Willingness To COVID-19 Vaccination: Empirical Evidence From EU

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Willingness to COVID-19 vaccination: empirical evidence from EU

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Abstract:

The unforgettable COVID-19 shock can only be reversed by a viable vaccination strategy. In this paper, we investigate willingness to be vaccinated (WTV) against the COVID-19. We provide first of its kind empirical evidence on the citizens (N=11,932) of the EU-27 by employing the recent data from the European Commission. Controlling for the correlations in the error terms, we utilize a simulated multivariate probit regression model. Our results show that amongst all the statistically significant drivers of the WTV, the positive perception (vaccination works and has no side effects); R&D information (clarity on how vaccination is developed, tested, authorized) has the largest impact on the WTV. We find that the group of variables on social feedback, and on trustworthy sources of information are to be considered for WTV policy. The counteracting policy gaps are also identified. Our work is novel and has implications for COVID-19 vaccination policies across the EU.

Keywords:

COVID-19; Vaccinations; Willingness; Pandemic; European Union.

1. Introduction

The COVID-19 pandemic will always be an unforgotten global shock to our way of life. After the acceptance of the worst pandemic reality and settlement of the panic, the world impatiently waited for the development of the COVID-19 vaccination as the only viable long-term solution (Koirala et al., 2020). A global act of multilateralism against the constraints to supply and ensure equitable access to tests, treatments, and vaccines the COVID-19 tools accelerator (ACT) is put in place (World Health Organization, 2021). It proposes a total of US\$ 38.1 billion in budget and motivates high-income countries to make a financial investment in its mission. Fast forward to 2021, pandemic continues, and lockdowns are still enforced but the vaccination era has also begun. COVAX the responsible authority on global COVID-19 vaccination from the ACT agreement set its aim to administer at least 2 billion doses to the most vulnerable in low and middle-income parts of the world, by the end of 2021 (GAVI, 2020). A study by Çakmaklı et al. (2021), measures that due to the interdependent trade and economic linkages the global economy can face a loss of US\$ 9.2 trillion, in the worst-case scenario where vaccinations are not provided to the developing world. In a scenario, where half of the developing world population is vaccinated, a global loss of US\$ 3.8

trillion is expected. The US\$ 1.9 trillion of it is lost in GDP of the developed economies. The global campaign to vaccinate everyone, and make COVID-19 a ‘people’s vaccination’ by removing its patents (Gonsalves & Yamey, 2021) can be confessed as an economic rationale, rather than a mere humanitarian one (Çakmaklı et al., 2021). Immunologists advocate reaching a so-called ‘herd-immunity’ that can minimize the chances of contraction drastically (Randolph & Barreiro, 2020). This herd immunity threshold increases along with an increase in the reproduction number i.e., how many are secondarily infected by the primary. At least 75% of the national population needs to be vaccinated assuming a reproduction number of 4. The world learned, and the end to the COVID-19 pandemic is set in sight and can now be navigated. By the end of September 2021 a 2.5 billion of the world population is fully vaccinated (Our World in Data, 2021). In the European Union (EU), 275 million from its 447 million citizens have only been fully vaccinated. This underachievement is also prevalent if, roughly, a non-risky population is not considered (see figure 1). If the fully vaccinated to population ratio for only risky population (15 and above) of the EU is estimated (vaccination quota), it shows that more than a quarter (27%) of EU citizens have refused to take vaccinations. Clearly, the EU does not lack access to doses, as the EU has actively made advance purchase agreements with individual vaccine producers (European Commission, 2020). Further demand for vaccinations also can be observed to be saturated and in a steep decline (see figure 2). Even though, in the data, 75% of sampled EU citizens agree that vaccines are the only way to end the pandemic. Yet there is a lack of or hesitancy to be vaccinated.

Fully vaccinated in EU-27 by mid-September of 2021

Source: own illustration using www.ourworldindata.org and Eurostat

Figure 1: Fully vaccinated in EU-27 by mid-September of 2021

Source: own illustration using www.ourworldindata.org

Figure 2: New COVID-19 vaccinations per million (worldwide)

