Mediation Analysis of Conspiratorial Thinking and Anti-Expert Sentiments on Vaccine Willingness

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Abstract

Objective: Vaccines are an effective means to reduce the spread of diseases, but they are sometimes met with hesitancy that needs to be understood.

Methods: In this study, we analyzed data from a large, cross-country survey conducted between June and August 2021 in 43 countries (N = 15,740) to investigate the roles of trust in government and science in shaping vaccine attitudes and willingness to be vaccinated.

Results: We found that, despite significant variability between countries, both forms of institutional trust were associated with a higher willingness to receive a COVID-19 vaccine. Further, we found that conspiratorial thinking and anti-expert sentiments predicted reduced trust in government and science, respectively, and that trust mediated the relationship between these beliefs and ultimate vaccine attitudes. Although most countries displayed similar relationships between conspiratorial thinking and anti-expert sentiments, trust, and vaccine attitudes, we identified three countries (Brazil, Honduras, and Russia) that demonstrated significantly altered associations between the examined variables in terms of significant random slopes .

Conclusions: We discuss and propose various additional local factors that future research should consider to understand how trust and attitudes towards governmental and scientific institutions may shape individuals' ultimate vaccine attitudes and decisions.

Keywords: *anti-expert sentiments, conspiratorial thinking, vaccine hesitancy, trust, government*

Introduction

The development of vaccines protecting against the SARS-CoV-2 virus (COVID-19) has been one of the most important tools in the global public health effort to fight the ongoing COVID-19 pandemic. Although the unprecedented speed and scale of the development, testing, and distribution of COVID-19 vaccines has been celebrated as a major accomplishment, the rollout of these vaccines has also been accompanied by significant hesitation and reluctance to receive the vaccine among many people around the world.

Unfortunately, vaccine hesitation is growing around the world; for example, the World Health Organization (WHO) identified it as the cause of a resurgence in cases of vaccine-preventable diseases and considered it a leading threat to global health in 2019 (Cascini et al., 2021). While vaccine hesitancy has existed as long as vaccines have, the outbreak of the COVID-19 pandemic has led to a resurgence of concerns about the safety and effectiveness of vaccines.

Understanding the psychological factors and beliefs underlying people's attitudes towards vaccines and their ultimate decisions on whether to be vaccinated is therefore critical to maximizing confidence and trust in the vaccination process. This is particularly the case in the event of diseases that pose a salient and pressing threat to global health and safety, such as COVID-19, which has spread rapidly throughout the world with devastating consequences, leading to over 6 million deaths within two years. Because the COVID-19 pandemic has affected individuals across the globe and vaccines became available along a rapid timeline, circumstances related to the COVID-19 pandemic provide an ideal model for understanding factors that impact vaccine hesitancy and willingness to get vaccinated.

Furthermore, several previous studies that developed and tested interventions focusing on vaccine hesitancy and willingness have targeted trust in institutions, including the government and the scientific research community (e.g., Geipel et al., 2022; Yousuf et al., 2021). These studies implemented interventions intending to alleviate mistrust in scientific findings on vaccine efficacy and risks (Geipel et

al., 2022), or to debunk vaccine misinformation associated with mistrust in governmental efforts to promote vaccination (Yousuf et al., 2021). Hence, better understanding psychological mechanisms underlying vaccine attitudes, particularly those associated with trust in institutions, will be able to provide useful insights about how to develop more effective interventions to promote vaccination based on evidence.

Psychological Factors Predicting Vaccine Attitudes

Vaccine uptake is critical to reducing the spread of disease, yet vaccine hesitancy is an obstacle faced by public health officials in many countries. Understanding the factors that predict vaccine attitudes can help officials develop targeted mitigation plans. A number of demographic variables have been linked to both general vaccination attitudes and specific attitudes about COVID-19; namely, hesitancy is greater among women, younger adults,people with lower socioeconomic status, people with lower education, people without insurance, rural residents, and racial/ethnic minority groups (e.g., Brandt et al., 2021; Nehal et al., 2021; for a systematic review, see Cascini et al., 2021).

Vaccine uptake differences across demographic groups and different countries are linked to trust and beliefs about the vaccine. For instance, women are generally less confident in getting vaccinated, which may be due to vaccine-related conspiracy theories targeting women, e.g., the alleged and unconfirmed risk of post-vaccine infertility (Nehal et al., 2021). Another consistent association seems to emerge between vaccine hesitancy and race or ethnicity. Ethnic and racial minority groups (especially Black and African American persons) exhibited greater vaccine hesitancy than White persons in the United States and United Kingdom (e.g., Brandt et al., 2021; Savoia et al., 2021), and greater hesitancy has also been linked to greater experiences of racial discrimination (Savoia et al., 2021). Given historical and ongoing mistreatment from government and medical institutions, mistrust of government vaccination programmes has emerged as a common theme underlying COVID-19 vaccine hesitancy among cultural or ethnic minority groups in the United Kingdom and the United States (e.g.,

Nguyen et al., 2021). Overall, this research suggests that vaccine hesitancy differences across demographics and countries are linked to different levels of trust, and that people get trapped "in a self-reinforcing cycle of mistrust" (Hornsey, 2022, p. 217). In particular, the extant literature has identified trust in government and science as important predictors of attitudes towards vaccines.

Trust in Government Predicts Vaccine Attitudes

Prior research has shown that trust in government is linked to diverse compliance behaviors for reducing the spread of COVID-19 (Lieberoth et al., 2021) and vaccine hesitancy (e.g., Lindholt, 2021). This phenomenon has been observed during vaccination campaigns for epidemic and childhood diseases before the outbreak of the COVID-19 pandemic across many countries and vaccines (e.g., Miyachi et al., 2020).

Likewise, patterns of institutional distrust have undergirded hesitation to receive the COVID-19 vaccine across the globe. Even before the public availability of these vaccines, hypothetical willingness to take a vaccine across 19 countries was found to be related to trust in government sources of information (Lazarus et al., 2021). As vaccines have become available worldwide, levels of government trust have been identified as a key variable associated with vaccine uptake across Europe, Australia, Asia, and Africa (e.g., Goodwin et al., 2022; McCarthy et al., 2022; Mundagowa et al., 2022). However, these effects are not monolithic, and researchers have investigated whether they depend on the politicization of the vaccine in local contexts (e.g., Rozek et al., 2021).

