Antecedents of Virus Conspiracy Beliefs

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Abstract. Problem: The COVID-19 "infodemic," marked by a mix of accurate and misleading information, significantly disrupted public health responses by promoting confusion, risky behaviors, and distrust in health authorities. Misinformation, including incorrect prevention tips and conspiracy theories about the virus's origins and vaccine efficacy, fueled public skepticism and led to widespread non-compliance with health guidelines. This environment highlighted the role of conspiracy beliefs, which thrive during crises as individuals seek certainty and control, ultimately rejecting scientific advice and exacerbating public health challenges. The study aims to examine the relationship between virus conspiracy beliefs and various individual and country-level variables, to develop better communication strategies and policies for effectively managing public behavior during health crises.

Methods: This study utilizes multilevel modeling to analyze data from the Eurobarometer 95.2 survey, conducted during the COVID-19 pandemic across 39 countries. The hierarchical structure of the data allows for the examination of both individual and country-level variables influencing virus conspiracy beliefs. The primary dependent variable is the belief in the statement "Viruses have been produced in government laboratories to control our freedom." Independent variables include individual coping mechanisms for uncertainty, levels of scientific knowledge, and attitudes towards science, which are assessed to determine their impact on forming conspiracy beliefs during a crisis. Moderators such as attitudes towards science and maternal education are also included to analyze their influence on these beliefs.

Discussion: Findings suggest that individuals' values towards faith or science significantly influence their susceptibility to virus conspiracy beliefs (VCB), particularly under conditions of uncertainty. Those who prioritize faith remain stable in their beliefs, while those who value science may increase in conspiracy beliefs when faced with existential threats. It highlights the necessity of tailoring science communication and public health strategies to diverse value systems and cultural contexts to combat misinformation effectively. Additionally, the effectiveness of educational interventions

varies with familial and socio-cultural backgrounds, emphasizing the need for customized approaches to enhance scientific literacy and critical thinking across different demographic groups.

Introduction

The COVID-19 pandemic was not only a formidable public health challenge but also a significant crisis of misinformation, often referred to as an "infodemic." This term, as defined by the World Health Organization, describes the overwhelming flood of information—both accurate and misleading—that accompanies a health crisis. The rapid dissemination of such information created confusion and leads to risky behaviors that compromise health, foster mistrust in health authorities, and undermine the effectiveness of public health responses. Misinformation ranged from incorrect advice on prevention and treatment methods to conspiracy theories about the virus's origins and the effectiveness of vaccines. This pervasive spread of misinformation hindered public health efforts by sowing confusion and distrust among the public. For instance, myths about the virus being artificially created or exaggerated led to underestimation of the threat, discouraging adherence to safety measures such as mask-wearing and social distancing. The consequences of this misinformation problem were profound, complicating the efforts of health officials to manage the spread of the virus effectively and to implement coherent public health responses. Addressing this issue requires improve communication strategies to counteract misinformation.

The infodemic, marked by a flood of both accurate and misleading information, created a complex backdrop for individuals navigating the crisis. The impact of this information varied significantly, influenced by individuals' ability to assess critically the credibility of sources and content. During crises, the need for control and understanding intensifies. In the absence of clear explanations or solutions, some individuals gravitate towards apparent patterns or narratives, regardless of their veracity, to compensate for this uncertainty. A key trait among these individuals is a low tolerance of ambiguity (ToA; Frenkel-Brunswik, 1949), which drives a heightened need for certainty and control. This psychological predisposition often leads to the adoption of conspiracy beliefs as a means to impose order and predictability in their lives. The COVID-19 pandemic, with its wide-reaching and intricate impacts, lacked straightforward explanations and contributed to global uncertainty, thus providing fertile ground for conspiracy theories to flourish (Van Bavel et al., 2020). The infodemic, with its blend of truth and falsehoods, offered a fertile ground for those in search of definitive answers.

Conspiracy beliefs are typically defined as a subset of erroneous beliefs where the cause of an event is attributed to a secret plot by powerful actors with a nefarious agenda, often operating outside the bounds of legality (Swami & Furnham, 2014). Belief in conspiracy theories often emerge during crises such as political instability, economic downturns, or public health emergencies.   In times of crisis, individual differences in conspiracy beliefs may affect the degree of adherence to necessary collective responses. Accurate beliefs foster helpful behaviours; erroneous beliefs foster unhelpful behaviours. Empirical evidence suggests that the aversive feelings that people experience in crises (i.e., fear, uncertainty, not feeling in control) stimulate a need to control and make sense of the situation, which increases the likelihood of perceiving conspiracies in such social situations (van Prooijen and Douglas, 2017).

Conspiracy beliefs, while offering individuals a perceived sense of control by reducing feelings of uncertainty and helplessness, pose significant risks, particularly during crises affecting public health. These beliefs can lead to a fundamental opposition to and rejection of the scientific method, a phenomenon that becomes critically detrimental not only to the believers themselves but also to society at large (Lewandowsky et al. 2013). Such beliefs can have harmful effects on public health efforts, as they may lead to skepticism and resistance towards medical advice and interventions. This skepticism is particularly pronounced among those who subscribe to conspiracy beliefs, as they are less likely to trust and follow the expert recommendations provided by scientists, epidemiologists, and physicians on measures to mitigate the effects of the crisis. Such skepticism can hinder effective disease control and prevention strategies, resulting in poorer health outcomes and prolonged crises (Poland & Jacobson, 2011). For example, beliefs that AIDS was a conspiracy to eradicate Black populations have negatively influenced prevention behaviors, such as the use of condoms or pre-exposure prophylaxis (Bogart et al., 2010). Ultimately, conspiracy beliefs not only mislead the public but also hinder effective public health responses by fostering distrust and non-compliance with science and health guidelines. Understanding the drivers behind these conspiracy beliefs is crucial for addressing the infodemics and helping to guide public behavior during ongoing and future crises.

