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Trust in official information as a key predictor of COVID-19 vaccine acceptance: evidence from a Czech longitudinal survey study

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Abstract

Background COVID-19 vaccine hesitancy (CVH) has become a critical public health issue, with attitudes toward vaccines emerging as a broader social issue. Public debates surrounding vaccines have expanded beyond health considerations to include issues of trust, misinformation, and societal values, making CVH a complex challenge that requires multifaceted solutions. Analyzing the various determinants of CVH is crucial for developing targeted strategies to improve vaccine acceptance in specific countries and to better prepare for future public health crises. However, no study to date has evaluated the determinants of CVH in a representative sample of the Czech population.

Methods A multiple hierarchical logistic regression was used to analyze the associations between various sociodemographic, trust and attitudinal factors with COVID-19 vaccine acceptance (CVA). The analysis utilized survey data from a representative longitudinal sample of the Czech population ($N = 1,407$).

Results After controlling for all other factors, trust in official statements from the Ministry of Health was the strongest predictor of CVA, followed by prior positive attitudes toward COVID-19 vaccination (prior to vaccine availability) and older age. Lower trust in COVID-19 misinformation also predicted CVA, while lower interest in COVID-19 media content was associated with CVA. Higher income initially predicted CVA but lost statistical significance after controlling for other variables. Interestingly, education did not play a role in CVA.

Conclusion CVH was primarily driven by distrust in government-provided information. Notably, vaccine refusers demonstrated a higher motivation to seek information on the topic, offering a promising opportunity for health policy interventions. Our findings suggest that strategies to reduce CVH should prioritize building trust in state institutions and effectively combating misinformation.

Keywords COVID-19, Vaccine hesitancy, Vaccine acceptance, Trust in institutions, Misinformation

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Introduction

Vaccine hesitancy poses a significant threat to public health, identified by the WHO as one of the biggest global health challenges [1]. Although vaccine hesitancy is not a new phenomenon and has posed challenges in combatting diseases such as measles [2], human papillomavirus [3], influenza [4], etc., the COVID-19 pandemic introduced some new and unique characteristics and exacerbated this issue. These included the universal focus of the media and public on the virus, its significant socioeconomic impacts [5], and the uncertainty surrounding the pandemic's progression [6]. Together, these factors may have heighten people's perception of risk and threat. Additionally, the unprecedented speed of COVID-19 vaccine development and authorization of the vaccines have created doubts and undermined public trust in their safety, making attitudes toward vaccination much broader societal issue.

Vaccine hesitancy is a multifaceted and historically evolving social phenomenon, influenced by a complex interplay of social and psychological factors. Even as the COVID-19 pandemic recedes and the mortality has decreased, it remains crucial for researchers and policymakers to assess thoroughly the extent and causes of vaccine hesitancy to develop effective strategies to combat it [7, 8]. The extent of COVID-19 vaccine hesitancy has been shown to differ significantly across European countries [5] and globally [5, 9, 10]. Extensive research has been conducted on the factors contributing to COVID-19 vaccine hesitancy (CVH) or acceptance (CVA) across various countries, including multinational studies, systematic reviews, and meta-analyses [5, 9, 10].

There are four consistently identified groups of factors explaining CVH. Firstly, the *sociodemographic* characteristics such as lower education [11–14], lower income [11, 15–18], younger age [13–17, 19], and female sex [12–14, 16, 17] have been associated with higher CVH. Previous studies further showed that vaccine hesitant individuals are often from rural regions or belong to ethnic minorities [11, 13, 16, 17]. Additionally, pre-existing medical conditions as well as being against vaccines in general have been repeatedly found to contribute to CVH [15, 20].

The second group of factors essential to understanding CVH involves the *perception of risks* associated with COVID-19 vaccines. These include concerns about safety, such as the belief that rapidly developed vaccines are too dangerous, and worries about side effects and unknown future effects [9, 10, 17, 21, 22]. Conversely, vaccine hesitancy has been associated with a lower perceived risk of COVID-19, with the virus viewed as less threatening [16, 17, 23], or even harmless [20].

The third group of factors is related to *mistrust* in institutions and information they provide, which have been highlighted as an important predictor of CVH [16, 18, 22]. Mistrust towards medical companies, and perceived political and economic motives driving the pandemic or vaccine development, collectively erode the beliefs and trust crucial for COVID-19 vaccine acceptance [24]. Prior studies connected CVH to mistrust towards national governments, health authorities and services [9, 10, 14–16, 22], and science in general [18]. Another related well-established factor contributing to CVH is the trust in misinformation and conspiracy theories [11, 18, 22, 25, 26].

