



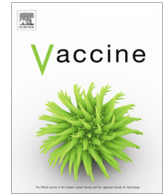
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Spirituality is associated with Covid-19 vaccination scepticism[☆]

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ABSTRACT

Vaccine scepticism poses a significant global health risk, which has again become clear during the ongoing Covid-19 pandemic. Previous research has identified spirituality as an important contributor to general vaccine scepticism. In the present manuscript, we assessed whether self-identified spirituality similarly contributes to scepticism towards Covid-19 vaccines, vaccine uptake, and indecisiveness in intention to be vaccinated. We conducted three studies online in the UK in late 2020, early 2021, and the summer 2021. In Studies 1 and 2 ($N = 585$), as expected, individuals who strongly identified as spiritual were more sceptical about Covid-19 vaccines. This association was explained by low faith in science, but not by conspiracy beliefs. Importantly, among the vaccinated participants, those who were more spiritual were more indecisive to get a Covid-19 vaccine. Using structural equation modelling (SEM), we further found that spirituality directly predicted lower likelihood of being vaccinated against Covid-19 (Study 3, $N = 456$). We also identified low science literacy as an additional predictor of Covid-19 scepticism, but not self-reported vaccine uptake. To conclude, spiritual beliefs are an important factor to consider when aiming to increase understanding of vaccine-related science scepticism and vaccination rejection.

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The most effective tool in ending the Covid-19 pandemic is vaccination. Several Covid-19 vaccines have been developed and proven to be safe and effective in generating an immune response against the virus (e.g., European Medicines Agency, 2020; UK Department of Health and Social Care, 2020; US Food and Drug Administration, 2020). Despite availability - at least in developed countries - and the enormous negative health, social, and economic impact of the pandemic, a substantial amount of people are sceptical towards Covid-19 vaccines and are unwilling to be vaccinated [3,7,19,24]. For example, 31 % of the British population was indecisive about getting a Covid-19 vaccine in mid 2021 [24], and similar rates have been noted in the US and various European countries [20,25]. Some demographic groups (e.g., younger people, and those with low income) rejected Covid-19 vaccines more than others [24]. Importantly, high levels of vaccine scepticism, especially at the beginning of vaccine rollout, might have been particularly detrimental to early mass vaccination and achieving population immunity. In the present manuscript, we define Covid-19 vaccination scepticism as a negative attitude towards Covid-19 vaccines

characterised by unwarranted beliefs, distrust, and exaggerated health risk associated with receiving a Covid-19 vaccine (e.g., worrying about their long-term effects or that their side effects outweigh the benefits) and distrust in scientists and authorities developing and approving the vaccines (e.g., thinking that Covid-19 vaccines development was rushed).

Why do so many people doubt vaccination against COVID-19? Earlier studies suggested that religiosity is one of the main roadblocks to science acceptance in general [23;25;32,29]. However, an accumulating body of literature indicates that self-identified or objectively measured *spirituality*, in particular, predicts scepticism towards vaccination [32,33,31]. While both religiosity and spirituality are belief systems associated with beliefs in supernatural agents, religious individuals follow specified practices, beliefs, and behaviours set out by a religious institution (e.g., the Catholic Church). On the other hand, spirituality has been characterised as a belief without belonging (e.g., [13] or a “privatised, experience-oriented religion” [38]). That is, spiritual individuals do not follow an organisation to guide their beliefs. Instead, they gain insights into the nature of reality by relying on personal experiences and an intuitive epistemology, which likely play an important part in

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shaping distrust towards vaccination [31]; also see [9;14]. Rutjens and van der Lee [31] argued that such an experiential approach to truth conflicts with scientific knowledge about vaccines, which is experienced by many as at least somewhat counterintuitive [36].¹ In the current work, we tested whether spirituality in a similar vein contributes to Covid-19 vaccine scepticism, indecisiveness to get vaccinated, and self-reported vaccine uptake.

Overall, research indicates that both self-identified and objectively measured spirituality predicts science scepticism in some but not other domains of science. Indeed, science scepticism is *heterogenous*—diverse predictors contribute to scepticism across different domains [30,33,31]. For example, religious orthodoxy predicts evolution scepticism but not other types of scepticism, while political orientation mainly predicts climate change scepticism. Importantly, spirituality has emerged as a consistent predictor of low general faith in science (i.e., a disbelief that science is the most reliable way to gain scientific knowledge) across cultures, an effect which was more pronounced in WEIRD (Western, Educated, Industrialized, Rich, and Democratic) than non-WEIRD countries [33]. The same cross-national study demonstrated that general vaccine scepticism was best predicted by low science literacy (i.e., poor understanding of basic concepts about science across many science domains) and high spirituality, but not religiosity (see also [1]). These findings have been further corroborated in studies conducted in the Netherlands and Greece [31,32]. Further, a study conducted in Australia demonstrated that higher beliefs in spiritual experiences as a source of knowledge also had higher levels of vaccine scepticism [1].

Altogether, building upon the growing body of evidence demonstrating that spirituality predicts vaccine scepticism, our primary prediction in the current research was that spirituality predicts scepticism towards Covid-19 vaccines. Further, based on evidence indicating that science literacy also contributes to vaccination scepticism, we hypothesised low science literacy to be an additional predictor of Covid-19 vaccination scepticism based on previous research showing that general vaccination scepticism is partially explained by low science literacy [32,31]. This prediction stems from earlier theoretical accounts of science scepticism suggesting that lack of basic science knowledge is the cause of negative attitudes towards science in general (see [27], for an overview). That is, because science is difficult to understand, people reject it. As the mechanisms behind vaccination are difficult to grasp and might seem counterintuitive, it is possible that lacking fundamental science knowledge across different scientific disciplines predicts less appreciation for a more complex science concerning Covid-19 vaccines.