Previous Work

Conspiratorial anti-science (CAS) and Virus conspiracy belief

As previously noted, a core element of conspiracy belief systems is a profound skepticism toward established science and the scientific community. This skepticism frequently aligns with anti-science sentiments, termed "conspiratorial anti-science" (CAS) beliefs by Boer and Aiking (2024), this concept highlights a perceived conflict between ordinary

citizens and the societal elite, which includes academics and experts. Many CAS theories feature narratives of scientists colluding with powerful entities such as governments or major corporations in sinister activities. These theories thrive on rumors that use such suspicions as their central argument, suggesting that these collaborations are intentionally designed to manipulate or harm the public. These rumors often focus on common themes such as the effects, origins, or supposed cures for various ailments, weaving a complex web of misinformation that challenges public understanding and response to scientific and medical advice.

In the context of COVID-19, rumours affecting CAS beliefs have varied widely. Some claim the virus is a hoax, exaggerated by governments to control the populace or justify harsh policies. Others believe the virus is a human-manufactured entity—allegedly engineered as a bioweapon by China to undermine Western nations. Additionally, there are theories that reject established medical advice, promoting alternative remedies as more effective treatments (Van Bavel et al., 2020). These diverse and often conflicting conspiracy theories about COVID-19 illustrate a broader pattern within conspiracy belief systems: a network of reinforcing suspicions that connect disparate beliefs about the origin of the virus. This interconnectedness suggests that acceptance of one conspiracy theory can make a person more susceptible to accepting others, even if they are unrelated (Goertzel, 1994). According to van Prooijen , & van Lange (2014), conspiracy belief systems are monological (i.e., interconnected and mutually supportive) in nature. According to Boer and Aiking (2024), despite the abundance of the rumours about the origin of the virus, the people who endorse a CAS worldview collectively agree on the notion that scientists collaborate with often malevolent, hidden forces that are responsible for spreading the virus, which we would name as a **virus conspiracy belief.**

Antecedents of conspiracy beliefs:

However, the monological nature of conspiracy beliefs is context-dependent. While belief systems within a specific domain, such as virus conspiracies, tend to be monological, they might be loosely coupled with beliefs in another domain. For example, an individual who strongly believes in various conspiracy theories related to the origin and spread of a virus may not necessarily endorse conspiracy theories about a hidden cure for cancer to the same extent. A typical explanation of conspiracy beliefs often describes them as a self-sustaining, monological system, heavily influenced by psychological traits such as a low tolerance for ambiguity and a tendency towards a paranoiac mistrust of authorities. A mistrusting mindset, often a defensive response characterized by intolerance to ambiguity, typically arises from perceived vulnerability and a sense of being under threat. This perception is usually linked to various individual differences in psychological factors such as low self-esteem, poor psychological well-being, feelings of powerlessness, and anger. This perspective suggests that individuals who exhibit these traits are more likely

to adopt conspiracy theories without selection as they provide simple, albeit flawed, explanations for complex societal events, thereby reducing psychological discomfort associated with uncertainty. However, focusing solely on psychological traits can lead to an over-pathologization of conspiracy beliefs, potentially oversimplifying the diverse and multifaceted reasons people might be drawn to different theories in different contexts. This assumption risks reducing all conspiracy belief adherence to individual psychological abnormalities or deficiencies, overlooking broader socio-cultural and political factors that also play significant roles (Sutton & Douglas, 2014).

A more nuanced perspective suggests that conspiracy beliefs are interconnected to the extent that they resonate with broader belief systems. According to research by Douglas, Sutton, and Cichocka (2017), conspiracy theories attract followers by addressing key social psychological needs. These include the epistemic need for understanding and certainty, the existential need for control and security, and the social need for enhancing self-image and group identity. Additionally, a range of sociological, demographic, and political factors significantly influence the allure of conspiracy theories. Their review of the empirical studies have shown that conspiracy beliefs are linked to various socio-psychological factors including perceived threats from societal changes, uncertainty, powerlessness, lack of socio-political control, perceptions of lower social status, less analytic thinking, lower levels of education and income, and membership in disadvantaged social groups. Political extremes, whether on the left or right, also show a higher propensity for endorsing conspiracy beliefs. These findings suggest that conspiracy beliefs are not just isolated thoughts but are intertwined with broader psychological and social dynamics. This comprehensive approach goes beyond simplistic, reductionist models to acknowledge the complex interplay between individual psychological motives and broader societal dynamics, offering deeper insight into the pervasive nature of conspiracy beliefs.

Hence, the antecedents of individual differences in conspiracy beliefs are context-dependent and may vary according to the domain of a particular conspiracy theory, reflecting the complex interplay between individual predispositions and the specific cultural, social, and political environments in which these beliefs are formed. For example, the appeal of a conspiracy theory may be stronger in communities experiencing significant socio-economic challenges, where feelings of disenfranchisement and injustice are prevalent. This suggests that while psychological needs drive the initial attraction to conspiracy theories, the context in which individuals find themselves can significantly influence the extent and nature of this belief adherence. Moreover, believing in a particular conspiracy theory instead of another one can have different motivators. For instance, the belief that a cure for cancer exists but is deliberately concealed by pharmaceutical companies often taps into deep-seated suspicions about corporate greed and the ethical integrity of the pharmaceutical industry. This type of conspiracy theory is

fueled by the perception that these companies prioritize profit over patient health, exploiting the sick for financial gain. These kinds of beliefs do not always stand on unsupported allegations, as they are sometimes grounded in historical instances where pharmaceutical companies have indeed engaged in unethical practices. They may have positive consequences since their adherents often call for more regulation of the pharmaceutical industry, arguing that stricter oversight could prevent such unethical behaviors and ensure that life-saving treatments are made available to the public. In contrast, virus conspiracy beliefs often stem from a distrust of government and scientific authorities rather than corporate entities. These theories may be driven by fears of government overreach, concerns about personal liberties, and skepticism towards the motivations behind public health measures. They may have negative consequences, such as violating public health measures, as well as causing divisiveness and political fragmentation

In the context of COVID-19 conspiracy beliefs, through a meta-review of the literature van Mulukom et al. (2022) identified several potential antecedents. Their review outlined diverse factors influencing individual susceptibility to COVID-19 conspiracy theories. These factors range from personal traits, such as intolerance to uncertainty and personality profiles, to broader demographic and social influences, including education and group identity dynamics. Key psychological traits like a low tolerance of ambiguity and a preference for intuitive over analytical thinking have been linked to higher susceptibility. Additionally, the study highlights the pivotal role of attitudes towards science, where distrust and low scientific literacy correlate with stronger belief in conspiracies. Social dimensions, particularly the influence of social media and trust in authorities, also significantly affect the endorsement and spread of misinformation. Understanding these multifaceted drivers is crucial for developing targeted interventions to counteract conspiracy theories effectively during the pandemic.