Against this backdrop, a clear research question is: what determines the willingness to be vaccinated (WTV) amongst the EU citizens? Alternatively, equally important is the question: what can be done to promote it, if this is the goal and only viable strategy? In this paper, using EU-wide recent data (European Commission, 2021), we investigate this relevant question. The mandates and policies related to COVID-19 have led to polarization and politics on vaccination throughout the world (German Lopez, 2021; The Economist, 2021). In the case of many countries including the EU, USA, Australia considerable portion of the population is still unvaccinated, which leads to division between the authorities and the communities and separation within the communities. To study these issues in-depth, we provide empirical evidence and data, based on public opinion and perception. We also try to fill the gap between the policies of the EU member states and their citizens' WTV. Based on the statistics it is important to analyze what determines an individual's willingness to get vaccinated and what factors need to be considered for the risky group to be vaccinated? In this research, we empirically analyze different factors that may increase individuals' willingness to vaccination with the assumption that vaccinations are a viable solution to end the pandemic given the goals and intentions of the EU, which are politically, economically, socially and health motivated. WTV and "vaccine hesitation" (or "vaccine acceptance") are likely to be complicated and multidimensional notions, as are most theoretically salient and politically controversial ideas (particularly those that represent human beliefs or attitudes). It is critical to comprehend the reasons why society is divided on vaccines in the current environment. Addressing the joint deterministic nature of our dependent variables, we employ the maximum simulated likelihood multivariate probit model as our econometric approach (Cappellari & Jenkins, 2003). Our empirical study is an important contribution and to the best of our knowledge a first of its kind that provides this contribution by using this novel rich data on EU-27. Our empirical

work to literature research on WTV in EU-27, which have implications for EU members and other countries.

2. Results

In table 1 we present our sample descriptive statistics. WTV is skewed distributed towards the immediate and hesitant acceptance, with only 18% never willing to be vaccinated. Positive perception and R&DInfo are the most mentioned driving factors. The second driving factors that are mentioned the most are medical advice and social adoption. Finally, social pressure is the second last mentioned factor and EUproduced is the least mentioned driving factor. There is almost a polarization in our sample to be satisfied with the vaccination strategy of the local government or the EU. An almost three-quarters of sample participants are confronted by social fear. On the other hand, personal fear is well far apart low from social fear. The EU families have a very high positive perception of the vaccination and have vaccinated their children. Similarly, general attitudes towards the safety and efficacy of vaccinations are also very high in our sample of EU citizens. We have an almost equal representation of both genders in our sample. A well above the average of almost 64% citizens have obtained 20 or more years of education, or currently are continuing it. An almost 22% of citizens are in the risky age group.

In table 2 we provide our pairwise Pearson's coefficients of correlation to describe the interdependence of our variables. All our variables are in their acceptable range and show no sign of multicollinearity that may cause over-specification and inconsistency in our estimates.

In table 3 we have provided our results using the outlined econometric methodology while in and figure 3 we show the visual summary of the main results. With a highly statistically significant result of the log-likelihood ratio test of rho, we can conclude that our econometric approach is correctly specified and the null hypothesis ($\rho=0$) can be rejected. All the individual rhos are also positive and statistically highly significant and show that joint determination is to be addressed. Due to limited interpretation possibilities of the probit model, post-estimates of marginal effects are usually done. However, the employed simulated method does not support any validated post estimates. Limited by the individual average marginal effects, the simulation allows for post-estimates on the marginal success probability ($\Pr(\text{depvariable}_i) = 1$) for each equation in table 4.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
WTV	11932	0.826	0.379	0.000	1.000
Socialpressure	11932	0.160	0.366	0.000	1.000
Positiveperception	11932	0.367	0.482	0.000	1.000
Socialadoption	11932	0.183	0.387	0.000	1.000
Medicaladvice	11932	0.200	0.400	0.000	1.000
EUproduced	11932	0.128	0.334	0.000	1.000

R&Dinfo	11932	0.327	0.469	0.000	1.000
Govsatisfaction	11932	0.491	0.500	0.000	1.000
EUsatisfaction	11932	0.552	0.497	0.000	1.000
Socialfear	11932	0.740	0.438	0.000	1.000
Personalfear	11932	0.132	0.339	0.000	1.000
Familyperception	11932	0.901	0.299	0.000	1.000
Vaccinesafetyattitude	11932	0.791	0.407	0.000	1.000
Vaccineefficacyattitude	11932	0.847	0.360	0.000	1.000
Gender	11932	0.510	0.500	0.000	1.000
Highereducation	11932	0.639	0.480	0.000	1.000
Riskyagegroup	11932	0.216	0.412	0.000	1.000