Trust in Science Predicts Vaccine Attitudes

In addition to trust in government, the success of vaccination campaigns depends on the populations' trust in the scientific process and in the researchers who develop and test vaccines. Low trust and mistrust of science and scientists have been identified as an ongoing concern for the credibility of scientific institutions (e.g., Chayinska et al., 2021; Hamilton et al., 2015), particularly in the medical field (Jaiswal & Halkitis, 2019).

In fact, individuals interpret new information from scientists about preventive and mitigation measures against COVID-19 in the context of existing levels of mistrust in science and scientific institutions. For example, vaccine hesitancy has been linked to distrust in the research and development process and to major concerns over the safety and side effects of potential vaccines (Griffith et al., 2021). Similarly, decreased trust in scientific facts and institutions increased vaccine hesitancy (e.g., Milošević Đorđević et al., 2021), while higher trust in scientists was associated with stronger intentions to get the COVID-19 vaccine (e.g., Thaker, 2021). Furthermore, trust in WHO and health practitioners was linked to lower likelihood to express vaccine hesitancy among respondents from 17 countries (Rozek et al., 2021).

Another source of scientific mistrust concerns the historical injustices committed in the name of medical science and research. The prevalence of mistrust among marginalized groups has been linked to this phenomenon. For example, in a content analysis of tweets from Canadian Twitter profiles, Griffith et al. (2021) found that alongside political skepticism, concerns about vaccine safety and lack of knowledge about vaccines, the historical legacy of scientific and medical institutions emerged as a theme underlying discussion of the COVID-19 vaccine. Members of groups historically targeted by scientific and medical research, such as the BIPOC (Black, Indigenous, and people of color) and LGBTQ+ (lesbian, gay, bisexual, transgender, queer+) communities, discussed a lack of trust in these institutions. For example, some users referred to the Tuskegee Study—in which treatment for syphilis was deliberately withheld from several hundred Black men in the United States, leading many of them to die from treatable symptoms of the disease—as a reason for their suspicion of the good intentions of medical research (see also Bogart et al., 2021). Considering historical injustices, it is understandable why distrust might be high among those who feel marginalized by the system (Hornsey, 2022).

The recent emergence of science itself as a politically contested issue has made trust in science especially critical to the reception of public communication by scientists on issues such as vaccination

and climate change (e.g., Hamilton et al., 2015). Although opposition to the COVID-19 vaccination programme is mostly associated with right-wing and populist politics, particularly within the United States (Sorell & Butler, 2022), anti-vaccine views extend across the political spectrum (Roberts et al., 2021). For example, Recio-Román et al. (2021) identify anti-vaccination messaging by populist politicians in Europe as a symbol of general opposition to political, intellectual, and media experts, including health professionals. These findings suggest that vaccine skepticism is driven by distrust of science, which has become a political issue advanced through politically-biased information and misinformation.

Conspiratorial Thinking and Anti-Expert Sentiments

Another major difficulty that governments and public health institutions have to confront during vaccination campaigns is the presence of conspiracy theories regarding vaccines (Hornsey, Harris, & Fielding, 2018). Conspiracy beliefs about vaccines have previously been shown to reduce intentions to vaccinate against a hypothetical disease, and parents who believe or cite anti-vaccine conspiracy theories have a lower intent and likelihood to vaccinate their children (e.g., Jolley & Douglas, 2014). With the emergence of COVID-19, a parallel "misinformation pandemic" has been identified as a contributor to the spread of the disease.

Much of the misinformation about COVID-19 that has flourished is related to the intentions and trustworthiness of scientists, governments, and public health institutions (e.g., Chayinska et al., 2021; Goodwin et al., 2022). For example, the QAnon conspiracy movement originating in the United States falsely argues that vaccines are being used by political and economic elites to implant microchips (Sorell & Butler, 2022).

These conspiracies regarding governments' true intentions behind the implementation of preventive measures have been shown to negatively predict general compliance with preventive guidelines against COVID-19 (Banai et al., 2021). Further, even beliefs in generic conspiracy beliefs—for instance, that there are secret organizations directing governments across the world or misleading the

population about what is really happening—have been found to negatively predict compliance with preventive guidelines against COVID-19 (Bruder & Kunert, 2022). In an online survey in the United Kingdom, higher levels of COVID-19 conspiratorial thinking were similarly found to correlate with a decreased willingness toward vaccination as well as with more generic vaccination conspiratory beliefs; the more extreme views held also correlated with the willingness to share these beliefs via social media, proposing a dynamic for their viral spread (Freeman et al., 2022). In terms of the underlying mechanism, a recent study has reported that conspiratorial thinking negatively predicts trust in government and science, and finally, vaccine attitudes and willingness via mediation and path analysis (Capasso et al., 2022).

Recent research has shown that COVID-19 conspiracy beliefs and conspiracy thinking—a predisposition to believe in conspiracy theories—negatively predict peoples' intentions to be vaccinated against COVID-19 even if none of the conspiracy beliefs explicitly refer to the dangers of the vaccines (Bertin et al., 2020). Importantly, the extant literature suggests that trust in specific institutions is associated with conspiracy theories and beliefs about those institutions (e.g., Lewandowsky et al., 2013; Mari et al., 2022). In other words, anti-expert sentiments have been linked to decreased trust in science (e.g., Milošević Đorđević et al., 2021), while conspiracy theories about the government have been associated with decreased trust in government (Einstein & Glick, 2015; Goodwin et al., 2022).

Purpose of this Study

The aim of this research is to explore the factors predicting vaccine attitudes and the willingness to get a COVID-19 vaccine during the early stages of global vaccine administration. Although one previous study examined a similar topic, it did not consider anti-expert sentiments in its model and relied on a relatively small-scale dataset collected from an unvaccinated-only sample from a single country (Capasso et al., 2022). Such limitations in the previous study warrant additional examination on the topic, which we conduct in the present study.

Drawing from the evidence reviewed in the previous sections, we expect that individuals' favorable vaccine attitudes will be positively correlated with their willingness to get a COVID-19 vaccine across countries (H1). We also assume, via two mediation models (see Fig. 1), that the negative relationship between conspiratorial thinking and vaccine attitudes will be mediated by one's trust in government (H2), and that the negative relationship between anti-expert sentiments and vaccine attitudes will be mediated by one's trust in the scientific research community (H3). Besides these three main hypotheses, we also propose six additional hypotheses related to the direct effects in each mediation model (i.e., H2a-H2c for the conspiracy belief model, H3a-H3c for the anti-expert model). Given the reviewed studies emphasizing cross-country differences in terms of vaccine uptake (e.g., Hornsey, 2022; Nehal et al., 2021), we also expect that the effects in each mediation model will vary across countries (i.e., H2d for the conspiracy belief model, H3d for the anti-expert model).