The Present Study

The aim of the present study is to test the relation between virus conspiracy beliefs and individual- and country-level variables. These variables were derived from Eurobarometer 95.2, aimed to measure "European citizens' knowledge and attitudes toward science and technology" (European Commission, 2021). The variables include some items that we expected to act as proxies for virus conspiracy beliefs and its antecedents as mentioned in the previous lines. The main analysis in this study was conducted using a nested regression model and multilevel modeling approach.

Methodology

Multilevel modeling is a statistical method that accounts for data with individual and group level structures, where observations are grouped within different levels. It allows researchers to consider both within-group and between-group variations, providing insights into how individual-level factors interact with group-level influences. A key aspect of the analysis is the comparison of two explanations for the observed country differences. Traditional multiple regression techniques treat units of analysis as independent observations, which can lead to underestimated standard errors and overstated statistical significance when hierarchical structures are not recognized. Multilevel models, however, can correctly estimate the effects of individual- and group-level variables. By using a multilevel modeling approach, we aimed to disentangle the effects of individual-level and country-level factors on virus conspiracy beliefs. This approach allows for a more accurate understanding of the complex relationships among variables, as it considers the potential influence of multiple levels of factors on the data being studied.

Sample

We used the data collected by the Eurobarometer 95.2 survey which is particularly valuable for investigating virus conspiracy beliefs because it was conducted during the COVID-19 pandemic, making it highly representative of the current context. It was carried out in 39 countries, including the 27 EU member states, candidate countries, and other European nations, provides a comprehensive dataset that captures the prevalence and determinants of virus conspiracy beliefs across a diverse range of populations. The timing of the survey is crucial, as it allows examining the factors associated with the emergence and spread of virus conspiracy theories during a global health crisis. The survey's extensive geographical coverage enables cross-national comparisons, shedding light on the context-dependent nature of conspiracy beliefs and their antecedent. In summary, the Eurobarometer 95.2 survey's representative sample, large sample size, and extensive coverage of relevant items make it an invaluable resource for investigating the factors that shape the emergence and spread of virus conspiracy theories across EU populations.

Variables

The dependent variable in this study is the response to the item "Viruses have been produced in government laboratories to control our freedom," (1: True; 2: False; correct answer) which serves as a proxy for virus conspiracy beliefs. While a similar study by Boer and Aiking (2024) constructed a summated index of "conspiratorial anti-science" (CAS) by combining this item with another statement about cancer cures being hidden

by commercial interests, we have concerns regarding the use of such an integrated index as mentioned before.

It is crucial to recognize that the factors influencing an individual's belief in conspiracy theories may vary depending on the specific domain of the conspiracy. People may have distinct motivations for subscribing to one conspiracy theory over another. For instance, the factors driving belief in a conspiracy about the origin of viruses may differ from those underlying belief in a conspiracy about hidden cancer cures. This is supported by the moderate correlation of 0.42 between the two items. This correlation may not be strong enough to assume that these items are measuring the same underlying construct. A latent variable, such as CAS, should be represented by a set of indicators that comprehensively capture the construct's breadth. With only two indicators, the latent variable may not be adequately represented, as the indicators may not cover the full range of CAS (for example, climate change item was not included in the construction of CAS, as it is very weakly correlated with these items. This raises concerns about the ad hoc selection of the items for the index construction). Moreover, indicators are often imperfect measures of the latent construct, and there is usually some degree of measurement error associated with each indicator. When using only two indicators, the impact of measurement error on the latent variable estimate may be more pronounced. This is because there are fewer indicators to "average out" the errors, which can lead to less precise estimates of the latent variable. .In summary, almost weak correlation between the two conspiracy belief items and the limited number of indicators suggest that constructing a single CAS index may not be the most appropriate approach.

By focusing on a single item specifically related to virus conspiracy beliefs, this study aims to capture the unique factors associated with this particular domain of conspiratorial thinking. This approach allows for a more targeted investigation of the psychological, social, and contextual factors that shape the acceptance of virus-related conspiracy theories during the COVID-19 pandemic. Furthermore, using a single item as the dependent variable reduces the potential for confounding effects that may arise from combining multiple conspiracy beliefs into a single index. By examining virus conspiracy beliefs in isolation, the study can provide clearer insights into the specific determinants of this type of conspiratorial thinking and its potential impact on public health responses during the pandemic.

Independent variables

Coping with uncertainty and threat: As previously discussed, the concept of a general conspiracy mentality is considered a common underlying factor in explaining belief in various conspiracy theories. As a proxy for this construct, we used the item: "*Our lives are threatened by organized crime and terrorism, from which we urgently need to protect ourselves*."

Thinking styles and cognitive biases: Individuals who have lower scientific knowledge are less able to distinguish between true and false information. As a proxy we used a summated index of science knowledge quiz items such as "*Antibiotics kill viruses as well as bacteria*."

Moderators

Attitudes towards science: Higher positive attitudes towards science is associated with fewer unfounded beliefs. As a proxy, we selected the item: **"***We depend too much on science and not enough on faith*."

