Cross-National Comparison of Religion as a Predictor of COVID-19 Vaccination Rates

Radosław Trepanowski1 · Dariusz Drążkowski1

Accepted: 7 April 2022 / Published online: 12 May 2022
© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2022

Abstract
We examined the effects of religiosity on COVID-19 vaccination rates using a cross-national comparison while controlling for socio-economic factors and culture. Our analysis, conducted on data from 90 countries representing 86% of the world population, showed that Christianity was negatively related to vaccination, while there was no relation with Islam, Buddhism, Hinduism, and nonbelief. The importance of religion, freedom of expression and belief, sex ratio, median age, and almost all cultural factors were not related to vaccination, whereas Human Development Index was. The influence of different religions on vaccination rates has also been described.

Keywords Religiosity · Vaccination rate · Cross-national comparison · COVID-19

Introduction
The ongoing pandemic caused by novel 2019 coronavirus (COVID-19) has highlighted the importance of vaccination against COVID-19 in overcoming the pandemic (Yamey et al., 2020). While several vaccines have been developed, the effectiveness of vaccination programs depends on high uptake among the population. Therefore, it is necessary to identify the characteristics of people who are hesitant to vaccinate against COVID-19 to design interventions and develop targeted messages encouraging them to vaccinate.

One group hesitant to vaccinate against COVID-19 may be religious people. Some studies have demonstrated that religious people have defied and ignored governmental recommendations on protective behavior during the COVID-19 pandemic (Dein et al., 2020; Drążkowski & Trepanowski, 2021; Kranz et al., 2020; Milligan

1 Faculty of Psychology and Cognitive Science, Adam Mickiewicz University, 89 Szamarzewskiego Street, PL-60-568 Poznan, Poland

✉ Radosław Trepanowski
radtre@amu.edu.pl

Springer
et al., 2021). For instance, people representing some religious denominations (e.g., Evangelicals) show resistance to COVID-19 prevention measures by not wearing masks (Adida et al., 2021; Gonzalez et al., 2021), ignoring social distancing recommendations (DeFranza et al., 2021; Linke, & Jankowski, 2022), or refusing to get tested for COVID-19 (Linke & Jankowski, 2020).

Linke and Jankowski (2022) showed that in societies with lower trust in science and a greater number of believers, people tend to test themselves less, and that gross domestic product further explains this relationship. Additionally, the authors indicated religious fundamentalism and internal religiosity as predictive of a lesser number of tests. Similar findings concerning mask-wearing were indicated by Gonzalez et al. (2021), who found that infrequent mask-wearing is associated with conservatism—both religious and political. Therefore, it is likely that religiosity negatively influences adherence to COVID-19 protective measures.

Some studies also demonstrated the negative influence of religiosity on COVID-19 vaccination intention (Murphy et al., 2021; Olagoke et al., 2020). Previous studies on vaccination against various diseases showed that religious people are less likely to be vaccinated than non-religious people (Grabenstein, 2013). Researchers (Boguszewski et al., 2020; Kranz et al., 2020; Murphy et al., 2021; Olagoke et al., 2020) explained the negative relationship between religiosity and compliance with protective behaviors and with the willingness to vaccinate against COVID-19 through the notion that religious people tend to believe in information sources that contradict scientific data (Simpson et al., 2016). According to Simpson and Rios (2019), the negative relationship between religion and vaccination can be explained by the fact that religious individuals might feel threatened by secularized science, leading to the belief that science aims to disprove God or any other higher being they believe in. This might lead to the belief that the cultural/religious status will lessen, and even that religious worldviews will somehow be curbed; thus, freedom of religious belief and expression will be restricted.

However, other studies have shown that religion does not significantly affect COVID-19 vaccination acceptance or that it even affects vaccination positively (Freeman et al., 2020; Guidry et al., 2021; Kilic et al., 2021; Sherman et al., 2021). For example, Lahav et al. (2021) show that Buddhists are more likely to get vaccinated than nonbelievers, while Orthodox Jews are less likely. In contrast, Kilic et al. (2021) showed no association between overall attitude to COVID-19 and religious attitude. Therefore, the association of religiosity with COVID-19 vaccination remains unclear. The mixed results may be explained by the fact that while researchers used different indicators of COVID-19 vaccination (e.g., intention to vaccinate, acceptance of vaccination, or vaccination hesitancy), the relationship between religiosity and COVID-19 vaccination was mainly studied within specific countries, and in relatively small populations. This may have limited the conclusions concerning the socio-cultural characteristics of particular countries or may have reflected the limited representativity of the study samples.

Determining the relationship between religiosity and COVID-19 vaccination would better enable the study of actual behavior; that is, COVID-19 vaccination rates, and analyses at the level of cross-national comparison. Cross-national
comparisons could clarify critical issues between countries, identify gaps in the literature, and provide new viewpoints on the researched subjects (Gharawi et al., 2009).