Subsequently, we also explored worldview variables that could explain the link between spirituality and Covid-19 vaccine scepticism. First, as spirituality has been identified as a robust predictor of general faith in science cross-culturally [33], we tested whether the expected association between spirituality and Covid-19 vaccine scepticism might be explained by low faith in science.

Second, several lines of research point to conspiracy beliefs predicting higher vaccination scepticism [12,15,31]. Interestingly, spirituality shares some important features with conspiracy beliefs. For example, spirituality and conspiracy beliefs may co-occur as they both refer to powerful agentic entities, paranormal events, or an intricate interconnectedness between various aspects in the world [8,37]. Because of such similarities, the term *conspirituality* has been coined [40]. Although some of the characteristics concerning spirituality and conspiracy beliefs might be also attributed to religiosity, spirituality has been found to predict general

and Covid-19-specific conspiracy beliefs [8]; see also [26]. Hence, we explored whether conspiracy beliefs, beyond faith in science, could explain additional variance in Covid-19 vaccine scepticism. We tested these issues in Studies 1 and 2.

Third, it is possible that spirituality might predict behavioural outcomes, such that stronger spiritual beliefs might involve a lower likelihood to be vaccinated against Covid-19. We tested this prediction in Study 3.

1. Method

To summarise, we had three aims. First, we assessed whether spirituality predicted Covid-19 vaccination scepticism, and whether scientific literacy also contributes to such scepticism. Second, we were interested to explore whether the hypothesised association between spirituality and Covid-19 vaccination scepticism could be explained by faith in science or conspiracy beliefs. Third, we tested whether spirituality also contributes to behavioural outcomes, that is, being vaccinated against Covid-19.

To achieve these aims, we conducted three studies in which we recruited samples of British participants. Our design was cross-sectional and based on self-report measures administered online, where participants expressed their agreement with a number of statements mainly tapping into: Covid-19 vaccination scepticism, faith in science, science knowledge, conspiracy beliefs, spirituality, and demographic variables (see Table 1 and the Main Predictors section below for details). The samples were balanced in terms of age and gender to reflect the composition of the British population. In order to measure self-reported vaccine uptake, we followed up the same participants 6 months later to examine to what extent they were indecisive to get vaccinated and whether they chose to be vaccinated against Covid-19. We conducted Study 1 ($N = 296$) after the first Covid-19 vaccine was approved for rollout in the UK, whilst Study 2 ($N = 289$) was conducted two months later when two more vaccines were approved. During this time, parts of the UK were under local lockdown restrictions due to high Covid-19 infection rates.² In each study, we measured participants' scepticism towards Covid-19 vaccines. We also measured faith in science (Studies 1 and 2) and conspiracy beliefs (Study 2) to test whether these variables would explain the hypothesised link between spirituality and Covid-19 vaccines scepticism. We then examined a range of potential predictors of Covid-19 vaccine scepticism, including science literacy, religiosity, religious orthodoxy, and political orientation, as well as demographic variables, such as gender, age, and education. Additionally, in Study 2, we also assessed participants' subjective science knowledge, and scientific reasoning skills as other potential predictors of Covid-19 vaccine scepticism. Further, we conducted Study 3 at the end of August 2021, as by this time the majority of people in the UK had had a chance to receive a Covid-19 vaccine. We followed up on participants from Studies 1 and 2 and asked them whether they received their vaccination and to what extent they hesitated in their decision to get vaccinated against Covid-19 (we only asked this question to vaccinated participants). In this question, we use the word *hesitancy* to refer to indecisiveness, rather than reluctance or refusal to vaccinate. To avoid conceptual confusion with vaccine hesitancy as defined by WHO, we refer to this type of hesitancy as indecisiveness.

1.1. Participants

We recruited 303 participants in Study 1 and 297 participants to Study 2 through Prolific, an online recruitment platform. We

¹ Shtulman suggests that intuitive theories of illness are grounded in people's behaviours rather than in the notion that they illness is caused by microbes. As a consequence, the notion of injecting dead or weakened strains of virus into the body to provide immunity strikes people as counterintuitive.

² See <https://www.gov.uk/government/speeches/prime-ministers-statement-on-coronavirus-Covid-19-19-December-2020>.