Method

Transparency and Openness

The dataset analyzed during the current study are available in the Open Science Framework repository: COVIDiSTRESS II Consortium, 2021. COVIDiSTRESS II Global Survey. https://osf.io/36tsd/. The first hypothesis was pre-registered before data collection in the COVIDiSTRESS II pre-registration (https://osf.io/pg3h8). The remaining hypotheses were pre-registered after data collection, yet before data analysis (https://doi.org/10.17605/OSF.IO/P47WH). The convenience sampling method is a limitation of the study. All analyses were done in *R*. Further details about employed tools and packages are available in the supplementary materials (Online Resource 1). All relevant source code files are available via GitHub (https://github.com/hyemin-han/COVIDiSTRESS2_Vaccine). Resultant RData files are available via OSF (https://osf.io/yw2qz/). Ethical approval for this study was obtained at the University of Salford (UK), as well as local ethical approval where required.

Data Collection and Participants

The COVIDiSTRESS II Global Survey, "Living a Year with the Pandemic", was administered in 40 languages and eight dialects from May 28 to August 29 2021. Participants from 137 countries participated in this online survey of experiences one year into the COVID-19 pandemic. After data cleaning to include only participants who provided informed consent and passed the attention check, data from 15,740 participants were analyzed. Demographic details regarding these participants have been presented elsewhere (Blackburn et al., 2022) and are available with the open-access dataset https://osf.io/36tsd/). Only participants who completed the scales of interest were included in the analyses below.

Due to the minimal requirements of some used statistical procedures, only responses from language groups where $N \geq 100$ were used for measurement invariance test and measurement alignment, and only responses from countries where $N \geq 30$ were used for multilevel modeling (Han, 2022a). This resulted in a total of 14,600 participants from 43 countries.

Measures

The COVIDiSTRESS II Global Survey included demographic questions, country of residence, and a number of scales. Relevant to our current hypotheses, the survey included the following measures: *Willingness to get vaccinated* (1 item), *Vaccine Attitudes* (Han, 2022a), *Trust in institutions* (Yamada et al., 2021), *Conspiratorial Thinking Scale* (Uscinski et al., 2020; 2016; Han et al., 2021), and *Anti-Expert Sentiment* (Uscinski et al., 2020). Full details about the survey and dataset are described in Blackburn et al. (2022).

Willingness to get vaccinated. Participants' willingness to get vaccinated was measured by one item, "*How willing are you to get the vaccine if one becomes available to you?*" Responses to this item were anchored to a 6-point Likert scale (1 = *not willing at all*; 6 = *very willing*). Participants were

informed about the focus of the survey, so it was implicit that the item referred to the COVID-19 vaccine.

Vaccine Attitude Question Battery. The Vaccine Attitudes Scale included six items (e.g., "*New vaccines are recommended only if they are safe*") that were adapted from the Vaccine Attitude Question Battery (VAQB; Han, 2022a). Vaccine attitudes were reported on a 6-point scale (1 = *strongly disagree*; 6 = *strongly agree*). Low scores indicate negative attitudes, and high scores indicate positive attitudes. The validation study indicated that one of the items (Item 4) should be excluded (Han, 2022a). Thus, we employed five out of six items in the present study. The VAQB showed good internal consistency for the full cross-cultural data (α = .85).

Trust. Participants were asked to rate how much they trusted institutions on a scale of 0 (*No trust*) to 10 (*Complete trust*). Each of the 7 items on the scale reflected trust in a specific institution. Two of the seven trust items were independently included in this analysis to reflect Trust in the Scientific Research Community and Trust in Government.

Conspiratorial Thinking Scale. We employed the Conspiratorial Thinking Scale (Uscinski et al., 2020, 2016) to examine participants' conspiratorial thinking within the context of the COVID-19 pandemic. The scale included four items (e.g., "*Much of our lives are being controlled by plots hatched in secret places*"). Responses were anchored to a 4-point Likert scale (1 = *strongly disagree,* 4 = *strongly agree*). The scale showed good internal consistency (α = .85).

Anti-Expert Sentiment Scale. The Anti-Expert Sentiment Scale (Blackburn et al., 2022; Han et al., 2022) was used to examine participants' sentiment regarding to what extent they distrust experts' advice during the COVID-19 pandemic. Three items (e.g., "*I am more confident in my opinion than other people's facts*") were presented to participants. Responses were anchored to a 6-point Likert Scale (1 = *strongly disagree,* 6 =*strongly agree*). The Anti-Expert Sentiment Scale demonstrated acceptable internal consistency (α = .73).

Data analysis

In the first step, the psychometric properties of scales (especially internal consistency and measurement invariance) were verified. To perform multilevel modeling for hypothesis testing across various countries, the (partial) metric invariance needed to be established to conduct meaningful comparisons of factor variances and covariances (Fischer & Karl, 2019). Measurement invariance was tested through multi-group confirmatory factor analysis with traditional criteria for a configural level of invariance (i.e., $RMSEA \leq .08$, $SRMR \leq .08$, $CFI \geq .90$, $TLI \geq .90$) and a metric level of invariance (i.e., $\Delta RMSEA < .015$, $\Delta SRMR < .030$, $\Delta CFI < .01$, $\Delta TLI < .01$) (Cheung & Rensvold). In the case that metric invariance was not established, the multi-group measurement alignment (Asparouhov & Muthén, 2014) would be used for the calculation of factor scores. The factor scores used for further analyses were calculated with the adjusted factor scores and intercepts estimated by measurement alignment. Such an approach has been recommended when measurement invariance is not achieved (Byrne & van De Vijver, 2010) because it assures that the scale measures the construct of interest equally across different languages. We considered the alignment process to sufficiently address the problem of non-invariance if at least 75% of non-invariance was absorbed through alignment (Asparouhov & Muthén, 2014). Then, for additional information, we examined brief descriptive statistics of variables of interest and correlation between them.