Table 2: Pearson’s coefficients of correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) WTV	1.000																
(2) Socialpressure	0.160	1.000															
(3) Positiveperception	0.191	0.181	1.000														
(4) Socialadoption	0.115	0.246	0.214	1.000													
(5) Medicaladvice	0.172	0.190	0.136	0.205	1.000												
(6) EUproduced	0.130	0.156	0.109	0.186	0.168	1.000											
(7) R&Dinfo	0.092	0.086	0.185	0.200	0.115	0.143	1.000										
(8) Govsatisfaction	0.285	0.112	0.037	0.059	0.100	0.077	0.000	1.000									
(9) EUsatisfaction	0.310	0.120	0.073	0.070	0.099	0.100	0.020	0.553	1.000								
(10) Socialfear	0.057	0.013	0.054	0.024	0.020	-0.002	0.053	0.004	0.037	1.000							
(11) Personalfear	0.009	0.015	-0.030	0.024	0.019	0.002	0.001	0.018	0.017	0.145	1.000						
(12) Familyperception	0.035	-0.039	0.047	-0.012	-0.006	-0.041	0.050	0.000	-0.002	0.153	-0.050	1.000					
(13) Vaccinesafety	0.424	0.076	0.113	0.051	0.109	0.055	0.024	0.275	0.286	0.086	0.002	0.170	1.000				
(14) Vaccineefficacy	0.416	0.076	0.136	0.048	0.103	0.053	0.057	0.242	0.263	0.127	-0.003	0.209	0.670	1.000			
(15) Gender	0.031	0.022	-0.030	-0.021	0.035	0.063	-0.024	0.006	-0.024	-0.054	0.015	-0.064	0.030	0.007	1.000		
(16) Highereducation	0.081	0.022	0.048	0.012	-0.002	0.020	0.031	0.052	0.051	0.071	-0.007	0.026	0.076	0.093	0.000	1.000	
(17) Riskyagegroup	-0.009	-0.032	-0.027	-0.043	0.026	-0.019	-0.025	-0.003	-0.049	-0.036	-0.050	0.093	0.013	0.020	0.037	-0.095	1.000

Table 3: Multivariate probit results

VARIABLES	(1) Social pressure	(2) Positive perception	(3) Social adoption	(4) Medical advice	(5) EU produced	(6) R&D info
WTV	0.895*** (0.0671)	0.706*** (0.0469)	0.565*** (0.0639)	0.778*** (0.0790)	0.740*** (0.0536)	0.424*** (0.0516)
Govsatisfaction	0.125*** (0.0322)	-0.0842** (0.0333)	0.0607** (0.0303)	0.0727** (0.0354)	0.0413 (0.0376)	-0.0774** (0.0346)
EUsatisfaction	0.183*** (0.0375)	0.0421 (0.0277)	0.0713** (0.0312)	0.106*** (0.0350)	0.210*** (0.0464)	-0.0236 (0.0354)
Socialfear	0.0623** (0.0300)	0.117*** (0.0305)	0.0340 (0.0324)	0.0490* (0.0279)	0.0148 (0.0373)	0.0945*** (0.0330)
Personalfear	0.0132 (0.0369)	-0.153*** (0.0493)	0.0755 (0.0540)	0.0871** (0.0407)	-0.0273 (0.0531)	-0.0291 (0.0415)
Familyperception	-0.221*** (0.0655)	0.0825* (0.0443)	-0.0985** (0.0464)	-0.158*** (0.0407)	-0.232*** (0.0547)	0.169*** (0.0398)
Vaccinesafetyattitude	0.0285 (0.0512)	0.0511 (0.0428)	0.0197 (0.0303)	0.0990*** (0.0358)	-0.0280 (0.0422)	-0.126*** (0.0484)
Vaccineefficacyattitude	0.0361 (0.0751)	0.270*** (0.0402)	-0.0156 (0.0501)	0.0865 (0.0544)	0.0141 (0.0648)	0.191*** (0.0489)
Gender	0.0569* (0.0325)	-0.0904*** (0.0236)	-0.0539* (0.0285)	0.0973*** (0.0288)	0.203*** (0.0289)	-0.0571** (0.0227)
Highereducation	-0.0284 (0.0288)	0.0755** (0.0294)	-0.0245 (0.0262)	-0.0474* (0.0281)	0.0426 (0.0392)	0.0477* (0.0273)
Riskyagegroup	-0.121*** (0.0425)	-0.0773*** (0.0244)	-0.156*** (0.0441)	0.101** (0.0438)	-0.0732 (0.0500)	-0.0823** (0.0333)
Constant	-2.010*** (0.0930)	-1.147*** (0.0824)	-1.318*** (0.0945)	-1.744*** (0.110)	-2.095*** (0.0727)	-0.795*** (0.0822)
Observations	11,932	11,932	11,932	11,932	11,932	11,932
Country dummies	YES	YES	YES	YES	YES	YES
Draws	110	110	110	110	110	110
Log pseudo-likelihood	-33688	-33688	-33688	-33688	-33688	-33688