Table 1
Samples' Characteristics Recruited in Studies 1 and 2.

| Predictors | Study 1 (N = 296) | Study 2 (N = 289) |
|---|--|--|
| Age (years) | M = 47.91 (SD = 17.40), range: 19–83 | M = 47.03 (SD = 17.27), range: 18–79 |
| Gender | Women: 149, Men: 147 | Women: 146, Men: 143 |
| Formal Education (years) | M = 15.50 (SD = 3.81) | M = 15.44 (SD = 3.70) |
| Subjective Science Knowledge | NA | M = 4.13 (SD = 1.36) |
| Scientific Reasoning Skills | NA | M = 6.84 (SD = 2.40) |
| Science Literacy | M = 12.01 (SD = 1.62) | M = 10.43 (SD = 2.61) |
| Subjective Socio-economic status | M = 5.34 (SD = 1.51) | M = 5.45 (SD = 1.56) |
| Science Training (yes/no) | No: 239, Yes: 57 | No: 234, Yes: 55 |
| Political Orientation | M = 3.46 (SD = 1.20) | M = 4.66 (SD = 1.80) |
| Religiosity | M = 2.30 (SD = 1.61) | M = 2.31 (SD = 1.76) |
| Religious Orthodoxy | M = 2.29 (SD = 1.62) | M = 2.20 (SD = 1.71) |
| Spirituality | M = 2.64 (SD = 1.53) | M = 2.77 (SD = 1.77) |
| Covid-19 Knowledge Test | M = 3.25 (SD = 0.89) | M = 3.30 (SD = 0.84) |
| Positive Covid-19 Test | Yes: 7, No: 289 | Yes: 17, No: 272 |
| Conspiracy Belief | NA | M = 4.79 (SD = 2.12) |
| Faith in Science | M = 4.96 (SD = 1.22) | M = 5.10 (SD = 1.35) |
| Outcome variables | | |
| Covid-19 Vaccine Scepticism | M = 2.82 (SD = 1.24) | M = 2.57 (SD = 1.27) |
| Covid-19 Vaccine Uptake (measured in Study 3) | Vaccinated: 92 % | Vaccinated: 88 % |
| Covid-19 Vaccine Indecisiveness (measured in Study 3) | M = 1.75 (SD = 1.41) | M = 1.53 (SD = 1.26) |

excluded participants who failed attention checks, such that the total sample size was 296 in Study 1 and 289 in Study 2. All participants were British nationals residing in the UK. We based these sample sizes on research indicating that correlations stabilise at samples comprising of 250 participants [35]. We increased the sample sizes to around 300 to compensate for potential data loss. We also recruited slightly larger samples such that they would reflect representative quotas to the UK population based on gender and age. Samples' characteristics are presented in Table 1. Participants received £0.86 for their participation. Both studies received ethics approval (Study 1: 2020-SP-12782; Study 2: 2020-SP-12942).

Further, we conducted Study 3, where recruited 456 participants who had previously participated in Studies 1 & 2 (N = 233 from Study 1; N = 223 from Study 2). The study was approved by the ethics committee (2021-SP-13855). Overall, 408 participants reported that they had received their Covid-19 vaccine, 2 had an underlying health condition and could not receive it (we excluded these participants from the analysis), whilst 46 participants chose not to be vaccinated.

1.2. Materials and procedure

All materials are presented in Supplemental Appendix A. We conducted Study 1 on December 11th, 2020, just after the first vaccine rollout in the UK (8th December 2020), and Study 2 on February 9th, 2021.³ At the time we conducted Study 2, 2 additional vaccines were approved. Across both studies, participants were asked to answer a series of questions online via Qualtrics software (Qualtrics, Provo, UT). Across most measures, participants indicated their answers on a scale (1 = *Strongly disagree*, 7 = *Strongly agree*), unless otherwise stated. The studies took 12 min to complete. Study 3 was conducted between 25th August and 14th September 2021.

1.3. Main predictors

1.3.1. Scepticism towards Covid-19 vaccines

We adapted 10 items to measure scepticism towards Covid-19 vaccines based on Lewandowsky's et al. [18] vaccination scepticism scale (e.g., "I believe that a Covid-19 vaccine will have negative side effects that outweigh the benefits of vaccination" or "The risk of a Covid-19 vaccine to maim and kill people outweighs its health benefits"). The meaning of the items across both studies was the same, however, in Study 2, we adapted the items phrasing to reflect the circumstances associated with the vaccines' approval at the time (more than one vaccine was approved for rollout). The examples of items in Study 2 are: "Covid-19 vaccines have been thoroughly tested in the laboratory. They wouldn't have been made available to the public unless they were known to be safe (reversed)" or "I believe that the development of Covid-19 vaccines has been rushed, so that the vaccines are not safe to the public" All Covid-19 scepticism items used in Studies 1 and 2 are presented in Online Supplemental Materials. Both scales were reliable (Study 1: $\alpha = 0.90$, Study 2: $\alpha = 0.91$). In Study 1, a factor analysis identified that the last item "I worry that Covid-19 vaccines will be ineffective in the long run" loaded to a lower extent onto the only identified component in comparison to the other items ($r = 0.20$), whilst in Study 2, the same item loaded onto a separate component. As this item conceptually represents what can be termed as reasonable scepticism towards vaccination, we removed this item from the analyses.

1.3.2. Faith in science

To measure faith in science we used 5 items from Rutjens et al. [30], for example: "The scientific method is the only reliable path to knowledge", "The only real kind of knowledge we can have is scientific knowledge" (all studies included this measure: Study 1: $\alpha = 0.85$, Study 2: $\alpha = 0.89$).

1.3.3. Covid-19 Knowledge Test

Participants completed a four-item multiple-choice test about facts associated with Covid-19. These items were taken from Calvillo et al. [2]. Examples include "According to the World Health Organization, what is the most common incubation period for Covid-19?" and "The most common Covid-19 symptoms are...".

