



Analyzing factors determining vaccination willingness against COVID-19 in Germany 2020

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ABSTRACT

The study is based on a German single-topic population survey on vaccination willingness against COVID-19 (VWC) by the authors (2020, n = 2014). The single-topic survey allowed us to test several competing explanations for VWC, as discussed in the literature. The VWC in the sample was 67.3%. Logistic regression was used to identify factors affecting VWC. Being at high risk from COVID-19 and having received flu vaccination have a positive impact on VWC. Perceived VWC of friends has a strong positive effect on respondents' VWC. Bivariate relationships of gender, age, and level of education with VWC were no longer significant in a multivariate analysis. Trust in alternative medicine and belief in conspiracy theories have a negative effect on VWC.

1. Introduction

Since the start of the global COVID-19 pandemic unprecedented efforts had been undertaken to develop an effective vaccine. Several vaccines were created within a very short time. This was an incredible demonstration of the power of scientific medicine. Vaccines provide the most effective protection against serious illness for large segments of the population.

At the same time, the development and approval of different COVID-19 vaccinations was widely discussed in the media and public. Media coverage of vaccine development was intense. The German vaccination strategy was herd immunity [1,2]. However, development and approval of a vaccine is only one part of the solution. For an effective protection of the population, vaccination uptake needs to be high. In order to test hypothesis about the uptake, the authors initiated a general population CATI (Computer Assisted Telephone Interviewing) survey during November and December 2020. At this point in time, several vaccines had already been developed and were in the process of being approved by regulatory bodies. Clinical trials and the approval process have been

covered intensely by media and received considerable public interest.

At the start of the vaccination campaign the goal of population immunity through achieving a vaccination threshold was pursued [3]. Although the public health perspective has turned away from a fixed threshold, high vaccination rates are still necessary to slow contagion [4,5]. Findings on vaccination willingness against COVID-19 (VWC) in Germany in 2020 varied between 54% and 71%, depending on the sampling method [6]. In this study, we try to identify predictors of VWC to achieve high vaccination rates.

2. Theoretical background and literature review

Studies of VWC as well as vaccination willingness against other diseases, identify the same set of predictors: gender, age, being at high risk from COVID-19, education, belief in conspiracy theories, peer group behavior, and previous vaccination experiences. We discuss these factors in turn.

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2.1. Gender and age

Previous studies demonstrated gender and age are predictors for VWC (among others: [7–9]). Men show a higher VWC than women [10,11]. This behavior can be considered as rational, as men face a higher risk in case of a disease [12,13]. Older people are more willing to be vaccinated than younger people [10,14]. Similar findings are reported for vaccination willingness against seasonal influenza [7,15].

2.2. Being at high risk from COVID-19

Higher age is a direct predictor for VWC; age also predicts being at higher risk. With regard to COVID-19, the Robert Koch Institute [16] considers as special medical risk the following factors: age above 50, smoking, obesity and a series of pre-existing medical conditions (cardiovascular disease, chronic lung disease, chronic kidney and liver disease, diabetes, cancer, weakened immune system). Individuals being at higher risk exhibit higher VWC [11,17]. Moreover, people expecting more serious consequences of a COVID-19 illness show a higher willingness to be vaccinated [18,19]. Similar effects are reported for seasonal influenza [15]. The majority of studies survey subjective health status as predictor. However, a cross-sectional study in ten lower- and middle-income countries asked for specific individual diagnoses (hypertension, diabetes, heart disease, pulmonary disease) and found no effect of pre-existing illness on the VWC [20].

The theoretical explanation for the generally observed effect of health status on VWC is provided by rational choice theory [21]. According to this, the expected value (product of probability and perceived benefit) of vaccination is higher for individuals who are at high risk from COVID-19.

2.3. Socio-Economic status and education

Epidemiological studies in several western countries indicate an association of low socioeconomic status with an increased risk of severe COVID-19 [22]. Following rational choice theory as mentioned above, vaccination willingness should thus be high among people with low socioeconomic status. However, Callaghan et al. [23] report for the US that VWC increases with level of income and that explicit vaccination refusal decreases with increasing income. Rosiello et al. [20] observed a non-linear, but positive monotone effect of household income on vaccination willingness in ten low- and middle-income countries.

