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Links between conspiracy beliefs, vaccine knowledge, and trust: Anti-vaccine behavior of Serbian adults

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ABSTRACT

Rationale: Immunization is a critical tool in the fight against infectious disease epidemics. Understanding hesitancy towards immunization is even more important nowadays, with the continuous threat of COVID-19 pandemic. Medical conspiracy beliefs, scientific skepticism, as well as low trust in governmental institutions, and evidence-based knowledge all have troubling effects on immunization.
Objective: To examine how these factors cross-react to influence vaccine behavior against any vaccine preventable disease (VPD), we hypothesized a model consisting of the belief in conspiracy theories as the predictor, and as the mediators subjective and objective vaccine knowledge, and trust in the health care system and science. The model was tested by examining the vaccine intentions for the children and self for any VPD.
Methods: Two separate studies were conducted on the representative samples of Serbian population; the first study investigated the intentions for child vaccination and the second study examined the vaccine intentions against any VPD, including adult vaccination. We used path analysis followed by logistic regression to analyze the data.
Results: The results revealed high vaccine hesitancy motivated by the belief in the vaccine conspiracy theories, through its effect on reduced trust in medical science and institutions, and low objective vaccine knowledge.
Conclusions: The results of this study may be used to implement appropriate policy changes and implementation of the public health campaigns to promote immunization with a wide range of vaccines against common diseases, such as measles, human papillomaviruses, or pertussis, and novel diseases, such as COVID.

1. Introduction

Vaccines are one of the most important advancements of modern medicine, as they prevent the individual from developing communicable diseases and in turn prevent widespread epidemics. For vaccines to be effective on a population level, 80–90% of community members need to be vaccinated to reach "herd immunity" and to prevent an epidemic (Anderson, 1992; Doherty et al., 2016; Fine et al., 2011). Positive effects of immunization such as the eradication of diseases drop in the number of outbreaks and mortality rates are well documented by the extensive clinical and epidemiological studies (e.g., Doherty et al., 2016). In addition, vaccination alleviates the economic and social burden of disease, increases the quality of life, and promotes gender equality (Bärnighausen et al., 2014). Yet, the outbreaks of diseases for which effective vaccines are available still occur worldwide. There are multiple reasons for outbreaks, such as poor or non-existent health care networks, inefficient batches of vaccines, vaccine shortages (Larson, 2014), or the emergence of new viral strains (Trogen et al., 2020). In addition to the situational factors, one of the major reasons for the recent outbreaks has been a rejection of immunization. It is estimated that 19.4 million children one year old or younger did not receive basic vaccines (WHO estimation for 2018). In the past two decades, large segments of the population hold anti-vax policy attitudes, especially in the USA, Canada, and Western Europe (Motta et al., 2018). The increased visibility of such groups across various media platforms has been linked to an increased frequency and size of the epidemic of vaccine-preventable diseases (Omer et al., 2009). This phenomenon took a turn for the worst with a severe threat from the SARS-CoV-2 pandemic and rejection of the

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vaccines against this virus. It has been reported that only around half of the populations across Europe were willing to get a SARS-CoV-2 vaccine once it becomes widely available (Trogen et al., 2020).

Vaccine-related behavior varies in form and intensity. While the majority of the global population still accepts vaccination, thus following all recommendations from public health officials, there are a growing number of people showing a variety of acceptance and rejection behaviors. These can range from: a) cautious immunization, regular immunization after extensive research of all available information from professional and unprofessional sources, b) hesitating to vaccinate, or being late with some vaccines, c) selective vaccination accepting some vaccines, and rejecting others, and lastly d) a complete rejection of all vaccines (Kumar et al., 2016; MacDonald, 2015). Thus, vaccine behavior represents a continuum between those who accept all vaccines with no doubts and those who refuse all vaccines with no doubts, where vaccine-hesitant individuals represent the heterogeneous group between these two extremes. Vaccine hesitancy has been reported for child vaccines, but similar trends have been observed for vaccination targeting the adult population, especially for recently introduced vaccines, such as human papillomavirus (HPV) or influenza vaccines (Collange et al., 2016; Kahan et al., 2010).

Immunization behavior is affected by numerous factors, including contextual and situational ones, such as politics, culture, and religion; vaccine and vaccination specific issues, such as vaccination plan, or reliability of vaccine supply; and individual/social group factors, that includes beliefs, attitudes, and knowledge (Brewer et al., 2017; Larson et al., 2014; Raithatha et al., 2003). Among diverse sets of beliefs affecting vaccination behavior, the effects of the belief in vaccination conspiracy theories have been reported (Jolley and Douglas, 2014; Shapiro et al., 2016). Vaccination conspiracy theories fall under the larger umbrella of medical conspiracies, which include the distrust in pharmaceutical companies, official medical practices, and myths about the vaccination side effects. Well-known vaccine conspiracy beliefs are that pharmaceutical companies created and released Coronavirus in order to sell their medications and vaccines (Biddlestone et al., 2020), the mumps-measles-rubella vaccine (MMR) causes autism in children and autoimmune disorders in adolescents (Maglione et al., 2014), the tetanus toxoid vaccine is used to control fertility (Larson et al., 2014), pharmaceutical companies had engineered the pandemic to sell their products (Hidiroglu et al., 2017) or that Zika virus is caused by genetically modified mosquitoes (Klofstad et al., 2019). Major explanations of conspiratorial beliefs are informational cues, political ideology, and predispositions toward conspiratorial views (Uscinski et al., 2016).

