little robust evidence on the prevalence of anti-science attitudes in non-WEIRD publics. On the one hand, these publics may hold science in high esteem, hoping that it will solve existential crises immediately affecting them, such as climate change or epidemic diseases (Drori et al., 2003; Solís Arce et al., 2021). On the other hand, segments of non-WEIRD populations may be skeptical or at least indifferent about scientific research as their daily lives pose practical challenges for which they deem academic expertise less relevant or helpful (see Guenther and Weingart, 2018).

Second, it is unclear if legacy media use can weaken anti-science attitudes not only in WEIRD but also in non-WEIRD countries, whether such weakening effects vary across countries—and if there are country-level factors that explain variation. First, *freedom of the press* can be conceived as one such factor: Citizens' chances of encountering media portrayals of science that question its societal authority are higher in countries with free and independent media (an Nguyen and Tran, 2019). Critical public attitudes toward science or science-related issues such as nuclear energy could therefore be more widespread if media freedom is high (Kim et al., 2013). Second, the *prevalence of populist rhetoric* within national public discourse could moderate links between media use and anti-science attitudes: Such rhetoric often challenges academic elites and "mainstream scientists" (Forchtner et al., 2018; p. 596), suggesting that scientific knowledge is useless, ideologically biased, and inferior to the commonsensical, emotional, and experiential knowledge of "ordinary people" (Mede and Schäfer, 2020, p. 480). Media in several countries have been found to disseminate populist ideas rather uncritically and provide populists with means to spread anti-scientific claims (Adam

et al., 2020; Thornborrow et al., 2021; Wettstein et al., 2018). Media audiences in these countries may then adopt those ideas and claims and develop critical attitudes toward science (see Müller et al., 2017). Third, *uncertainty avoidance* tendencies among certain cultures could affect the potential of legacy media to temper anti-science sentiment: This potential may be lower in media systems in which journalists (or audiences) are more inclined to avoid covering (or encountering) uncertainties, controversies, and ambiguities like those that science and scientific innovations entail (Ruan et al., 2019). Public support for anti-scientific narratives, such as conspiracy theories, are therefore often more pronounced in societies with stronger uncertainty avoidance tendencies (Mari et al., 2021). Correspondingly, uncertainty tolerance may be associated with low public resentment toward science (Bauer and Süerdem, 2016). Concludingly, we assume that a link between legacy media use and anti-science attitudes is moderated by the following country-level factors: *Freedom of the press* (Freedom House, 2021), *prevalence of populist rhetoric in political discourse* (Norris, 2020), and *uncertainty avoidance* (Hofstede et al., 2010).

Overall, there is little systematic, cross-cultural survey evidence on anti-science attitudes and their relationship with legacy media use—albeit such evidence is required to make substantive claims about the global challenge that public anti-science attitudes pose to societal well-being, education, and democracy, and about the potential of legacy media to reduce these attitudes. This study addresses this caveat. It relies on a secondary analysis of survey data collected for the World Values Survey in 2017–2020, as well as three country-level indicators, and tests the following research questions and hypothesis:

RQ1: How prevalent are anti-science attitudes across countries worldwide?
H1: Anti-science attitudes are negatively associated with legacy media use.
RQ2: How does the association hypothesized in H1 vary across countries?
RQ3: How can national levels of press freedom, populism, and uncertainty avoidance explain the variation assumed in RQ2?

Methods

Data. We utilized nationally representative data of the World Values Survey (WVS), a large-scale, recurring survey assessing public perceptions, beliefs, and behaviors across a wide range of cultural, social, and political issues in numerous countries worldwide (Inglehart et al., 2004). We drew on the 7th WVS wave, which was conducted from January 2017 to August 2020 and relied on face-to-face interviews[1] in 49 countries on all continents (Haerpfer et al., 2020). Descriptive analyses included all 49 countries ($N = 70{,}867$; gender: 47.4% male; age: $M = 42.7$, $SD = 16.3$). Inferential analyses used data from 38 of these 49 countries ($N = 54{,}658$; gender: 47.2% male; age: $M = 43.4$, $SD = 16.8$), because anti-science attitudes, media use, and relevant covariates were not measured in some countries (see Supplementary Table S3 for a list of countries and country-level sample characteristics).

The WVS is a well-established extensive survey project led by experienced researchers who continuously develop its design and instruments (Haerpfer and Kizilova, 2017). Scholars from several fields, including communication studies, have used it for highly cited academic publications (e.g., Tsfati and Ariely, 2014). However, the WVS is subject to similar caveats like other comparative surveys: Difficulties include cross-national differences in sampling procedures, fieldwork periods, interviewing techniques, and questionnaire translations (Curtice, 2007; Esmer, 2004; Heath et al., 2005), as well as limited measurement invariance and external item validity (Alemán and Woods, 2016; Johnson and Mislin, 2012). We acknowledge these caveats, but we do not think that they pose major obstacles to our analyses—and emphasize that the WVS is eventually one of the best freely available sources for survey data from non-WEIRD countries currently existing (Haerpfer and Kizilova, 2017).