Mother's education: Mother's education significantly impacts parenting practices and interactions with their children, shaping childhood formation, which in turn can influence an adult's approach to complex societal issues like virus conspiracy theories (VCT).

Control variables

In addition to these items, we have included several socio-demographic variables as control variables. These include, age, gender, education, religiosity, left-right orientation, social class and life satisfaction. Besides these socio-demographic variables, we have also included using online social networks and blogs (e.g. video hosting websites) as the main source of information.

Results

We tested two hypotheses about the effects of the antecedent variables on VCB.

> **Hypothesis 1a: The effects of "coping with uncertainty and threat" and "esteeming science more than faith" and their interaction on VCB. As the level of "coping with uncertainty and threat" increases VCB would decrease. As the level of "esteeming science more than faith" increases VCB would decrease. A significant interaction effect is expected.**

> **Hypothesis 1b: The effects are dependent on the country context.**

As discussed earlier, many studies identified coping with uncertainty as a main antecedent of VCB. In this study, we contribute to this mainstream thesis by adding and testing the moderating effect of valuing science more than faith.

When faced with the uncertainty and existential anxiety caused by the COVID-19 pandemic, some individuals may turn to their faith as a way to cope. By placing more value on faith than science, they may find comfort and meaning in religious or spiritual explanations rather than scientific ones, making them more susceptible to conspiracy theories that align with their faith-based worldview. Moreover, people who value faith more than science may be more prone to confirmation bias, seeking out information that supports their existing beliefs while dismissing contradictory evidence. When confronted with uncertainty and threat, they may selectively attend to conspiracy theories that confirm their faith-based perspective. Lastly, faith-based beliefs can be deeply ingrained and resistant to change, even when presented with contradictory evidence. Individuals who strongly value faith may cling to their beliefs during the pandemic and be more likely to embrace conspiracy theories that provide a sense of certainty and control.

Hierarchical regression

Stepwise, the following models were tested: Null model[1] that only includes the intercept (no predictors); next, we added socio-demographic variables as control variables; then we added the independent variable (threatened by uncertainty) and social media as main source of information; finally, we added the interaction between the IV and the moderator (faith vs science). Analysis of Variance for the models shows that each model significantly improves the fit compared to the previous, more constrained model, confirming the interaction effect.

An interesting finding is a counter-evidence against the mainstream hypothesis that being threatened by uncertainty is the major cause of conspiracy belief. While the effect is significant in the standalone model 3, it becomes insignificant when the significant interaction is added (Table 1). When we check the interaction lines, for the line representing -1 standard deviation below the mean of the faith vs science, the slope is almost flat, indicating that for those people who esteem faith more than science, threatened by uncertainty has little to no effect on the VCB (Figure 1). Conversely, the line for +1 standard deviation above the mean shows a sharply declining slope, suggesting that the dependent variable significantly decreases when the moderator is high, that is, for those people who esteem science more, not endorsing VCB falls much

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[1] A null model in stepwise regression refers to the initial model that contains no predictor variables, only including the intercept. It provides a baseline against which more complex models can be compared to assess improvement in fit.

faster when feelings of unthreatened increases. This counterintuitive result suggests that even among those who generally trust science, increased existential threats or uncertainties can lead to a paradoxical increase in conspiracy beliefs. This might occur because heightened uncertainty can undermine trust in currently available scientific explanations and lead individuals to seek alternative explanations, including conspiracy theories.

Table 1. Hierarchical Regression Analysis of the Effects of Uncertainty and Esteem for Science on Virus Conspiracy Beliefs (VCB)

| Predictor	Model 1	Model 2	Model 3
Regression coefficients and standard errors			
Intercept	1.56 (0.02)**	1.69 (0.03)**	1.28 (0.03)**
Age	0.03 (0.00)**	0.03 (0.00)**	0.03 (0.00)**
Gender(2=woman)**	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)
Education	0.03 (0.00)**	0.02 (0.00)**	0.02 (0.00)**
Religiosity	-0.03 (0.00)**	-0.03 (0.00)**	-0.02 (0.00)**
Social class	0.04 (0.00)**	0.03 (0.00)**	0.03 (0.00)**
Life satisfaction	-0.10 (0.00)**	-0.09 (0.00)**	-0.09 (0.00)**
Mother's education		0.04 (0.00)**	0.04 (0.00)**
Social media		-0.11 (0.01)**	-0.09 (0.01)**
Threatened by uncertainty		-0.13 (0.01)**	-0.02 (0.02)
Faith vs Science			0.11 (0.01)**
Uncertainty:Science			-0.03 (0.01)**
Note: * p < .05, ** p < .01, *** p < .001			
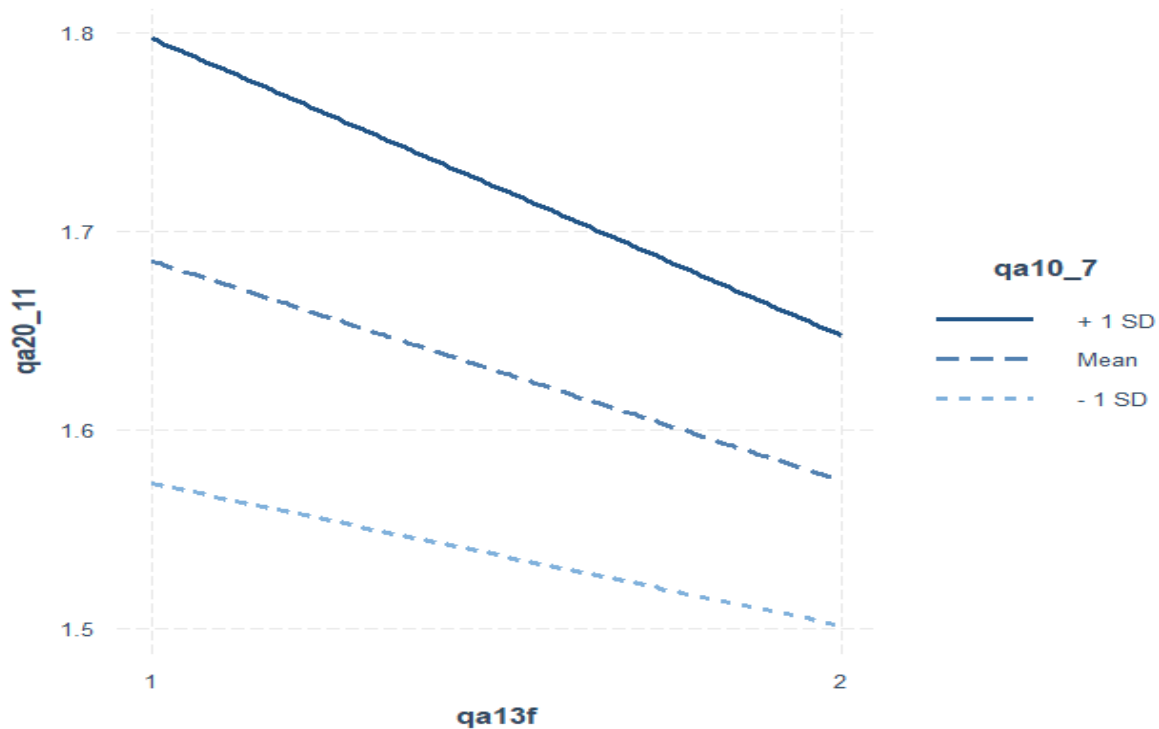
Figure 1. The Interaction plot Effects of Uncertainty (qa13f) and Esteem for Science (qa10_7) on Virus Conspiracy Beliefs (VCB, qa20_11)