Different psychological characteristics greatly influence vaccination. Specifically, studies confirm that people with higher levels of **conspiratorial thinking**, higher beliefs in moral purity, and higher sensitivity to needles will be more likely to delay vaccination (Callaghan et al., 2019). Furthermore, multiple studies found that negative attitudes toward experts make people more likely to deny scientific consensus and endorse conspiracies that oppose it (Fernbach et al., 2019; Merkley, 2020; Motta, 2018), although knowledge level is not always a prerequisite to adherence to conspiratorial thinking. For example, a person highly knowledgeable about politics, but with low trust in the institutions is very prone to conspiracies (Miler, et al., 2016). Keeping in mind the spillover effects (Motta, 2018), we hypothesized that conspiracy beliefs might have an impact on vaccination hesitancy by rejecting official medical recommendations widely recognized by medical experts, such as following specific scheduling of immunization.

In addition to belief in conspiracy theories, scholars also confirmed that the **lack of trust in science (science skepticism)**, **rejection of the medical research** results, and the **lack of evidence-based knowledge** about vaccines have a major impact on immunization behaviors (Yaqub et al., 2014). One of the common strategies of the anti-vaccine movement is the refutation of scientific research and the shifting of their hypothesis (Kata, 2010). The Internet offers easy access to the vast amount of health-related information from professional and unprofessional sources, and social media enables the fast spread of information among seemingly unrelated groups of people around the world. Recently, a large number of inaccurate, non-scientific websites proliferated, spreading fake news and conspiracy theories about the harmful effect of vaccines including those against coronavirus. These sites have called into question facts backed by the scientific consensus about vaccination, climate change, genetically modified organisms, and evolution (Hamilton et al., 2015; Kahan et al., 2012). The World Health Organization (WHO) warns that the risks of immunization received proportionately greater media attention than its positive effects on a variety of media platforms. This media approach has enormous consequences on public health behavior (Jolley et al., 2020; Mari et al., 2021). Others have also pointed out that the belief in conspiracy theories itself contributes to the erosion of trust in institutions (Mari et al., 2021; Einstein and Glick, 2015) and in scientists (Jolley and Douglas, 2014).

Another important factor determining vaccination behavior is **confidence**, measured as confidence in specific vaccines, or trust in the provider. The majority of studies have explored trust in vaccines (Larson et al., 2014), while confidence in policy, national programs, and primary care are investigated less frequently. Nevertheless, it has been shown that trust in government predicted H1N1 vaccination (Freimuth et al., 2014), or that trust in Food and Drug Administration predicted consumption of antiviral medication (Quinn et al., 2015). In line with these findings are the results showing that those who consult the official government sources of information are more likely to get vaccinated (Bish et al., 2011; Kennedy et al., 2011). Trust is the crucial key in overcoming the current SARS-CoV-2 pandemic and is associated with greater compliance with health guidelines such as adoption of social distancing and lockdown measures (Devine et al., 2020). This evidence suggests that trust in government, as the main body setting the vaccination schedule and recommendations, is an important factor in the decision process regarding vaccination.

Studies confirm that anti-intellectual attitudes (such as negative affect toward scientists and other experts) are associated with policy-relevant scientific consensus, support for political movements, and politicians (Motta, 2018). Adopting scientific knowledge about current coronavirus is of crucial importance. It has been reported that proper knowledge about COVID-19 is related to a positive attitude towards protective measures (Abdelhafiz et al., 2020). Lack of **scientific knowledge** might further increase distrust in government institutions, medical institutions, and pharmaceutical companies (Allum et al., 2008). Furthermore, social media enables and even encourages group polarization and homogenization around health issues, by assembling people in on-line communities that exchange their shared, but often unverified or incorrect narratives and worldviews in the echo chambers (Del Vicario et al., 2016a, 2016b; Del Vicario and Vivaldo, 2016). Confirmation bias, namely the search for confirmatory evidence that fits with preexisting beliefs, occurs quite easily when people are free to choose what information they will expose themselves to. Research has shown that media literacy (knowledge and motivations for news consumption) can shape how conspiracy narratives are endorsed (Craft et al., 2017). This evidence would suggest that people with a strong belief in vaccine conspiracy theories would tend to select and endorse information that confirms their previous convictions about vaccine behavior. As a first consequence, objective knowledge, measured by one's information of objectively verifiable facts, can be undermined, because the believers do not expose themselves or discard the correct scientific information. A second potential consequence is that the level of vaccine-related knowledge can affect the perception of one's expertise (subjective knowledge) or overestimate the knowledge about specific scientific facts. This is especially true for extreme attitudes; for example, people with extreme beliefs know the least about genetically modified foods but they think they know the most (Fernbach et al., 2019). Some studies confirm a Dunning-Kruger effect showing that people low in autism awareness (basic facts knowledge and dismissal of misinformation about autism) should be the most likely to think that they are better

informed than medical experts about the causes of autism (Motta et al., 2018). Such overconfidence occurs because people do not trust experts and has important policy implications. Endorsement of conspiracy theories serves both ideological and psychological needs (Miller et al., 2016).