Moreover, we relied on three country-level indicators to measure factors that could explain why media effects vary across countries:

(1) Freedom of the press: Measured with the Freedom of the Press Index, which is annually published by the non-profit, non-governmental organization *Freedom House*. On a scale from 0.0 to 100.0, it reflects the ability of domestic "print, broadcast, and digital media to operate freely and without threat of repercussions" (Freedom House, 2021; higher scores indicate more freedom; $M = 57.6$, $SD = 27.2$, range within sample: 9.0–98.0). For each country, we used the score that *Freedom House* had assigned to it when the WVS was fielded in that country.
(2) Prevalence of populist rhetoric: Measured with a continuous index composed from two items measured in the Global Party Survey 2019, which asked 1861 experts to assess the agendas and rhetoric of 1043 political parties in 163 countries (Norris and Inglehart, 2019). To obtain this index, we proceeded as follows: First, we selected two items that asked experts how strongly each party in a given country favors populist vs. pluralist rhetoric (11-point Likert scales, 0 = strongly favors pluralist rhetoric – 10 = strongly favors populist rhetoric) and how important populist rhetoric is for each party in that country (11-point Likert scales, 0 = no importance – 10 = great importance). Second, we computed mean values of these two items across all parties within each country. Third, we averaged these values, which resulted in a single aggregate measure for the prevalence of populist rhetoric within national political discourses (higher values indicate higher prevalence; $M = 6.10$, $SD = 0.90$, range within sample: 4.0–8.4).
(3) Uncertainty avoidance: Measured with the Uncertainty Avoidance Index, which is one of several scores Hofstede (1980) devised to quantify national cultures across the world. On a scale from −150.0 to 230.0, it captures the degree to which citizens of a given country refrain from being exposed to ambiguity and controversy (higher values indicate higher avoidance; $M = 69.8$, $SD = 21.7$, range within sample: 29.0–112.0). Unlike the other two country-level indicators used in this study, this index is not based on expert ratings but on large-scale employee surveys—which bears certain limitations such as coverage and sampling errors (Gerlach and Eriksson, 2021), but it is arguably a more valid approach to measuring latent values within national cultures than using external expert ratings (Smith et al., 2002). We drew on the most current Uncertainty Avoidance Indices, the majority of which stem from Hofstede's original studies in 1980 (Hofstede et al., 2010).

These indicators are established measures frequently used in global comparative research (Coffé, 2017; Mari et al., 2021; Norris, 2020). Even if some scholars have legitimately argued that they ignore within-country differences, are limited in their capability to express the bandwidth of aspects they aim to grasp, and depend on certain normative ideals, they are still useful proxies for estimating country characteristics on an aggregate level (Bollen, 1980; Freudenberg, 2003).

Measures. *Anti-science attitudes* were measured with a mean score of three items (10-point Likert scales, 1 = completely disagree – 10 = completely agree).

(1) "We depend too much on science and not enough on faith", which reflects rejection of the epistemic and cultural authority of science and preference for religious or alternative beliefs (Miller, 2004; $M = 5.60$, SD = 2.93, range: 1–10).
(2) "One of the bad effects of science is that it breaks down people's ideas of right and wrong", which captures the belief that science erodes established moral worldviews (Kam, 2005; $M = 5.52$, SD = 2.86, range: 1–10).
(3) "It is not important for me to know about science in my daily life", which taps cognitive disengagement from scientific knowledge and expertise (Evans and Durant, 1995; $M = 4.58$, SD = 2.95, range: 1–10).

These items have been validated in numerous public opinion studies and are widely used survey measures for capturing three essential components of public reservations against science, i.e., (1) preference of faith over scientific expertise, (2) moral resentment toward science, and (3) disinterest in scientific knowledge (see Chan, 2018). They correlated moderately (Cronbach's $\alpha = 0.54$) and captured one underlying concept: Multilevel Exploratory Factor Analysis implemented via multigroup Exploratory Structural Equation Modeling (ESEM; Marsh et al., 2011) indicated that they loaded on one common factor ($\chi^2 = 728.374$, df = 96, $p < 0.001$; CFI = 0.953, TLI = 0.929, RMSEA = 0.079, SRMR = 0.036). Therefore, the resulting mean score represented a reliable measure of respondents' anti-science attitudes ($M = 5.23$, SD = 2.12, range: 1–10).