1.3.4. Science literacy test

Participants indicated whether a series of statements (e.g., The centre of Earth is very hot) about science were true or false (the option "I don't know" was included in Study 2). We adapted the test from Hayes & Tariq [10], Kahan et al. [16], and Rutjens et al. [30]. In addition to the original items, we expanded the test and included the following statements: "The continents on which we live have been moving their location for millions of years and will continue to move in the future", "The oxygen we breathe comes from plants", "The earliest humans lived at the same time as the dinosaurs". All the statements with true/false items are included in Online Supplemental Materials (all studies included this measure).

1.3.5. Political orientation

We asked participants to indicate the extent to which they considered themselves left- or right-wing from 1 (*Left-wing*) to 10 (*Right-wing*) and progressive from 1 (*Very progressive*) to 10 (*Very conservative*). As the variables were highly correlated, we collapsed them, Study 1: $r = 0.72$, Study 2: $r = 0.74$, Study 3: $r = 0.76$.

³ See <https://www.bbc.co.uk/news/health-55274833>.

1.3.6. Religiosity

We asked participants to indicate how religious they were on a scale from 1 (*not religious at all*) to 7 (*very religious*). All studies included this item.

1.3.7. Religious Orthodoxy

We asked participants to express their agreement with two questions: “God has been defined for once and for all and therefore is immutable” and “Religion is the one thing that gives meaning to life in all its aspects” (Study 1: $r = 0.81$, Study 2: $r = 0.83$, Study 3: $r = 0.71$; adapted from Fontaine et al. [6] and Rutjens et al. [30]).

1.3.8. Self-identified spirituality

As spirituality is defined in the literature as a privatised, and experience-oriented religion suggesting that people might have their own individual definitions of their spiritual beliefs, we used a measure of self-identified spirituality, instead of an objective measure, in order to capture a diverse group of spiritual individuals. Participants were asked to indicate on a scale from 1 (*not at all*) to 7 (*very much*) whether they considered themselves as spiritual and whether other people considered them as spiritual (Study 1: $r = 0.85$; Study 2: $r = 0.90$, Study 3: $r = 0.85$; [30]).

1.3.9. Demographics

We asked participants to report age, gender, religious denomination, years of formal education, subjective social-economic status, and whether they had science training (yes/no). We also asked participants whether they tested positive for Covid-19 at some point (yes/no), but we did not include this as a predictor in the analysis, as the majority reported they did not test positive (see Table 1).

1.3.10. Scientific reasoning scale

Participants read 11 scenarios about scientific processes and indicated whether they were true or false (they could also select “I don’t know”), adapted from Drummond and Fischhoff [4], e.g., A researcher finds that American states with larger parks have fewer endangered species. True or False? These data show that increasing the size of American state parks will reduce the number of endangered species (only Study 2 included this measure).

1.3.11. Subjective science knowledge

Participants indicated to what extent they considered themselves knowledgeable about science (one item; only Study 2 included this measure).

1.3.12. Belief in conspiracy theories

We used one item to measure participants’ belief in conspiracy theories based on a well-validated measure by Lantian et al. [17]. Participants indicated whether a statement suggesting that the official version of some events (e.g., 09/11 attacks) “could be an attempt to hide the truth from the public” on a scale from 1 (*Completely false*) to 9 (*Completely true*). Only Study 2 included this measure.

Across Studies 1 and 2 we also included other measures that are not discussed in the present manuscript (i.e., intention to be vaccinated against Covid-19, general vaccine scepticism, Covid-19 prevention measures scepticism, Covid-19 conspiracy beliefs, and intentions to comply with Covid-19 prevention measures).

1.3.13. Vaccination indecisiveness and uptake

In Study 3, we asked participants to indicate to what extent they hesitated to get a Covid-19 vaccine on a scale from 1 (*Not at all*) to 7 (*A lot*) and whether they were fully vaccinated against Covid-19 or not. Participants also had an option to indicate that they did not receive a vaccine due to underlying health conditions.

Two participants indicated having underlying health conditions and hence were removed from the analysis. We included other measures that are beyond the scope of the present manuscript, and hence are not discussed further.

2. Analytical strategy

To provide robust evidence for our predictions, we used two types of analysis. First, we estimated hierarchical regressions to test whether spirituality predicted Covid-19 vaccination scepticism, controlling for worldview and demographic variables, and whether the effect of spirituality would be reduced when faith in science and conspiracy thinking were introduced into the models. Second, to obtain direct evidence for the potential mediating role of faith in science in the relationship between spirituality and Covid-19 vaccine scepticism, we estimated structural equation models (SEM). We tested the direct and indirect mediation between spirituality and Covid-19 vaccination scepticism via faith in science. Finally, we explored whether spirituality predicted whether participants were indecisive to be vaccinated against Covid-19 and whether they got vaccinated directly and indirectly (controlling for ideological/worldview and demographic variables) via faith in science and Covid-19 vaccination scepticism. We tested this by estimating hierarchical regressions and SEM.

All anonymised data files and analyses code are available on Open Science Framework: https://osf.io/753bt/?view_only=d69940a9175344eeb1ee989d52b93399.

3. Results

3.1. Studies 1 & 2: Covid-19 vaccine scepticism

3.1.1. Study 1

A summary of the results is presented in Table 2. As hypothesised, we found that higher spirituality and low science literacy significantly predicted higher Covid-19 vaccine scepticism (Supplementary Table 3, Step 1). We then entered faith in science as a predictor (Supplementary Table 3, Step 2). This analysis indicated that faith in science was the strongest predictor of vaccine scepticism, while spirituality was no longer significantly associated with scepticism. Further, partial correlations revealed that the relative importance of spirituality in predicting scepticism decreased when faith in science was introduced into the model (Step 1: partial $r = 0.13$; Step 2: partial $r = 0.05$). These analyses suggest that faith in science partially explained the relationship between spirituality and Covid-19 vaccine scepticism.