We developed a model that identifies key factors – trust, and knowledge – that could lead from anti-vaccine beliefs to lower vaccine intentions against any vaccine-preventable disease (VPD). Indeed, although there are ample reports that correlate the distrust in the institutions and belief in conspiracy theories with the vaccine behaviors, there are limited data on the underlying processes that lead from belief in medical conspiracy theories to anti-vaccine behavior against VPD. The association of the vaccine conspiracy belief and vaccine hesitancy warrants further examination. We additionally sought to elucidate the link between immunization intention and the objective and subjective knowledge about vaccination, belief in conspiracy theories, and trust in health care systems on the vaccine intentions. Since there is an ongoing crisis in immunization coverage and barriers to immunization are numerous, our empirical approach is to look at how mentioned barriers of immunization inter-correlate. We hypothesized a general pervasive effect of the belief in conspiracy theories, so that such beliefs may impact variables more strongly and closely related to the intentions. Thus, we expect that the endorsement of vaccine conspiracy theories would be negatively correlated with trust in science and official medical institutions and with the objective scientific knowledge about vaccination, while we cannot hypothesize the direction of correlation with the subjective perception of knowledge about immunization. Here, we hypothesized a mediation model (Fig. 1), in which the endorsement of vaccine conspiracy theories would have both a direct negative effect on vaccine behavior against VPD and an indirect effect through distrust in science and official medical institutions, the lack of objective vaccine knowledge. We tested the vaccine intention model on two different representative samples of Serbian citizens, adults, and parents of children under the age of 18, in two different studies, both using probability samples. We investigated if decisions about different recipients (adults and children) in the immunization process for VPD depend on the same factors. These are two different sets of questions since parents decide on vaccination for their children that is more multifaceted than their vaccination (Brewer et al., 2017). Therefore, research related to adult immunization decisions investigated specific vaccines such as influenza, or human papillomavirus (HPV). Considering an ongoing pandemic of COVID-19 and the hesitancy to vaccinate against SARS-Cov-2, we also discuss current knowledge regarding vaccine behavior and conspiracy beliefs along with the results obtained in this study.

Notably, the immunization schedule for children in Serbia is comparable to those in the US, EU, and Canada, including tuberculosis, hepatitis B, polio, Diphtheria-Tetanus- Pertussis, influenza type B hemophilia, and MMR. Reports indicate decreasing immunization coverage in the past decade consistently. In 2011, 96% of 35-month-old children were immunized on time, but that number dropped to 81% in 2014 (Multiple Indicator Cluster Surveys, UNICEF, 2015). Immunization coverage is the lowest for the MMR vaccine, but there was a decrease in coverage for other mandatory vaccines in the past ten years. Notably, the massive SARS-CoV-2 vaccination effort is underway in Serbia but it is facing strong immunization hesitancy.

In summary, the aims of our study were: a) to measure the vaccine-related intentions for child and adult targets; b) to examine the psychological underlying processes, i.e., the structural relations between conspiracy belief, knowledge and trust, and vaccine-related behavior, for both child and adult targets. Taking into account all the above mentioned, we postulated one general hypothesis: medical conspiracy belief will have a direct impact on vaccination intentions and indirect through trust and knowledge.

2. Methods: studies 1 and 2

We carried out two separate studies, Study 1 and Study 2, on a representative sample in Serbia. Face-to-face interviewing was implemented. The average length of the interview was approximately 30 min. Research procedures adhered to the American Psychological Association ethical guidelines and were approved by the Ethical Board of the Institute for Political Studies, Belgrade, Serbia.

Study 1: A total of 1481 adults (aged 18+) in Serbia were recruited in a stratified three-stage probability sampling procedure. The study was conducted in November 2017 by the Institute of Political Studies, Belgrade. The sampling frame was based on the data from the 2011 Census. Sampling was done in three stages. The first stage sampling was done by polling station territory (212 sampling points). The second stage included households selected by random route technique starting from the randomly selected addresses (seven households by sampling points). The third stage included respondents randomly selected within households.

Study 2: A total of 1480 adult (aged 18+) citizens of Serbia were recruited for the interview in a stratified three-stage probability sampling procedure in May 2018. The sampling procedure and the Institution carrying the research was the same as described in Study 1.

The sample demographics consisted of 52% male and 47.7% female (Study 1) and 53% male and 47% female (Study 2). The education level was primary school or less, 10.7% and 8.8% (Study 1 and Study 2 respectively), high school 66% and 68.6%; college and graduate degree, 22.9%, and 22.6%. The proportions of responders in each age group were the following: 18–25 years 13% and 14.1% (Study 1 and Study 2);