Lower education is associated with vaccine hesitancy in several studies: The study by Hornsey et al. [24] confirms these findings for Spain and show a higher willingness to be vaccinated with increasing education. In their systematic review of studies on COVID-19 vaccination determinants Nehal et al. [9 25] present a significant association of education and VWC in 14 out of 25 articles. Similarly, Troiano and Nardi [7] report in their review of 15 studies lower vaccination approval is observed among people with low education. Therefore, education is expected to increase VWC.

2.4. Peer effect

Personal social networks foster the spread of disease-specific information and attitudes as well as health behavior in general. The underlying mechanisms are social learning, social contagion, and social diffusion. This mechanism also applies attitudes towards vaccination as well [26]. This link has already been empirically shown for the willingness to vaccinate against seasonal influenza [15]. Religious affiliation also appears to impact VWC [27,28], indicating effects of larger social networks and the existence of opinion leaders. Thus, we assume people are less willing to be vaccinated if their peers are also unwilling.

2.5. Conspiracy beliefs

Belief in conspiracy theories, collectively referred to as conspiracy beliefs, is seen as a general political attitude pattern [29]. Evidence suggests that lower willingness to adhere to policies containing COVID-19 (including vaccinations) is prevalent among people holding conspiracy beliefs [30,31]. The link between vaccination refusal and belief in conspiracy theories has been observed before COVID-19. Shapiro et al. [32], for example, report a negative association between the “Vaccine-related-Conspiracy-Belief-Scale” (VCBS) and willingness to receive HPV vaccination among young males.

2.6. Vaccination experience

The literature shows a positive effect of past vaccination experience on vaccination willingness (VW): Past positive vaccination experiences increase VW with an influenza vaccine, whereas negative vaccination experience decrease VW [15]. The same has been reported for a COVID-19 vaccine [14]. In addition, Chor et al. [33] and Seale et al. [34] observe vaccination willingness against H1N1 was higher among individuals who had received an influenza vaccination before. Caserotti et al. [19] reached the same conclusion for Italy.

2.7. Evidence-based medicine and complementary alternative medicine

People receiving a vaccination recommendation from medical staff (doctors / nurses) show a higher willingness to be vaccinated against influenza. The frequency of contact with the health care system, e.g. number of doctor visits, also positively affects VW [15].

Evidence suggests that physicians with additional training in naturopathy/homeopathy advise fewer or a lower number of vaccinations [35,36]. Furthermore, an association is observed between opposition to vaccination and advocacy of alternative medicine [37]; conversely VWC is higher among individuals who have confidence in evidence-based medical procedures [38].

Evidence for Spain suggests that distrust in conventional medicine lowers vaccination willingness in general and also for the COVID-19 vaccination. This relationship is stronger for users of complementary and alternative medicine (CAM). Nevertheless, trust in CAM is observed to be a weak predictor of vaccine hesitancy [24].

3. Materials and methods

3.1. Study design and sample

The study is based on a single-topic survey of the general population on VWC commissioned by the authors. The fieldwork of this national survey was done between November 12, 2020 and December 10, 2020. The telephone (landline and mobile) survey is a probability sample from a sampling frame representing the adult population living in Germany. The method was chosen to circumvent the problems of self-recruitment for online surveys [39].

The final sample contained 2014 respondents. In contrast to online surveys, this sample represents nearly the whole age range (age range 18 to 95 years, median age 52, average age 50.1) and non-Internet users are also interviewed [40]. 50.8% of respondents in the sample are female, 49% male, and 0.1% diverse².

3.2. Dependent variables

Our dependent variable is the VWC. We recoded the four different

² Gender identity was asked as male, female, diverse (identifying as neither male, nor female). Please refer to Economic and Social Council/United Nations [41] for an overview of existing practices in large sample surveys.

answer options (“yes”, “more likely”, “less likely”, “definitely not”) into a dichotomous variable “willing” (“yes”, “more likely”; 67.3 %) and “not willing” (“more likely not”, “definitely not”).

