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Health literacy, religiosity, and political identification as predictors of vaccination conspiracy beliefs: a test of the deficit and contextual models

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The primary focus of this paper is to investigate the influence of science literacy, particularly health literacy, on vaccine-specific conspiracy beliefs, within the broader context of vaccine hesitancy. The authors tested deficit (scientific literacy shapes science attitudes) and contextual models (contextual variables exert direct influence and influence the connection between literacy and science attitudes) in a survey research study ($N = 729$) in Croatia. The analytical approach included structural equation modeling with vaccination conspiracy beliefs as the outcome variable and health literacy, religiosity, and political identification as predictors. The results showed that lower health literacy and higher religiosity were related to higher vaccination conspiracy beliefs, which was not the case for political identification. In addition, the moderating effect of religiosity on the relationship between health literacy and conspiracy beliefs was confirmed. In contrast, the moderating effect of political identification was not confirmed, thus partially confirming the stronger version of the contextual model. The authors comparatively discuss the results by evoking specific socio-political characteristics of Croatian society as well as the reactions of political and religious organizations to the COVID-19 pandemic.

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Introduction—the deficit and contextual models

Generally speaking, conspiracy theories are defined as beliefs that certain actions and/or events are acts of conspiracy undertaken by covert actors with hidden agendas (Grimes, 2016). More specifically, in terms of vaccination, beliefs in conspiracy theories include claims of a hidden agenda of the pharmaceutical industry related to vaccine development and distribution, assumptions about the connection between vaccines and their adverse effects, ideas about concealment of information about vaccines by institutional actors, and similar claims (Shapiro et al., 2016). While most vaccination conspiracy theories predate the COVID-19 pandemic, new narratives surrounding vaccination conspiracy theories have emerged during the pandemic. For example, during the pandemic, skepticism revolved around the origin of the virus, followed by the idea that the vaccines were developed to execute a clandestine depopulation plan or that consumption of disinfectants can kill the virus (van Bavel et al., 2020; Borah et al., 2022). In general, conspiracy beliefs are not a benign phenomenon, and they are associated with various healthcare challenges such as making harmful health decisions, reduced trust in healthcare professionals, and a shift towards alternative forms of healthcare treatment (Lamberty and Imhoff, 2018; van Prooijen and Douglas, 2018). Vaccine-specific conspiracy beliefs also influence decisions and willingness to vaccinate (Jolley and Douglas, 2014; Pisl et al., 2021). Furthermore, during the COVID-19 pandemic, belief in conspiracy theories was connected to lower institutional trust, and weaker support for governmental regulations such as the adoption of social distancing (Pummerer et al., 2022). Additionally, people who believe in a specific conspiracy theory tend to accept others that do not have to be necessarily thematically related (Swami et al., 2011), thus representing “conspiracy mentality” (Moscovici, 1987) that can influence attitudes and behaviors in other domains.

In general, when it comes to strategies relevant to mitigating conspiracy beliefs, some authors argued that providing factual and correct information can reduce such beliefs (Jolley and Douglas, 2017). The so-called “deficit model” of public understanding of science underscores the importance of scientific information, critical thinking, and understanding of scientific methods when fostering a positive public perception of science and technology. The link between scientific literacy and public perception of science explained by the so-called deficit model implies the public is passive and knowledge-deficient, with communication flowing only in one direction. In contrast, the scientific community is perceived as the main producer of objective, unquestionable, and value-free knowledge (Bauer et al., 2007). „Poor“ results on scientific literacy tests have been interpreted as the result of the distortion of information within the media/public or a complete lack of information (Horst, 2008; Weigold, 2001). Research studies in this area have pointed a small to moderately positive correlation between accumulated knowledge about scientific facts and positive attitudes toward science (Allum et al., 2008; Bauer et al., 1994; Grimston, 1994; McBeth and Oakes, 1996; Miller et al., 1997; Pavić and Šuljok, 2022; Sturgis and Allum, 2001; Wynne and Wynne, 1992). More specifically, Fasce and Picó (2019) summarized previous research about various types of unwarranted beliefs (conspiracy beliefs, superstitions, etc.) concluding that, notwithstanding their methodological ambiguities and limitations, the studies didn't demonstrate a strong and conclusive link between scientific literacy and such beliefs.

In opposition to the deficit model, another strand of research, dubbed „contextual approach“ (Miller, 2001), has been largely based on the constructivist orientation in the sociology of knowledge (Yearley, 1994) and related to various contextual variables and their influence on public perception of science.

Moreover, critiques within the contextual approach that address scientific literacy's importance in shaping views toward science and technology highlighted that such a relationship is not unambiguous and causal (Bucchi and Neresini, 2002; Hisschemöller and Midden, 1999). Within this approach, scientific „facts“ are not as straightforward as they might seem to the scientific community, and their understanding is guided by the values and concerns that the lay public considers relevant to their lives. In a nutshell, the contextual approach contains two claims. The first one is that various social variables can exert a stronger influence than knowledge in shaping attitudes, views, and beliefs regarding science and scientific production (e.g., Lewenstein, 2003). The second claim implies that such determinants can exert a moderating influence on the relationship between knowledge and science attitudes (e.g., Bauer et al., 1994). Among others, political identification and religiosity are also often researched as moderators, but not when vaccination conspiracy beliefs are concerned.