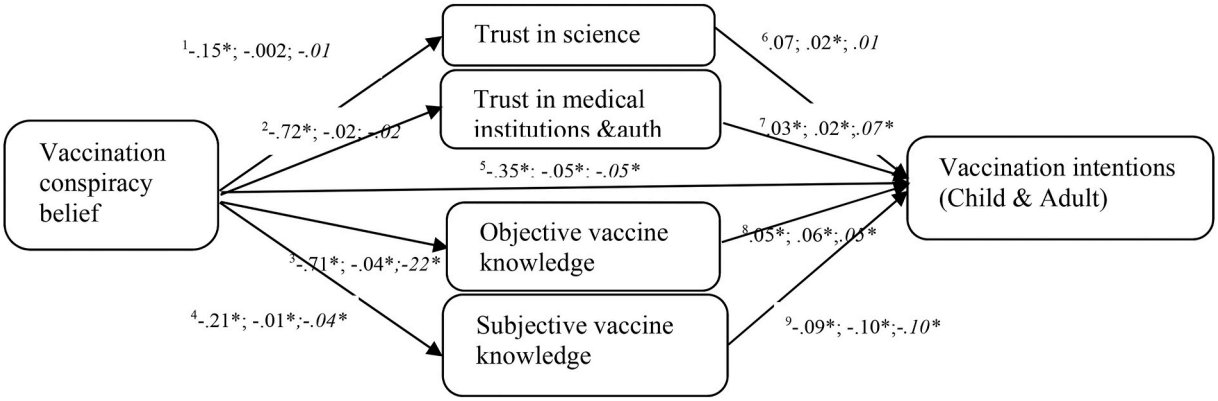

Fig. 1. Model for immunization intention (Study 1; Study 2: child and adult) The first number in the figure refers to immunization intention for a child in study 1; The second number in the figure refers to immunization intention for a child in study 2, and the third number refers to immunization intention for an adult in study 2; Note: The apices refer to the paths, whose estimates are described in Table 5.

26–45 years 50.3% and 45.2%; 46+, 36.7%, and 40.7%. Respondents with child(ren) up to 7 were 23% and 26.6%, and 47.1% and 32.6% had children aged 7–18 years old. Finally, 33% (Study 1) and 40.8% (Study 2) had no children.

The missing data were also examined. Little's MCAR test showed that values were missing completely at random in the 2018 data set, but not in the 2017 data set (χ^2 (105) = 201.26, $p < .01$). The specific analysis showed that only one variable in the 2017 data set had a significant number of missing values: vaccination conspiracy belief (20.8% NA). While two variables had a larger number of missing values in the 2018 data set: Trust in science (26.2% NA), and vaccination conspiracy belief (24.5% NA).

We did a logistic regression to test whether any variables from the data set would predict missing values. The regression showed that objective knowledge was a significant predictor of missing values in vaccination conspiracy belief scale, but given that this relationship did not replicate in the 2018 data set, the previous relationship could be attributed to chance. The inconsistency of the missing analysis patterns, model robustness to change in the way we handle missing data, and consistency of the relationship between variables in both models support that missing values are not a significant confounding factor and can be assumed to be MAR. The data was therefore imputed. Values were imputed using linear interpolation, this type of imputation uses other variables in the data set to predict the missing values based on non-missing adjacent values. Justification for such a technique can be found in the small SD changes between old and new variables, which were 0.2 for vaccine conspiracy and >0.02 for all other variables (Lodder, 2014; Sidi and Harel, 2018). Missing values on all variables were corrected (except for the child vaccination behavior, which was analysed separately in a data set in which only participants with children were analysed). The linearly interpolated data set was compared to a data set where missing values were imputed using multiple regression method. The results of this analysis are shown in Supplementary Online Material (Missing value additional analysis section). We found no significant changes in results, suggesting that our model has high robustness.

2.1. Instruments: studies 1 and 2

Vaccine conspiracy scale was assessed using six items in Study 1 & 2, with a scale from one (*I completely disagree*) to five (*I completely agree*) (Study 1, $\alpha = 0.88$; Study 2, $\alpha = 0.94$). The scale was adapted from Schapiro's et al. (2016) vaccine conspiracy beliefs scale.

Trust in health institutions and authorities was assessed using six items in Study 1 & 2 (trust in Medical staff – nurses – pediatricians, overall medical system, official medicine, pharmaceutical industry, traditional medicine) with a scale from one (*I completely disagree*) to four (*I completely agree*) (Study 1, $\alpha = 0.82$; Study 2, $\alpha = 0.83$).

Trust in science was assessed in Study 1 using four items like "I am amazed by the achievements of modern science" with a scale from one (*I completely disagree*) to five (*I completely agree*) ($\alpha = 0.50$), used on the Serbian population in UNICEF survey about vaccination (Unicef, 2018–2019). The measure for trust in science was different in Study 2 taking into consideration low statistical reliability observed in Study 1. Trust in science was then assessed in Study 2 using four items (McCright et al., 2013), such as the "scientists create knowledge that is unbiased and accurate; that is useful; scientists inform the public on important issues," etc., measured from one (*I completely disagree*) to five (*I completely agree*) ($\alpha = 0.79$).

Subjective perception of vaccine-related knowledge was assessed in both studies using one question that asked respondents to rate their knowledge about vaccination, with ranking from one (*I am completely uninformed*) to five (*I am fully informed*).