The primary objective of this study is to establish the relationship between the percentage of followers of different religions and the COVID-19 vaccination rates in a specific country. Insights into the characteristics of vaccination-hesitant groups could help tailor vaccination campaigns to increase vaccination coverage. Four dominant religions (Christianity, Islam, Buddhism, and Hinduism) and nonbelief factions (agnosticism and atheism) were considered. As the World Health Organization (2013) reported that sex, culture, and socio-economic factors affect immunization alongside religion, we included sex, culture, economic, and social development of countries in the examined model. Moreover, as some authors claim (e.g., Martínez-Torrón, 2021), vaccination may restrict freedom of religion or belief for some, which prompted the inclusion of this variable. The importance of religion in a given country was also included, as only those deeming religion an essential aspect of their life let it influence their health decisions. Controlling these factors helps reduce the risk of observing spurious correlations so that the relationship between individual religions and vaccination can be estimated.

Data and Methods

We gathered and analyzed data from nine sources to examine the influence of various factors on worldwide vaccination rates. We downloaded the ARDA National Profiles 2011 (Harris et al., 2018) dataset, consisting of multiple databases on religiosity, from the Association of Religious Data Archives website—only data from FreedomHouse 2009 (Freedom House, 2009) and World Christian Database 2010 (Johnson and Zurlo, 2010) embedded within this dataset were utilized. Furthermore, only religions with populations greater than five hundred million were chosen for this study. We also gathered additional data on religiosity from Gallup World Poll 2020 (The Gallup Organization, 2020) which was supplemented with the Berkessel et al. (2021) study. These data included answers to a single question on the importance of religion in the daily life of the poll participants. The authors aggregated the data to reflect the importance of religion in all 156 countries taking part in the poll.

Cultural factors were analyzed from data on Hofstede’s cultural dimensions (Hofstede, 2015; Hofstede et al., 2010) downloaded from multiple data sources as indicated in Supplementary Table 1, as each was somewhat incomplete. Using various data sources, it was possible to gather complete information on the six-dimensional model of national culture in 96 countries or the four-dimensional model in 118 countries. We used the six-dimensional model to represent a more complex view of national cultures.

Unemployment rate data were downloaded from the CIA’s World Factbook (Central Intelligence Agency, 2021), while the data on total female and male populations, as well as sex ratio, were acquired from World Population Prospects 2019 (United Nations, 2019).
Data on the COVID-19 pandemic and socio-economic factors were acquired from a *Global Database of COVID-19 Vaccinations* (Mathieu et al., 2021; Ritchie et al., 2020), which can be freely accessed through the ourworldindata.org website. The authors of this database update it daily, but not every country creates reports on COVID-19 as often—some report weekly, biweekly, monthly, or at irregular intervals. Therefore, if we used data gathered on a single day in our study, information on many of the countries would be missing. We downloaded data from December 1, 2021; then, we filled what was missing with data from the closest, most complete report, from either December or November 2021. The data were only filled for the countries with complete data on all other variables; that is, in 93 countries, from the original 241. All the variables used in the study, and their sources are described in Supplementary Table 1.

Several countries were excluded from the final analysis because of missing data regarding key variables. After removing countries with incomplete data on the six-dimensional model of national culture, 96 countries remained. Three countries were missing data on the sex ratio (Cape Verde, Hong Kong, and Taiwan), and one country (Qatar) was missing data on people vaccinated per hundred. (Only the total vaccination rate was reported.) No data on the importance of religion were reported in two countries: Macedonia and São Tomé and Príncipe. With those countries excluded, 90 remained, consisting of 86% of the total human population in 2010.

The collected data were analyzed in R 4.1.2. (R Core Team, 2021) and JAMOVI (1.6; 2021). We used R libraries ggplot2 (Wickham, 2016), sf (Pebesma, 2018), rnaturalearth (South, 2018), and naturalezaearthdata (South, 2017) to describe and visualize geographical patterns (Fig. 1). We then conducted correlation analyses.
with Spearman’s rho and employed a hierarchical linear regression analysis. Supplementary Tables 1–4 are available at Open Science Framework: https://osf.io/ngua3/?view_only=97fdddfd4e7d4216ac48188387c7e324.

Results

There is a high international variance in vaccination rates, ranging from 2.06 in Burkina Faso to 89.78 in Portugal (Supplementary Table 2 and Fig. 1). The mean vaccination rate in the studied sample was 55.74 (SD = 23.59). Oceania, Europe, North America, Japan, and South Korea have the highest Human Development Index (HDI) and the greatest freedom of expression and belief. The latter is also markedly high in South Africa and South America.

African, South American, and Middle Eastern countries placed greater importance on religion than did North American, Asian, European, and Oceanian countries. Hinduism was most prevalent in South Asia, as was Buddhism. Islam was greater numbers in the Middle East and North Africa, while Christianity in Europe, the Americas, Oceania, South Africa, and Russia.

We conducted correlation analyses with Spearman’s rho. The results are presented in Supplementary Table 3. Nonbelief and all religions, except for Christianity and Islam, correlated positively with vaccination rates. Islam correlated negatively (rho = −0.366, p < 0.001). Unemployment rates (rho = −0.433; p < 0.001) and religion importance (rho = −0.533; p < 0.001) also correlated negatively with vaccination rates. Age median (rho = 0.541; p < 0.001), HDI (rho = 0.706; p < 0.001), and freedom of expression and belief (rho = 0.524; p < 0.001) correlated positively with vaccination rates. Only individualism (rho = 0.416; p < 0.001), indulgence (rho = 0.368; p < 0.001), and power distance (rho = −0.556; p < 0.001) correlated with vaccination rates in the six-dimensional model of national culture.