Therefore, in this paper, we aim to extend previous research by situating the topic of vaccination conspiracy beliefs into the above-mentioned general approaches to the public understanding of science, to explore (1) whether higher levels of knowledge (health literacy) are related to the lower level of endorsement of vaccination conspiracy beliefs, and (2) whether political identification and religiosity are related to the acceptance of vaccination conspiracy beliefs, as well as whether they can moderate the relationship between the knowledge and conspiracy beliefs, i.e., whether they can distort the hypothesized effect of knowledge.

Literacy and contextual factors of vaccine conspiracy beliefs

Scientific/health literacy. Scientific literacy is a multidimensional concept that embodies the assessment of knowledge related to the understanding of science and specific habitus within science by the public (Durant, 1994). As such, it is considered as a knowledge and understanding of scientific concepts that are necessary for a fully functioning adult to manage everyday challenges in modern society (Turiman et al., 2012). But Evans and Durant's (1995) study revealed that even though people who hold positive views of science overall, when confronted with morally or ethically contentious scientific research, they might exhibit negative attitudes. A study conducted in 24 countries by Rutjens et al. (2021) also indicated the heterogeneity of science skepticism. They established that levels of skepticisms varied across science domains and that the different predictors drove science skepticism in different domains. As for health literacy, some authors emphasize its conceptual links to literacy which refers to individual knowledge, and among other skills, competence to access, understand, and implement health information within everyday healthcare (Lorini et al. 2018; Sørensen et al., 2012). While Ploomipuu et al. (2020) assert that health literacy includes more specific health-related factors than science literacy, they highlight that some aspects of science literacy are aligned with health literacy in terms of knowledge, way of thinking, responsible action, problem-solving, and decision making. Additionally, some authors see scientific literacy as a component of health literacy while others emphasize the need for differentiation (Nutbeam, 2000; Zarcadoolas et al., 2005). Nutbeam (2000) also highlighted the overlap between scientific literacy and health literacy that was observed when addressing complex societal health challenges. This paper adopts a view on health literacy as a concept overlapping with scientific literacy, i.e., it is related to the aspects of scientific literacy, such as knowledge and skills to comprehend or critically evaluate health information needed for positive public health outcomes.

As Jolley and Douglas (2014) noted, vaccination conspiracy theories can reflect suspicion and mistrust concerning scientific research on vaccine efficacy and safety. Such suspicions regarding scientific research may contribute to vaccine hesitancy which has been linked to health literacy in several research studies (Lorini et al., 2018; Montagni et al., 2021; Sørensen et al., 2013). However, the link between health literacy and vaccination conspiracy beliefs has been under-researched so far. Duplaga (2020) did a study on the relationship between COVID-19 conspiracy beliefs, health literacy, and e-health literacy among Polish Internet users. The research highlighted an association between higher health literacy and lower support for two coronavirus conspiracy beliefs (state control and surveillance). Similar conclusions were made in a study that established a link between lower digital health literacy and COVID-19 misinformation (Naeem and Boulous, 2021). A study conducted by Pisl et al. (2021) highlighted that the effects of digital health literacy on COVID-19 conspiracy theories were moderated by cognitive reflection, noting the importance of scientific literacy in terms of critical thinking. On the other hand, Luo and Jia (2022) conducted a study and found a significant negative correlation between scientific literacy and COVID-19 conspiracy beliefs, but only for one item related to the origin of the virus.

Contextual factors. Conspiracy beliefs do not arise in isolation but are the result of a complex set of contextual factors that shape general beliefs, especially in the cases of social insecurities (Douglas et al., 2019; van Prooijen and Douglas, 2018). Therefore, it is crucial to explore a wide spectrum of contextual factors that correlate with conspiracy beliefs. As already noted, among other factors addressed within the contextual model of public understanding of science, the topics of politics and religion are common research topics.

As for the previous research in the domain of political factors, significant relationships between vaccination conspiracy beliefs and conservative ideology or Republican partisan identity have been found in several studies in the U.S., Featherstone et al., (2019) found that liberal political orientation was negatively associated with the acceptance of vaccine conspiracy beliefs. Similarly, Joslyn and Sylvester (2017) found that Republicans were less likely than Democrats to endorse vaccination conspiracy beliefs when it comes to childhood vaccines. In addition, studies that explored the relationship between vaccine hesitancy and political orientation found that conservatives were less likely to express pro-vaccination beliefs and that liberals were significantly more likely to endorse pro-vaccination statements, while conservative and moderate parents were less likely to report having fully vaccinated their children (Baumgaertner et al., 2018; Rabinowitz et al., 2016). However, Ward et al. (2020) in France found that there was no traditional left-right division in attitudes toward COVID-19 vaccines. Still, there was a division between people who felt close to the established parties (less prone to vaccine hesitancy), and the people who felt close to the Far-Left and Far-Right parties or did not feel close to any party (more prone to vaccine hesitancy). Moreover, Choi and Fox (2022) found that political partisanship alone is a less relevant factor of hesitancy than trust in public health institutions, while Lasher et al. (2022) found that political ideology was not directly related to vaccine hesitancy.