Fourthly, prior studies have identified several *information*-related factors contributing to CVH. These include limited information about the virus and low health literacy [11, 13, 24], including misunderstandings about herd immunity [20, 22]. Furthermore, confusion stemming from the rapid development of the epidemic and the inconsistent and contradictory information provided to the public have also played a significant role in CVH [15, 24]. Another well-established factor contributing to CVH is the use of social media as information source [14, 21, 22, 27–29], where false and misleading information about COVID-19 has been widely disseminated [30]. Some studies have identified social/peer influence as another predictor associated with CVH [31]. While prior studies found positive associations of low health literacy and a lack of information with CVH, only a few studies have examined active searching for COVID-19 news content or personal engagement with this news content rather than mere exposure. For example, close attention to COVID-19 news has been found to be significant in vaccine hesitancy [32]. To the best of our knowledge, no research has specifically examined the interest (motivation) in seeking COVID-19 information in the media. This would help determine whether combating CVH is hindered by vaccine-hesitant individuals' frustration with the issue, unreceptiveness and unwillingness to receive information about the issue.

A personal perspective on such a complex issue as vaccination is generally built not on direct experience—which requires deep knowledge of biology and medicine—but rather on mediated experience and trust in information sources. In the Czech Republic, vaccination was unanimously promoted by state authorities as an effective and safe measure against COVID-19 by two successive governments from opposing political parties, based on a consensus within the expert community. These messages were disseminated through public and mainstream media, ultimately becoming a social norm. On the other hand, alternative information sources presented a wide range of claims, including messages that the pandemic was a hoax, that the virus was either harmless or artificially created as a biological weapon, and that vaccines were harmful [33]. We operationalized trust in

information reflecting these dichotomous perspectives—socially normative versus anti-system attitudes—into two variables: Trust in official statements regarding vaccination from the Ministry of Health and Trust in misinformation about COVID-19. While it is well established that these factors have been associated with vaccine uptake/refusal in many countries, the significance of these predictors has not been explicitly discussed in comparison to other widely recognized predictors, such as sociodemophraphic characteristics and prior trust in vaccines, measured before COVID-19 vaccines were developed. This study aims to determine the extent to which trust in official versus anti-system information played a role in explaining vaccine uptake compared to socioeconomic predictors and prior attitudes toward vaccines––before misinformation about vaccination became widespread and society became significantly polarized on the issue. Additionally, we added a novel factor to our analyses, the interest (motivation) to seek COVID-19 information in the media, to evaluate whether vaccine-hesitant individuals were willing to engage with mediated information on this issue. Although trust in other information sources, such as influence of peers, have been associated with CVH, we opted not to include them. Our study was driven by a public health policy perspective, where individuals—including peers—are also targeted by information campaigns and mediated messages.

Additionally, no study to date has evaluated the determinants of CVH in a representative sample of the Czech population. While Zidkova et al. [14] investigated vaccination intentions in a representative sample at the outset of universal vaccination, other studies have focused solely on specific subgroups within the Czech population [34–36]. Examining determinants of CVH on a representative Czech sample is needed for developing effective strategies to combat vaccine hesitancy.

To address these gaps, the present study examines the associations between CVH and various factors, including sociodemographic characteristics, prior attitudes towards vaccination before COVID-19 vaccines were developed, trust in official government information versus misinformation about COVID-19, and the previously unexplored factor of interest in COVID-19 information. Importantly, we compare the predictive power of these factors in explaining CVH. To this end, we analyzed survey data from a longitudinal dataset representative of the Czech population using a hierarchical logistic regression. The primary objective of this analysis was to understand the role of trust in information sources, helping to determine the emphasis placed on this issue when developing intervention strategies aimed at increasing COVID-19 vaccine acceptance, as well as to inform strategies for managing future epidemics.