Finally, we conducted a hierarchical linear regression analysis (Supplementary Table 4 and Table 1). Model 1 included socio-economic variables (HDI, unemployment rates, sex ratio, median age), Model 2 included six dimensions of national culture, and Model 3 included religion-related variables (religions, importance of religion, freedom of expression, and belief). The assumptions for multicollinearity and homoscedasticity were violated; hence, we standardized the variables. This type of data—aggregated or estimated from auxiliary sources—tends to have unusual sampling variation.

Some of the variables used in the study had very high correlations because of co-occurrence or mutual exclusiveness. For instance, Christian and Muslim populations in most cases were mutually exclusive (Fig. 1), which led to high negative correlations between them. Standardization did not solve the multicollinearity issue between the variables representing different religions; we conducted five separate regressions for Model 3: four for each religious belief and one for nonbelief, which reduced the problem.

In the first model of the hierarchical linear regression analysis, the analysis revealed that socio-economic variables accounted for 59% of the variation in
Table 1  Hierarchical linear regression with vaccination rate as dependent variable (Model 3)

| Independent variables | Model 3A Christians | Model 3B Muslims | Model 3C Hindu | Model 3D Buddhists | Model 3E Nonbelievers |
|-----------------------|---------------------|-----------------|---------------|--------------------|-----------------------|
| Socio-economics       |                     |                 |               |                    |                       |
| HDI                   | 0.47* (0.07; 0.86)  | 0.44* (0.03; 0.85) | 0.49* (0.08; 0.90) | 0.49* (0.09; 0.89) | 0.44* (0.04; 0.84)    |
| Rate of unemployment  | −0.18* (−0.33; −0.03) | −0.16† (−0.32; 0.00) | −0.14 (−0.30; 0.01) | −0.14 (−0.29; 0.01) | −0.15† (−0.31; 0.00)  |
| Sex ratio             | 0.02 (−0.15; 0.20)  | 0.10 (−0.08; 0.29)  | 0.08 (−0.09; 0.26)  | 0.11 (−0.06; 0.28)  | 0.12 (−0.05; 0.29)    |
| Median age            | 0.25 (−0.11; 0.62)  | 0.26 (−0.12; 0.65)  | 0.23 (−0.14; 0.62)  | 0.17 (−0.22; 0.56)  | 0.28 (−0.09; 0.66)    |
| National culture      |                     |                 |               |                    |                       |
| Power Distance        | −0.16 (−0.37; 0.06) | −0.19 (−0.42; 0.03) | −0.20 (−0.42; 0.02) | −0.16 (−0.38; 0.06) | −0.20 (−0.41; 0.02)   |
| Individualism         | −0.18 (−0.40; 0.05) | −0.18 (−0.42; 0.06) | −0.20 (−0.43; 0.04) | −0.13 (−0.37; 0.10) | −0.20 (−0.43; 0.04)   |
| Masculinity           | 0.00 (−0.13; 0.15)  | 0.02 (−0.12; 0.17)  | 0.03 (−0.11; 0.17)  | 0.01 (−0.13; 0.15)  | 0.02 (−0.12; 0.16)    |
| Uncertainty avoidance | −0.01 (−0.18; 0.15) | 0.05 (−0.22; 0.12)  | −0.03 (−0.20; 0.14) | −0.02 (−0.19; 0.15) | −0.04 (−0.21; 0.13)   |
| Long-term orientation | −0.09 (−0.32; 0.14) | −0.06 (−0.30; 0.17) | −0.07 (−0.30; 0.17) | −0.06 (−0.29; 0.17) | 0.08 (−0.31; 0.16)    |
| Indulgence            | 0.22* (0.03; 0.40)  | 0.16 (−0.03; 0.36)  | 0.17 (−0.01; 0.35)  | 0.14 (−0.03; 0.33)  | 0.17 (−0.01; 0.35)    |
| Religion              |                     |                 |               |                    |                       |
| Importance of religion| −0.06 (−0.29; 0.18) | −0.05 (−0.30; 0.20) | −0.06 (−0.31; 0.18) | −0.05 (−0.30; 0.19) | 0.05 (−0.24; 0.33)    |
| Freedom of expression and belief | 0.13 (−0.08; 0.34)   | −0.00 (−0.21; 0.21) | −0.01 (−0.06; 0.23) | 0.04 (−0.15; 0.24)  | 0.02 (−0.17; 0.21)    |
| Christians            | −0.24* (−0.45; −0.03) | −                  | −                  | −                  | −                      |
| Muslims               | −                  | −0.01 (−0.23; 0.20) | −                  | −                  | −                      |
| Hindus                | −                  | −                  | 0.08 (−0.06; 0.23)  | −                  | −                      |
| Buddhists             | −                  | −                  | −                  | 0.12 (−0.02; 0.28)  | −                      |
| Nonbelievers          | −                  | −                  | −                  | −                  | 0.14 (−0.06; 0.34)    |
| $R^2$                 | 0.68               | 0.67              | 0.67             | 0.67               | 0.67                   |
| $\Delta R^2$          | 0.02               | 0.01              | 0.01             | 0.01               | 0.01                   |
| $F$                   | 12.7****           | 11.5***           | 11.8***          | 12.1***            | 11.9***                |

*p < 0.05; **p < 0.01; ***p < 0.001; †p = 0.05−0.06
vaccination rates, $F(4, 85) = 31.30, p < 0.001$. In the second model, with the addition of the national culture variables, the model explained 66% of variation, $F(10, 79) = 15.50, p < 0.001$, while the third models explained 67–68% of variation with the addition of religion-related variables.