Objective scientific vaccine-related knowledge was assessed using nine questions about child vaccination, such as against which diseases are BCG & MMR vaccine used (BCG is a vaccine primarily used against tuberculosis and MMR against measles, mumps, and rubella), which groups of children should not be vaccinated, etc. (Unicef, 2018–2019). The scale for objective knowledge was from zero (no correct answers) to nine (all correct answers) in Study 1. Objective scientific vaccine-related knowledge in Study 2 was assessed using four questions about vaccination (against which diseases are DiTePer & MMR & HPV vaccine used, etc.). The scale for objective knowledge was ranging from zero (no correct answers) to 4 (all correct answers).

Future vaccination behavior of the child was assessed in Study 1 and **Future vaccination of both the child and adult population** against any VPD was measured in Study 2. In both studies, we used a direct question about immunization intentions and ranked from four (*I will definitely vaccinate my child/myself*) to one (*I will refuse all vaccines for child/myself*). To clarify the coding procedures, we have measured: 1) Full rejection - I will refuse all vaccines for child/myself; 2) Hesitant - I will vaccinate child/myself with some, but I will refuse some vaccines; 3) Hesitant - I will most probably vaccinate child/myself according to the schedule; 4) Full vaccine adopters - I will vaccinate my child according to the schedule; I will vaccinate myself with all recommended vaccines.

We measured a standard set of **socio-demographic questions in both studies**: age, gender, economic and employment status, number of children in a household, religiosity, and ethnicity.

3. Results

3.1. Study 1

We selected only people that have at least one child under the age of 18 in Study 1 when analyzing child vaccination ($n = 698$). Our data shows that 63.3% of the examined parents still intend to vaccinate their kids following the full schedule. Vaccine hesitancy (scored as 2 and 3 on the 4-point scale) is reported by 32.8% of parents, and full rejection is reported by 3.9%. There are some differences in vaccine intention by socio-demographic variables. More inclined to vaccinate are older, more educated male parents.

In Table 1, the means and standard deviations of all scales are presented with the correlation coefficients of all variables. The endorsement of the anti-vaccine conspiracy belief is in the middle or slightly above the midpoint showing that the Serbian adult population leans toward believing in medical conspiracy theories. The majority of variables are significantly correlated with the parent's intention to vaccinate the child under the age of 18, except subjective knowledge. Vaccination hesitance, selective vaccination, and rejection are associated with higher belief in vaccine conspiracy, distrust in science and medical institutions, and lack of objective knowledge about vaccination (Table 1).

As predicted, regression analyses revealed that anti-vaccine

Table 1
Correlation matrix, means, standard deviations for all measured variables for Study 1 (people with children under the age of 18).

	1	2	3	4	5	6
CT Vaccination (1)	1					
Trust in science (2)	-.161	1				
Trust in medical institutions (3)	-.143**	.257**	1			
Objective knowledge (4)	-.216**	.156**	.148**	1		
Subjective knowledge (5)	-.128**	-.050	.019	.126**	1	
Vaccine intentions CHILD (6)	-.336**	.172**	.222**	.228**	-.027	1
Scale range	1–5	1–5	1–6	0–9	1–5	1–4
Mean	2.94	3.56	2.86	5.37	2.71	3.45
SD	.79	.70	.53	2.44	1.18	.80

Note. CT = conspiracy theories.
**$p < .01$ two-tailed; *$p < .05$ two-tailed.

conspiracy beliefs were a significant predictor of parents' vaccination intentions, trust, and vaccine knowledge. Examining the potential mediators of this effect, five separate regression analyses were conducted. As shown in Table 2, anti-vaccine conspiracy beliefs were a significant predictor of immunization intentions and all other measured variables.

3.2. Study 2

We tested the same model for adult and child immunization intentions against any VPD to confirm previous data, and to assess if decisions about different actors in the immunization process rely on the same factors. People that have at least one child under the age of 18 in Study 2 were included in child vaccination behavior analysis ($n = 478$). Data revealed relatively high vaccine hesitancy and selective immunization for the child (58.2% of the examined parents still intend to vaccinate their kids following the full schedule, vaccine hesitancy is reported by 38.5%, and full rejection is reported by 3.3%) and even higher for the adults (48.9% of full adopters, and 5% of full rejection; $N = 1480$).

Similarly, to the previous study, an older, higher educated population is more inclined to vaccinate. Correlation patterns almost completely replicated those in Study 1. Vaccination hesitance, selective immunization, and full rejection (concerning both child and adults) against any VPD are associated with belief in vaccine conspiracy, distrust in science and medical institutions, and lack of objective knowledge about vaccination and high subjective self-perception of vaccine knowledge (Table 3).

Regression analyses in both samples (parents $n = 478$ and adults $n = 1480$) revealed that anti-vaccine conspiracy beliefs were a significant predictor of vaccination intentions and the other mediators. As shown in Table 4, anti-vaccine conspiracy beliefs were a significant predictor of adult and child vaccine intentions, knowledge, and trust.

3.3. Model testing: studies 1 and 2

When analyzing the models' (Fig. 1) accuracy using path analysis, we relied on conventional recommendations. We conducted two path analyses for Study 2, relating to child and adult vaccination intentions. Only respondents with at least one child under the age of 18 were selected in the analysis for child vaccination (Study 1 $n = 698$; Study 2 $n = 478$) and all respondents were included for the adult vaccination intention.