Materials and methods

Participants and procedure

Participants were invited to participate in the longitudinal panel study [37] in spring 2020. The study aimed at monitoring the various participants' behaviors and attitudes via CAWI method, such as the motivation to get vaccinated and vaccine hesitancy, together with their mental health, media use, social status, etc. Participants were recruited from the Czech National Panel, as a part of European National Panels [38], ensuring that the resulting sample corresponded to the population for cross-cutting of age and sex, and cross-cutting education and region. In the current study, data were collected at different time points (from December 2020 to February 2023), which are specified below for each variable. In the current study, we analyzed data from 1,407 participants of the panel (51.4% females) aged between 18 and 89 years (M = 54.14, SD = 15.12). Due to missing data, 230 participants were excluded, resulting in a final sample of 1,177 participants for analysis. The sample of each wave was constructed to be quota-representative of the adult population of the Czech Republic. To ensure repeated participation of various socio-demographic groups, it was necessary to adjust the current sample through post-stratification weighting. This adjustment was based on current population distributions (using data from the Czech Statistical Office) for the following characteristics: sex, age, education, size of place of residence, region, cross-cutting of age and education, cross-cutting of age and sex, and employment status. Sociodemographic description of the sample is provided in Table 1. The inclusion criteria were proficiency in the Czech language, permanent residence in the Czech Republic, and being over 18 years of age. The procedure was in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments. The study was approved by the Ethics Committee of National Institute of Mental Health (CZ) (no. 181/21). All participants provided digital informed consent.

Measures

Only self-reported measures were administered. Information on acceptance of the COVID-19 vaccine [CVA] was assessed by asking participants whether they had been vaccinated and, if so, how many times (0, 1, 2, or 3 times) on February 2022 to February 2023. For the analysis, the number of shots was not considered; instead, the responses were dichotomized into a binary variable: 1 (yes) for those who received at least one dose, and 0 (no) for those who were not vaccinated. Factors were selected from the longitudinal dataset to align with the current study's aim and based on the available literature on

Table 1 Description of predictors entering multiple hierarchical regression analysis

N **= 1407**	**M**	**SD**	**MIN**	**MAX**
AGE	54.14	15.12	18	89
TRUST-MIS[1]	16.03	5.36	6	30
ATTITUDES-VAC[2]	17.31	8.45	7	35
ATTITUDES-VAC[2] unvaccinated (*N* = 212)	10.84	5.421	7	28
ATTITUDES-VAC[2] vaccinated (*N* = 965)	18.70	8.215	7	35
INCOME	N	%		
1 Above poverty line	144	10.2		
2 Low income	560	39.8		
3 Upper income	524	37.2		
4 High income	179	12.7		
Total	1407			
EDUCATION				
1 Elementary	54	3.8		
2 Apprenticeship	404	28.7		
3 High school	517	36.7		
4 University	432	30.7		
Total	1407			
INTEREST-NEWS[3]				
1 Not interested at all	43	3.1		
2 Rather not interested	194	13.8		
3 Rather interested	661	47.0		
4 Very interested	509	36.2		
Total	1407			
TRUST-MH[4]				
1 Not at all	193	13.7		
2 Rather not	244	17.3		
3 Neither not, nor yes	517	36.7		
4 Rather yes	388	27.6		
5 Completely yes	65	4.6		
Total	1407			

[1] Trust in misinformation about COVID-19; [2] Prior attitudes toward COVID-19 vaccination; [3] Interest in COVID-19 news; [4] Trust in official statements of the Ministry of Health

predictors of COVID-19 vaccine hesitancy. We categorized variables into four blocks:

1. Social status. Sociodemographic information included AGE, SEX (1: male, 2: female), EDUCATION level (collected in March 2020) (1: elementary education, 2: certificate of apprenticeship, 3: high school education, 4: university degree), equalized household INCOME (1: below poverty line, 2: low income, 3: upper income, 4: high income) (collected in April 2022).
2. Prior attitudes toward COVID-19 vaccines. To measure the perceived severity of pandemic risk, as well as trust in the vaccines, we included a question assessing willingness to pay for the COVID-19 vaccine [ATTITUDES-VAC]. Participants were asked, "Would you be willing to pay for a medically verified and approved COVID-19 vaccine if it were available?" Responses were assessed across seven price points [1: if it was free, 2: 1–100 CZK (approx. 0.04–4 EUR), 3: 101–300 CZK (approx. 4–12 EUR), 4: 301–500 CZK (approx. 12–20 EUR), 5: 501–800 CZK (approx. 20–31.5 EUR), 6: 801–1000 CZK (approx. 31.5–39.5 EUR), 7: 1001–2000 CZK (approx. 39.5–78.7 EUR)] using a 5-point scale (1: definitely not– 5: definitely yes). ATTITUDES-VAC was measured in December 2020, prior to the availability of COVID-19 vaccines, and was calculated as the sum of responses across these seven items.
3. Trust. Trust in official statements of the Ministry of Health [TRUST-MH] was assessed in April 2022 with question "How much do you trust official statements of the Ministry of Health regarding COVID-19 vaccination"? Participants rated these items on a 5-point scale ranging from 1 ("Not at all") to 5 ("Completely"). Trust in misinformation about COVID-19 [TRUST-MIS]: based on responses collected in April 2022, we developed a questionnaire based on locally prevalent COVID-related messages identified by the Ministry of the Interior of the Czech Republic [39]. Initially, the questionnaire contained fifteen items, which were reduced to six based on results from a pilot study (N = 423, 317 women, aged 18–81, M = 37.1). The pilot study was conducted using an online form platform, advertised through institutional Facebook pages. Items were excluded based on exploratory factor analysis, item analysis, and Cronbach's alpha coefficient. Exploratory Factor Analysis, using Parallel Analysis with Oblimin rotation, identified a one-factor structure. We retained only items with high factor loadings (≥ 0.75) and low uniqueness (≤ 0.40). Subsequently, we ensured that the final set of items were clear, concise, and easy to understand. After the item reduction, Cronbach's alpha slightly decreased from 0.954 to 0.946, but still indicating strong internal consistency. The final TRUST-MIS questionnaire included the following items: "The coronavirus was developed artificially as a biological weapon"; "The epidemic is fake, the situation has never been so serious"; "Epidemic measures were ineffective and counterproductive."; "Western pharmacological vaccine companies are untrustworthy"; "Vaccines are dangerous for the vaccinated"; "The discrimination against Russian and Chinese vaccines is largely driven by political reasons"; Participants rated these items on a 5-point scale ranging from 1 ("I do not agree at all") to 5 ("I completely agree"). This questionnaire demonstrated good internal consistency 0.846.

4. Interest in COVID-19 news content [INTEREST-NEWS], assessed in April 2022, was measured by asking participants „To what extent have you been interested in the following news content over the past two weeks?“ with the “COVID-19 pandemic” being listed among other topics. Responses were rated on 5-point scale (1: “I was not interested at all”– 5: “I was very interested”). A description of all variables is provided in Table 1.

Statistical analysis

A hierarchical logistic regression analysis (method ENTER) was performed to identify the factors associated with COVID-19 vaccine hesitancy. Participants' acceptance of COVID-19 vaccination was the dependent variable. Independent variables were clustered in four blocks entering the analysis in discrete steps. Block 1 of the regression model consisted of sociodemographic variables, namely AGE (in years), SEX (female /reference category/ or male), EDUCATION (elementary / reference category/, apprenticeship, high school or university), INCOME (poverty /reference category/, low, upper, high). In Block 2, ATTITUDES-VAC total score entered the analysis as a possible predictor of vaccination acceptance. In Block 3, trust in information sources– TRUST-MH (1-ref. cat., 2, 3, 4, 5) and TRUST-MIS total score– entered the analysis. In Block 4, we added interest in COVID-19 information in the media (INTEREST-NEWS; 1-ref. cat., 2, 3, 4). This analytical approach allowed us to examine the predictive role of trust-related factors and interest variables, controlling for sociodemographic factors. In total, four regression models were tested, one for each group of factors. To evaluate model performance, we used Nagelkerke R^2 test to assess model fit, the Hosmer & Lemeshow test to evaluate model calibration, -2 Log Likelihood tests for model fit comparisons, and the Chi-square test (χ^2) to determine overall model significance. Analyses were conducted in SPSS version 25.

Results

A total of 965 respondents (82%) were vaccinated, while 212 respondents (18%) refused the vaccine. The Final Model (Model 4) of the hierarchic logistic regression successfully predicted a total of 86.7% of cases. The positive predictive value (PPV = 95.24%) and sensitivity (SEN = 89.24%) showed that the model was highly effective at predicting vaccinated individuals. However, specificity (SPE = 69.53%) and negative predictive value (NPV = 48.61%) were lower, showing moderate performance in identifying non-vaccinated cases. Metrics for evaluating performance of all models of the hierarchic logistic regression are provided in Table 2. All models were statistically significant. By adding predictors, the models gradually improved their fit, with the Final Model's Nagelkerke R^2 indicating a moderate fit (R^2 = 0.489), explaining 48.9% of the variance in COVID-19 vaccine acceptance. This means that about half of the variation in whether someone accepted the vaccine was accounted for by the predictors in the Final Model. This represents a substantial improvement from Model 1, which included only sociodemographic predictors, and explained only 8% of the variance in vaccine acceptance. Next, the results of the Hosmer & Lemeshow Test suggested good model calibration of the Final Model (χ^2/df = 5.18/8, p = 0.738), showing the best calibration of all the models. These results indicate that the predicted probabilities of vaccine acceptance closely align with the observed outcomes in the data. Finally, the decreasing – 2 Log likelihood values across the models (Model 1 → Model 2 → Model 3 → Final Model) demonstrated improvements in model fit as predictors were added. Particularly large improvements were observed between Model 1 → Model 2 and Model 2 → Model 3, i.e. after adding ATTITUDES-VAC to Model 2, as well as TRUST-MIS and TRUST-MH to Model 3. Specifically, the model fit improved by 19.8% after adding ATTITUDES-VAC. The same improvement of 19.8% was observed when trust in official statements and trust in misinformation were included.