Multilevel regression

However, this result is due to cross-national differences. For the multilevel regression, the significant random effects for the interaction term suggest that the relationship between threatened by uncertainty and science vs faith, varies by country, which could be important for understanding how these variables interact in different cultural or national contexts (Figure 2).
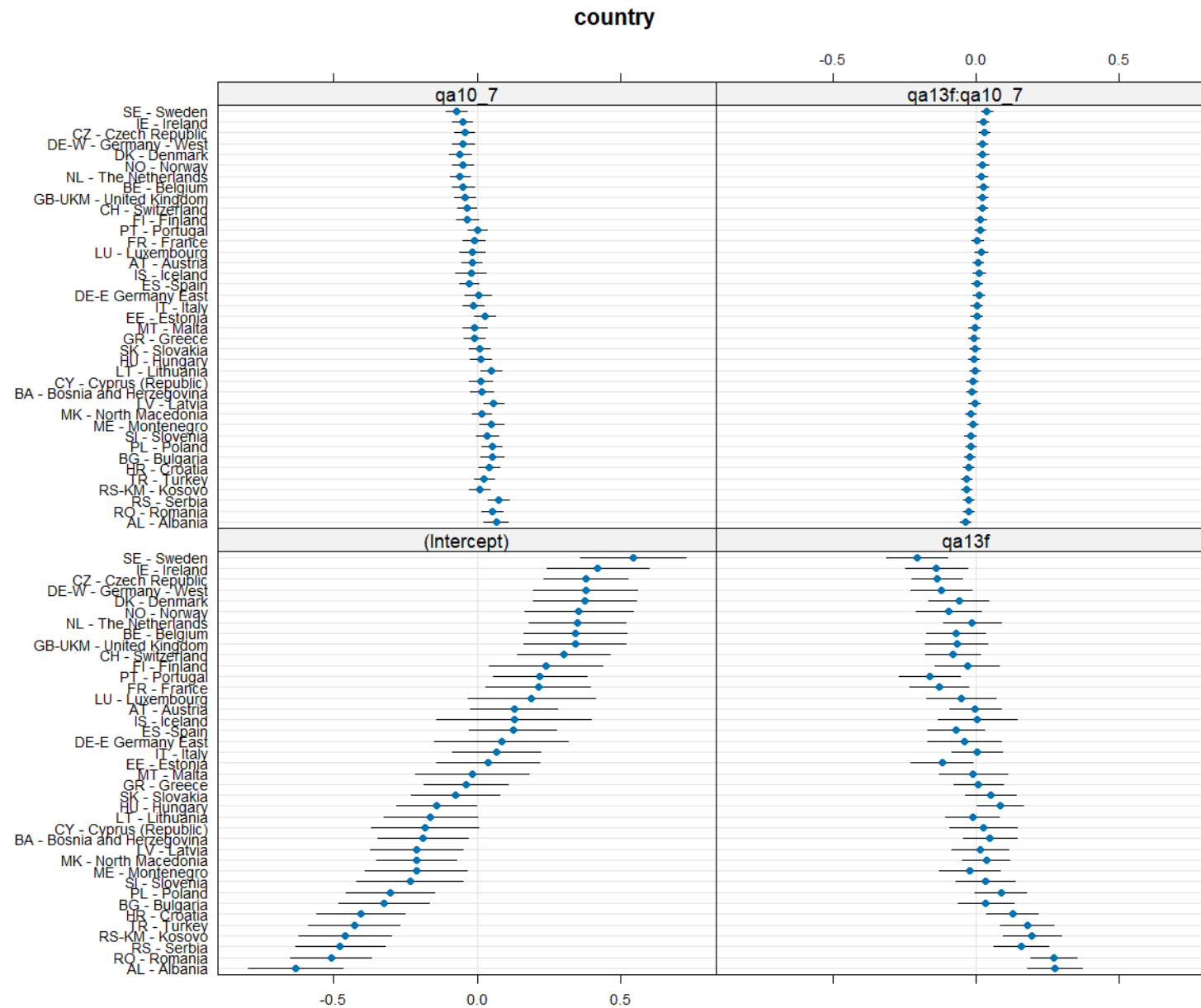
Figure 2. Multilevel regression: Country Effects of Uncertainty (qa13f) and Esteem for Science (qa10_7) on Virus Conspiracy Beliefs (VCB, qa20_11)

While the interaction effect is positive for the countries where not believing in virus conspiracy theories (VCT) is high, and feelings of being threatened by uncertainty are low, it is the reverse for the countries where the former is low and the latter is high. That is, in countries like Sweden, Czech Republic, (former) West Germany, Denmark, the Netherlands, Belgium, and France the interaction effect is positive, implying that for those who generally trust science, increased existential threats or uncertainties can lead to a paradoxical increase in conspiracy beliefs. This suggests that in these countries, higher trust in scientific approaches does not necessarily insulate individuals from the influence of conspiracy theories when faced with significant uncertainty. A common point in these countries is the rise of secular extreme right parties, which often promote nationalist and anti-establishment sentiments that can resonate during times of crisis. These parties sometimes leverage conspiracy theories to explain complex socio-political events in a simplified manner, appealing to the fears and uncertainties of the populace.