Only HDI was significant among all five models in Model 3, with unemployment rates being close to significance in two (3B and 3E) and significant in 3A. Model 3A (i.e., the model in which Christianity was introduced) had four significant predictors of country-wide vaccination rates (1) HDI ($\beta = 0.24, p = 0.020$); (2) Unemployment rates ($\beta = -0.18, p = 0.020$); (3) Indulgence ($\beta = 0.22, p = 0.021$); and (4) Christianity ($\beta = -0.24, p = 0.022$). Religion provided no significant results in the remaining alternative model.

Discussion

This study was the first to examine the role of religiosity in COVID-19 vaccination rates using a country-level comparison. We used data extracted from nine secondary data sources from 90 countries. The results show that religiosity at the level of cross-country comparison analyses is not associated with the COVID-19 vaccination rates, except for Christianity.

Our results indicate that the proportion of Christians in a given country was negatively related to the vaccination rates after accounting for socio-economics and cultural factors. The ratio of Muslims, Buddhists, and Hindus in a given country was not associated with the vaccination rates. There was also no association between vaccination rates and the proportion of nonbelievers, the importance of religion, and the freedom of expression and belief. Our analyses demonstrated that HDI was the strongest predictor of COVID-19 vaccination rates among all study variables. Unemployment rates and indulgence (cultural factor) were significant determinants of vaccination rates, but only for separate regression analyses conducted for specific religions.

Our analyses indicated that only Christianity was predictive of the actual vaccination rates in country-level analyses. No such effects were observed for other religions and other religion-related variables; that is, the importance of religion and freedom of expression and belief. These results are consistent with previous research showing that religiosity is not significantly related to COVID-19 vaccination acceptance (Freeman et al., 2020; Guidry et al., 2021; Kilic et al., 2021; Sherman et al., 2021) and is in opposition to findings showing that religiosity is negatively related to vaccination against COVID-19 (e.g., Murphy et al., 2021; Olagoke et al., 2020). Although negative correlations between different religions and vaccination rates or positive correlations between freedom of belief and vaccination rates have been observed, most become non-significant after introducing socio-economic and culture variables into the regression model. This shows that researchers should include socio-economic and cultural variables in studies on the relationship between religion and vaccination (or health) to avoid spurious correlations.

Negative relationships between religiosity and vaccination are usually explained by the fact that religiosity is associated with a lack of trust in science (Simpson
et al., 2016), which has been demonstrated for Muslims (Islam et al., 2021), Hindus, and Christians (Simpson et al., 2016). However, these studies suggest that we cannot solely explain the results of our study through a lack of trust in science among Christians, as the same pattern was observed among Muslims and Hindus. The finding that only Christianity is associated with vaccination hesitancy suggests that specific mechanisms related to a particular religion may explain this relationship. Thus, there may be specific anti-vaccination attributes of Christianity and pro-vaccination attributes of Islam, Buddhism, and Hinduism that compensate for the negative relationship between religiosity and trust in science.

**Christianity**

Our findings that Christianity is negatively related to the vaccination rates are notable as the official stance of most Christian denominations is either in favor of vaccination or, at the very least, not against it (King, 2021). The heads of the Catholic, Protestant, and Orthodox churches have declared that vaccination against COVID-19 is compatible with the doctrines of the faith and even morally desirable (Thinane, 2022). However, some Christians and clergy members are against COVID-19 vaccination because of the possibility of some vaccines being produced from aborted fetus tissue, which violates the Christian viewpoint on abortion (King, 2021; Thinane, 2022). An example of this, as elucidated by Glenza and Pengelly (2021), is the condemnation of the Johnson and Johnson COVID-19 vaccine as being “morally compromised” by some of the heads of the Roman Catholic church in the USA, even though the producer stressed that there was no fetal tissue in their vaccine.

There are some smaller Christian denominations where vaccines are considered incompatible with the religious doctrine, up to several decades ago or till the present day; for example, Amish, Church of Christ, Scientist, Dutch reformed congregations, Jehovah’s Witnesses, and the Church of the First Born (Grabenstein, 2013). Corcoran et al. (2021) pointed to Christian nationalists, a group of very conservative believers, as one of the U.S.’s most anti-vaccine and anti-scientific groups.