Results from the hierarchical logistic regression on COVID-19 vaccine acceptance is presented in Table 2. Overall, after controlling for sociodemographic variables in Block 1, all predictors consistently and significantly contributed to the variability of the CVA criterion in all subsequent blocks, with TRUST-MH being the most significant predictor. Regarding social status, assuming control of other predictors in the analysis, AGE was found to be a statistically significant factor. One year of AGE increased the average odds of being included in the vaccinated group by 3.6%. Although INCOME was significant when controlling for sociodemographic variables in Model 1, it lost significance in subsequent models after adding additional predictors. Despite this, the odds ratio values remained high across all models. In Final Model, compared to the “Below poverty line” group used as a reference category, respondents in the “Low-income” group had a 59.9% higher chance, “Upper-income” a 96.3% higher chance, and “High-income” a 199.8% higher change of being included in the vaccinated group. These results suggests higher income is associated with higher odds of being vaccinated. EDUCATION was not statistically significant in any of the models. Prior attitudes toward COVID-19 vaccines (ATTITUDES-VAC) was a significant predictor in all models. Controlling for other variables, ATTITUDES-VAC increased the odds of being included in the vaccinated group on average by 9.9%.

Concerning trust, both trust in COVID-19 misinformation (TRUST-MIS) and trust in official statements of the

Table 2 Results from the hierarchical logistic regression on COVID-19 vaccine acceptance (CVA) and performance metrics of the models. Vaccinated (*N* = 965); unvaccinated (*N* = 212); significant p-values are reported in bold

CVA (criterion)	Model 1		Model 2		Model 3		Model 4	
	OR	*p*	OR	*p*	OR	*p*	OR	*p*
SEX – 1-males; 0-females (ref. cat)[1]	0.896	0.500	1.144	0.445	0.842	0.40.81	0.848	0.424
AGE	1.026	0.000	1.024	0.000	1.036	0.000	1.036	**0.000**
INCOME– Above poverty line (ref. cat.)								
Low income	1.599	0.045	1.271	,343	1.469	0.184	1.582	0.116
Upper income	1.963	0.006	1.559	,094	1.552	0.143	1.723	0.073
High income	2.998	0.001	2.035	,052	1.674	0.208	1.781	0.167
EDUCATION - Elementary (ref. cat.)								
Apprenticeship	0.733	0.434	0.796	,588	0.675	0.407	0.719	0.478
High school	1.037	0.927	0.973	,948	0.663	0.385	0.684	0.413
University	1.645	0.230	1.377	,469	0.875	0.787	0.900	0.829
ATTITUDES-VAC[2]			1.170	,000	1.094	0.000	1.099	**0.000**
TRUST-MIS[3]					0.845	0.000	0.841	**0.000**
TRUST-MH[4]– Not at all (ref. cat.)								
Rather not					1.764	0.029	1.933	**0.014**
Neither not, nor yes					3.558	0.000	3.666	**0.000**
Rather yes					8.618	0.000	8.793	**0.000**
Completely yes					7.782	0.017	6.748	**0.021**
INTEREST-NEWS[5]– Not interested at all (ref.cat.)								
Rather not interested							0.164	**0.000**
Rather interested							0.263	**0.006**
Very interested							0.277	**0.012**
Nagelkerke R^2	0.080		0.278		0.476		0.489	
Hosmer & Lemeshow Test (χ^2/df)	12.48/7		6.13/8		10.50/8		5.18/8	
P	0.131		0.630		0.231,		0.738	
-2 Log likelihood	1063.3		903.3		716.76		702.16	
χ^2/df	12.29/3		160.02/3		36.40/3		14.61/3	
P	**0.006**		**0.003**		**0.001**		**0.002**	

[1] Reference category; [2] Prior attitudes toward COVID-19 vaccination; [3] Trust in misinformation about COVID-19; [4] Trust in official statements of the Ministry of Health; [5] Interest in COVID-19 news

Ministry of Health (TRUST-MH) were significantly associated with vaccine acceptance in all models. Controlling for other variables, TRUST-MIS decreased the odds of being included in the vaccinated group on average by 15.9%. Regarding TRUST-MH, in comparison with the group that "absolutely did not trust" Ministry of Health, individuals who "rather did not trust," "were undecided,", "rather trusted," and "absolutely trusted" Ministry of Health had a chance of being included in the vaccinated group by 93.3%, 266.6%, 779%, and 574.8%, respectively.