Notably, the WVS also contains some items that measure pro-science attitudes, e.g., "Science and technology are making our lives healthier, easier, and more comfortable" (Haerpfer et al., 2020). Single studies utilized items like these after reverse-coding them to measure reservations against science (Nisbet et al., 2002). However, we had multiple reasons not to follow this approach, as we detail in the Supplementary Material: First, pro-science and anti-science views cannot necessarily be conceptualized as opposing ends of the same continuum, hence it is problematic to equate absence of the former with presence of the latter (All European Academies, 2019; see also above). Second, existing research has shown that combining anti-science items and reverse-coded pro-science items in one aggregate score introduces artificial dimensionality into that score and lowers its validity and reliability (Mede et al., 2021; Schriesheim and Eisenbach, 1995). Third, additional analyses indicated that the three anti-science items (see above) and three reverse-coded pro-science items contained in the WVS loaded on two distinct factors (see Supplementary Table S1 and Supplementary Fig. S2) that correlated only very weakly ($r = 0.01$). Multilevel Exploratory Factor Analyses showed that a forced 1-factor solution with all these six items fitted the data much worse than a 1-factor solution that only contained the three anti-science items (see Supplementary Table S2). Eventually, including the three reverse-coded pro-science items in our anti-science score did not improve its reliability (Cronbach's α of 3-item score: 0.54; Cronbach's α of 6-item score: 0.53).

Legacy media use was measured with a mean score of three items asking for how often respondents use daily newspapers, TV news, and radio news to obtain information about "what is going on in this country and the world" (4 = daily, 3 = weekly, 2 = monthly, 1 = less than monthly, 0 = never). Items correlated moderately (Cronbach's $\alpha = 0.51$), which is plausible and somewhat desirable as they refer to a relatively broad scope of information sources (see Taber, 2018, who argues that reliability test statistics are not necessarily useful when evaluating scores that capture phenomena that manifest in a wide range of cognitions, attitudes, or behaviors). The resulting mean score can thus be considered a valid aggregate measure for people's legacy media use ($M = 2.23$, SD = 1.08, range: 0–4).

We controlled for a set of sociodemographic and attitudinal covariates that were shown to affect public beliefs about science globally (e.g., Crettaz von Roten, 2019; O'Brien and Noy, 2018; Sturgis et al., 2021). These included gender (binary), age (in years), education (9 categories, ISCED-2011 classification), income (1 = lowest income group – 10 = highest income group), town size (1 = under 2000 – 10 = 500,000 and more), religiosity (1 = God not important at all – 10 = God very important), and political orientation (1 = left – 10 = right).

Analysis. To test our research questions and hypothesis, we fitted Bayesian regression models with the R package brms (Bürkner, 2021) and weakly informative priors (Nalborczyk et al., 2019). All analyses can be reproduced with the data and code we share in the Open Science Framework (OSF) at https://osf.io/w4gey. For all estimates, we will report means and 89% Highest Density Intervals (HDI) of posterior distributions (McElreath, 2020).

The prevalence of anti-science attitudes across countries (RQ1) was derived from posterior probability distributions of intercepts of 49 Bayesian null models (one for each country), each of which regressed the anti-science score on 1. The relationship of anti-science attitudes and legacy media use (H1 and RQ2) was examined in a Bayesian multilevel model that included the anti-science score as outcome variable, media use as a predictor, and country-level varying intercepts and slopes of media use, and controlled for the sociodemographic and attitudinal covariates (Model 1). Moderators of varying media use effects (RQ3) were explored by adding cross-level interactions of media use and the three country-level indicators to Model 1 (Model 2).

We decided to employ Bayesian methods as they have a number of advantages over conventional (i.e., frequentist) approaches: For example, Bayesian analysis expresses the uncertainty about an estimate with a credible interval that can be interpreted straight-forwardly as the probability that the true value of this estimate falls within that interval. Frequentist analysis, however, allows only approximations to the uncertainty about estimates, because quantities indicating this uncertainty (p-values, confidence intervals) are contingent upon the collected data. Moreover, Bayesian methods are particularly useful for cross-country studies such as ours, because they outperform frequentist methods in estimating the variances of random effects (see Scharkow, 2019). Nevertheless, we also ran frequentist versions of all analyses presented below, finding that results differed only very marginally (see replication files on OSF).