Likelihood ratio test of

 $\rho_{01} = \rho_{02} = \rho_{03} = \rho_{04} = \rho_{05} =$ $\rho_{06} = \rho_{07} = \rho_{08} = \rho_{09} = \rho_{10} =$ $\rho_{11} = \rho_{12} = \rho_{13} = \rho_{14} = \rho_{15} =$ $\rho_{16} = \rho_{17} = \rho_{18} = \rho_{19} = 0$

Clustered standard errors by country in parentheses (27 clusters)

*** p<0.01, ** p<0.05, * p<0.1

3. Discussion

As expected, our main results are in line with the literature. Interestingly, there are several crucial novel insights that are to some extents are observed in society but have never been validated with empirical evidence, especially in the context of the COVID-19 pandemic. Our results show that future vaccine compliance is positively driven by all of the dependent variables. In combination with mean marginal predicted probabilities in table 4, the largest average contribution is from the positive perception (36%) and secondarily from the R&Dinfo (32%). The literature specifically guides us that in the presence of a range of swirling sentiments combined with unstoppable misinformation, novel uncertainty, and risk of mortality, it is only natural to continue with the ‘wait-and-see’ strategy or to go to the trustworthy sources of information. This primary source of information is not the doctors but rather research and development information of the vaccinations. The doctors are the secondary source of information (20%), and given the articulation of the question, plausibly, they are to some extent the providers of the primary source of information as well. Similarly, social adoption (18%) and recommendation from those who are already vaccinated encourage others to get vaccinated. Our other dependent variables show that social pressure (16%) and EU production (12%) are the last two drivers that play a positive role. The social pressure due to the replication effect acts as a feedback mechanism and EU production due to the proximity is an indicator of a positive reliance and trust in the quality of the vaccination. Therefore, a combined role of confirmation that there are no side-effects plus encouraging and compulsive positive feedback from the society is the first cluster of future drivers of WTV. An important addition to this is the sources of information with high trust. This is our second cluster of drivers of WTV. A clear policy implication, as already emphasized in the literature, is to provide trustworthy information (at various levels) that will eventually trickle down in creating positive feedback on the effective working of the vaccination.

However, these clear policy implications are counteracted by several variables. Our estimates on control variables show that in the presence of the positive perception and information on vaccination development, the survey participants are dissatisfied with the government’s vaccination strategy. This can be possibly described as a criticism on the effective governance to supply the vaccination to the general population. This is the absence of supply in the presence of demand. This can also be further confirmed by looking at the insignificance of the EU satisfaction variable under these two dependent variables. This is because the supply is effectively managed by the EU institutions and the lack of effective local supply can only be attributed to the local government. Alternatively, from the lens of trust, a lack of trust in local government is causing a decline in the WTV.

Fear indicators show that social fear is highly significant in driving the WTV with the positive perception and R&Dinfo. Whereas it contributes with relatively less significance to drive WTV via social pressure and medical advice. On the other hand, personal fear is highly significant and negative for positive perception. This implies that the recovered from COVID-19 with a natural immunity are not impacted by any of our drivers but reject the perception that there are no side effects. It is plausible to infer that these recovered due to their illness are indicating towards a long-term effect of being infected by the virus. This behavior can be further confirmed by including the positive and statistically significant impact of this personal fear on WTV under medical advice. This confirms that these are the recovered who would have taken vaccination only due to hospitalization.

The highly interesting role of a family’s health literacy shows that it only supports WTV if R&Dinfo is clearly available. These scientific families are also observant of the society to analyze the side-effects of the vaccination, however, less so as compared to its reliance on the development, authorization, and

testing information. Such scientific families reject and filter all other sources of feedback from society and do not rely on any other sources of (*mis*-)information. This emphasizes our argumentation in the literature review on the importance of patents as a source of information given suitable health literacy.