When it comes to the previous research studies on the relationship between religion and vaccination conspiracy beliefs, Kosarkova et al. (2021) found that spirituality and religious fundamentalism were related to vaccination conspiracy theories in the Czech Republic, while Łowicki et al. (2022) in a research conducted in Poland detected a connection between religious

fundamentalism and COVID-19 conspiracy beliefs scale that included some items covering vaccination conspiracy beliefs. However, in the same study, the connection between the centrality of religion and COVID-19 conspiracy beliefs was not detected. The connection between personal religiosity and vaccination conspiracy beliefs was also established in a research study in Croatia (Pavić and Šuljok, 2022), and another study in Croatia showed that higher levels of religiosity were connected with beliefs in conspiracy theories about the coronavirus (Tonković et al., 2021). Additionally, some research studies found a connection between religiosity and various measures of vaccine hesitancy before and during the COVID-19 pandemic. For instance, Best et al. (2019) found a negative influence of both religious and spiritual beliefs on HPV vaccination among college women in the USA, while Rutjens et al. (2021) found that spirituality was a significant predictor of vaccine skepticism in the USA. The only large-scale, general population study of vaccine hesitancy in Croatia before the COVID-19 pandemic found that religiosity was positively connected to hesitancy, but the effect was almost negligible (Repalust et al., 2017). However, we should also note that some research studies did not establish an association between religiosity and vaccine hesitancy (Reynolds, 2014; Williams et al., 2021).

The moderating effects of political identification were confirmed and in the cases of science topics such as embryonic stem cell research (Nisbet, 2005; Nisbet and Markowitz, 2014) and global warming (Hamilton, 2011; Hamilton and Keim, 2009; McCright and Dunlap, 2011), while the moderating impact of religiosity was also detected in the cases of attitudes regarding science and opinions about embryonic stem cell research (Ho et al., 2008) and nanotechnology (Brossard et al., 2009). It is worth noting that in these studies, the effect of knowledge/literacy was more positive for conservatives and religious people, i.e., that the effect of knowledge/literacy was stronger for more religious and right-wing people, while it was either less positive or non-existent for liberals and non-religious.

Research goals and hypotheses

Based on the above discussion, in this study, we aimed to extend the previous research studies on vaccination conspiracy beliefs in several ways. First, we can note that the moderating effects of religion and political identification on the connection between literacy and science attitudes have been found in other science domains but have not been researched concerning the issue of vaccination conspiracy beliefs. Second, we should note that most research studies have been conducted in the United States and that the contextual determinants can vary depending on the specific socio-political dynamics. And third, health literacy, religiosity, and political ideology intercorrelate and thus can be easily confounded without taking into account all of them simultaneously (Rutjens et al., 2021).

Therefore, in this study, we simultaneously test for possible interactions between health literacy and selected contextual variables – religiosity and political identification – related to a specific science topic (vaccination) and in a specific socio-political context during the COVID-19 pandemic in Croatia. Specifically, we try to determine: (1) whether health literacy is connected to vaccination conspiracy beliefs, (2) whether religiosity and political identification are connected to vaccination conspiracy beliefs (a “weaker” version of the contextual model), and (3) whether the contextual variables moderate the connection between health literacy and vaccination conspiracy beliefs (a “stronger” version of the contextual model). Namely, contextual factors might not only be connected to vaccination conspiracy beliefs, but they might also moderate the impact of scientific (health) literacy on

vaccination conspiracy beliefs, making it different for people who hold values that are more “pro-science” oriented. Additionally, although we do not directly test various explanations of the impact of politics and religion on vaccine hesitancy, drawing on the study results and the analysis of the actions of the main Croatian political and religious actors during the COVID-19 pandemic, we aim to offer some provisional insights and lay the foundations for future studies.

Therefore, the research hypotheses are as follows:

H1. Health literacy is negatively correlated with vaccination conspiracy beliefs.

H2. Religiosity is positively correlated with vaccination conspiracy beliefs.

H2a. Religiosity moderates the connection between health literacy and vaccination conspiracy beliefs.

H3. Right-wing political identification is positively correlated with vaccination conspiracy beliefs.

H3a. Right-wing political identification moderates the connection between health literacy and vaccination conspiracy beliefs.

Overall, H1 implies that the deficit model is correct. H2 and H3 arise from the weaker version, while H2a and H3a are deduced from the stronger version of the contextual model.

Measurements, sampling and analytical approach

This study utilized the shorter version of the HLS-EU-Q health literacy scale (Sørensen et al., 2013). The six-item scale includes items such as judging the reliability of health risk information in the media and using doctor-provided information to make decisions about one’s illness. The HLS-EU-Q6 has a strong correlation ($r = 0.82$) with the longer variant of the HLS-EU-Q, as reported by Bas-Sarmiento et al. (2020). Additionally, HLS-EU-Q6 used in this research was previously validated in several countries (Bergman et al., 2023; Lorini et al., 2019; Mialhe et al., 2021). Cronbach’s alpha in the current study was 0.76.