On the other hand, in countries like Albania, Romania, Serbia, Bulgaria, and Turkey, where there is a lower baseline trust in science and higher perceived threats or uncertainties, the interaction effect is negative, implying a decrease in the belief in virus conspiracy theories (VCT). This trend aligns with expectations based on the cultural and social dynamics of these countries. Here, faith or traditional beliefs may provide a framework that offers comfort and meaning, potentially mitigating the allure of conspiracy theories during uncertain times.

> **Hypothesis 2a: The effects of the level of "scientific knowledge", "familial educational background" and their interaction on VCB. We are expecting positive effects for both and significant interaction effect**

> **Hypothesis 2b: The effects are dependent on the country context.**

Common sense and research consistently imply that individuals with lower scientific knowledge are more susceptible to conspiracy theories and misinformation, possibly due to hasty reasoning processes (Landrum, 2019; Prooijen, 2017). However, this effect is not always straightforward. Susceptibility may also be influenced by factors such as belief in simple solutions, overconfidence in one's own reasoning abilities, and epistemic beliefs, which are often formed during early childhood. Mother's education plays an important role in this formation. Previous research suggests that a mother's level of education significantly influences her child's health outcomes and educational attainment (e.g. Ross & Mirowsky, 2011). The theory of resource substitution suggests that the beneficial effects of education on outcomes like analytical thinking are greater for individuals with fewer alternative resources, such as those from less educated family backgrounds. This theory can be extended to understanding VCT effects, where mother's education might play a compensatory role, enhancing resilience against misinformation

in less resourceful environments. Mothers with higher education levels are likely to foster environments that promote the acquisition of scientific knowledge and critical thinking skills.

Hierarchical regression

Besides the null and control models, we added the model with scientific knowledge as IV, and the interaction model (knowledge X mother's education). We included the mother's education as a proxy for the familial educational context. Ideally, we should include both father's and mother's education to avoid gender stereotypes. However, although it is changing for middle-class families in a few developed countries, the mother is still the main caregiver in most situations. Hence, to keep the model parsimonious and not to reduce the power of the statistical tests we used only the mother's education as a proxy for familial background. The goal is to find a balance between model complexity and explanatory power.

Analysis of Variance for the models shows that each model significantly improves the fit compared to the previous, more constrained models, confirming the interaction effect.

The results indeed provide evidence for our hypothesis, showing that the interaction effect is negatively significant, and the positive effect of knowledge increases when the interaction is added (Table 2). This suggests that while a higher level of knowledge generally reduces susceptibility to virus conspiracy theories (VCT), this effect is moderated by mother's education.

When examining the interaction effects in relation to mother's education and scientific knowledge, the analysis reveals a distinct pattern in the slopes of the regression lines.

 Specifically, for individuals whose mothers' education is one standard deviation below the mean, the slope of the regression line is steeper compared to those whose mothers' education is one standard deviation above the mean. This pattern becomes less evident at higher levels of scientific knowledge. This interaction suggests that educational interventions aimed at increasing scientific literacy might have differential impacts depending on the educational background of one's mother. It highlights the importance of tailored educational approaches that consider the familial and socio-cultural context of individuals. For those from less educated backgrounds, increasing scientific knowledge could yield significant benefits in terms of reducing susceptibility to misinformation. Conversely, for those from more educated backgrounds, interventions might need to focus more on enhancing existing knowledge and applying it critically. These findings are in line with the theory of resource substitution.

Table 2. Hierarchical Regression Analysis of the Effects of Scientific Knowledge and Mother's education on Virus Conspiracy Beliefs (VCB)