**Islam**

While there have been some examples of Islamic leaders who were not convinced of the legitimacy of COVID-19, nor the need for precautionary restrictions and vaccinations, nevertheless the majority of imams and Muslim organizations have encouraged their faithful to get vaccinated against COVID-19 (King, 2021; Thinane, 2022). In Islam, vaccination is neither forbidden nor inconsistent with religious laws. As preserving life is aligned with preserving religion, receiving a COVID-19 vaccination is a form of compliance with *Sharia* law (Mardian et al., 2021; Sholeh & Helmi, 2021). Many imams and Muslim organizations continue to encourage the faithful to get vaccinated against COVID-19 (King, 2021; Thinane, 2022). Even before the COVID-19 pandemic, many Islamic leaders announced *fatwas* describing how vaccination is consistent with Islamic principles (Grabenstein, 2013).
Buddhism

The essential precept of Buddhism prohibits taking of life and mandates moral commitment not to destroy life. Therefore, Buddhists particularly understand and stress the importance of saving lives through vaccination (Thinane, 2022). Buddhism interprets treatment as an act of mercy, and thus, the prevention of diseases through vaccination can be perceived similarly (Grabenstein, 2013). Moreover, there are many historical reports of medical treatments by Buddhists based on vaccination (Cha, 2012). The link between Buddhism and vaccination was exploited in Bhutan, where the government collaborated with the religious authorities by choosing the correct date to start vaccination, the right first person to be vaccinated, and the right mantra—a special prayer in warding off diseases (Rocha, 2021).

Hinduism

Similarly, in Hinduism, there is evidence of a centuries-old practice of immunization, which leads to the belief that vaccination is an act of worship, with a lack of conformity enraging the Gods (Sweetman & Malik, 2016). The idea of vaccination is described in the religious texts of the Harivamsa Purana and is attributed to Dhanwantari, the God of Ayurveda (the God of the traditional system of Hindu medicine; Maharaj, 2021).

HDI

Our results are relevant to the investigation of the relationship between religiosity and health. We showed that HDI was positively related to vaccine rate: the higher the HDI, the higher the vaccine rate was in most countries. Thus, people from more (vs. less) developed countries are more likely to get vaccinated, possibly because of higher income, better health services, and education, compounding HDI factors. Previous studies indicate that HDI also influences overall vaccination rates and vaccine hesitancy with other vaccines (de Cantuária Tauil et al., 2016; García-Toledano et al., 2021; Hayman, 2019). García-Toledano et al. (2021) explained that vaccination is usually more regulated in countries with higher (vs. lower) HDI and that these societies are more aware of the importance of vaccination. This highlights the effect of better education systems and a greater number of resources that can be used in health promotion. Countries with lower HDI might also have trouble affording the vaccine.

Socio-economic Factors

Similar to prior studies (e.g., Guo et al., 2022) on the influence of socio-economic factors on vaccination, unemployment rates were also negatively related to the COVID-19 vaccine rates, but only for separate regression analyses conducted for
specific religions. The remaining sociodemographic variables used in this study—sex ratio and median age—had no significant relationship with vaccine rates.

**Culture**

Despite having high correlations with remaining variables, culture dimensions had no relation to vaccination rates in the model, excluding the indulgence dimension. Indulgence was only significant in the model with Christianity after accounting for religious variables. Indulgence relates to enjoying life and free gratification (Hofstede Insights, 2022). Restraint stands in opposition to indulgence and relates to suppressed needs, gratification, and high regulation with social norms. The indulgence dimension was not previously explored in the context of vaccination.

Nevertheless, research on national culture and COVID-19 shows that more indulgent countries might have fewer deaths (Windsor et al., 2020) but simultaneously experience more issues inciting people to conform with COVID-19 rules (Gokmen et al., 2021; Wang, 2021). This is not inconsistent with our results as indulgent societies might have a greater desire to restore normalcy, that is, not have to follow COVID-19 rules such as social distancing and engaging in various social activities freely, and are therefore more likely to get vaccinated.

**Practical Implications**

Our study has some practical implications. We suggest that Christian religious institutions should be used for disseminating information about COVID-19 vaccination safety and outcomes. It is crucial for practitioners and researchers to engage in discussions with religious leaders and congregants to better understand specific concerns about the vaccine, such as the vaccine being potentially derived from human tissue. This will enable the creation of educational messages aimed at religious people that are compatible with their beliefs (Shelton, 2013); for instance, messages explaining in detail what vaccines consist of and how they are made. Given the role belief plays in the vaccination process, healthcare providers might have to address vaccine concerns among individuals with strong beliefs.

**Limitations**

This study has several limitations, which yield recommendations for future research. First, including all countries worldwide was not possible because of missing data. However, the overall number of countries in the analysis was sufficiently high (comprising 86% of the total human population). Second, the data used in the study were collected with different methodologies at different times, which may have influenced the results. Third, as religion is a multifactorial and complex factor, future studies should examine other correlates of religious beliefs (e.g., religious conservatism) to examine the link between religion and vaccination rates. Finally, the number of
countries with high populations of Hindus and Buddhists was relatively small; thus, significant effects for them might not have registered in the model.

**Conclusion**

The most notable contribution of this study is the exploration of the relationships between different religions and COVID-19 vaccination rates on cross-national comparisons. Christians were less likely to get vaccinated, after controlling many socio-economic and cultural variables; contrastingly, being a nonbeliever, Hindu, Muslim, or Buddhist had no relationship with the COVID-19 vaccination rates. Our results expand on existing knowledge about the determinants of vaccination against COVID-19. Although previous research postulated a negative influence of religiosity on vaccination rates (e.g., Murphy et al., 2021; Olagoke et al., 2020), only Christianity was associated with lower vaccination rates. Our results contradict previous findings showing that Islam is associated with lower willingness to vaccinate (e.g., Khan et al., 2020). The strength of our study is that we analyzed the actual vaccination rates, not a subjective assessment of willingness to take the COVID-19 vaccine, as most studies investigated. Nevertheless, the current study also indicated that HDI is the strongest determinant of actual vaccination rates in the case of COVID-19 vaccination, while national culture, sex ratio, and median age are not.