3.3. Independent variables

The questionnaire includes 100 items. Only data based on questions asking for gender, age, education, peer group behaviour, previous experience with vaccinations, attitudes towards evidence-based medicine, and belief in conspiracy theories is reported in this paper. We discuss details of the operationalization in the section on results.

3.3.1. Conspiracy beliefs

Four questions from the Vaccine-related Conspiracy Belief Scale (VCBS) [32] covered vaccination conspiracy beliefs. The internal consistency of these items is Cronbach’s $\alpha = 0.81$. Unexpectedly, item non-response is very high (529 out of 2014 respondents answered, “do not know”, 71 respondents refused to answer) for the question on the autism-vaccination link theory. To avoid losing 29.8% of the sample, the question is excluded from further analysis. Following Shapiro et al. [32] we build the VCBS as the average of the remaining three questions: “Pharmaceutical companies downplay the dangers of vaccines”, “Side effects of vaccines are often concealed”, “The effectiveness of vaccines is often exaggerated” (options: “don’t agree at all”, “more likely don’t agree”, “more likely do agree”, “agree fully”).

3.3.2. Complementary alternative medicine

The scale “Belief in the effectiveness of complementary and alternative medicine” (CAM) is constructed from three items: “There is a lot of evidence for the effectiveness of homeopathy in the treatment of diseases”, “CAM can help with many health problems better than evidence-based medicine”, “The success of alternative practitioners is underestimated” (options: “don’t agree at all”, “more likely don’t agree”, “more likely do agree”, “agree fully”). The internal consistency is Cronbach’s $\alpha = 0.71$.³ Similar to the VCBS index, we constructed an index (average of the three items).

3.4. Analysis

We analyze bivariate and multivariate associations between the independent and the dependent variables. For bivariate analysis, cross-tabulations (χ^2 -test for categorical variables and *t*-test for metric variables) and bivariate logistic regressions were used.

A logistic regression model was used for multivariate analysis. We estimate two models to explain VWC: One model includes only standard socio-demographic and socio-economic variables (age, education, and gender), the other model includes all remaining factors discussed above. All computations were done with SPSS 27.

4. Results

4.1. Vaccination willingness against COVID-19 (VWC)

Overall, VWC in our sample is 67.3 % (“yes for sure” 39.5 % and “likely yes” 27.8 %). This matches exactly the percentage of the population vaccinated at least once in September 2021 in Germany [43]. 32.7 % are vaccine-skeptical and vaccine-refusing. The most frequently cited reason is feared side effects (71.5 %). In addition, 12.5 % of the sample are skeptical of all kinds of vaccination.

³ The items were adopted from the studies of GESIS [42] and Lamberty and Imhoff [37].

4.2. Bivariate analysis

4.2.1. Gender, age and being at high risk from COVID-19

Men show a higher willingness to be vaccinated (69.7 %) than women (64.9 %, χ^2 -test: $p = 0.023$; OR = 1.245, 95% CI (1.031; 1.504), $p < 0.02$). VWC also clearly increases with age (OR = 1.017, 95% CI (1.011; 1.022), $p < 0.001$). The mean age of those willing to be vaccinated was 52 years and therefore significantly higher than that of those not willing to get vaccinated ($\bar{x} = 47$ years, *t*-test: $p < 0.001$).

Nearly half of the sample (44.5 %) of the respondents self-assessed themselves as being at high risk⁴ (risk-group membership). The VWC in this group (77.6 %) is about 18 % higher than in the reference group (59.2 %, χ^2 -test: $p < 0.001$). Bivariate logistic regression (cf. Table 1) shows a significant increase of VWC of persons at high risk (OR = 2.381, 95% CI (1.950; 2.908), $p < 0.001$). These results are in line with research discussed above.

4.2.2. Education

The level of education was recoded according to the International Standard Classification of Education (ISCED) 2011. The German educational system allows for different levels of lower and upper secondary education. In the recoded variable on educational attainment, we differentiate between ISCED 1 (no degree), ISCED 2 (lower secondary degree), ISCED 3 (upper secondary degree) and ISCED 4 (tertiary degree). VWC increases strongly with the educational level (37,7 % ISCED 1, 80,6 % ISCED 4). A bivariate logistic regression (cf. Table 1) shows a significant increase in the VWC with the level of education.