| Regression coefficients and standard errors			
Variable	**Model 1 (b, SE)**	**Model 2 (b, SE)**	**Model 3 (b, SE)**
Intercept	1.56 (0.02) ***	0.87 (0.02) ***	0.69 (0.03) ***
age	0.03 (0.00) ***	0.02 (0.00) ***	0.02 (0.00) ***
gender(2=woman)	0.00 (0.01)	0.03 (0.01) ***	0.03 (0.01) ***
education	0.03 (0.00) ***	0.01 (0.00) ***	0.01 (0.00) ***
religiosity	-0.03 (0.00) ***	-0.01 (0.00) ***	-0.01 (0.00) ***
Social class	0.04 (0.00) ***	0.03 (0.00) ***	0.02 (0.00) ***
Life satisfaction	-0.10 (0.00) ***	-0.06 (0.00) ***	-0.06 (0.00) ***
social media		-0.07 (0.01) ***	-0.07 (0.01) ***
Science knowledge		0.33 (0.00) ***	0.39 (0.01) ***
Mother's education			0.07 (0.01) ***
Know:Mother			-0.02 (0.00) *
Note: * p < .05, ** p < .01, *** p < .001			
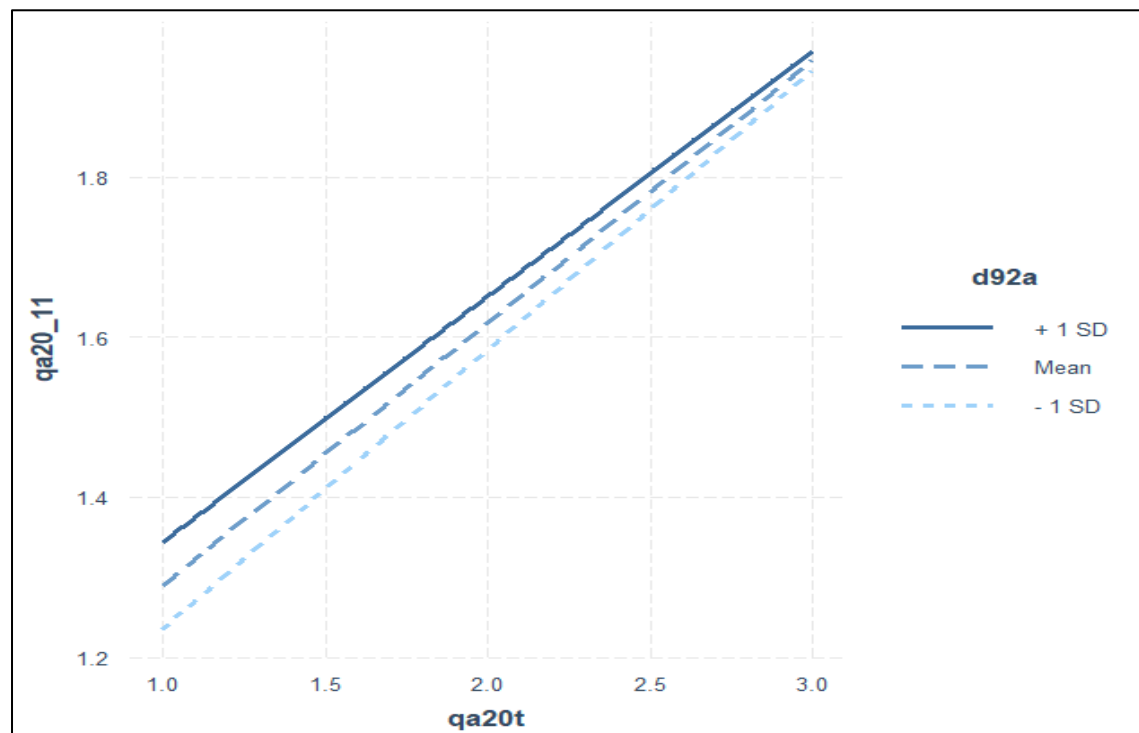
Figure 3. Interaction plot the Effects of Scientific Knowledge(qa20t) and Mother's education (d92a) on Virus Conspiracy Beliefs (VCB)

Multilevel regression

The presence of significant random effects and their correlations suggest that the model accounts for complex variability in the data, which is crucial for accurate predictions and inferences, especially in multi-country studies. For the multilevel regression, the significant random effects for the interaction term suggest that the effect of the interaction between knowledge and mother's education varies by country, which could be important for understanding how these variables interact in different cultural or national contexts (Figure 2). In more affluent countries, where human development is already high, the interaction effect between knowledge and mother's education on VCB is not significant. This could be due to a generally higher baseline of education and access to information, which might mitigate the influence of individual differences in mother's education. Conversely, in less affluent countries, this interaction effect is positively significant. This indicates that in contexts where general education levels may be lower, the educational background of a mother significantly enhances the effect of knowledge in reducing susceptibility to VCB. This could be because in these settings, the influence of a mother's education might play a more critical role in shaping an individual's perceptions and resilience against misinformation.
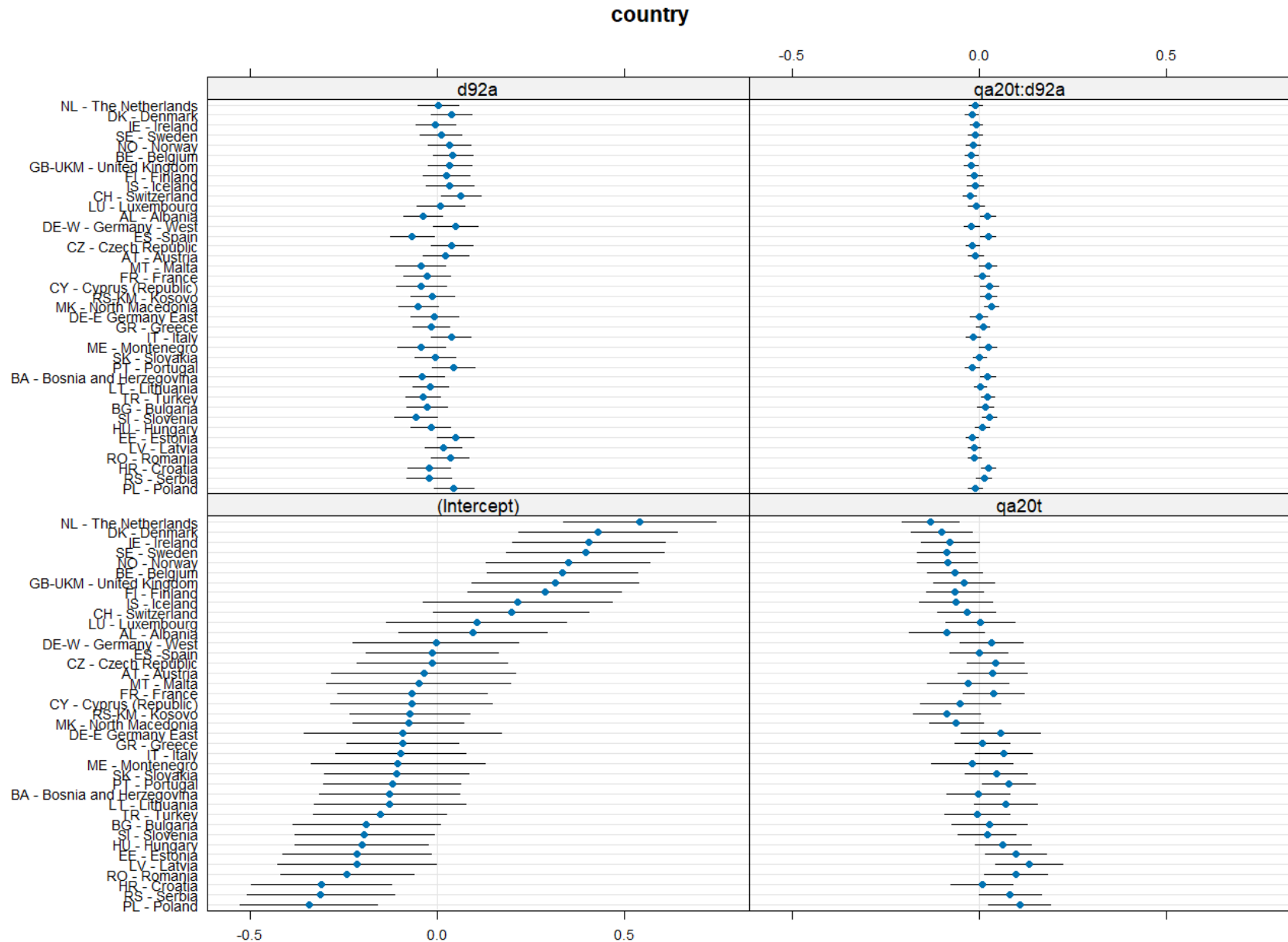
country