**Author contributions** Both authors contributed to the study conception, design and data interpretation. Material preparation, data collection and analyses were performed by RT. The first draft of the manuscript was written by DD and RT. All authors read and approved the final manuscript.

**Funding** The authors received no financial support for the research, authorship and/or publication of this article.

**Declarations**

**Conflict of interest** The author declares they have no potential conflict of interest.

**Ethical Approval** All procedures were performed in accordance with guidelines provided by the Ethics Board of Faculty of Psychology and Cognitive Science at Adam Mickiewicz University. No human participants took part in the study, as only secondary data were used.

**Informed Consent** Consent was obtained from all participants who were included in the study.

**References**

Adida, C., Cottiero, C., Falabella, L., Gotti, I., Ijaz, S. S., Phillips, G., & Seese, M. (2021). Taking the Cloth: How Religious Appeals Increase Compliance with COVID-19 Prevention Measures. *SocArXiv*. https://doi.org/10.31235/osf.io/yt3e7.
Berkessel, J. B., Gebauer, J. E., Joshuaan, M., Bleidorn, W., Rentfrow, P. J., Potter, J. & Gosling, S. D. (2021). National religiosity eases the psychological burden of poverty. *Proceedings of the National Academy of Sciences, 118*(39), https://doi.org/10.1073/pnas.2103913118.

Boguszewski, R., Makowska, M., Bożewicz, M., & Podkowskińska, M. (2020). The COVID-19 pandemic’s impact on religiosity in Poland. *Religions, 11*(12), 646. https://doi.org/10.3390/rel11120646

de Cantuária Tauil, M., Sato, A. P. S., & Waldman, E. A. (2016). Factors associated with incomplete or delayed vaccination across countries: A systematic review. *Vaccine, 34*, 2635–2643. https://doi.org/10.1016/j.vaccine.2016.04.016

Central Intelligence Agency. (2021) *World factbook*. Retrieved 10.01.2022 from: https://www.cia.gov/.

Cha, S. H. (2012). The history of vaccination and current vaccination policies in Korea. *Clinical and Experimental Vaccine Research, 1*(1), 3–8. https://doi.org/10.7774/cevr.2012.1.1.3

Corcoran, K. E., Scheitle, C. P., & DiGregorio, B. D. (2021). Christian nationalism and COVID-19 vaccine hesitancy and uptake. *Vaccine, 39*(45), 6614–6621. https://doi.org/10.1016/j.vaccine.2021.09.074

Dein, S., Loewenthal, K., Lewis, C. A., & Pargament, K. I. (2020). COVID-19, mental health and religion: An agenda for future research. *Mental Health, Religion & Culture, 23*(1), 1–9. https://doi.org/10.1080/13674676.2020.1768725

DeFranza, D., Lindow, M., Harrison, K., Mishra, A., & Mishra, H. (2021). Religion and reactance to COVID-19 mitigation guidelines. *American Psychologist, 76*(5), 744–754. https://doi.org/10.1037/amp0000717

Drążkowski, D., & Trepanowski, R. (2021). I do not need to wash my hands because I will go to Heaven anyway: A study on belief in God and the afterlife, death anxiety, and COVID-19 protective behaviors. *PsyclArXiv Preprints; COVID-19*. https://doi.org/10.31234/osf.io/hw3u.

Freedom House. (2009). *Freedom in the World* [online resource]. http://www.freedomhouse.org.

Freeman, D., Loe, B. S., Chadwick, A., Vaccari, C., Waite, F., Rosebrock, L., Jenner, L., Petit, A., Lewandowsky, S., & Lambe, S. (2020). COVID-19 vaccine hesitancy in the UK: The Oxford coronavirus vaccine hesitancy, attitudes, and narratives survey (Oceans) II. *Psychological Medicine*. https://doi.org/10.1017/S0033291720005188

García-Toledano, E., Palomares-Ruiz, A., Cebrián-Martínez, A., & López-Parra, E. (2021). Health education and vaccination for the construction of inclusive societies. *Vaccines, 9*(8), 813. https://doi.org/10.3390/vaccines9080813

Gharawi, M. A., Pardo, T. A., & Guerrero, S. (2009). Issues and strategies for conducting cross-national e-government comparative research. *Proceedings of the 3rd International Conference on Theory and Practice of Electronic Governance - ICEGOV ’09*. https://doi.org/10.1145/1693042.1693076.

Glenda, J., & Pengelly, M. (2021). Catholics in New Orleans and St. Louis told to avoid Johnson & Johnson vaccine. *The Guardian*. https://www.theguardian.com.