3.1.2. Study 2

We applied the same strategy as in Study 1. We first conducted a hierarchical regression analysis (see Supplementary Table 4, Steps 1–2). Supporting our hypothesis and results from Study 2, we found that higher spirituality and low science literacy significantly predicted higher Covid-19 vaccine scepticism. Further, as in Study 1, faith in science partially explained the relationship between spirituality and Covid-19 vaccine scepticism (partial correlations in Step 1: partial $r = 0.13$; Step 2: partial $r = 0.05$). We found no evidence for conspiracy beliefs to have additional explanatory power in the link between spirituality and scepticism (see Supplementary Table 4, Step 3; partial correlations: Step 1: partial $r = 0.13$; Step 2: partial $r = 0.06$, Step 3: partial $r = 0.05$).⁴

⁴ When only conspiracy beliefs were introduced in Step 2 (without faith in science), spirituality marginally predicted vaccine scepticism (partial correlations: Step 1: $r = 0.13$, Step 2: $r = 0.10$).

Table 2
Hierarchical Regression Results Across Studies 1 and 2 (Significant Predictors Only).

| Outcome | Study 1 | | Study 2 | | |
|-----------------------------|--|--|--|---|--|
| | Step 1 | Step 2 | Step 1 | Step 2 | Step 3 |
| Covid-19 Vaccine Scepticism | +Spirituality –Age –SES –Science Literacy | –Faith in Science –Age –SES –Science Literacy | +Spirituality +Religious Orthodoxy –Age –SES –Science Literacy | –Faith in Science –Age –SES +Religious Orthodoxy –Religiosity | +Conspiracy Beliefs –Faith in Science –SES +Religious Orthodoxy |

Note: – indicates a negative predictor, whilst + indicates a positive predictor.

Overall, across Studies 1 and 2, we supported the hypotheses by demonstrating that spirituality contributed to higher Covid-19 scepticism. We then found that this relationship was likely explained by faith in science (Studies 1 and 2), but not conspiracy beliefs (Study 2).

4. Establishing the mediating role of faith in science using SEM

In Study 1, as a first step, we tested the direct effect of the predictor (spirituality) on the dependent variable (Covid-19 vaccination scepticism) without the mediator. Then, we tested the direct effect of the mediator (faith in science) on Covid-19 vaccination scepticism. We found that the full mediation model (see Fig. 1) had a better fit than the partially mediated model (see Supplemental Appendix B: Study 1 Mediation Models). Additionally, we tested alternative models as recommended by Danner et al. (2015) [41]. The results are presented in Supplemental Table 1 and supported the conclusion from the regression analyses.

Supporting the results from Study 1, in Study 2, we found the full mediation model (see Fig. 2) had the best fit and was conceptually more meaningful compared to the partial mediation model and to the alternative models (see Supplemental Appendix B: Study 2 Mediation Models and Supplemental Table 2).

To summarise, the SEM results converge with our previous analyses, suggesting a unique association among spirituality, faith in science, and Covid-19 vaccine scepticism. Also, although experimental data are needed, the current evidence suggest that faith in science helps explain the relation between spirituality and Covid-19 vaccine scepticism.

5. Study 3: Vaccination intentions and Covid-19 vaccine uptake

In Study 3, we investigated behavioural intentions concerning Covid-19 vaccines as well as self-reported uptake of these vaccines. First, we present data associated with the extent to which participants were indecisive to get vaccinated. Second, we discuss vaccine uptake.

5.0.1. Covid-19 vaccine indecisiveness

Moving beyond attitudes towards Covid-19 vaccines, we subsequently examined the contribution of spirituality to being indecisive about getting Covid-19 vaccination. We combined the data from Studies 1 and 2 where we measured demographics and ideological/worldview variables. We used these variables as predictors of vaccine indecisiveness, which we measured in a follow-up study (Study 3). We estimated a multilevel hierarchical regression with intercepts varying across studies.⁵ First, we entered spirituality and the control variables (ideology/worldviews and demographics) in Step 1. We subsequently included faith in science in Step 2, and

⁵ This is because we combined our data from Studies 1 & 2. Note that only participants who reported being vaccinated answered the question about indecisiveness.

Covid-19 vaccination scepticism in Step 3. The results are presented in Supplemental Table 5. As expected, we found that higher spirituality significantly predicted more indecision to get Covid-19 vaccination (Supplemental Table 5, Step 1).

We found that when faith in science was included in the model, it significantly predicted indecisiveness, such that low faith in science was associated with high indecisiveness, whilst spirituality was no longer a significant predictor (Supplemental Table 5, Step 2; partial correlations: Step 1: $r = 0.10$; Step 2: $r = 0.07$). In Step 3, we found that vaccine scepticism was the strongest predictor of vaccine indecisiveness with faith in science no longer explaining variance in indecisiveness (see Supplemental Table 5, Step 3; partial correlations: Step 1: $r = -0.21$; Step 2: $r = -0.04$).