Regarding the main analysis, we tested each hypothesis with multilevel modeling (MLM) from both frequentist and Bayesian perspectives to examine whether the evidence supporting the hypothesis and predictors of interest in the model were significant. For Bayesian MLM, we employed the default Cauchy prior, Cauchy (0, 1), for regression analysis and model selection (Rouder & Morey, 2012). To examine which model best predicts a dependent variable of interest, we compared different models with Bayes Factors (BF). The compared models include:

Model 0 (M0): DV ~ control variables + random intercepts (country)

Model 1 (M1): DV ~ predictors + control variables + random intercepts

Model 2 (M2): DV ~ predictors + control variables + random slopes + random intercepts

In all cases, demographic variables were added to the models as control variables. For the model comparison, we calculated three Bayes Factors, BF_{10}, BF_{20}, and BF_{21}. The three BFs indicate BF of M1 vs. M0, M2 vs. M0, and M2 vs. M1, respectively. When a specific BF value was extremely large to report (e.g., BF ≥ 100), we reported the log(BF).

Once the best model was identified, we examined whether predictors of interest were significant. First, we tested the hypothesized model with both frequentist and Bayesian MLM. Once MLM was completed, we examined whether predictors of interest in the tested model were significant from both frequentist ($p < .05$) and Bayesian (BF ≥ 3) perspectives.

Second, in addition to statistical significance (whether a predictor is significantly non-zero), we also examined the practical significance of predictors of interest (whether a predictor's effect is not trivial) with effect size indicators (ROPE; Kruschke, 2018). We set the region of equivalence to default (-0.1 to 0.1) which corresponds to negligible effect size. The 89% HDI was used. In this process, variables were standardized for better convergence during Bayesian MLM and ease of interpretation. This rather exploratory analysis is reported in the Supplementary material (Online Resource 1).

Results

Measurement Invariance Testing

Before testing hypotheses, we examined measurement invariance among the three scales that assume latent factors. However, even the lowest level of invariance, configural measurement invariance, was not achieved for both VAQB (*RMSEA* = .09, *SRMR* = .03, *CFI* = .93, *TLI* = .86) and Conspiratorial Thinking Scale (*RMSEA* = .16, *SRMR* = .04, *CFI* = .94, *TLI* = .82). Although the Anti-Expert Sentiment Scale yielded satisfactory fit indices for the configural model (*RMSEA* = .00, *SRMR* = .00, *CFI* =

1.00, *TLI* = 1.00), its metric invariance was also not established (Δ*RMSEA* = .09, Δ*SRMR* = .04, Δ*CFI* = .06, Δ*TLI* = .08). These results correspond to what Han (2022a) reported in his validation study.

Hence, we used measurement alignment for all three scales. We found that this process absorbed 97% of the non-invariance in factor loadings and 100% of that in intercepts in VABQ; 97% of the non-invariance in factor loadings and 99% of the non-invariance in intercepts in Conspiratorial Thinking Scale; and 86% of the non-invariance in factor loadings and 99% of that in intercepts in Anti-Expert Sentiment Scale. The aforementioned indicators suggest that the extracted factor scores are reliable and suitable for other analyses.

Descriptive statistics and correlation analysis

For additional information, we examined brief descriptive statistics, Mean and SD, of the tested variables, conspiratorial thinking, anti-expert sentiments, trust in government, trust in the scientific research community, vaccine attitudes, and vaccine willingness. The descriptive statistics are reported in Table S1. In addition, we also performed correlation analysis to see bivariate correlation between the tested variables. The result is demonstrated in Table 1.

Association between Vaccine Attitudes and Willingness

We started by testing the association between vaccine attitude and willingness via MLM (H1). Bayesian MLM indicated that M2, the model with random intercepts and slopes, was the best model for our cross-cultural data. The calculated model BFs were: BF_{10} = infinite, BF_{20} = infinite, and $\log(BF_{21})$ = 186.73. When M2 was examined, a Bayesian test of the effect of vaccine attitude indicated that the effect was significantly greater than zero, *b* = .64, *e* = .03, 95% *CI* = [.59, .68], BF = infinite. Frequentist MLM also supported the presence of a large effect of vaccine attitude, *t*(3.90) = 26.48, *p* < .001, *d* = 1.38. Hence, we conclude that H1 was very strongly supported by the evidence. Given that M2 was found to be the best model, the random slopes of vaccine attitude on willingness were deemed to significantly

vary across countries from the lowest slope in Russia, *b* = -.36, 95% Bayesian *CI* [-.42, -.30], and the highest slope in Japan, *b* = .23, 95% Bayesian *CI* [.17, .31].

We then tested the hypotheses for each mediation model. For all hypothesis tests, the full MLM results, including all estimated coefficients of all predictors and control variables, are available via the OSF (https://osf.io/qbpzy/).

Association between Conspiratorial Thinking and Vaccine Attitudes

First, we tested the direct relationship between conspiratorial thinking and trust in government (H2a). Bayesian MLM demonstrated that M2, the model with random intercepts and slopes, was best among all candidate models, BF_{10} = infinite, BF_{20} = infinite, $\log(BF_{21})$ = 45.74. In M2, the negative association between conspiratorial thinking and trust in government was very strongly supported by evidence, *b* = -.27, *e* = .03, 95% *CI* = [-.32, -.22], BF = infinite. The result of frequentist MLM also demonstrated the presence of a medium effect of conspiratorial thinking, $t(3.74) = -9.70$, $p < .001$, $d = -.62$. Second, H2b predicting a positive association between trust in government and vaccine attitude was also very strongly supported by evidence. M2 was found to be the best model, $\log(BF_{10})$ = 493.50, $\log(BF_{20})$ = 612.29, $\log(BF_{21})$ = 118.87. When M2 was examined, we found that the aforementioned positive association was very strongly supported by evidence, *b* = .25, *e* = .03, 95% *CI* = [.20, .30], BF = infinite. Similarly, frequentist MLM also reported the presence of a medium effect of trust in government, $t(4.02) = 8.39$, $p < .001$, $d = .64$. Third, the negative association between conspiratorial thinking and vaccine attitude, H2c, was also very strongly supported by data. M2 was reported as the best model, BF_{10} = infinite, BF_{20} = infinite, $\log(BF_{21})$ = 120.65. In M2, the negative effect of conspiratorial thinking was very strongly supported by evidence, *b* = -.30, *e* = .03, 95% *CI* = [-.35, -.26], BF = infinite. Frequentist MLM also supported the presence of a medium effect of conspiratorial thinking, $t(4.47) = -10.57$, $p < .001$, $d = -.74$.