Assuming control of other predictors in the analysis, the results showed that INTEREST-NEWS was a significant factor. In comparison with the group "Not interested at all" (reference category) in news about the COVID-19 pandemic, individuals who was "rather not interested" had, on average, 83.6% lower chance of being included in the vaccinated group. Individuals from the group that was "rather interested" had 73.7% lower chance, and individuals who were "very interested" had 72.3% lower chance of being vaccinated.

Discussion

General findings

The present study, analyzing data from the longitudinal dataset representative of the Czech population, examined multiple factors that explained 48.9% of the variance in COVID-19 vaccine acceptance (CVA). The study incorporated a new factor––interest in seeking COVID-19 information in the media––and a novel measure of prior attitudes toward COVID-19 vaccines before their availability. The results of hierarchical logistic regression revealed that trust in official statements of Ministry of Health regarding COVID-19 was the strongest predictor of CVA, followed by prior willingness to accept the vaccine, older age and distrust in COVID-19 misinformation. Additionally, lower interest in seeking information about COVID-19 in the media also contributed to CVA. In sum, adding trust-related factors to the model––prior attitudes to vaccines, trust in official information, trust in misinformation––substantially improved the models. These factors therefore explained the variance in CVA much more effectively than socioeconomic status.

Trust-related factors

Our findings corroborate previous evidence syntheses [9, 10, 13, 17, 20] and studies conducted in various countries [15, 16, 22, 40], which consistently show that trust in government and health system are common predictors of CVA. Additionally, our study confirms earlier findings specific to the Czech population, showing that trust in the government was one of the strongest predictors of vaccination intentions in the spring of 2021, right as COVID-19 vaccines became available [14]. A comparison with our data from April 2022 reveals an increase in trust in the government from 19.2% [14] to 32.2% in our sample, considering the answer "rather yes" and "completely yes" as „trust". However, this observation should be interpreted with caution, as the exact wording of the question assessing trust in government slightly differed. It is noteworthy that our results show a higher vaccine uptake in the Czech population (82%) compared to the 59% willingness to get vaccinated reported by Zidkova et al. [14].

The second strongest predictor of CVA in our results was the willingness to accept the vaccine, assessed before the COVID-19 vaccine was developed, through participants' stated willingness to pay for the vaccine. This factor served as a proxy for the perceived seriousness of COVID-19 and general trust in vaccination and its effectiveness, prior to the spread of misinformation about COVID-19 vaccines and before society became polarized on the issue. To the best of our knowledge, no prior research has introduced this specific measure, which was made possible by the longitudinal design. This finding aligns with previous studies that identified perceived risk of COVID-19 [16, 17, 23] and trust in vaccination [20, 22] as repeatedly replicated predictors of CVA. Furthermore, our analysis identified low trust in COVID-19 misinformation as another determinant of CVA, consistent with previous research [11, 18, 22, 25, 26]. In sum, trust-related factors accounted for most of the variance in CVA. Prior attitudes toward vaccines, as well as trust in official/ anti-system information contributed equally (19.8%) to predicting whether respondents received the vaccine. Therefore, trust-related factors played a more substantial role in explaining CVA than sociodemographic factors (8%). This finding aligns with the broader observation that cognitive factors, including trust, represents most important predictors of CVA [31].

Interest in seeking COVID-19 information

Controlling for all other factors, interest in information regarding COVID-19, the novel factor being examined in our study, was negatively associated with CVA, although the predictive power of this factor was much lower compared to the other predictors of CVA. While previous studies have linked CVH to a lack of health literacy and insufficient health information [11, 13, 24, 41], our results did not associate CVH with lower education, and indicated that vaccine hesitant individuals are more motivated to seek COVID-19 information than those who accepted the vaccine. This behavior may reflect a stronger drive to reduce uncertainty about COVID-19 and perceived insufficiency of information, as has been proposed in prior research [42]. This heightened need for information presents an opportunity for strategies to combat vaccine hesitancy. However, our findings also reveal that vaccine acceptance heavily depends on the sources of information that individuals trust. While vaccine-hesitant individuals were more motivated to seek COVID-19 information, they also tend to mistrust official sources and public health measures. In this context, information-based strategies alone may be insufficient, as these messages are likely to be dismissed by vaccine-hesitant individuals due to their existing mistrust toward official information.