At the time when the data collection was conducted, there were no validated scales that covered vaccination conspiracy beliefs related to the COVID-19 pandemic, and our judgment was that the general vaccination conspiracy scale used in the study would reflect current vaccination issues. Therefore, a general vaccination conspiracy beliefs scale (Shapiro et al., 2016) was used. The scale comprised seven items scored on a seven-degree Likert scale, such as: “The government is trying to cover up the link between vaccines and autism”; “Vaccine safety data is often fabricated”; „Pharmaceutical companies cover up the dangers of vaccines”, etc. The Croatian language version was also validated on a sample

of university-educated people (Pavić and Šuljok, 2022). Cronbach alpha in the current study was 0.95.

Both political identification and religiosity were measured on a 1 to 10-point scale, with lower results denoting lower religiosity and left-wing political identification.

As control variables, the educational index of parents, place of residence, gender, and field of study were used. The educational index of the parents was measured on a scale running from 1 to 5, place of residence was measured as urban or rural, gender as female and male. The field of study was divided into (a) social studies, arts and humanities, and (b) science, technology, engineering, and mathematics.

The sample used in the study comprised 729 university students from eight faculties and departments of Josip Juraj Strossmayer University of Osijek (Croatia). The study programmes wherein the data were collected were also randomly chosen, taking into account the proportional representation of the various fields of science. The share of students studying in the social sciences, arts and humanities fields was very similar in comparison to the share in the overall student population of the University (50.48% vs 51.02%). Probably due to the differences in attendance, i.e., the fact that the number of students who will attend classes could not be accurately predicted, female students were slightly overrepresented (64.75% vs 59.04%). The students filled in the questionnaires during the classes, wherein the average duration of the survey was about 10 min. Only three students implicitly refused to participate. That is, they submitted blank questionnaires. Study approval was obtained from the ethics committee of the Faculty of Humanities and Social Sciences Josip Juraj Strossmayer University of Osijek. Participants were informed of the aim of the research and agreed to participate with a full guarantee of anonymity and the right to withhold their consent at any time during the study participation. The data were collected in September and October 2021.

The descriptive statistics of the study variables are listed in Table 1.

A comparison with a nationally representative research study which employed the same indicators (Pavić, 2023) showed that students from the sample were somewhat less religious in comparison with general population (5.36 vs 5.55) and less right-wing (5.81 vs 6.09). As for vaccination conspiracy beliefs, we were not able to directly compare the data from the current study with the population data.

As the method of data analysis, we employed structural equation modeling (SEM), which allows simultaneous analysis of the complex relationships of a number of independent and dependent variables, while acknowledging measurement errors

Table 1 Descriptive statistics of the study variables.

	N	Minimum	Maximum	Mean	Std. Deviation
Vaccination conspiracy beliefs	729	7	49	22.98	11.46
Health literacy	729	6	24	15.94	3.37
Political identification	729	1	10	5.81	2.98
Religiosity	729	1	10	5.36	2.33
Educational index of parents	729	1	5	3.47	1.00
Place of residence					
Urban	456 (62.55%)	-	-	-	-
Rural	273 (37.45%)	-	-	-	-
Gender					
Female	472 (64.75%)	-	-	-	-
Male	257 (35.25%)	-	-	-	-
Field of study					
STEM	361 (49.52%)	-	-	-	-
SSA&H	368 (50.48%)	-	-	-	-

Table 2 Intercorrelation matrix.

	Vaccination conspiracy	Health literacy	Political identification	Religiosity	Educational index of parents	Place of residence	Gender	Field of study
Vaccination conspiracy	1	-0.25 ^a	0.15 ^a	0.27 ^a	-0.19 ^a	-0.13 ^a	-0.04	-0.06
Health literacy	-0.25 ^a	1	0.03	-0.05	0.16 ^a	0.08 ^b	-0.04	0.17 ^a
Political identification	0.15 ^a	0.03	1	0.43 ^a	0.01	-0.05	0.14 ^a	0.12 ^a
Religiosity	0.27 ^a	-0.05	0.43 ^a	1	-0.14 ^a	-0.17 ^a	-0.09 ^b	0.12 ^a
Educational index of parents	-0.19 ^a	0.16 ^a	0.01	-0.14 ^a	1	0.25 ^a	0.06	0.11 ^a
Place of residence	-0.13 ^a	0.08 ^b	-0.05	-0.17 ^a	0.25 ^a	1	0.01	-0.04
Gender	-0.04	-0.04	0.14 ^a	-0.09 ^b	0.06	0.01	1	0.13 ^a
Field of study	-0.06	0.17 ^a	0.12 ^a	0.12 ^a	0.11 ^a	-0.04	0.13 ^a	1

^aThe correlation is significant at 0.01 level (two-tailed).
^bThe correlation is significant at 0.05 level (two-tailed).

Table 3 Model fits.