Results

RQ1 analyses showed that anti-science attitudes are, on average, moderately prevalent worldwide ($M = 5.23$ on a scale from 1–10; 89% HDI: 5.22–5.24). However, they fluctuate considerably across countries: On the one hand, populations of many Latin American nations like Nicaragua, Bolivia, Colombia, and Mexico have higher anti-science scores (see Fig. 1; see Supplementary Figs. S3–S8 for means, standard errors, and response frequencies of individual items). On the other hand, populations of several Anglo-American and East Asian countries like Australia, Japan, the US, and China are less inclined to prefer faith over science, think science undermines moral values, and deem scientific knowledge unimportant. Yet anti-science attitudes are not necessarily more widespread in non-WEIRD nations: Indonesia and Ethiopia, for example, are among the least critical countries

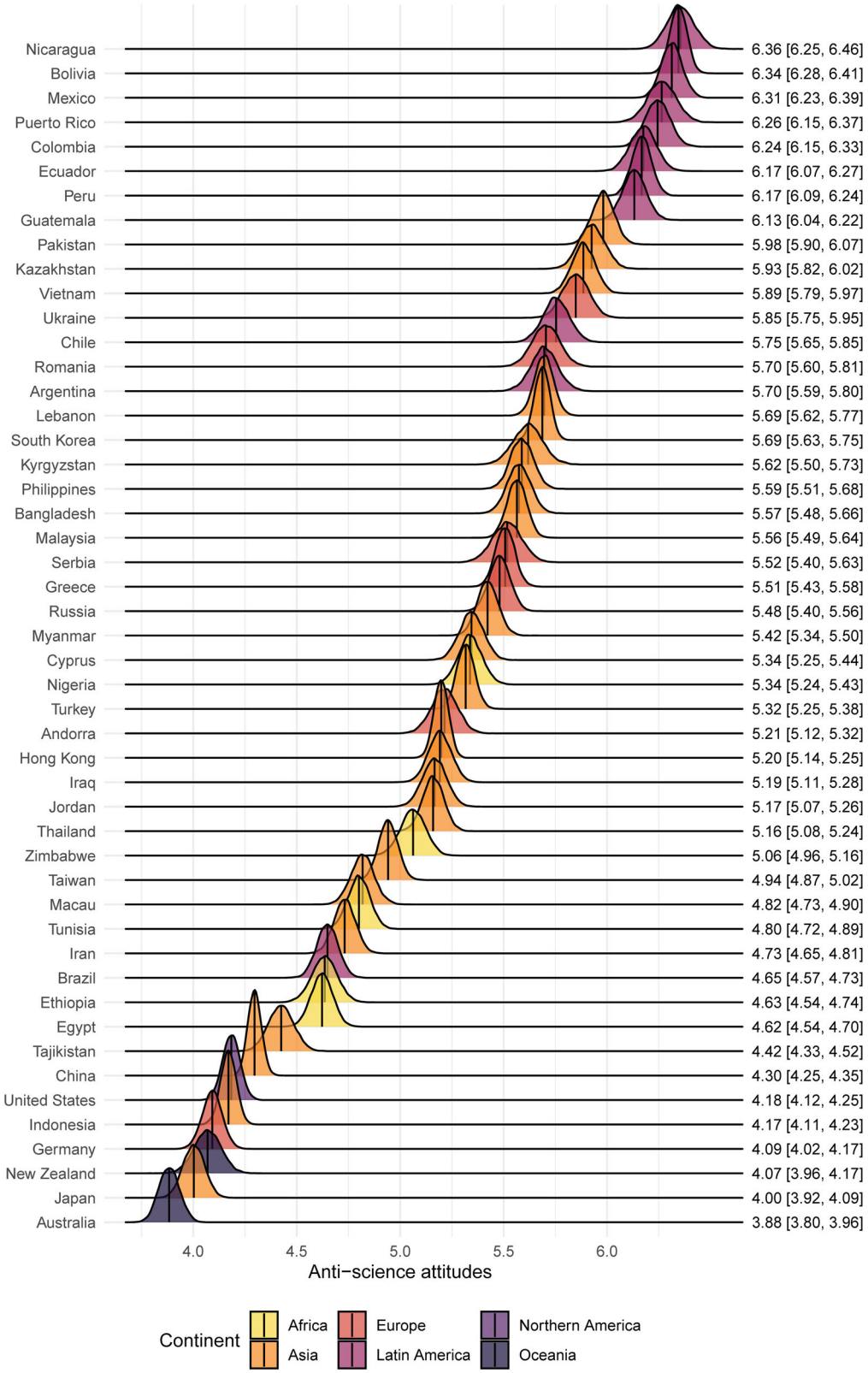

Fig. 1 Posterior probability distributions of anti-science attitudes across countries. *Note*: Vertical lines represent posterior probability distribution means of intercepts of Bayesian null models fitted within country subsamples. Values reported indicate distribution means as well as lower and upper bounds of 89% HDIs. Intercept of Bayesian null model fitted within full sample: 5.23 [5.22, 5.24].

included in the analysis. Meanwhile, WEIRD populations vary somewhat in their views: Most tend to be less negative about science (e.g., New Zealand, the US, Germany), whereas others are more critical (e.g., Greece).