Sociodemographic factors

While previous studies often found that being female and older, having higher education, and higher income was most frequently associated with CVA [10], in our model, only age predicted CVA in the final model, with older participants being more likely to accept the vaccine, consistently with other studies [13, 15–17, 19]. Higher income showed a large effect size in predicting CVA, but it was not statistically significant when controlling for other predictors. Furthermore, neither sex, nor education was significantly associated with CVA. While research on COVID-19 vaccine hesitancy often identifies higher education and male sex as important predictors of CVA, varying patterns across populations highlight socio-cultural differences across regions [43]. In some countries, differences on sex, income and/or education are absent, suggesting context-specific influences [44, 45]. For example, studies in more egalitarian societies, demonstrating more socio-economic homogeneity, report gender, income, and education gaps in predicting CVA less frequently [46, 47]. Our results may also reflect the influence of more consistent public health messaging [43]. Overall, socioeconomic status did not play as significant role in CVA as trust-related factors. Our findings suggest that CVH was not primarily a sociodemographic issue but rather a more complex phenomenon rooted in distrust in official information and preexisting mistrust in vaccines and their effectiveness, accounting for most of the variance of CVA.

General discussion and future directions

Building on previous studies highlighting various forms of mistrust/distrust as central to CVH [16, 18, 22, 48], our findings may reflect a broader and more significant social trend–– the erosion of trust in institutions and

societal structures, a phenomenon potentially amplified by the global health crisis [49, 50]. Therefore, investigating the causes of mistrust in institutions and official information sources should be a broader research priority, informing not only vaccine uptake strategies but also deepening our understanding of how contemporary societies navigate crises and adapt to evolving information ecosystem in the digital age. For example, some of the research on COVID-19 vaccine hesitancy reflecting the erosion of trust in institutions has revisited the concept of anomie, which describes a situation where social authorities are perceived as untrustworthy and social norms as uncertain and ineffective for individuals [51, 52]. In such perception of a cultural milieu, individuals struggle to differentiate between accurate and fake information, often leading them to adopt the later. On one hand, they consume a constant flow of information, as indicated in our findings of higher interest in COVID-19 information among CVH individuals. On the other hand, they are inclined to trust rhetorically powerful, simplistic, and all-encompassing interpretations of COVID-19 situation, as reflected in our findings by higher trust in COVID-19 misinformation in CVH [52, 53].

The provided evidence on a Czech sample suggesting that CVH is driven by a crisis of trust in information rather than a lack of information or lack of interest in information about COVID-19 presents significant challenges for developing effective strategies combating vaccine hesitancy. Traditional intervention programs that rely on information dissemination to combat COVID-19 vaccine hesitancy have shown mix or weak results. Some studies from the United States found that messages emphasizing the low risk of side effects and effectiveness of COVID-19 vaccines increased willingness to get vaccinated [54, 55], while a similar study from United Kingdom did not confirm such effects [56]. A multinational comparison of public health messages revealed that none of the tested messages consistently increased CVA across all countries; in fact, some messages even decreased willingness to get vaccinated, particularly in countries with low trust in government and high levels of misinformation beliefs [5]. Individuals who do not trust public information and instead trust misinformation may perceive misinformation corrections as attacks on their values, rendering interventions ineffective or even counterproductive [57]. This underscores the need for advanced strategies that go beyond simply providing information. Research shows that anti-misinformation and anti-conspiracy arguments are not successful when presented after misinformation exposure. Instead, inoculation is one of the most effective strategies [57, 58], with its effects shown to be long-lasting [59]. Effectiveness of cognitive inoculation has been experimentally confirmed in addressing COVID-19 vaccine hesitancy through the use of short video messages [60]. The efficacy of this method offers significant promise for countries with high levels of COVID-19 vaccine hesitancy and high trust in misinformation.

This strategy may be particularly effective because CVH individuals were not avoiding information about COVID-19; rather, they were actively seeking the information, as shown in our results. Given our findings that prior attitudes toward vaccination were significantly associated with the uptake of vaccines in the future, a successful inoculation intervention against COVID-19 vaccine hesitancy could be a crucial preventive measure in future epidemics. Our findings also suggest that such interventions should primarily target younger citizens and rather those with lower incomes, irrespective of their educational attainment. This effort should be complemented by enhanced communication strategies from the Ministry of Health and other state authorities to increase public trust in these institutions.