Path analysis demonstrated optimal fit in all measured indices for Study 1: HF/DF = 4.71, RMSEA = 0.073, NFI = 0.936 and CFI = 0.946, AIC = 64.85. Path analysis for the model of child vaccination's and the model of adult vaccination's intentions from the Study 2 demonstrated exceptional fit in all measured indexes: for adult vaccination HF/DF = 5.39, NFI = 0.947, CFI = 0.955, RMSEA = 0.054, AIC = 67.56; and for child vaccination HF/DF = 2.65, NFI = 0.943, CFI = 0.961, RMSEA = 0.059, AIC = 56.600.

As hypothesized, anti-vaccine conspiracy beliefs predicted vaccination intentions against any VPD. Parents who endorsed anti-vaccine conspiracy theories considerably more than median exhibited lower intention to vaccinate their children. Furthermore, anti-vaccine conspiracy beliefs were associated with the hypothesized mediator variables, lack of trust, and knowledge. When all indicators were pulled together, each was a significant mediator of the relationship between anti-vaccine conspiracy beliefs and vaccination intentions against any VPD.

To sum up, there is a statistically significant direct effect of belief in vaccination conspiracy and vaccination intention. Besides direct effect, belief in vaccine conspiracies has also significant indirect effect through trust and knowledge in both situations, when the decision about personal or child vaccination is made.

Table 2
Five separate regressions examining anti-conspiracy belief as a predictor; four mediator variables as criteria and vaccine intention (child).

	Criterions	Standardized Beta	*t*
1	Child vaccination intentions	-.366	−10.364**
2	Trust in science	-.161	−4.314**
3	Trust in medical authorities	-.143	−3.798**
4	Objective knowledge	-.216	−5.822**
5	Subjective perception of knowledge	-.128	−3.411**

**$p < .01$; *$p < .05$.

4. Discussion

Inadequate vaccination has severe outcomes for the global population, decreasing productivity and increasing disabilities, health costs, and death from vaccine-preventable diseases. WHO reported large outbreaks of measles in the past decade, affecting developed (among others France, Italy, Israel, and the US), and developing nations (DR Congo, Madagascar, Ethiopia, Ukraine, Kazakhstan, Philippines, Brazil, and India), nations with excellent health care (EU, Israel, and the US) and countries with war conflicts (Yemen, Iraq, Syria). Most of the reported cases were children younger than five that did not receive a single dose of MMR, followed by teenagers and young adults with one to two doses, and adults older than 30 that were not vaccinated or had only one MMR dose. For example, Spain had more than 4700 cases in 2011–2012, and Egypt had more than 7600 cases in 2014–2015. Data from the WHO show that in 2018 the number of patients in Serbia has tripled, placing Serbia second in Europe, after Ukraine, by the number of infected people (WHO, Immunization Analysis and Insights). However, a significant drop in the number of cases occurred in 2019 worldwide. It is noteworthy to mention that a similar trend in the decrease of infected people also occurred in Serbia, with 702 cases in 2017, 5076 cases in 2018 that dropped to 15 at the time of our Study 1 and 2, in 2019. In addition, current SARS-CoV-2 pandemic brings the issue of vaccine hesitancy against VPD to the scientific forefront. It would be important to examine the relevant changes in public policy, Internet use, public advertisement campaigns, and other possible causes for this large drop in VPD cases in countries around the world.

The reasons for outbreaks can be generally divided into two broad categories, human behavior and attitudes (vaccine hesitancy or rejection) and human errors (inadequate health system, contaminated or ineffective batches of vaccines, inexperienced or untrained health professionals, or shortage of the vaccines). A detailed systematic review of the quantitative studies investigating decisions to vaccinate revealed several factors underlying the low vaccination. These include a) vaccine factors, such as general side effects, vaccine effectiveness, the experience of vaccination, belief in the danger of immune overload; b) health care system/government that include health professionals who sometimes do not agree with accepted medical facts; c) information provided about the vaccine, demonstrated as dissatisfaction with or perceived inadequacy of information/knowledge; d) disease factors, such as the lower perceived likelihood of catching a vaccine-preventable disease; e) parenting/social context, that manifests as the disinclination to vaccinate for the benefit of society, valuing parents' right to choose whether to vaccinate or the lack of peer support (Brewer et al., 2017; Brown et al., 2010). These factors prompted an effort to understand the decision-making underlying the vaccine behavior to better understand the hesitancy to vaccinate and inform changes in public policies and science communication to build up immunization coverage. The results reported in this study address this call.

We investigated the high level of vaccine hesitancy and selective vaccination against any VPD in the Serbian population on representative samples in two separate studies. The results confirm that the belief in anti-vaccine conspiracy theories directly affects vaccine intentions for adults and children targets, and it is also mediated by decreased trust in scientific facts about immunization. Anti-vaccine conspiracy theories appear to introduce a powerful set of misinformation, and therefore may

Table 3
Correlation matrix in Study 2 for child and adult vaccination intentions (all respondents).