5.0.2. Covid-19 vaccine uptake

Finally, we tested whether Covid-19 vaccine uptake was also predicted by spirituality. To test this, we estimated a multilevel hierarchical logistic regression with vaccine uptake an outcome (1 – vaccinated, 0 – unvaccinated). We used the same predictors in each step as for the vaccine indecisiveness analysis. We found that spirituality did not predict vaccine uptake (see Supplemental Table 6, Step 1). Further, in Step 2, we found that higher faith in science was associated with significantly higher likelihood of being vaccinated, whilst Step 3 revealed that vaccine scepticism was the strongest predictor of vaccine uptake, with the other predictors no longer contributing to it.

Overall, while spirituality was an important predictor of Covid-19 vaccine indecisiveness among the vaccinated participants, we did not find evidence for spirituality to contribute to Covid-19 vaccine uptake.

6. Study 3: Vaccination intentions and Uptake: SEM analysis

To shed additional light onto the previously found effects and provide an overall picture of the associations among spirituality, faith in science, scepticism, and behavioural intentions and outcomes, we estimated two SEM models. We examined whether spirituality predicted Covid-19 vaccine behavioural outcomes by combining the data and predictors from all studies.⁶

6.1. Covid-19 vaccine indecisiveness

We estimated SEM models using combined data across Studies 1–3 (see Appendix B for measurement models fit indices). In this model, we first specified mediation paths, whereby spirituality was entered as a predictor of vaccine scepticism via faith in science, controlling for ideology/worldview and demographic variables. Second, in the same model, we tested for predictors of Covid-19 vaccine indecisiveness by including a direct path for spirituality

⁶ As the hierarchical regression analyses suggested that the study context did not explain significant amounts of variability in the dependent variables (as indicated by ICCs), we did not conduct multilevel analyses.

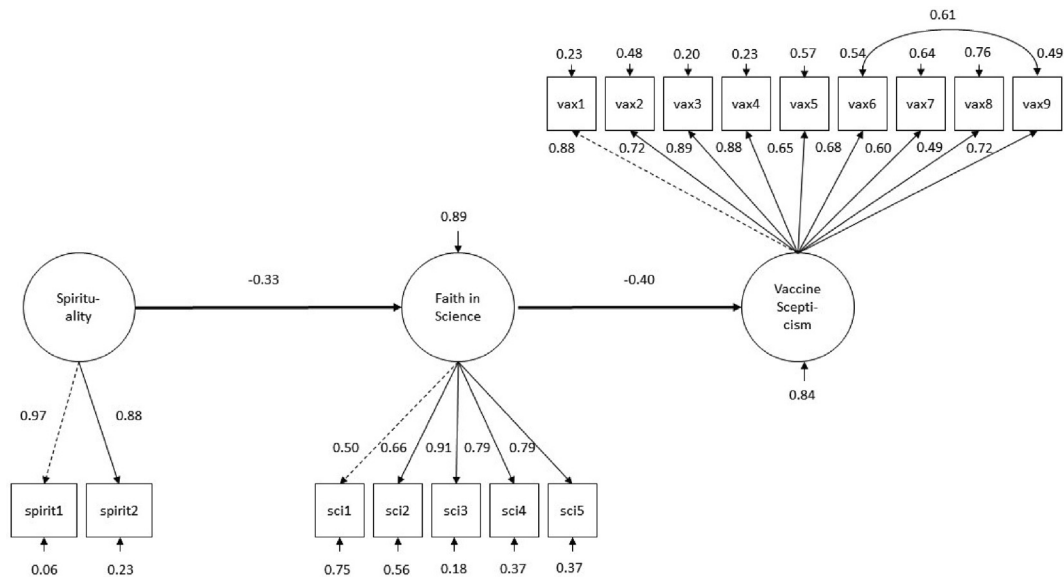


Fig. 1. Standardised Estimates for the Fully Mediated Structural Equation Model of Study 1. Note. Thin lines represent the measurement model, and structural components of the model are displayed with bold lines.