H1 tests suggested that globally, frequent use of newspapers, TV, and radio does not weaken anti-science attitudes ($b = 0.008$, 89% HDI: −0.032–0.048). Hence, in contrast to previous research on public perceptions of science, we did not find evidence for a

Table 1 Bayesian multilevel models predicting anti-science attitudes across countries.

	Model 1: Legacy media use			Model 2: Country-level indicators and cross-level interactions		
Predictors	**Estimate**	**Estimated error**	**HDI (89%)**	**Estimate**	**Estimated error**	**HDI (89%)**
Fixed effects						
(Intercept)	4.241	0.138	4.034–4.469	4.018	1.332	1.938–6.156
Gender (male)	−0.109	0.019	−0.130–−0.077	−0.109	0.018	−0.137–−0.079
Age	0.004	0.001	0.003–0.005	0.004	0.001	0.003–0.005
Education	−0.090	0.005	−0.098–−0.081	−0.090	0.005	−0.098–−0.081
Income	0.015	0.005	0.007–0.023	0.015	0.005	0.007–0.022
Town size	−0.004	0.005	−0.011–0.004	−0.004	0.005	−0.011–0.004
Religiosity	0.118	0.004	0.111–0.124	0.118	0.004	0.112–0.124
Political orientation (right)	0.048	0.004	0.042–0.054	0.048	0.004	0.042–0.055
Legacy media use	0.008	0.025	−0.032–0.048	−0.500	0.249	−0.892–−0.106
Freedom of the press				0.000	0.006	−0.009–0.009
Prevalence of populist rhetoric				−0.052	0.179	−0.346–0.222
Uncertainty avoidance				0.007	0.006	−0.002–0.016
Legacy media use × freedom of the press				−0.000	0.001	−0.002–0.002
Legacy media use × prevalence of populist rhetoric				0.068	0.033	0.013–0.119
Legacy media use × uncertainty avoidance				0.002	0.001	0.000–0.003
Random effects						
Intercepts (SD)	0.758	0.097	0.601–0.902	0.768	0.104	0.601–0.920
Effects (SD)	0.143	0.020	0.110–0.173	0.133	0.021	0.100–0.165
Residuals (SD)	1.915	0.006	1.905–1.926	1.915	0.006	1.905–1.926

Note: Models contained country-level varying intercepts and slopes of media use. Models fitted using the R package brms v2.15.0 (Bürkner, 2021) and weakly informative priors (Nalborczyk et al., 2019). Observations = 44,055, Levels = 38. Model 1: Adjusted ICC = 0.140, Conditional ICC = 0.133, WAIC = 182,361.1 (SE = 293.0). Model 2: Adjusted ICC = 0.134, Conditional ICC = 0.125, WAIC = 182,362.0 (SE = 293.0).

negative association between legacy media use and anti-science attitudes. Yet in line with most of this research, we did find that people are more likely to hold such attitudes if they are female, older, and lower educated, have fewer income, are more religious, or prefer right-leaning political positions (see Table 1, Model 1).

But *in certain countries*, people are indeed less likely to endorse anti-science attitudes if they use legacy media more often, for example in Thailand, Ethiopia, Nigeria, and the US (see Fig. 2). However, media use does not always undermine reservations against science—but can also exacerbate them: In countries like Turkey, Bangladesh, Cyprus, Bolivia, Serbia, or Peru, higher newspaper, TV, and radio use translates into *stronger* anti-science attitudes. Analyses also showed that 14% of the global variance of anti-science attitudes is due to country differences. Overall, we found limited support for H1, while we did find evidence for the varying media use effects that RQ2 assumed.

RQ3 analyses indicated that country differences in the association of media use and anti-science attitudes can be explained by differences in the prevalence of populist rhetoric in domestic political discourses: When including cross-level interactions between legacy media use and the three country-level indicators, we found that media use *increases* anti-science attitudes in countries with *high* prevalence of populist rhetoric, and *decreases* these attitudes in countries with *low* prevalence ($b = 0.068$, 89% HDI: 0.013–0.119). Press freedom and uncertainty avoidance do not seem to have considerable impact on the relationship between media use and anti-science attitudes (see Table 1, Model 2).

Discussion

Public resentment toward science has been discussed as a major challenge to informed citizenries, societies' crisis resilience, and democratization worldwide (Flinders, 2021). Population surveys have therefore investigated the prevalence and explanatory factors of such resentment, and suggested it can be reduced through frequent use of legacy media (Anderson et al., 2012). However, these investigations offered limited evidence on the interplay of anti-science attitudes and media use in non-WEIRD countries. This study addressed this shortcoming, drawing on a secondary analysis of the World Values Survey 2017–2020.