After supporting all hypotheses about the direct relationships between the variables of interest, H2a to H2c, we tested the mediation role of trust in government in the relationship between conspiratorial thinking and vaccine attitude, H2. We compared M0, M1, and M2 and found that M2 was again the best model: BF_{10} = infinite, BF_{20} = infinite, log(BF_{21}) = 204.83 (see Figure 2 for the model). The estimated direct effect was -.25 (95% *CI* [-.30, -.20]), the indirect effect was -.05 (95% *CI* [-.06, -.03]), the mediator effect was .17 (95% *CI* [.12, .22]), and the total effect was -.30 (95% *CI* [-.35, -.24]). A total of 15.16% (95% *CI* [10.10, 20.21]) of the total effect was mediated. Thus, we conclude that H2 was supported, as the relationship between conspiratorial thinking and vaccine attitude was partially mediated by trust in government. H2d was also supported by evidence given that M2, the model including random slopes, was the best fitting model, indicating that the mediation model varied across countries. In the case of the random slopes of conspiratorial thinking, the slopes varied from the lowest in Czech Republic, *b* = -.29, 95% Bayesian *CI* [-.39, -.19], and the highest in Honduras, *b* = .29, 95% Bayesian *CI* [.14, .43]. Similarly, the random slopes of trust in government significantly varied from the lowest in Brazil, *b* = -.22, 95% Bayesian *CI* [-.33, -.12], and the highest in Italy, *b* = .21, 95% Bayesian *CI* [.10, .32].

Association between Anti-Expert Sentiments and Vaccine Attitudes

First, we examined whether anti-expert sentiments negatively predicted trust in the scientific research community (H3a). Bayesian MLM indicated that M2 was best among candidate models, BF_{10} = infinite, BF_{20} = infinite, log(BF_{21}) = 59.68. The negative effect of anti-expert sentiments was very strongly supported by evidence, *b* = -.34, *e* = .03, 95% *CI* = [-.38, -.30], BF = infinite. Frequentist MLM also supported the presence of a medium effect of anti-expert sentiments, $t(4.44) = -13.71$, $p < .001$, $d = -.69$. Second, the positive association between trust in science and vaccine attitude (H3b) was also very strongly supported by evidence. M2 was found to be the best model, BF_{10} = infinite, BF_{20} = infinite, log(BF_{21}) = 151.90. The positive effect of trust in science was very strongly supported by both Bayesian

MLM (*b* = .43, *e* = .03, 95% *CI* = [.38, .48], BF = infinite) and Frequentist MLM (*t*(3.80) = 13.83, *p* < .001, *d* = 1.11). Third, the negative relationship between anti-expert sentiments and vaccine attitude (H3c) was also tested. Among candidate models, M2 was the best model, BF_{10} = infinite, BF_{20} = infinite, log(BF_{21}) = 73.65. The negative relationship between anti-expert sentiments and vaccine attitude was very strongly supported by evidence: Bayesian MLM (*b* = -.29, *e* = .03, 95% *CI* = [-.33, -.24], BF = infinite), and frequentist MLM (*t*(4.32) = -11.68, *p* < .001, *d* = -.71).

We then tested H3, the mediation effect of trust in science in the relationship between anti-expert sentiments and vaccine attitude. Again, M2 was found to be the best model, BF_{10} = infinite, BF_{20} = infinite, log(BF_{21}) = 166.43. When M2 was tested, we found that the relationship was partially mediated by trust in science (see Figure 3 for the model). The estimated direct effect was -.16 (95% *CI* [-.19, -.12]), the indirect effect was -.12 (95% *CI* [-.15, -.10]), the mediator effect was .37 (95% *CI* [.31, .43]), and the total effect was -.28 (95% *CI* [-.32, -.24]). Results indicated that 43.99% (95% *CI* [35.78, 52.21]) of the total effect was mediated by trust in science. Hence, H3 was supported. Furthermore, H3d was also very strongly supported by evidence as M2 including random slopes was the best model, indicating that the mediation model varied across countries. In the case of the random slopes of anti-expert sentiments, the random slopes varied from the lowest in Norway, *b* = -.16, 95% Bayesian *CI* [-.26, -.06], and the highest in Honduras, *b* = .08, 95% Bayesian *CI* [-.02, .20]. Similarly, the random slopes of trust in science significantly varied from the lowest in Bolivia, *b* = -.23, 95% Bayesian *CI* [-.30, -.10], and the highest in Other, *b* = .30, 95% Bayesian *CI* [.06, .54]; Estonia among countries, *b* = .21, 95% Bayesian *CI* [.08, .34].

Complementing these results, we conducted additional, non-preregistered analyses examining whether vaccine attitude mediated the relationship between trust (including both trust in government and science) and vaccine willingness as visually depicted in Fig. 1. Similar to the previous mediation analyses, M2 was the best model, BF10 = infinite, BF20 = infinite, log(BF21) = 336.22, and confirmed a partial mediation. When trust in government was the variable of interest, the estimated direct effect

was .02 (95% CI [-.00, .05]), the indirect effect was .04 (95% CI [.02, .07]), the mediator effect was .58 (95% CI [.53, .63]), and the total effect was .07 (95% CI [.03, .10]). Results indicated that 64.25% (95% CI [27.40, 101.10]) of the total effect in the relationship between trust in government and willingness was mediated by vaccine attitude. A similar trend was found when trust in the scientific research community was the variable of interest. The estimated direct effect was .08 (95% CI [.06, .11]), the indirect effect was .22 (95% CI [.19, .26]), the mediator effect was .58 (95% CI [.53, .63]), and the total effect was .31 (95% CI [.27, .35]). In this relationship, 72.68% (95% CI [65.29, 80.08]) was mediated by vaccine attitude. In short, the relationship between trust in government and science, and vaccine willingness was partially mediated by vaccine attitude.

Exploratory analysis: Testing a multiple mediation model with multiple, simultaneous pathways

We conducted additional exploratory analysis on whether there would be multiple, simultaneous pathways between conspiratorial thinking, anti-expert sentiments, trust in government and science, and vaccine attitudes. In our pre-registration, we hypothesized that there would be two simple, separate pathways, conspiratorial thinking → trust in government → vaccine attitudes and anti-expert sentiments → trust in the scientific research community → vaccine attitudes. However, there may be components of people's trust in government and in the scientific research community that are better captured by elements from the "opposing" pathway. For example, anti-expert attitudes can encompass negative attitudes towards politicians (Attwell et al., 2021) and many conspiracies involve scientific or medical experts, such as vaccine developers (Rutjens et al., 2021). Thus, it is quite possible that both anti-expert sentiments and conspiratorial thinking could jointly predict both trust in government and trust in the scientific research community. To test this possibility, we consider whether including these additional predictors in both paths is better supported by the observed data than our simpler model.