Figure 4. Multilevel regression: Country Effects of Scientific Knowledge(qa20t) and Mother's education (d92a) on Virus Conspiracy Beliefs (VCB)

Discussion

This study offers valuable insights into the factors that lead to conspiratorial, anti-scientific beliefs, with a particular emphasis on virus conspiracy beliefs (VCB). Gaining a deep understanding of these antecedents is essential for crafting targeted interventions that can successfully curtail the spread and influence of such beliefs. This knowledge is not only crucial for informing effective public health strategies but also has significant implications for policy-making. By addressing these underlying factors, interventions can be better designed to disrupt the cycle of misinformation and enhance public health outcomes.

The effect of the interaction between coping with uncertainty and threat and esteeming science more than faith on VCB.

The findings from this study reveal complex dynamics in how individuals' values towards faith or science influence their reactions to uncertainty and their susceptibility to conspiracy theories. For those who prioritize faith over science, uncertainty does not significantly increase conspiracy beliefs, possibly because they rely on faith or other forms of knowledge that provide stability beyond the fluctuating nature of scientific discourse. In contrast, individuals who hold science in high regard might experience a paradoxical increase in conspiracy beliefs under increased existential threats, as such uncertainties can shake their trust in current scientific explanations, prompting them to seek alternative, even conspiratorial, explanations.

Individual Level Implications

For effective science communication, it is crucial to tailor strategies to these differing value systems. For faith-oriented individuals, especially youth, partnerships with local educators and respected community figures can help integrate scientific literacy with faith-based values, debunking conspiracies. For those who value science, emphasizing the adaptability and robustness of the scientific method during crises can help maintain trust. Educational initiatives should also foster critical evaluation skills to combat misinformation and build resilience against the destabilizing effects of uncertainty.

Country Level Implications

At the country level, understanding these dynamics is vital for designing public health communications, particularly in crises like pandemics. In countries with high esteem for science, promoting critical information evaluation can generally mitigate conspiracy beliefs, but during high uncertainty, additional strategies to reinforce trust in science are

necessary. Conversely, in countries with lower scientific trust, enhancing educational frameworks to improve critical thinking and scientific literacy is crucial. Tailoring messages to the specific cultural and social contexts of different countries, and addressing how uncertainty impacts perceptions directly, can help reduce the spread of conspiracy theories.

The effect of thinking styles and cognitive biases on VCB

Individual Level Implications

The findings underscore the importance of contextualizing educational interventions within the familial and socio-cultural backgrounds of individuals to enhance scientific literacy effectively. The impact of these interventions appears to vary significantly based on the educational level of one's mother, suggesting that a one-size-fits-all approach may not be as effective. For individuals from less educated backgrounds, targeted programs aimed at building foundational scientific knowledge can be crucial in reducing susceptibility to misinformation. Conversely, for those from more educated backgrounds, the focus should shift towards enhancing critical thinking and the application of scientific knowledge. This tailored approach can ensure that educational initiatives are more directly aligned with the needs and existing knowledge bases of different demographic groups, potentially leading to more successful outcomes in combating misinformation.

Country level Implications

The findings at the country level suggest that public health campaigns and educational programs need to be tailored to the specific cultural and economic contexts of different countries. In less affluent countries, programs that focus on enhancing education at a family level, particularly targeting mothers and caregivers, could be particularly effective. Furthermore, resources for combating VCB through education and public health initiatives might be prioritized differently based on these findings. More resources might be needed in less affluent countries to address the significant interaction effects of knowledge and mother's education.

Conclusion

This study not only highlights the complex interplay between individual values toward faith or science and their susceptibility to conspiracy theories but also emphasizes the influential role of a mother's educational background in shaping responses to virus conspiracy beliefs (VCB). The research uncovers two pivotal hypotheses: first that the level of esteem for science versus faith affects how individuals cope with uncertainty and

existential threats, with those valuing faith showing less susceptibility to conspiracy theories in uncertain times, possibly due to their reliance on stable, faith-based knowledge systems. Conversely, those who highly regard science may experience an increase in conspiracy beliefs during such times as their trust in current scientific explanations falters. The second hypothesis underscores the impact of a mother's education on the effectiveness of educational interventions aimed at combating VCB. For individuals from less educated backgrounds, basic scientific education is crucial, whereas for those with more educated mothers, enhancing critical thinking and application of scientific knowledge is more pertinent. Both hypotheses stress the need for tailored approaches in both individual and country-level public health strategies to effectively mitigate misinformation and enhance overall scientific literacy and public health outcomes.

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