Model	CMIN/df	p	CFI	TLI	RMSEA	90% CI lower	90% CI upper	AIC	BCC
1 - health literacy	2.28	0.000	0.975	0.967	0.041	0.034	0.047	444.86	449.38
2 - health literacy (with interactions)	2.40	0.000	0.943	0.930	0.044	0.041	0.047	1202.181	1215.882

(Hair et al., 2014). The primary strength of SEM in comparison to alternative approaches and statistical models lies in its capability to perform intricate, multifaceted, and highly precise analyses of empirical data, encompassing diverse aspects of the subject under investigation, including abstract concepts (latent variables) and theoretical constructs (Tarka, 2018) that were present in our study. The following fit index benchmarks are employed as an indication of good model fit: (1) relative chi-square test (CMIN/df) < 3 (Kline, 2015); (2) RMSEA less than 0.05 (Browne and Cudeck, 1992), and (3) CFI and TLI > 0.9 (Marsh et al., 2014). Given the short length of the questionnaire and the method of data collection, missing data were very rare (from 0% at variables such as gender and place of residence to 1.23% at a variable that was part of the vaccination conspiracy beliefs scale) and were handled with the regression multiple imputation method. Maximum likelihood was chosen as a method of parameter estimation, while the minimum sample size was determined employing a rule of thumb demanding 10 cases per indicator variable (Nunnally and Bernstein, 1994), which in our case represented a minimum of 400 cases.

Results

In order to gain initial insights into the data, in Table 2, bivariate correlations between the study variables are presented. The most important findings to highlight are negative bivariate correlations between vaccination conspiracy beliefs and health literacy, as well as the fact that more religious and right-wing people are more likely to endorse such beliefs. Religiosity and right-wing political identification are also positively correlated.

We tested two structural models in total. The first model included health literacy, religiosity, and political identification as predictors of vaccination conspiracy beliefs, as well as the educational index of parents, place of residence, gender, and the field of study as control variables. The second model is extended with variables containing the interaction of health literacy, politics, and religiosity. Table 3 presents the model fit indices of the two models, which both indicate an acceptable fit with the data.

In the following figures, standardized coefficients of the two models with acceptable fits are presented. From Fig. 1 we can note

that the results of the model with health literacy, as a more specific measure of knowledge, revealed that both health literacy and religiosity are significant predictors of vaccination conspiracy beliefs. In other words, students with lower levels of health literacy and higher levels of religiosity showed higher vaccination conspiracy beliefs. A higher educational index of parents and the male gender also predicted lower vaccination conspiracy beliefs in this model. It is also noteworthy that political identification is not connected with vaccination conspiracy beliefs.

In the case of the interaction effects, the results indicate the presence of a moderating effect of religiosity. In other words, the negative regression coefficient of the interaction between religiosity and health literacy indicates that the effect of literacy is stronger among individuals with higher levels of religiosity. In the process of probing the interaction, when religiosity was decreased by one standard deviation, the unstandardized coefficient dropped to -0.30 and became insignificant, while at the level of one standard deviation above the mean, it was significant and amounted to -0.75. The moderating effect of political identification was not confirmed (Fig. 2).

In the following Table 4, we summarized the results of our models with conclusions related to the hypotheses tested. We confirmed the main effects of health literacy and religiosity. Additionally, we confirmed the interaction between religiosity and health literacy, while the main effects of political identification and the interaction effect of political identification and health literacy were found to be non-significant.

Discussion

The main goal of this study was to expand previous research on vaccination conspiracy beliefs by applying and testing two models coming from the field of public understanding of science. With the appearance of the deficit model, scientific literacy was considered to be highly important for fostering positive perception towards science, including vaccine-related topics. But the relationship between literacy and attitudes, implied in the deficit model, although weak but significant (Allum et al., 2008), is not predictive in all cases. Therefore, more complex conceptual and methodological approaches are sought when it comes to the deficit model's

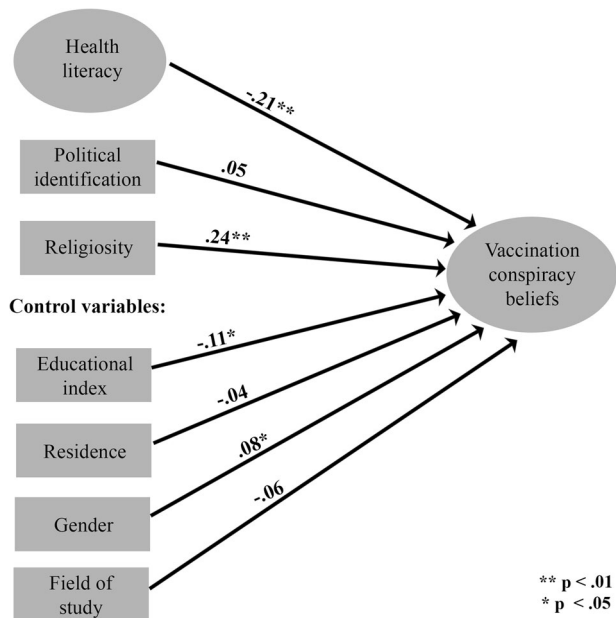


Fig. 1 Model 1. Model with health literacy, political identification and religiosity as predictors (standardized coefficients).