To examine this possibility, we conducted additional exploratory Bayesian mediation analysis. First, we created a simple model (Ms), which only assumed the aforementioned single pathways. Second, we also created a complex model, a multiple mediation model (Mc). In this model, trust in government would be predicted not only by conspiratorial thinking but also by anti-expert sentiments. In the same manner, we also hypothesized that trust in the scientific community would be predicted by both anti-expert sentiments and conspiratorial thinking. Then, these two mediation models were compared with a model BF, BFsc. The resultant log(BFsc) = -236.87 suggests that Mc, the complex model assuming multiple, simultaneous pathways, was significantly better supported by data compared with Ms, the simpler model that we initially hypothesized in the pre-registration. The full path models, Ms and Mc, are reported in Figures S1 and S2, respectively.

Discussion

Vaccines are an important scientific advancement that have prevented death and improved the lives of millions of individuals worldwide. However, vaccine hesitancy is a frequent issue governments and health officials must manage. The extant literature has identified many demographic and psychological factors that contribute to vaccine hesitancy, including levels of trust in the government and the scientific community (e.g., Cascini et al., 2021; Goodwin et al., 2022; Hornsey, Harris, & Fielding, 2018; McCarthy et al., 2022; Mundagowa et al., 2022). Here we report findings of a large cross-country study (k = 43; N = 15,740) investigating the roles of trust in government and science in shaping attitudes toward vaccines. All pre-registered hypotheses, H1 to H3d were supported. All hypothesized associations were found to be significant with all reported effect sizes ranging from medium (H2a, H2b, H2c, H3a, H3c) to large (H1, H3b), and their directions were as predicted at the global level. Bayesian mediation analysis with random slopes identified that the effects were significantly variable across countries for both H2d and H3d, and that Bayes factors were found to be greatest when the models included random slopes.

We explored each country's random slope with the H2 and H3 models. In almost all countries, the random slopes of conspiratorial thinking predicting vaccine attitudes were negative, and those of trust in government were positive. In most countries, the random slopes of anti-expert sentiments predicting vaccine attitudes were negative, and the random slopes of trust in science were positive. Our results are thus consistent with similar large-scale studies showing that vaccine hesitancy is linked to conspiratorial thinking, trust in scientists, government, and national health authorities (e.g., Lindholt, 2021). We discuss exceptions to this pattern in further detail below.

Vaccine Attitudes and Vaccine Willingness

General vaccine attitudes were positively correlated with the willingness to get a COVID-19 vaccine across countries, as expected. We used vaccine willingness as a best proxy for behavior or planned behavior using self-report during a time when the COVID-19 vaccine was not yet available to all. This indicates that vaccine attitudes reflect intended behaviors related to vaccine uptake, and therefore may be a valid measure to predict actual vaccination behavior (e.g., Kessels et al., 2012). This finding also contributes to a growing body of literature using this dataset to validate the VAQB, previously in terms of reliability and now in terms of convergent validity (Han, 2022a; Han et al., 2022; Blackburn et al., 2022). Additionally, we found significant variances in the random slopes across different countries as indicated in Table S2 .

Despite the general pattern at the population level, we also discovered that there was significant variability in the slopes across countries. We found that a random slope in Russia demonstrated an unexpected pattern, which was contrary to the general pattern observed at the global level. Additional exploratory Bayesian analysis indicated that the random slope of vaccine attitudes in Russia was negative and the effect size was not negligible (see Online Resource 1 and Table S2). This may reflect the low levels of vaccine acceptance in Russia and the difficulties Russia has faced with vaccine refusal (Roshchina et al., 2021). At the time of data collection in Russia, less than 11.3% of

Russian residents had begun vaccination, despite higher percentages in many other countries in this study and the early domestic release of the vaccine at the beginning of 2021 in Russia.

It should also be noted that the survey was administered earlier in the Russian Federation than in other countries due to changes in national policies related to research ethics. In May of 2021, the COVID-19 vaccines were relatively new, and vaccine hesitancy tends to be higher with novel vaccines (Dubé et al., 2014). In fact, vaccine rates in Russia jumped from approximately 11.3% to 29% between the date that data collection in Russia was halted and the date the survey closed (Mathieu et al., 2021). Thus, this difference may reflect a difference in the COVID-19 vaccine timeline and perhaps a difference in vaccine brand availability over time; when the vaccines were newer, even individuals with favorable attitudes may have preferred to wait before receiving the vaccine.

Trust Predicts Vaccine Attitudes and Willingness

Our findings also highlight the important role of trust in reducing vaccine hesitancy, confirming prior findings (e.g., Lazarus et al., 2021; Goodwin et al., 2022; McCarthy et al., 2022; Mundagowa et al., 2022; Rozek et al., 2021). Trust in government and trust in the scientific research community were not only associated with favorable attitudes to vaccines, but both also had a significant indirect relationship with vaccine willingness through vaccine attitudes. Beyond these indirect associations on vaccine willingness via vaccine attitude for both institutional trust measures, trust in the scientific community also had a direct association with vaccine willingness. These findings confirm the important role of trust, especially in science, in reducing vaccine hesitancy given its associations with favorable general attitudes towards vaccines as well as willingness to get a COVID-19 vaccine.

Trust in Government Mediates the Link Between Conspiratorial Thinking and Vaccine Attitudes

As predicted, conspiratorial thinking is negatively related to both trust in government and vaccine attitudes. Notably, the negative relationship between conspiratorial thinking and vaccine attitudes is mediated by trust in one's government. Lower levels of trust in government help explain the

negative association between conspiratorial thinking and unfavorable vaccine attitudes. In general, these findings are in line with and expand what have been reported in Capasso et al. (2022), which only included conspiratorial thinking in its mediation model and examined a small-scale single-country dataset collected only from unvaccinated participants.

We explored each individual country's slope with the H2 model. In almost all countries, vaccine attitudes were negatively associated with conspiratorial thinking and positively associated with trust in government. The exceptions were Honduras in the case of conspiratorial thinking and Brazil in the case of trust in government. However, there was significant variability in the size of the slopes across countries. We found interesting patterns from the examined random slopes from exploratory Bayesian analysis (see Online Resource 1 Supplementary methods and Tables S3 and S4). The random slope of conspiratorial thinking in Honduras was greater than zero, and its effect was not negligible. Furthermore, the random slope of trust in the government was negative and significant in Brazil.