Focusing on three components of anti-science attitudes—preference of faith over scientific expertise, moral reservations, and cognitive disengagement—we showed that public resentment toward science varies substantially across the world, but is generally more prevalent in several Latin American and less prevalent in most Anglo-American nations. This suggests that global variation in anti-science attitudes is partly due to sociopolitical and cultural factors: Perhaps populist governments in countries like Nicaragua, Bolivia, and Mexico have cultivated certain anti-scientific or anti-technocratic reservations among the population or got elected because they tapped existing reservations (Barrenechea and Dargent, 2020). Meanwhile, Australians and US Americans, for example, may rather subscribe to a "deference to scientific authority", i.e., an authoritarian-like socialized trait, which generates "an almost natural pro-science or pro-technology view" (Brossard and Nisbet, 2007, p. 44).

However, anti-science attitudes do fluctuate among Latin American and among Anglo-American countries. This indicates that they are not necessarily associated with literacy, national wealth, democratic deficiency, or other heuristics for distinguishing between WEIRD and non-WEIRD societies (see Schlipphak et al., 2021). Rather, anti-science attitudes may often depend on specific local conditions: In Nigeria, for example, public perceptions of science were shown to result from a complex interaction of high trust in scientific institutions, strong religious beliefs, prominent promoters of conspiracy theories, and post-colonial resentment toward Western science (Falade, 2019; Falade and Bauer, 2018; Obadare and Okeke, 2011). After all, our analyses showed that country differences explain only a limited amount of variance of anti-science attitudes, while the majority of such variance is due to individual-level predictors such as gender,