4.2.3. Peer group

When asked about vaccination intentions of their peer group⁵, almost two thirds of the respondents assume that their friends and close acquaintances would get vaccinated. 67.8 % of those who believe that their friends would get vaccinated would definitely get vaccinated; another 22.7 % would be more likely to get vaccinated. Among those who believe that hardly any of their friends would get vaccinated, 88.7 % would not get vaccinated. A peer group effect can be found; VWC significantly increases in all groups (“less than half” OR = 6.298, 95% CI (3.887, 10.204), $p < 0.001$; “more than half” OR = 32.192, 95% CI (19.763, 52.438), $p < 0.001$; “almost all” OR = 74.795, 95% CI (44.229, 126.484), $p < 0.001$) with reference to persons whose friends are not vaccinated (cf. Table 1).

4.2.4. Conspiracy beliefs

Agreement with VCBS is not consistent across questions: 5.4 % of respondents “do not agree at all” with all statements in the VCBS (VCBS = 1), while 7.2% “agree fully” with all statements (VCBS = 5). A bivariate logistic regression shows VWC decreases with increasing agreement with the VCBS (OR = 0.251, 95 % CI (0.213, 0.295), $p < 0.001$) (cf. Table 1).

4.2.5. Attitude to Evidence-based medicine

Vaccine refusal is closely associated with trust in alternative

⁴ The definition of risk groups in the survey was adopted from the definition of the national body responsible for immunization recommendations, the Robert-Koch-Institut (cf. [16]). The question was phrased: “Doctors consider some populations to be particularly at risk for corona virus disease. These include the elderly, smokers, severely overweight people, and people with pre-existing conditions such as cardiovascular disease, chronic lung disease, chronic kidney or liver disease, people with weakened immune systems, cancer, or diabetes. Would you include yourself in one of these groups?” (Answer options: “yes”, “no”, “don’t know”, “prefer not to answer”).

⁵ “Do you think most of your friends and close acquaintances would get vaccinated?” Answer options: “Hardly anyone”; “Less than half”; “More than half”; “Almost all”; “Does not apply (have no friends or close acquaintances)”; “Don’t know”; “Prefer not to answer”.

Table 1
Aggregated Bivariate Logistic Regression.

Variables	Dependent variable: VWC			
	B (SE)	p	OR (95% CI)	n
Gender (ref. female)				1973
male	0.219 (0.096)	0.023	1.245 (1.031; 1.504)	932
Constant	0.613 (0.066)	<0.001	1.846	
Age				1957
Constant	0.017 (0.003)	<0.001	1.017 (1.011; 1.022)	
Constant	-0.109 (0.136)	0.423	0.897	
Risk (ref. no risk)				1976
risk group membership	0.868 (0.102)	<0.001	2.381 (1.950; 2.908)	935
Constant	0.371 (0.061)	<0.001	1.450	
Education (ref. tertiary degree / ISCED4)				1957
ISCED 1 (no degree)	-1.830 (0.290)	<0.001	0.160 (0.091; 0.283)	12
ISCED 2 (lower secondary education)	-0.829 (0.147)	<0.001	0.436 (0.327; 0.583)	758
ISCED 3 (upper secondary education)	-7.78 (0.175)	<0.001	0.459 (0.326; 0.647)	397
Constant	1.418 (0.134)	<0.001	4.127	
VWC peers (ref. hardly anyone)				1895
Less than half	1.840 (0.246)	<0.001	6.298 (3.887; 10.204)	372
More than half	3.472 (0.249)	<0.001	32.192 (19.763; 52.438)	758
Almost all	4.315 (0.268)	<0.001	74.795 (44.229; 126.484)	628
Constant	-2.071 (0.228)	<0.001	0.126	
VCBS	-1.383 (0.083)	<0.001	0.251 (0.213; 0.295)	1773
Constant	4.270 (0.227)	<0.001	71.494	
CAM	-0.800 (0.075)	<0.001	0.450 (0.388; 0.521)	1750
Constant	2.776 (0.204)	<0.001	16.051	
Measles (ref. no vaccination)				430
children in HH received vaccination	2.736 (0.905)	0.002	15.420 (2.618; 90.809)	
Constant	-2.530 (0.899)	0.005	0.080	
TBE (ref. no vaccination)				1939
respondent received vaccination	0.602 (0.103)	<0.001	1.826 (1.493; 2.235)	
Constant	0.517 (0.063)	<0.001	1.677	
Influenza (ref. no vaccination)				1971
respondent received vaccination	1.137 (0.100)	<0.001	3.117 (2.563; 3.790)	
Constant	0.101 (0.071)	0.155	1.106	