One possibility for these differences across countries is that some countries were actively promoting and disseminating vaccines while others had countervailing pressures. For instance, some governments demonstrated vaccine-skeptical policies or beliefs, and this may have led to conspiracies about restrictions of vaccines instead of (or in addition to) conspiracies about enforcing vaccine uptake that may change the local dynamics. In the context of this study, the Brazilian president's distrust of the vaccine has affected the degree of hesitancy in Brazil (Paschoalotto et al., 2021). Those placing their trust in the Brazilian government at the time this survey was collected may therefore have been influenced by or attracted to its vaccine-skeptical policies. This may explain why the relationship between trust in the government and vaccine attitudes in Brazil was the opposite of that in other countries.

Another related possibility for different slopes is that the relationship between conspiratorial thinking, government trust, and vaccine attitudes may have been influenced by different vaccine

availability across countries. In other words, in some countries, conspiracies might be about lack of access to vaccines rather than government pressure, incentives, and enforcement policies to take the vaccine. This might reduce the size of the relationship or reverse it depending on the prevalence of such conspiracies. At the time that this survey was administered (June–August 2021), vaccine availability differed greatly across countries (Mathieu et al., 2021). Future studies using available data from the COVIDiSTRESS II Global Survey Blackburn et al., 2022) could examine such country-level moderations.

There has also been speculation about the political intent of vaccine donations from China in Honduras, Brazil, and other Latin American countries under the guise of "vaccine diplomacy" in exchange for increased economic and political presence in the region (Runde, 2021). China used both donations and purchases to expand its power over the low- and middle-income countries, and to promote and strengthen anti-U.S. allied networks (Vadlamannati et al., 2022). While China positioned itself as a vaccine donor for these critically impacted countries, the lower efficacy rates of the Chinese vaccines could have created doubt or hesitancy among the public to receive these vaccines. Thus, China's donations might have moderated the relationships between the examined variables in certain countries (e.g., Brazil and Honduras) where vaccine distribution was linked to political pressure from China. This suggests that vaccine attitudes and ultimate willingness to take the vaccine are predicted not only by pre-existing individual beliefs and government trust, but may also be predicted by politicization and foreign policy.

Such politicization may have exacerbated conspiratorial thinking in the case of Honduras. Allegations of corruption and illegal activities carried out on behalf of the President and his brother have been leveled against the government of Honduras, which may have increased conspiratorial thinking regarding corruption related to COVID-19 vaccine administration (Oxford Analytica, 2020). Further research should be conducted to determine the role of vaccine availability in the relationship between conspiratorial thinking, government trust, and vaccine attitudes.

Trust in Scientific Research Community Mediates the Link Between Anti-Expert Sentiments and Vaccine Attitudes

As predicted, anti-expert sentiments are negatively related to both trust in the scientific research community and vaccine attitudes. More importantly, the negative relationship between anti-expert sentiments and vaccine attitudes is mediated by one's trust in the scientific research community. Lower levels of trust in the scientific community help explain the negative association between one's anti-expert sentiments and one's vaccine attitudes. The effects of anti-expert sentiments and trust in scientific communities on vaccine attitudes were consistent across countries in this study. In addition to these general patterns, we also found significant variability in the associations in certain countries. One interesting pattern observed from exploratory Bayesian analysis was the negative random slope of trust in science in Honduras (see Online Resource 1 supplementary methods and Tables S5 and S6). The effect size of this negative random slope was not negligible; thus, those with greater trust in science in Honduras had more negative attitudes towards the COVID-19 vaccine.

Overall, Honduras exhibited an atypical pattern of results both with regard to trust in science and conspiratorial thinking. One possibility is that Honduras's ability to respond to the COVID-19 pandemic was hindered by the presence of existing disease outbreaks in the country. Honduras has a long history of dealing with the dengue and dengue haemorrhagic fever epidemic, which affected 71,216 people in 2019 (Eichengreen et al., 2021). Previous experience living through an epidemic has been shown to decrease trust in science and negatively impact vaccine attitudes (Eichengreen et al., 2021). In addition, the nation experienced two Category 4 hurricanes during the first year of the pandemic. That led to a sharp GDP decline of 9 percent, while income and employment sank, with about 400,000 people losing their jobs during 2020 (The World Bank, 2022).

Hence, another epidemic and two natural disasters coinciding with the COVID-19 pandemic may have complicated the pandemic experience in the country. Consistent with this possibility, Honduras

was one of the countries in the current study with the lowest vaccination rates at the time of the study (3.2% - 26.8% from the beginning to the end of the data collection period; Mathieu et al., 2021).

One additional point to note is that when the multiple mediation model assuming multiple, simultaneous associations between conspiratorial thinking, anti-expert sentiments, trust in the scientific research community, and trust in government was examined, it was better supported by data compared with the original simple mediation model that we hypothesized. Due to the conceptual simplicity, we initially hypothesized such a single mediation model. However, in reality, both trust variables might be better predicted by both conspiratorial thinking and anti-expert sentiments, not only one of them. In fact, the previous validation study demonstrated that both conspiratorial thinking and anti-expert sentiments are negatively associated with trust in general, which both are also correlated with each other (Han et al., 2022).

Limitations and Future Directions

Although we reported significant findings that can contribute to the field in the present study, several limitations warrant future studies. First, although we collected a large-scale dataset across the globe, the cross-sectional nature of the data limits the interpretability and validity of the findings, particularly those associated with potential biases from mediation analyses (Maxwell et al., 2011). Of course, models with reversed arrows might be tested to examine alternative path models. However, when the models are in the same equivalence class, which originates from a cross-sectional dataset, it becomes impossible to examine which model is superior to others (Thoemmes, 2015). Thus, to be able to examine causality better, future studies may need to analyze multiple time-point or longitudinal data. Of course, the necessity of further longitudinal studies does not completely nullify the implications of our study. As Grosz et al. (2020) proposed, findings from our cross-sectional mediation analyses would still be able to provide insights about how to set pathways and conduct causal inferences to future longitudinal studies.

Second, in order to maximize the global reach of our study across a large number of countries, we relied on a snowball sampling method. As a result, the sample we obtained may not be representative of the respective national populations. Although there is variability between countries, the direction of the relationship between anti-expert sentiments and trust in scientific communities on vaccine attitudes was consistent in most cases. This indicates that the relationship between these factors is fairly robust across countries, but their strength may be influenced by other factors. Therefore, future studies might benefit from relying on more nationally representative samples as well as controlling for various country-level variables.