	1	2	3	4	5	6	7
CT Vaccination (1)	1						
Trust in science (2)	.004	1					
Trust in medical institutions (3)	-.033	.151**	1				
Objective knowledge (4)	-.180**	-.064*	.055*	1			
Subjective knowledge (5)	-.061*	.012	-.006	.108**	1		
Vaccine intentions (Child) (6)	-.406**	.045	.083**	.147**	-.090**	1	
Vaccine intentions (Adults) (7)	-.364**	.102**	.126**	.147**	-.081**	.744**	1
Scale range	1–5	1–4	1–4	0–4	1–5	1–4	1–4
Mean	2.68	3.38	2.84	1.35	2.5	3.33	3.22
SD	1.03	.91	.56	1.34	1.08	.83	.86

Note. CT = conspiracy theories.
**$p < .01$ two tailed; *$p < .05$ two tailed.

Table 4
Six separate regressions examining anti-conspiracy belief as a predictor. Four mediator variables as criteria and vaccine intention (child and adult).

	Criterions	Standardized Beta	*t*
1	Adult vaccination intentions	-.364	−15.027**
2	Child vaccination intentions	-.406	−17.079**
3	Trust in science	.004	.146
4	Trust in medical authorities	-.033	−1.250
5	Objective knowledge	-.180	−7.031**
6	Subjective perception of knowledge	-.061	−2.250*

**$p < .01$; *$p < .05$.

Table 5
Standardized indirect effects of the path analyses (see Fig. 1).

	FIRST MODEL Child vaccination Study 1		SECOND MODEL Adult vaccination Study 2		THIRD MODEL Child vaccination Study 2	
	B	95% CI	B	95% CI	B	95% CI
Path 1	-.15*	-.22, −.08	-.002	-.04, .05	-.01	-.14, .02
Path 2	-.72*	-.11, −.35	-.02	-.05, .01	-.02	-.06, .03
Path 3	-.71*	-.96, −.47	-.04*	-.04, −.02	-.22*	-.40, −.17
Path 4	-.21*	-.32, −.08	-.01*	-.02, −.01	-.04*	-.04, −.02
Path 5	-.35*	-.42, −.27	-.05*	-.05, −04	-.05*	-.05, −.04
Path 6	.07	-.01, .14	.02*	.01, .03	.01	-.01, .13
Path 7	.03*	.01, .04	.02*	.01, .03	.07*	-.01, −.02
Path 8	.05*	.03, .07	.06*	.03, .09	.05*	.02, .08
Path 9	-.09*	-.10, −.01	-.10*	-.14, −.07	-.10*	-.13, −.06

reduce vaccination and damage health in general. Furthermore, belief in conspiracy theories with medical content may fuel other related psychological processes, as it impacts the trust in official medical science sources and providers. The more people endorse conspiracy beliefs, the less they will adopt scientific consensus about vaccine benefits. Therefore, our results strongly suggest that conspiracy belief serves as a barrier for trust in health issues and adopting scientific knowledge. Indeed, conspiracy beliefs undermine both, their objective and subjective knowledge, an effect that people may not be completely aware of. These beliefs threaten public health even more, since adopting objective scientific knowledge is important for progress in behavior of the general population. We have also confirmed the presence of a negative impact of medical conspiracy belief on trust in science in general. We found that those who endorse conspiracy theories do not trust official institutions and sources of information that represent evidence-based scientific facts. Furthermore, this study empirically demonstrates that similar processes explain the decisions for the adult's and children's vaccinations. The anti-vaccine behavior is stronger for the adult than the child vaccination and strongly correlates with the belief in medical conspiracy theories.

In the light of the current pandemic of COVID-19 for which the effective vaccines were developed (Voyseu et al., 2021; Polack et al., 2020), it is notable to mention the anti-vaccine movement against these vaccines. First, globally there is a considerable minority that rejects the vaccine either completely (8.1%) or to a certain degree (6.1%), and this rejection is actually exasperated if it is recommended by the employer (Lazarus et al., 2020). Other studies investigated the vaccine intentions among various groups of people in the US (Callaghan et al., 2020; Latkin et al., 2021; Motta, 2020; Pogue et al., 2020; Romer and Jamieson, 2020), Italy (Barello et al., 2020; Caserotti et al., 2021; Graffigna et al., 2020; Palamenghi et al., 2020), Israel (Dror et al., 2020), UK (Freeman et al., 2021; Salali and Uysal, 2020), Hong Kong (Kwok et al., 2021), Saudi Arabia (Al-Mothaihef and Padhi, 2020). The overall conclusion is that socioeconomic status determines the vaccine hesitancy, such as lower education level, income, and some ethnic minorities, such as Black, being the ethnic minority correlates with the higher hesitancy to take the COVID-19 vaccine (Callaghan et al., 2020; Freeman et al., 2021; Latkin et al., 2021), with some variability between countries. One of the most important factors that influences high hesitancy to vaccination is belief in conspiracy theories (Romer and Jamieson, 2020), mistrust in biomedical research (Palamenghi et al., 2020), and specifically in the effectives and safety of the COVID-19 vaccines (Latkin et al., 2021; Motta, 2020; Callaghan et al., 2020) exposure to patients and perceived risk of succumbing to the disease (Dror et al., 2020; Graffigna et al., 2020). The belief in conspiracy theories related to COVID-19 affected both vaccine hesitancy and resistance to preventive measures and showed stable across longer periods between the first and second wave of the disease (Romer and Jaimeson, 2020). Thus, data obtained so far on the vaccine hesitancy and overall behaviors in COVID-19 pandemic shows similarities with data reported in our studies that are not related to any disease specifically, rather against any vaccine preventable disease. Namely, the main factors inducing vaccine hesitancy are belief in conspiracy theories, trust in medical institutions, and low objective knowledge about vaccines. Knowledge of these factors may enable the cross-over of effective communication strategies for public health campaigns promoting vaccinations. In light of these findings, Su et al. (2020) suggested a more focused classification of vaccine non-adopters to vaccine conspirators, vaccine-hesitant, and vaccine-uniformed to better tailor communication campaigns. Taking into account data from our study and those of the others mentioned above, we would argue that these groups are not so clear-cut, as vaccine hesitancy/rejection is governed by more than one factor.