Gokmen, Y., Baskici, C., & Ercil, Y. (2021). The impact of national culture on the increase of COVID-19: A cross-country analysis of European countries. *International Journal of Intercultural Relations, 81*, 1–8. https://doi.org/10.1016/j.ijintrel.2020.12.006

Gonzalez, K. E., James, R., Bjorklund, E. T., & Hill, T. D. (2021). Conservatism and infrequent mask usage: A study of US counties during the novel coronavirus (COVID-19) pandemic. *Social Science Quarterly, 102*(5), 2368–2382. https://doi.org/10.1111/ssqu.13025

Grabenstein, J. (2013). What the world’s religions teach, applied to vaccines and immune globulins. *Vaccine, 31*(16), 2011–2023. https://doi.org/10.1016/j.vaccine.2013.02.026

Guidry, J. P., Laestadius, L. I., Vraga, E. K., Miller, C. A., Perrin, P. B., Burton, C. W., & Carlyle, K. E. (2021). Willingness to get the COVID-19 vaccine with and without emergency use authorization. *American Journal of Infection Control, 49*(2), 137–142. https://doi.org/10.1016/j.ajic.2020.11.018

Guo, Y., Kaniuka, A. R., Gao, J., & Sims, O. T. (2022). An epidemiologic analysis of associations between county-level per capita income, unemployment rate, and COVID-19 vaccination rates in the United States. *International Journal of Environmental Research and Public Health, 19*(3), 1755. https://doi.org/10.3390/ijerph19031755

Hayman, D. T. S. (2019). Measles vaccination in an increasingly immunized and developed world. *Human Vaccines & Immunotherapeutics, 15*(1), 28–33. https://doi.org/10.1080/21645515.2018.1517074

Harris, J., Martin, R. R., & Finke, R. (2018). *Data from the ARDA National Profiles, 2011 Update: Religion Indexes, Adherents and Other Data*. Retrieved 10.01.2022 from: https://www.thearda.com/.

Hofstede, G., Hofstede, G., & Minkov, M. 2010. *Cultures and organizations: The software of the mind (3rd ed.).* McGraw-Hill.
Hofstede, G. J. (2015). *Dimension data matrix*. Retrieved 10.01.2022 from: https://geerthofstede.com.

Hofstede Insights (2022). *Compare countries*. Retrieved 10.01.2022 from: https://www.hofstede-insights.com.

Islam, M. S., Kamal, A. H. M., Kabir, A., Southern, D. L., Khan, S. H., Hasan, S. M., & Seale, H. (2021). COVID-19 vaccine rumors and conspiracy theories: The need for cognitive inoculation against misinformation to improve vaccine adherence. *PLoS ONE*, 16(5), e0251605. https://doi.org/10.1371/journal.pone.0251605

Johnson, T. M., & Zurlo, G. A. (2010). *World Christian Database 2010* [Online resource]. Brill. https://worldchristiandatabase.org/

Khan, Y. H., Mallhi, T. H., Alotaibi, N. H., Alzarea, A. I., Alanazi, A. S., Tanveer, N., & Hashmi, F. K. (2020). Threat of COVID-19 vaccine hesitancy in Pakistan: The need for measures to neutralize misleading narratives. *The American Journal of Tropical Medicine and Hygiene*, 103(2), 603–604. https://doi.org/10.4269/ajtmh.20-0654

Kilic, M., Ustundag Ocal, N., & Uslukilic, G. (2021). The relationship of COVID-19 vaccine attitude with life satisfaction, religious attitude and COVID-19 avoidance in Turkey. *Human Vaccines & Immunotherapeutics*, 17(10), 3384–3393. https://doi.org/10.1080/21645515.2021.1938493

King, D. (2021). *Faith and the COVID vaccine: What religions have doctrinal reasons for being unvaccinated?* The Compassus Dispatch. https://eu.dispatch.com

Kranz, D., Niepel, C., Botes, E., & Greiff, S. (2020). Religiosity predicts unreasonable coping with COVID-19. *Psychology of Religion and Spirituality* [Advance online publication]. https://doi.org/10.1037/rel0000395

Lahav, E., Shaharabani, S., Rosenboim, M., & Tsutsui, Y. (2021). Is stronger religious faith associated with a greater willingness to take the COVID-19 vaccine? Evidence from Israel and Japan. *The European Journal of Health Economics*. https://doi.org/10.1007/s10198-021-01389-8

Linke, M., & Jankowski, K. S. (2022). Religiosity and the spread of COVID-19: A multinational comparison. *Journal of Religion and Health*. https://doi.org/10.1007/s10943-022-01521-9

Maharaj, B. (2021). Religion, vaccines, medical ethics and just distribution – a Hindu perspective. Daily-Maverick. https://bit.ly/3DJM0mv

Mardian, Y., Shaw-Shaliba, K., Karyana, M., & Lau, C.-Y. (2021). Sharia (Islamic Law) perspectives of COVID-19 vaccines. *Frontier in Tropical Diseases*, 2, 788188. https://doi.org/10.3389/fitd.2021.788188

Martínez-Torrón, J. (2021). COVID-19 and religious freedom: Some comparative perspectives. *Laws*, 10(2), 39. https://doi.org/10.3390/laws10020039

Mathieu, E., Ritchie, H., Ortiz-Ospina, E., Roser, M., Hasell, J., Appel, C., Giattino, C., & Rodés-Guirao, L. (2021). A global database of COVID-19 vaccinations. *Nature Human Behaviour*, 5, 947–953. https://doi.org/10.1038/s41562-021-01122-8