treatment methods. 6.0% of respondents justify their skepticism towards vaccinations with their belief in naturopathy. With increasing belief in the effectiveness of alternative treatment methods (CAM), the VWC decreases (OR = 0.45, 95% CI (0.388, 0.521), $p < 0.001$) (cf. Table 1).

4.2.6. Previous experience with vaccinations

A large proportion of the sample has previous experience with various vaccinations. 59.2% report previous flu vaccinations, and 43.2% have had a TBE (tick-borne encephalitis) vaccination. 95.9% of respondents with children under the age of 18 in the household have had at least one child vaccinated against measles. Previous vaccination

experience increases VWC (cf. Table 1).

For the multivariate analysis we use only the influenza vaccination as indicator for past vaccination experience. Reasons for this decision are the response rate and vaccination recommendation. In contrast to influenza, TBE is only prevalent in parts of Germany and therefore not recommended everywhere. The item therefore picks up a regional effect we cannot control for. The question on measles vaccination has a high non-response rate, it applies only to parents with young children.

5. Multivariate analysis

For predicting willingness to be vaccinated with a COVID-19 vaccination, a multivariate logistic regression model is reported. Based on the literature review and the bivariate analysis presented above the decision to get vaccinated is expected to be determined by: male sex (+), age (+), education (+), high risk from COVID-19 (+), previous influenza vaccination (+), estimated VWC of friends/acquaintances (+), belief in vaccine-related conspiracy theories VCBS (-), and belief in alternative treatment methods CAM (-). The results of the multivariate logistic regression model are reported in Table 2.

Including the additional variables in model 2 strongly increases model fit (Nagelkerke R^2 increases from 0.086 to 0.504). However, two of the previously significant demographic variables (gender and age) no longer have a significant effect on VWC. For education, we observe a significant linear effect in Model 1. After controlling for the other variables in model 2, only a weak but significant effect of category ISCED2 remains.

VWC increases with being at high risk from COVID-19 (self-assessment) and with the expected VWC of the social peer group. Vaccination willingness is lower when belief in alternative treatment methods (CAM) and approval of conspiracy theories is higher. People who are advocates of homeopathy and alternative treatment methods are less willing to get vaccinated; as are believers of vaccine-related conspiracy theories. The effect previous influenza vaccinations have on the VWC is negative. This contrasts to the bivariate results presented above and to findings in the literature.

6. Discussion

To understand factors influencing the willingness to get vaccinated we commissioned a telephone population survey. In contrast to surveys based on online convenience-samples, this survey mode includes under-covered subpopulations such as older or socially isolated persons [44]. Several competing explanations discussed in the literature could be assessed in a multivariate regression model.

Getting vaccinated has personal and public benefits. Therefore, factors correlated with the willingness to get vaccinated may be interpreted as motivators for public and personal good.

67.3% of the sample were willing to get vaccinated. The usually reported significant effects of education, gender, and age on the VWC do not persist after controlling for confounders and mediators in the multivariate analysis. The analysis reported here, therefore, provides evidence for the need to include effects of social networks, political attitudes and trust in science for the prediction of vaccine hesitancy.