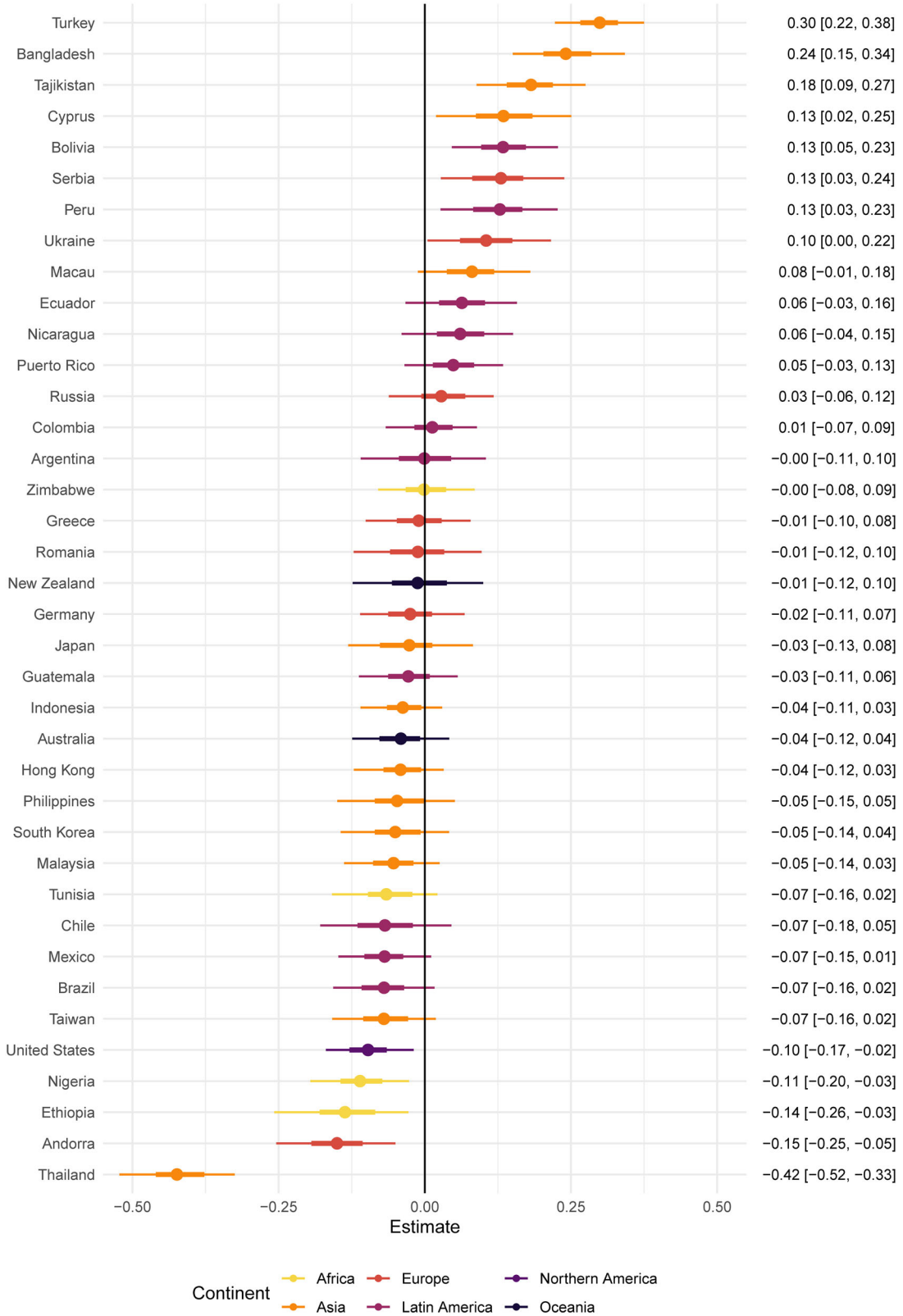

Fig. 2 Country-level effects of legacy media use on anti-science attitudes. Note: Points represent means of posterior probability distributions of varying slopes of media use (estimated with Bayesian multilevel regression, Model 1). Thin horizontal lines represent 89% HDIs. Thick horizontal lines represent 50% HDIs. Values indicate distribution means as well as lower and upper bounds of 89% HDIs.

age, education, income, religiosity, and political orientation. This confirms previous findings (European Commission, 2021; Wellcome Trust, 2019), and suggests that public resentment toward science is primarily a function of sociodemographic characteristics and individual worldviews rather than those country-level factors examined in this study.

Scholarship suggests that legacy media can reduce anti-science sentiment among their audience, as they cultivate positive views

of science, educate citizens, and connect publics to science and scientific discourse. Our analyses did not provide support for this assumption *in general*, yet *for specific nations* like the US, Nigeria, and Thailand. In these countries, frequent use of newspapers, TV, and radio is indeed linked to less negative attitudes toward science. Perhaps media in these countries often promote pro-science views among their audiences, for example through positive portrayals and affirmative evaluations of scientific research (Besley and Shanahan, 2005; Liu and Priest, 2009; Nisbet et al., 2002). This result corresponds with existing research showing that legacy media use can strengthen trust in science and scientists (Anderson et al., 2012; Cacciatore et al., 2018; Hilgard and Jamieson, 2017). Increasing the reach of, and exposure to, legacy media may thus be a promising approach for science communication strategies aiming to temper public reservations against science—at least in many of the nations included in our analysis.

However, in countries like Turkey, Bangladesh, and Bolivia, legacy media use is not associated with weaker but *stronger* anti-science attitudes. Newspapers as well as radio and TV stations in these countries may not necessarily cultivate appreciation of scientific expertise and sympathy for scientists among their audiences. Instead, they might promote skeptical perspectives on science, emphasizing partisan cues (Kreps and Kriner, 2020) or failures of scientists (Ophir and Jamieson, 2021). Turkish newspaper coverage on genetic engineering, for example, has been shown to make frequent use of personal attacks on scientists and endorse a rather critical stance toward scientific institutions, "eventually leading to a decline in the authority of science" (Süerdem, 2019, p. 153).

While the style and slant of local media coverage may be one reason for country-specific media effects on anti-science attitudes, our study suggests an additional explanation—i.e., the prevalence of populist rhetoric in political discourse. Across all 38 nations included in the analysis, legacy media use was more likely to increase anti-science attitudes in countries where political parties frequently promote populist claims. Accordingly, legacy media seem to have worse chances to reduce reservations against science in publics perpetuated by populist discourse, and better chances in publics free from such discourse. This finding resonates with the results of previous WVS analyses, which suggested that political contexts condition the relationship of trust and media use (You and Wang, 2020). It could be explained in at least two ways: First, it might be that citizens who are often exposed to the rhetoric of populist parties develop skeptical attitudes toward legacy media and refrain from using them, because these parties often accuse legacy media of being deceitful, corrupt, and conspiring with a societal elite (Fawzi and Krämer, 2021). In consequence, legacy media would become limited in their ability to cultivate pro-science attitudes among the supporters of populist parties. Second, it might also be that legacy media themselves convey populist sentiment among their users when reporting about the claims of populist parties (Müller et al., 2017), thereby "normalizing" populist rhetoric (Katsourides and Pachita, 2021). Populist rhetoric often entails criticism of scientific expertise and the alleged "truth-speaking sovereignty [of] academic elites" (Mede and Schäfer, 2020, p. 482), so media audiences may then be more likely to adopt anti-science attitudes.