Most of the studies investigating vaccine intentions and barriers are quantitative, correlational, or experimental. Experimental studies examined the vaccination intentions on various small population samples in developed countries, using an imaginary disease as an indicator (Betsch et al., 2013; Jolley and Douglas, 2014). These studies reported that conspiracy theories, feelings of powerlessness, disillusionment, and mistrust in authorities (Jolley and Douglas, 2014), high-risk perception, and low subjective numeracy (Betsch et al., 2013) are associated with reduced vaccination intentions. Although claiming causality, those

studies were limited in scope with non-representative sampling and imaginary settings. They did not provide an accurate assessment of the actual reasons for anti-vaccine behavior (vaccine hesitancy). The anti-vaccine behaviors were studied mostly using the correlational quantitative methods, quota sampling, and telephone interviews for data collecting (Brown et al., 2010). In the current research, we improved the sampling by utilizing a probability sample, and we also used face-to-face interviews which offer greater accuracy of the collected data. Further study on a larger representative sample in a more granulated manner, such as different geographical areas with low and high vaccination rate, would provide additional parameters that would elucidate the vaccine hesitancy/anti-vaccine behavior with more accuracy and greater detail. Noteworthy is that our studies are not related to vaccination against specific disease therefore results could be used for any VPD, and consequently to inform public policies of immunization against current SARS-CoV-2 virus.

4.1. Limitations

There are some limitations to this study that we addressed here. Since both studies are correlational, we cannot claim causality between the measured variables. Therefore, we introduced path analysis to evaluate causal models and large representative samples implemented in both studies provide solid correlational data applicable to the population in general. Additionally, self-reported measures about future immunization intention are another limitation of this study. Since we relied on self-reported measures for assessing the vaccine behavior, our data might be sensitive to social desirability. Future research can address this methodological issue by observing real behavior, comparing self-reporting with observation or public health records. This approach could be a more reliable indicator and would provide stronger empirical evidence. The measure of vaccination intentions of parents of older children (for example, 17 years old) lacks accuracy, but we believe parents provided general answers (about the general vaccination behavior in the future, based on the previous behavior). However, a clear pattern of path parameters was observed. Moreover, the scope of the studies could be broader. Further surveys could be designed to answer questions about additional social consequences of conspiracy beliefs that may suggest effective approaches to appropriately address this alarming trend of misinformation, like considering the effect of communication about the disease.

5. Conclusions

The results of this study, carried out on large representative samples of the Serbian adult population, revealed three main reasons for the high vaccine hesitancy against any VPD for both children and adults. First, vaccine hesitancy is driven by the belief in vaccine conspiracy theories. Second, we found a strong correlation between belief in conspiracy theories and reduced trust in medical science and institutions. Finally, a strong link between belief in the conspiracy and low objective vaccine knowledge and low vaccine intentions was observed. These parameters together affect vaccine behavior and may reduce vaccine intake that enables multiple outbreaks of preventable infectious diseases and a threat to public health. This study suggests that low medical literacy, an abundance of misinformation on social media and the Internet, and distrust in official institutions are all strongly correlated to vaccination refusal.

To improve public health and reduce the number of outbreaks policy changes are needed. The false information surrounding it, including various conspiracy theories regarding the source and spread of the disease, the trust in the institutions, and the adoption of scientific knowledge, are all going to be critical for the immunization against VPD. Frequently, fake news and conspiracy theories cannot be easily filtered and repressed by mainstream media or social pressure. The Internet has made healthcare information widely accessible, but the status of true and false information is equal, science and pseudoscience are not clearly separated, and experts and amateurs occupy equal space and potentially have an equal influence on the public (Kata, 2010; Zimmerman et al., 2005). Therefore, better communication related to the positive aspects of vaccination, government campaigns to promote vaccination, adequate science education, and engagement of social media may be used to reduce the misinformation. The results presented here may have practical implications for the current COVID-19 pandemic, as well as other pro-immunization campaigns. Further research is needed to elucidate relevant factors and cross interactions that drive vaccine behavior. This information could inform communication strategies that better address the lack of scientific knowledge, improve confidence in the health system, and promote fact-based decisions regarding immunization.

Credit author statement

Dr. Milošević-Đorđevićwas involved in all aspects of this study, including design of the questionnaire, analysis of the data, writing of the manuscript, and obtaining the funds. Dr. Mari was involved in writing of the manuscript. Ms. Vdović contributed to data analysis, handling missing data and abstract writing. Dr. Miloševićwrote the manuscript and contributed to the design the questionnaires. The authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2021.113930.

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