VWC is higher for people being at high risk from COVID-19. This includes people in older age, with previous ailments, and obesity. The question asked for self-rating these conditions. Respondents considering themselves being at-risk of COVID-19 potentially see more personal benefits in getting the vaccination. Respondents not at-risk of COVID-19 would (primarily) receive the vaccination for the public good of herd immunity. Interest in personal health seems to be a more relevant driver for VWC than interest in public health.

People with prior experience with influenza vaccinations are less willing to get vaccinated with a COVID-19 vaccine once we control for additional confounding variables. This effect is in contrast with findings for other countries.

Table 2
Multivariate Logistic Regression.

Model	Dependent variable: VWC					
	B (SE)	OR (95% CI)	p	B (SE)	OR (95% CI)	p
Male (ref. female)	0.280 (0.101)	1.323 (1.085, 1.613)	0.006	0.229 (0.150)	1.258 (0.938, 1.686)	0.125
Age [years]	0.022 (0.003)	1.022 (1.017, 1.028)	<0.001	0.005 (0.004)	1.005 (0.996, 1.013)	0.300
Education (ref. ISCED 4)			<0.001			0.007
ISCED 1	-1.740 (0.299)	0.175 (0.98, 0.315)	<0.001	-1.275 (0.722)	0.279 (0.068, 1.151)	0.78
ISCED 2	-1.089 (0.154)	0.337 (0.249, 0.456)	<0.001	-0.726 (0.225)	0.484 (0.311, 0.752)	0.001
ISCED 3	-0.718 (0.178)	0.488 (0.344, 0.691)	<0.001	-0.419 (0.256)	0.658 (0.399, 1.085)	0.101
Risk (ref. no risk)				0.818 (0.159)	2.266 (1.659, 3.096)	<0.001
Influenza (ref. none)				-0.847 (0.151)	0.429 (0.319, 0.577)	<0.001
VWC peers (ref. hardly anyone)						<0.001
Less than half				1.378 (0.276)	3.966 (2.310, 6.811)	<0.001
More than half				2.693 (0.281)	14.782 (8.528, 25.620)	<0.001
Almost all				3.365 (0.311)	28.934 (15.718, 53.264)	<0.001
VCBS				-0.764 (0.111)	0.466 (0.375, 0.579)	<0.001
CAM				-0.380 (0.105)	0.684 (0.557, 0.840)	<0.001
Constant	0.310 (0.192)	1.364	0.106	1.786 (0.493)	5.966	<0.001
n	1933			1541		
Omnibus test	$\chi^2 (5) = 121.824 (p < 0.001)$			$\chi^2 (12) = 654.947 (p < 0.001)$		
-2 Log-Likelihood	2310.415			191.973		
Pseudo R ² (Nagelkerke's)	0.086			0.504		

Respondents believing friends and relatives will get vaccinated are also more willing to be vaccinated. This points to a peer group effect on the opinion towards vaccination, which is in line with former research [15,45]. The importance of social network effects on health behaviour are well known in social epidemiology [46,47].

People believing in alternative medicine are less willing to get vaccinated. Vaccines are a treatment option of conventional, evidence-based medicine. Advocating homeopathy and alternative treatments excludes conventional treatment options. Even though alternative treatment options may not be harmful by themselves, their rejection of conventional medicine may result in negative personal and public health outcomes. Agreeing with items reflecting vaccine-related conspiracy theories, also reduces the VWC. These respondents have increased fears associated with vaccinations and strongly overstate potential side-effect. A personal or public gain from a vaccination is strongly outweighed by expected side-effects.

7. Conclusion

Our results may help framing future vaccination campaigns. Since the peer effect is strong, role models for specific social groups should be identified and encouraged to promote vaccinations through different channels [48]. The observed impact of belief in alternative medicine and belief in conspiracy theories on vaccine refusal reflect a distrust in evidence-based medicine, science, and political institutions at large. Future research should develop new strategies for these subgroups, which might be missed by traditional public health campaigns.

Limitations

VWC, as other attitudes, is subject to change, as are infection incidence and risk assessments. Although this study reflects the situation before the German vaccination campaign began, we consider the correlations between the variables as rather stable. Data is based on a probability random sample of the German population. Therefore, the findings are not necessarily generalizable to other countries.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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