These dynamics possibly undermine the ability of legacy media to foster trust in science (Huber et al., 2019), connect the public to societal discourse around science (Schäfer, 2016), and provide citizens with "the best available evidence" for political and everyday decision-making (Scheufele and Krause, 2019, p. 7667). They seem to be particularly pronounced in Latin American countries like Bolivia and Peru as well as in Cyprus and Turkey, which drove the interaction effect of media use and populism on anti-science attitudes (see Fig. 2). On the one hand, this is plausible: In Bolivia, populist leaders like former president Evo Morales have publicly ostracized important academics and intellectuals (McKay and Colque, 2021), often leveraging government-controlled media outlets and news agencies (Waisbord, 2011). Meanwhile, Cyprus has seen a "mainstreaming" of populist and commonsensical rhetoric within political and media discourse (Katsourides and Pachita, 2021), which has potentially triggered, or resulted from, strong public anti-science resentment: Among all 27 countries surveyed for the Special Eurobarometer 2021, Cypriotes showed the strongest beliefs in conspiracy theories and least sympathy for scientists (European Commission, 2021). On the other hand, however, we did not find a link between populism, media use, and anti-science attitudes in countries where political rhetoric, news media coverage, and public attitudes are also pervaded by populist ideas, such as Romania (Chiruta, 2021; Corbu et al., 2017; Rutjens et al., 2022). This suggests that such a link, if existing, depends on factors that we did not analyze in this study.

One such factor could be people's use of *digital* media like social networking sites, instant messengers, or alternative news platforms (Huber et al., 2019; Mari et al., 2021; Yan et al., 2021). These media allow populists to circumvent presumed elite influence (Hopster, 2021) and provide them with a public arena (Jungherr and Schroeder, 2021) for supplying citizens with anti-scientific claims—often reaching especially those users who already endorse these claims (see Schulz, 2019). Low press freedom may even fuel this dynamic, because citizens often rely on digital media when they suspect that legacy media are censored or slanted (Wei et al., 2014).

Overall, our analysis provides valuable findings on public reservations against science in WEIRD and non-WEIRD countries and the potential of legacy media to reduce or promote these reservations. Further research should scrutinize these findings—and seek to compensate their limitations: First, it could investigate the relationship of social media use and anti-science attitudes, as well as moderation effects of populism and press freedom.

Second, follow-up studies could tackle caveats of our legacy media use measurement: We aimed to investigate a general repertoire of traditional news media and thus relied on an aggregate score of newspaper, TV, and radio use. However, media use can vary considerably across different types of media (Newman et al., 2021). Future research should thus explore use of single legacy media specifically, include additional media channels such as magazines, or focus on science media use in particular. This would allow testing if the prevalence of populist rhetoric has stronger interaction effects among frequent TV viewers, for example, and weaker interaction effects among frequent quality newspaper readers, which would correspond with previous findings on news use and political populism (Schulz, 2019).

Third, further research could examine cultural and media contexts more thoroughly: Our study considered only one media context factor (i.e., freedom of the press), while there are many more, e.g., ownership concentration, Internet diffusion, or government regulation (Hallin and Mancini, 2011). The Freedom of the Press Index covers several of these factors and has been used frequently in related research (Coffé, 2017), hence we chose it—but we hope that future studies will incorporate further indicators. Such studies could also address caveats of the Uncertainty Avoidance Index, which reflects a contested concept and primarily relies on data that has been criticized for being dated and biased (Gerlach and Eriksson, 2021). For example, one could utilize refined uncertainty avoidance measurements or focus on related phenomena, such as risk aversion or anomie (see Achterberg et al., 2017).

Fourth, follow-up research should also investigate *causal* links of legacy media use and anti-science attitudes: We modeled these attitudes as an outcome of media use, drawing on previous research and well-established theoretical assumptions. Yet media use may also be conceived as a function of anti-science attitudes (see Metag, 2020). As we relied on cross-sectional data, we could not test this—but we encourage experiments or panel studies to do so (see Merkley and Loewen, 2021).

Fifth, qualitative research may scrutinize semantic challenges to measuring anti-science attitudes, exploring what respondents understand as "science" (Koch et al., 2020) and whether their attitudes refer to academic institutions, scientific principles and methods, or science as whole (Achterberg et al., 2017). Eventually, findings of any such scholarship would call for further discussion of the societal status of science (Dahlgren, 2018) and implications for science communication practice (Schäfer and Metag, 2021).

Data availability

The code and data used in this study are available in the OSF repository, https://osf.io/w4gey.

Received: 6 September 2021; Accepted: 17 January 2022;
Published online: 02 February 2022

Note

1 Exceptions: Australia, Japan, New Zealand (postal interviews), Hong Kong, Malaysia (web-based and face-to-face interviews), and the United States (web-based and telephone interviews).

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Acknowledgements

I am grateful to Timothy O'Brien and Daniela Mahl, who reviewed an earlier version of the article and provided valuable feedback and many helpful ideas. I also thank Nick Allum, Martin Bauer, John Besley, Adrian Rauchfleisch, and Mike S. Schäfer, whose thorough comments on the conceptualization and the statistical analyses of this study have improved it considerably.

Competing interests

The author declares no competing interests.

Ethical approval

This article does not contain any studies with human participants or animals performed by the authors. Ethical approval was therefore not provided.

Informed consent

Informed consent for participation was not required for this study in accordance with the national legislation and institutional requirements.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1057/s41599-022-01058-y.

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