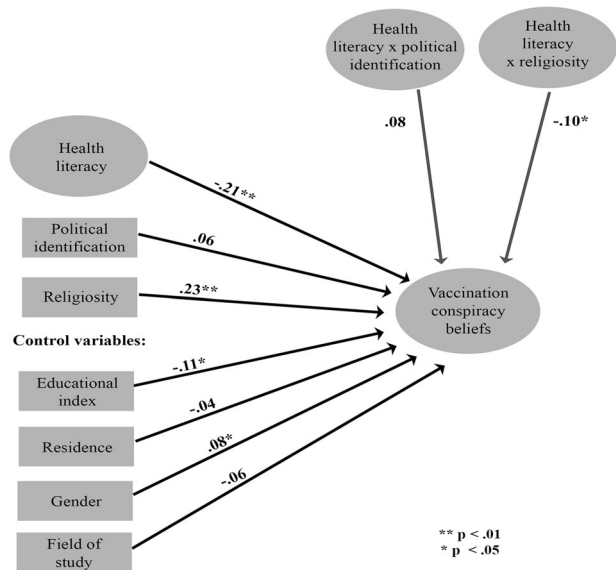


Fig. 2 Model 2. Model with interaction of health literacy and contextual variables (standardized coefficients).

approach to addressing the role of literacy in vaccine conspiracy beliefs. Therefore, in this study, we aimed to investigate the main and moderating effects of contextual variables such as political identification and religiosity when it comes to vaccination conspiracy beliefs as one of the causes of vaccine hesitancy.

Notwithstanding the fact that the previously validated vaccination conspiracy measurement scale employed in this research covered vaccines in general, and not vaccination conspiracies related to the COVID-19 vaccination, we interpret the study results in the light of the social context of the COVID-19 pandemic in Croatia. Namely, even though it can be argued that these kinds of vaccination conspiracy beliefs are not completely the same, i.e., that COVID-19 conspiracies comprise new and specific beliefs, it can also be assumed that the respondents mainly have

in mind the current vaccination situation when giving responses to the questions about general vaccination conspiracies. Furthermore, a study conducted in Croatia (Bagić et al., 2022) determined that a large majority of the COVID-19 vaccine-hesitant individuals expressed a lack of trust in vaccines in general. This suggests a connection between COVID-19 vaccine hesitancy and hesitancy in general.

As for the current study, the results confirmed the direct connection between health literacy and vaccination conspiracy beliefs. In other words, students with a higher level of health literacy were less likely to endorse vaccination conspiracy beliefs. Therefore, even though the deficit model has been often criticized (Bucchi and Neresini, 2002; Hisschemöller and Midden, 1999), its usefulness when explaining science attitudes might still hold to a degree. As for the contextual model approach, the results of our study confirmed that religiosity is a significant predictor of vaccination conspiracy beliefs, aligning with some of the previous research on the role of religiosity in the context of vaccination conspiracy beliefs (Kosarkova et al., 2021; Pavić and Šuljok, 2022; Tonković et al., 2021). Moreover, the moderating influence of religion was established, but in the opposite direction than in the previously mentioned studies related to attitudes in other science domains. In other words, in our study, literacy had a higher effect among more religious people, while in the above-mentioned studies covering other science domains, literacy had a higher effect among less religious people. The inverted interaction effect points to the possibility of a ceiling effect, i.e., that among the people with high average positive science perception (such as among less religious persons) the effect of literacy might not be operative anymore. For instance, Borah et al. (2022) found that media literacy had a higher conditional effect on persons with higher conservative media use when it comes to COVID-19 behavior willingness. This means that persons who can critically think about the source and nature of the information can reduce their negative attitudes to a greater extent when they are already highly present. Even though this study comes from a slightly different research field (media literacy vs science literacy), it suggests that future studies should investigate two possible opposite sources of the interactive effects. Namely, religiosity and political orientation may have an “immunizing” effect on literacy, as suggested by the results of the studies in other science domains. However, higher skepticism towards science also provides an opportunity for literacy to strongly reduce such skepticism. The results of the current study might also suggest that health literacy, or science literacy in general, may be a proxy variable for greater trust in science. In other words, knowledge may induce trust, which then translates into more positive attitudes toward science. This hypothesis seems realistic because even people with high health (scientific) literacy usually do not understand very complex research in the field of vaccination, and this conclusion applies to other research areas as well, bearing in mind the high level of complexity and specialization that exists in all fields. This idea should be tested in future research, where trust in science would represent a mediating variable between literacy and science attitudes.

The contextual influence of politics and religion on vaccine conspiracy beliefs can be approached in two ways. The first, “ideological” approach, refers to substantive differences in endorsement of vaccine conspiracy beliefs regarding political ideologies or religious worldviews. The second, “institutional approach” stems from the struggles for institutional and symbolic power and therefore may be influenced by contingent factors partially, but not always and completely, connected to substantive ideological differences. It rests upon a general idea of top-down elite influence on political opinions, which states that mass

Table 4 Hypotheses testing.