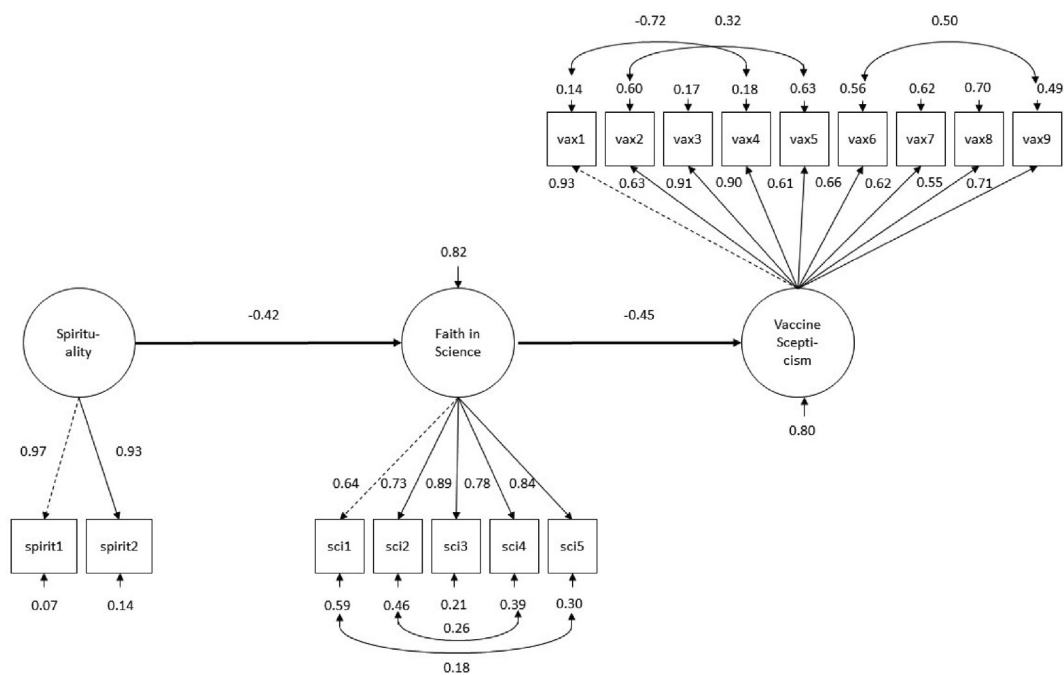


Fig. 2. Standardised Estimates for the Fully Mediated Structural Equation Model of Study 2. Note. Thin lines represent the measurement model, and structural components of the model are displayed with bold lines.

(i.e., excluding faith in science and Covid-19 vaccine scepticism) and an indirect path (i.e., including faith in science and Covid-19 vaccine scepticism) in another model controlling for ideology/worldviews and demographic variables. The results are presented in Fig. 3a-b (see Supplemental Appendix C for details).

6.2. Covid-19 vaccine uptake

Finally, we estimated similar models including mediation between spirituality and vaccination scepticism via faith in science, controlling for worldview/demographic variables, and additional paths whereby spirituality was entered as a direct and indirect predictor of Covid-19 vaccine uptake with control vari-

ables included. The results are presented in Fig. 4a-b (see Supplemental Appendix C for details).

6.3. Summary

We found support for the previous regression and SEM analyses suggesting that spirituality contributes to vaccine scepticism via faith in science, controlling for worldviews and demographics. Importantly, we showed that vaccine scepticism directly predicts higher indecisiveness about getting vaccinated among vaccinated participants.⁷ However, this association is not significant when faith

⁷ The model fit indices suggested that this model showed a poorer fit for the data as compared to standard cut-off indices.