Conclusion

In conclusion, we analyzed factors related to vaccine willingness in 43 countries during the early stages of global COVID-19 vaccine administration between June through August of 2021. We found further supporting evidence validating the VAQB, as scores regarding vaccine attitudes were positively related to vaccine willingness. We also showed that in nearly all countries, the negative relationship between conspiracy beliefs and vaccine attitudes is mediated by trust in one's government. Differences between countries may reflect differences in vaccine availability across countries or differences in vaccine enforcement and countervailing pressures. Finally, we found that the negative relationship between anti-expert sentiments and vaccine attitudes is mediated by one's trust in the scientific research community in all countries analyzed.

The fact that almost all countries showed the same directional relationship between the associations between anti-expert sentiment, trust in science and vaccine attitudes, as well as the associations between conspiratorial thinking, trust in government, and vaccine attitudes at the global level, suggests that these relationships are widely shared. However, in several countries, such as Russia, Brazil, and Honduras, we were able to find random slopes that significantly contradicted the general trends with non-trivial effect sizes. Such observations from the random slopes may suggest that local

factors regarding beliefs about scientific experts or governments' support for COVID-19 prevention policies can influence populations' vaccine attitudes and, ultimately, their vaccine behavior. A better understanding of both the psychological processes involved in vaccine willingness and the local conditions that differ between countries will provide insight for national and international researchers and policymakers to develop future interventions aiming to increase trust in the institutions involved in the vaccination process.

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Table 1

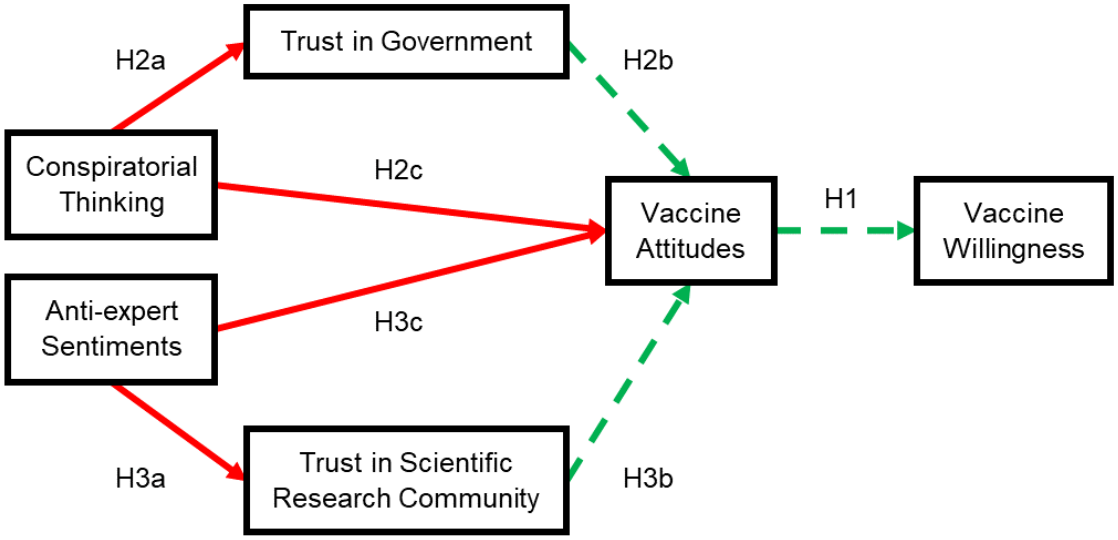
Bivariate correlation between tested variables (Pearson correlation coefficients)

	1	2	3	4	5
1. Conspiratorial thinking					
2. Anti-expert sentiments	.42				
3. Trust in government	-.40	-.18			
4. Trust in the scientific research community	-.38	-.42	.46		
5. Vaccine attitudes	-.34	-.46	.30	.58	
6. Vaccine willingness	-.29	-.37	.22	.47	.68

Note. All associations reported $p < .05$ after false discovery rate correction.

Figure 1

Hypothesized *conceptual model*



Note. Line drawing with direct and indirect effects as outlined in the hypotheses. Solid line (H2a, H2c, H3a, H3c) = negative direct effect; Dashed line (H2b, H3b, H1) = positive direct effect.

Figure 2

Result of H2 mediation analysis (conspiratorial thinking → trust in government → vaccine attitudes)

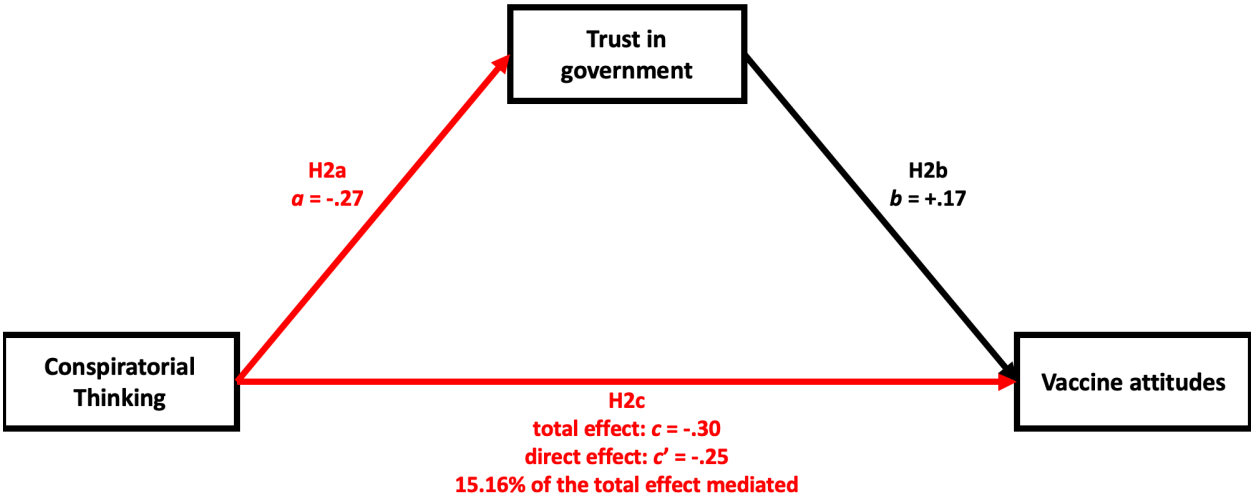


Figure 3

Result of H3 mediation analysis (anti-expert sentiments → trust in the scientific research community → vaccine attitudes)