Hypothesized Relationships (model1)	Standardized estimates	p-values	Conclusion
H1: Health literacy → Vaccination conspiracy beliefs.	-0.21	0.00**	Supported
H2: Religiosity → Vaccination conspiracy beliefs	0.05	0.00**	Supported
H3: Political identification → Vaccination conspiracy beliefs	0.024	0.237	Not supported
Hypothesized Relationships (model2)			
H1: Health literacy → Vaccination conspiracy beliefs.	-0.21	0.00**	-
H2: Religiosity → Vaccination conspiracy beliefs	0.23	0.00**	-
H3: Political identification → Vaccination conspiracy beliefs	0.06	0.158	-
H2a. Health literacy → Vaccination conspiracy beliefs (moderated by religion)	-0.10	0.044*	Supported
Interaction probing			
Low level - religion:	-0.06	0.313	
Mean level - religion:	-0.10	0.044*	
High level - religion:	-0.16	0.02*	
H3a. Health literacy → Vaccination conspiracy beliefs (moderated by political identification)	0.08	0.168	Not supported

*p < 0.05; **p < 0.01.

opinions are mainly formed as reflections of elite discourses (Zaller, 2012).

In the field of religion, the “ideological approach” emphasizes the epistemological differences that can bring science and religion into conflict (the symbolic epistemological conflict approach) or, in some cases, lead to the creation of ideas that contribute to the advancement of science (the symbolic directional influence approach) (Evans and Evans, 2008). The conflict does not necessarily have to be related to truth claims but can also be related to the moral evaluation of scientific progress, therefore making the link between religion and conspiracy beliefs a complex phenomenon within its specific context. In such cases, religious leaders may prohibit their followers from vaccinating if the vaccines are against their religious beliefs (Kanozia and Arya, 2021) or the engagement of trusted religious authorities can give credibility to vaccine conspiracy rumors (Trangerud, 2023), such as those that vaccines contain human tissues or religiously forbidden animal products (Kołłataj et al., 2020; Kuzelewska and Tomaszuk, 2022). On the other hand, the direct impact of religiosity can be related to the institutional power struggles between science and religion (Evans and Evans, 2008), and we conjecture that this was the case in Croatia during the COVID-19 pandemic. We draw this tentative conclusion from the actions of the Croatian Catholic Church, by far the largest religious organization in the country. That is to say, we can note that the support of the Croatian Catholic Church to COVID-19 vaccination was not consistent and unequivocal. Even though in December 2020 The Congregation for the Doctrine of the Faith of the Holy See confirmed the moral acceptability of COVID-19 vaccines, the Episcopal Conference of Croatia has never made an explicit call for vaccination, although it supported other epidemiological measures designed to contain the pandemics (Episcopal Conference of Croatia, 2020). However, the Episcopal Conference also emphasized that vaccination has to be voluntary and warned about „... an atmosphere of certain pressures on persons who manifest the problem of their own conscience...” (Episcopal Conference of Croatia, 2020). Moreover, Croatian bishops also emphasized that “bearing in mind that the basis of social order is respect for man and his dignity, it is necessary to take into account the arguments and reasons of individuals who, for justified reasons, exclude the possibility of vaccination” (Episcopal Conference of Croatia, 2021). In none of these cases, any specific objections to COVID-19 vaccines related to their theological or moral underpinnings, dangers, or inefficiencies were not mentioned. Once more, we must add that our conclusions about the relationship between religiosity and vaccine conspiracy beliefs are

only provisional and that future studies should aim to directly measure and in-depth explore possible religion-based moral and theological concerns about various types of vaccines, as well as some religion-based distrust in science and conspiracy theories that were already present before the COVID-19 pandemic (Bramadat, 2017).

The results of this study failed to confirm either the direct connection of political identification with vaccination conspiracy beliefs, when all other variables are controlled for, or the moderating influence on the connection between health literacy and vaccination conspiracy beliefs, in contrast to some already mentioned studies related to other science domains (Brossard et al., 2009; Ho et al., 2008; Nisbet, 2005; Nisbet and Markowitz, 2014). Even though we did not test any mediation models, and given a small bivariate correlation ($r = 0.15$) between political identification and vaccination conspiracy beliefs established in this research, a possible explanation would be that religiosity mediates the relationship between political identification and vaccination conspiracy beliefs, i.e., that right-wing persons have higher conspiracy beliefs only because they are more religious. A rather small bivariate correlation between political identification and vaccination conspiracy beliefs can be explained in two ways. First, it is possible that political identification is not very salient for the student population. Second, earlier we stated that there are two approaches in explaining the influence of political affiliation on attitudes about science, the first one emphasizes political and ideological beliefs, and the second one political partisanship, i.e., top-down elite influence of political elites. In Croatia, science topics did not figure prominently in the ideological battles between political parties, i.e., there were no clear-cut differences between right-wing and left-wing parties in this regard, for example in the United States. Even though the coverage for mandatory vaccination just before the COVID-19 pandemic amounted to only from 89% (Hib revaccination) to 98% (BCG) (Croatian Institute for Public Health, 2019) and the expressed complete vaccine refusal in general population amounted to 10% (Repalust et al., 2017), vaccination was not an issue that was frequently discussed in the public arena. The COVID-19 pandemic changed the situation to a degree, and all political parties had to take a stand on the issue of COVID-19 vaccination. Even though none of the political parties expressed overall criticism of the vaccines or any other kind of criticism towards science, more extreme right-wing parties (*Most* and *Domovinski Pokret*) took a firm position against compulsory vaccination and expressed harsh criticism of the public health measures aimed at containing the pandemic. The governing centre-right party (*Croatian*