Implications

Our findings suggest that COVID-19 vaccine uptake was primarily driven by trust-related factors, with trust in government-provided information emerging as the most significant predictor of CVA. Notably, sociodemographic factors played much less prominent role, reflecting greater socio-economic homogeneity in vaccine acceptance in the Czech Republic. Future vaccination campaigns should be integrated into broader public policy efforts aimed at boosting trust in public institutions and combating misinformation. Our study underscores the effectiveness of strategies like inoculation in countering COVID-19 misinformation. Additionally, multidisciplinary research should focus on understanding the root causes of trust erosion in institutions and the growing support for anti-system tendencies in contemporary societies. Although our study focuses on the Czech population, mistrust in institutions and the spread of misinformation have emerged as critical issues in many countries worldwide. Research on COVID-19 vaccine acceptance consistently highlights that these factors significantly influence vaccine uptake, often more so than sociodemographic characteristics. Given the global nature of these challenges, the implications of our findings may be relevant to other countries dealing with similar issues of mistrust and misinformation.

Limitations

While our study has significant strengths, including a longitudinal design, using data representative of the Czech population, a large sample size, and robust findings, we acknowledge several limitations in our study. First, while our model's overall accuracy demonstrates strong performance, particularly in predicting vaccinated

individuals, it is less effective in identifying non-vaccinated individuals. Second, our findings are specific to the Czech Republic and primarily relevant for its health policymakers, which aligns with our study's objectives. However, our results also reinforce findings from other countries, highlighting the central role of trust in public institutions in CVA as a broader issue. Third, the study's scope was limited to a specific set of factors, and additional possible determinants of CVA were not explored. Nevertheless, our primary goal was to examine trust-related factors and the willingness to receive information, controlling for sociodemographic factors.

The next limitation of this study is the simplification of vaccine uptake behavior into a binary classification of vaccination status. This approach may overlook important nuances, such as individuals who received a single dose for practical reasons (e.g., access to public venues) despite holding negative attitudes toward vaccination. However, this binary classification is straightforward and serves as a useful initial step in analyzing the factors behind vaccine refusal, with more detailed categorizations reserved for future research. Additionally, the exclusion of 230 participants due to missing data may have affected the representativeness of the sample. Furthermore, we acknowledge the potential biases inherent in self-reported responses, which could influence the accuracy of reported vaccination behaviors and attitudes. Future studies should consider alternative data collection methods to mitigate these biases.

Conclusions

Our findings suggest that CVH was primarily driven by low trust in official information sources, followed by prior attitudes toward COVID-19 vaccines, older age, and trust in misinformation about COVID-19. In sum, trust-related predictors, rather than sociodemographic factors, explained most of the variance in CVH. Therefore, effective preventive strategies to address vaccine hesitancy should prioritize increasing trust in state institutions and vaccination while simultaneously combating misinformation in the long term. Future research using longitudinal design should refine the measurement of vaccine uptake by considering the number of booster doses. Additionally, trust-related factors could be further explored by investigating the underlying causes of trust/mistrust in information sources.

Abbreviations

ATTITUDES-VAC	Prior attitudes toward COVID–19 vaccines
CAWI	Computer–assisted web interviewing
CVA	COVID–19 vaccine acceptance
CVH	COVID–19 vaccine hesitancy
INTEREST-NEWS	Interest in COVID–19 news content
TRUST-MH	Trust in official statements of the Ministry of Health
TRUST-MIS	Trust in misinformation about COVID–19

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Author contributions

Conceptualized the study: JH 30%, DG 30%, JK 20%, MH 20%. Supervised the study: JH 100%. Designed the survey: DG 40%, MH 40%, JH 20%. Designed and conducted the statistical analysis: JK 70%, LT 30%. Drafted the manuscript: DG 80%, JK 10%, LT 10%. All authors contributed to manuscript revision.

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Data availability

The dataset supporting the conclusions of this article is available in the OSF data repository: https://osf.io/z3bv2/?view_only=9b2b8b89e4a6402da1e8a09c15eff369

Declarations

Ethics approval and consent to participate

The procedure was in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments. The study was approved by the Ethics Committee of National Institute of Mental Health (CZ) (no. 181/21). All participants provided digital informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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