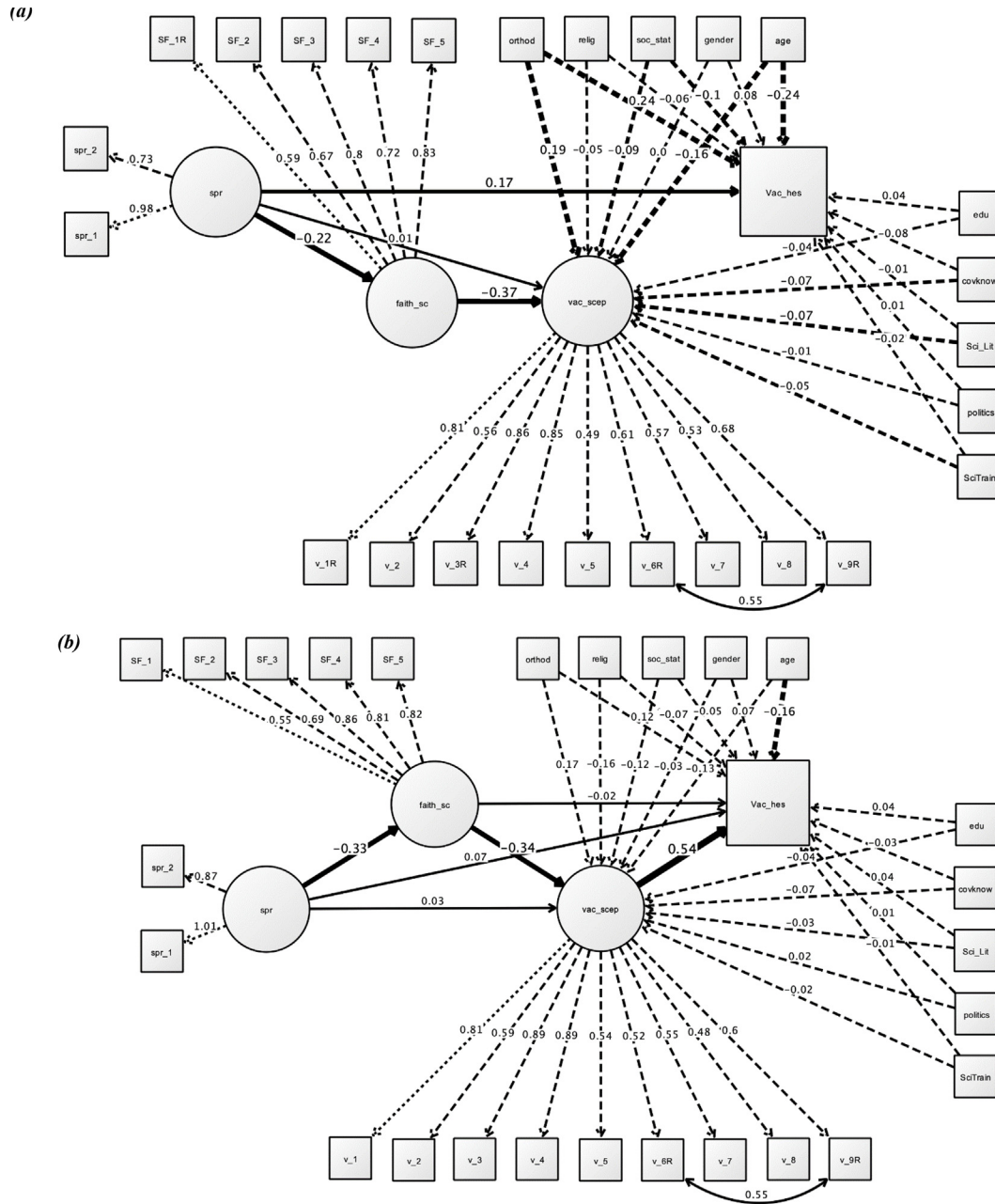


Fig. 3. Standardised Estimates for Model Including the Fully Mediated Structural Equation Model (Spirituality, Faith in Science, and Covid-19 Vaccination Scepticism) and Spirituality Directly (a) and Indirectly (b) Predicting Covid-19 Vaccine Indecisiveness.

in science and Covid-19 vaccine scepticism are included, suggesting that the link between spirituality and indecisiveness can be explained by low faith in science and high Covid-19 vaccine scepticism. Finally, we found evidence for a direct effect of spirituality on the likelihood of being vaccinated against Covid-19, with highly spiritual individuals being less likely to get vaccinated. Again, our further analyses indicated that this link is likely explained by low faith in science and increased Covid-19 vaccine scepticism.

7. Discussion

Vaccine rejection poses a significant threat to public health. This has been made even more salient during the Covid-19 pandemic. As the pandemic unfolded, many people across the globe became

sceptical about Covid-19 vaccines [26;39]. Previous research identified spirituality as an important predictor of scepticism towards vaccination in general [31]. In the current research, we aimed at assessing whether self-identified spirituality was also a relevant antecedent of scepticism towards Covid-19 vaccines and behavioural responses to these vaccines, i.e., indecisiveness to be vaccinated and vaccine uptake. Using samples of the British population balanced in age and gender, across two studies, we supported our predictions. We found that self-reported spirituality was indeed predictive of higher scepticism towards Covid-19 vaccines. Further, as hypothesised, low science literacy also contributed to such scepticism, independently of spirituality.

Using hierarchical regressions combined with structural equation modelling, we obtained evidence suggesting a strong association among spirituality, faith in science, and vaccination

increased scepticism. We did not obtain evidence suggesting that conspiracy beliefs explain the association between spirituality and Covid-19 vaccination scepticism. Although conspiracy beliefs might share important psychological functions (e.g., epistemic, or social needs) with spirituality [8], it is likely that spiritual individuals do not rely on conspiracy theories to gain knowledge about vaccination. Instead, they might rely more on faith in intuition or personal experiences to form attitudes towards health-related science domains, as opposed to conspiracies and scientific findings [31,1]. In turn, faith in intuition has been found to predict stronger negative attitudes towards vaccines [34].

Finally, we would like to note our participant samples were limited to British users of an online recruitment platform. Although this could limit generalizability of our findings to British population, we recruited balanced samples in terms of age and gender that aimed at representing the composition of the British population. Further, the results of our studies are correlational in nature and no causal inferences should be made about the effect of spirituality on Covid-19 vaccine scepticism.

8. Practice recommendations

We suggest that in order to improve vaccination rate of Covid-19 vaccines, it is important to focus on and address two main correlates of Covid-19 vaccine scepticism: High spiritual beliefs and low science literacy - both of these predictors were equally as important in contributing to vaccine scepticism, but only spirituality was directly involved in behavioural intentions (i.e., vaccine indecisiveness) and vaccine uptake. First, improving vaccination rates could involve increasing general faith in science among spiritual individuals, as this variable was crucial in explaining the relationship between spirituality and vaccine scepticism. This could be achieved by tailoring science communication about Covid-19 boosters by using examples of beneficial personal/intuitive experiences of people who plan to or have already received Covid-19 vaccines [5,11]. For example, this could be done by describing positive bodily experiences associated with being better protected against Covid-19 after receiving a vaccine, e.g., discussing how the vaccine helped to boost and connect with a person's inner strength. Further, spirituality has been recently linked to pro-environmental attitudes [28]. Hence, stressing that vaccines are natural, rather than artificial or "chemical", could help convince spiritual individuals that vaccination cannot poison them or the environment. Second, designing educational programs to increase people's basic scientific knowledge could further tackle the problem of high scepticism associated with low science literacy and reduce the feeling that science is counterintuitive. Previous research has shown promising effects of educational programs on science acceptance in the domain of genetically modified foods [22].

9. Conclusion

The current findings contribute to the accumulating body of research on attitudes towards science by demonstrating that self-identified spirituality is a crucial individual difference predictor of scepticism towards Covid-19 vaccination. Additionally, we show that the link between spirituality and scepticism is explained by low faith in science. Importantly, spirituality is also a direct antecedent of behavioural responses to Covid-19 vaccines involving increased Covid-19 vaccine indecisiveness and lower likelihood of vaccine uptake. Further, we identified science literacy as another consistent correlate of vaccine scepticism. To conclude, spirituality is a crucial belief system explaining vaccination-related responses and should be acknowledged when considering attempts to reduce vaccination rejection.

Data availability

I've included the link to my data and materials in the manuscript

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Bastiaan T. Rutjens reports financial support was provided by European Research Council.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2022.11.050>.

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