Democratic Union - HDZ) expressed support for vaccination, and this goes for the strongest oppositional left-wing parties (*Social Democratic Party—SDP* and *Možemo*), even though the latter were critical towards the overall management of the health crisis. Notwithstanding the fact that we did not measure background political and socio-psychological variables, the results of the current study lend some indirect support to the studies that imply that political partisanship is more important than ideology. Scientific topics in Croatia were not positioned as relevant social and political topics. In such a situation, political influence on science attitudes during the COVID-19 pandemic partially fell back on partisanship, which in the case of vaccination attitudes in Croatia, has not followed a completely clear-cut Left-Right line.

Overall, we propose that, within the contextual model, it could be useful to investigate various ad-hoc factors not necessarily connected to political and/or religious ideologies. In other words, it is important to investigate specific socio-political contexts and their influences on vaccine hesitancy since it is very unlikely that universal effects will be found. We believe that a promising avenue of research is to differentiate between ideological battles and institutional battles since the former deal with values and the second with power.

Conclusion and limitations

The overall conclusions of this study point to the fact that knowledge, that is, health literacy, is indeed inversely connected to vaccination conspiracy beliefs. However, the connection between religiosity and vaccine conspiracy beliefs points to the conclusion that people can disregard scientific recommendations not only because of the lack of knowledge/literacy but also because of the perceived ethical misconduct or other trust issues that are not related to the cognitive dimension of science. In other words, health literacy, or even knowledge in general, is important but not sufficient to explain vaccination conspiracy beliefs. Given that no moral or theological concerns about the COVID-19 vaccines have been raised in Croatia during the pandemic, we tentatively concluded the balance of power between religious and secular institutions might be the explanation of the findings. Similarly, we also indirectly attributed the lack of connection between political identification and endorsement of vaccination conspiracy beliefs to “institutional” and not “ideological” reasons. However, in the current study, we confirmed only the moderating influence of religiosity on the relationship between health literacy and vaccination conspiracy beliefs, even though in a direction that is opposite to the one previously established in other science domains. Therefore, we found only partial support for the thesis of the moderating effect of the values on the connection between knowledge (health literacy) and science attitudes (vaccine conspiracy beliefs), which are present in the stronger versions of the contextual model. The overall conclusion is that we found confirming evidence for both deficit and contextual models, which is not surprising given that the latter can be seen as a complement of the former, that is, that they are not necessarily and completely mutually exclusive. Therefore, the findings suggest that health literacy is important, but should not be the only variable when designing vaccination campaigns or interventions for reducing vaccination conspiracy beliefs or vaccine hesitancy in general. This insight is particularly noteworthy, given that promotion campaigns regarding vaccination in Croatia were primarily developed on the idea of improving public literacy, and thus did not cover the segments of the population whose vaccine skepticism can be attributed to other sources.

The main limitation of our study is related to the student sample employed in the research, which limits the internal and external validity of the results. As noted earlier, in Croatia student population is somewhat less religious and politically less right-wing in comparison to the general population. Second, we started with the idea that the impact of religion and politics on various

science attitudes highly depends on the specific socio-political context. Therefore, our results should be tested on other populations and countries in future research to enhance the generalizability of the findings. The third limitation of the study stems from the fact that we used self-perceived health literacy as a measurement of health literacy and the possibility that it can be confounded with other variables that can be related to vaccination attitudes, such as trust in the healthcare system. Fourth, our assumption that endorsement of the general vaccination conspiracy beliefs was under the strong influence of the COVID-19 health crisis should also be tested in future research that would measure specific COVID-19 vaccination conspiracy beliefs.

Data availability

The data that support the findings of this study are available on request in Repository of the Faculty of Humanities and Social Sciences Osijek at <https://urn.nsk.hr/urn:nbn:hr:142:277056> reference number 142:277056.

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Author contributions

Conceptualization: ŽP, EK and AŠ. Methodology: ŽP and EK. Data collection: ŽP. Data analysis: ŽP, EK, and AŠ. Writing—original draft: ŽP and EK, AŠ. Writing—review and editing: ŽP, EK, and AŠ. Project administration: ŽP.

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Competing interests

The authors declare no competing interests.

Ethical approval

Ethics Committee of the Faculty of Humanities and Social Sciences Josip Juraj Strossmayer University of Osijek approved the study (Ethical approval code: 2158-83-02-19-2).

Informed consent

Informed consent was obtained from all participants.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1057/s41599-023-02439-7>.

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