Milligan, M. A., Hoyt, D. L., Gold, A. K., Hiserodt, M., & Otto, M. W. (2021). COVID-19 vaccine acceptance: Influential roles of political party and religiosity. *Psychology, Health & Medicine*. https://doi.org/10.1080/13548506.2021.1969026

Murphy, J., Vallières, F., Bentall, R. P., Shevlin, M., McBride, O., Hartman, T. K., & Hyland, P. (2021). Psychological characteristics associated with COVID-19 vaccine hesitancy and resistance in Ireland and the United Kingdom. *Nature Communications*, 12(1), 1–15. https://doi.org/10.1038/s41467-020-20226-9

Olagoke, A. A., Olagoke, O. O., & Hughes, A. M. (2020). Psychological pathways linking public trust during the coronavirus pandemic to mental and physical well-being. *Frontiers in Psychology*, 11, 3139. https://doi.org/10.3389/fpsyg.2020.570216

Pebesma, E. (2018). Simple features for R: Standardized support for spatial vector data. *The R Journal*, 10(1), 439–446. https://doi.org/10.32614/RJ-2018-009

R Core Team (2021). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. [Computer software]. https://www.R-project.org/

Ritchie, H., Mathieu, E., Rodés-Guirao, L., Appel, C., Giattino, C., Ortiz-Ospina, E., Hasell, J., Macdonald, B., Beltekian, D., & Roser, M. (2020). *Coronavirus Pandemic (COVID-19)* [Online resource]. https://ourworldindata.org/coronavirus

Rocha, I. C. N. (2021). Employing medical anthropology approach as an additional public health strategy in promoting COVID-19 vaccine acceptance in Bhutan. *The International Journal of Health Planning and Management*, 36(5), 1943–1946. https://doi.org/10.1002/hpm.3191
Shelton, R. C., Snavely, A. C., De Jesus, M., Othus, M. D., & Allen, J. D. (2013). HPV vaccine decision-making and acceptance: Does religion play a role? *Journal of Religion and Health, 52*(4), 1120–1130. https://doi.org/10.1007/s10943-011-9553-x

Sherman, S. M., Smith, L. E., Sim, J., Amlôt, R., Cutts, M., Dasch, H., & Sevdalis, N. (2021). COVID-19 vaccination intention in the UK: Results from the COVID-19 vaccination acceptability study (CoV-AccS), a nationally representative cross-sectional survey. *Human Vaccines & Immunotherapeutics, 17*(6), 1612–1621. https://doi.org/10.1080/21645515.2020.1846397

Sholeh, M. A. N., & Helmi, M. I. (2021). The COVID-19 vaccination: Realization on halal vaccines for benefits. *Samarah, 5*(1). https://doi.org/10.22373/sjhk.v5i1.9769.

Simpson, A., Piazza, J., & Rios, K. (2016). Belief in divine moral authority: Validation of a shortened scale with implications for social attitudes and moral cognition. *Personality and Individual Differences, 94*, 256–265. https://doi.org/10.1016/j.paid.2016.01.032

Simpson, A., & Rios, K. (2019). Is science for atheists? Perceived threat to religious cultural authority explains US Christians’ distrust in secularized science. *Public Understanding of Science, 28*(7), 740–758. https://doi.org/10.1177/0963662519871881

South, A. (2018). *rnaturaleza rth: World Map Data from Natural Earth*. [Computer software]. https://cran.r-project.org.

South, A. (2017). *rnaturaleza rthdata: World Vector Map Data from Natural Earth Used in ‘rnaturaleza rth’*. [Computer software]. https://cran.r-project.org.

Sweetman, W., & Malik, A. (2016). *Hinduism in India: Modern and contemporary movements*. Sage.

The Gallup Organization (2020). *Gallup World Poll 2020*. www.gallup.com.

The jamovi project (2021). *jamovi* (Version 1.6) [Computer software]. https://www.jamovi.org.

Thinane, J. S. (2022). Religious perspectives on Vaccination: Mandatory Covid-19 vaccine for SA Churches. *Pharos Journal of Theology, 103*. https://doi.org/10.46222/pharosjot.10312.

United Nations (2019). *World Population Prospects 2019*. Department of Economic and Social Affairs. Retrieved 10.01.2022 from: https://population.un.org/wpp/.

Wang, Y. (2021). Government policies, national culture and social distancing during the first wave of the COVID-19 pandemic: International evidence. *Safety Science, 135*, 105138. https://doi.org/10.1016/j.ssci.2020.105138

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis* [Computer software]. Springer-Verlag. https://ggplot2.tidyverse.org.

Windsor, L. C., Yannitell, R. G., Windsor, A. J., Ostergard, R., Allen, S., Burns, C., et al. (2020). Gender in the time of COVID-19: Evaluating national leadership and COVID-19 fatalities. *PLoS ONE, 15*(12), e0244531. https://doi.org/10.1371/journal.pone.0244531

World Health Organization. (2013). *The SAGE Working Group. What influences vaccine acceptance: a model of determinants of vaccine hesitancy*. http://www.who.int.

Yamey, G., Schäferhoff, M., Hatchett, R., Pate, M., Zhao, F., & McDade, K. K. (2020). Ensuring global access to COVID-19 vaccines. *The Lancet*. https://doi.org/10.1016/S0140-6736(20)30763-7

**Publisher’s Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.