The impact of safety attitude towards the vaccinations shows that it remains positive after taking medical advice. On the other hand, as soon as clarity on R&Dinfo is provided it becomes negative. It is intuitive to suggest that this is because the way COVID-19 vaccination has been developed, tested, and authorized does not meet any normal cycle of vaccination development. Therefore, in line with expectations, this attitude turns negative and discourages WTV. However, considering the efficacy attitude, even though, the R&Dinfo is not very encouraging, vaccination is still the only viable effective solution and increases the level of trust in R&Dinfo. By the very definition of efficacy, it is highly significant to drive the WTV after learning from society that it is effective and has no side effects. These conflicting concerns have been visible in the literature, our results confirm it for COVID-19.

Our demographic variables show that the male survey participants mainly rely on medical advice and trust in EU produced vaccinations, along with a smaller extent of dependence on social pressure. Highly interesting in this group of variables is the highly educated participants. These highly educated are mainly reliant on the positive perception of the vaccinations, less so reliant on R&Dinfo, and reject the medical advice. In the specific case of COVID-19, the possession of information decoding capabilities does not lead to very high trust levels in R&Dinfo, most likely due to the comparative safety concerns of the vaccination development that lead to rejection of medical advice. The driving factor of WTV via high education is the observation of the efficacy of the vaccinations from their society. Contrary to this, the elderly participants in a risky group are rejecting vaccination under all other driving factors with the only exception of medical advice. These risky participants have always been the primary focus of any vaccination strategy that is mediated by the local doctors. Moreover, due to their age, it can be expected that they share a rather higher level of trust in their doctors based on their frequent visitation and medical history of underlying diseases. Therefore, it is only plausible to conclude that their doctors act as the primary and only source of information.

Table 4: Mean marginal success probability of each equation

Variable	Obs	Mean	Std. Dev.	Min	Max
Socialpressure	11932	0.160	0.088	0.005	0.464
Positiveperception	11932	0.368	0.121	0.030	0.622
Socialadoption	11932	0.184	0.071	0.019	0.407
Medicaladvice	11932	0.200	0.091	0.008	0.459
EUproduced	11932	0.128	0.063	0.009	0.360
R&Dinfo	11932	0.327	0.090	0.057	0.594

Our results have identified counteracting gaps that are crucial to address WTV and may act as levers of policy formation. The gap between governance and WTV: citizens are dissatisfied with vaccination governance and will refuse vaccination even if they observe no side effects and have clarity on vaccination's R&Dinfo. Trust levels have to be actively restored in the local government that may have been eroded due to misinformation. The gap between hospitalization and WTV: those who have recovered are in fear of the long-term effects of vaccinations. A naturally immune recovery has to be researched and maintained because the recovered will not show WTV, unless medically forced. The

gap between family perception, information, and WTV: a family with a positive general perception of vaccinations, mistrusts most sources of information gathering and mainly relies on the clarity of vaccination development, testing, and its authorization process. Health literacy act as a filter to misinformation. R&D information has to be made public to debunk misinformation and increase trust. The gap between safety, efficacy, and WTV: safety may be counteracting but efficacy is driving WTV. The efficacy of vaccinations has to be balanced against safety concerns, the way it has always been in vaccine compliance. The gap between higher education and WTV: highly educated would like to stand in the waiting line to be vaccinated. They take into account the abnormal development of the vaccination and mistrust medical advice. A conflict of interest has to be detached between the medical experts and the promotion of vaccinations combined with the elimination of the understandable safety concerns. The gap between risky age group, doctors, and WTV: the risky and the elderly have no acceptance of vaccinations unless the doctor advise them. This is maybe for the best but lower social encounters as a safety measure may be another reason for the elderly to rely only on the doctors in their residencies. Our results validate many of the anecdotal observations during the COVID-19 pandemic and vaccine literature. The role of trust in community and information has emerged as the conclusive two pieces of the puzzle to ensure future WTV.

4. Conclusion

Despite the COVID-19 pandemic, only around 73 percent of EU inhabitants (15 and +) have been immunized, with more than 104 million people still needing to be immunized. Vaccine reluctance is a key impediment to conducting immunization programs in the setting of a pandemic. Our findings reveal that, of all the statistically significant determinants of WTV, positive perception (vaccination works and has no adverse effects); and R&D information (clarity on how the vaccine is created, tested, and authorized) on the vaccine's adverse effects had the greatest impact on WTV and were the most important causes for vaccination hesitation and rejection. Obtaining reliable and accurate information about available vaccinations is the most essential element that may enhance vaccination acceptability.

We find many counteracting factors, that have appeared in the polarized debate on WTV. These counteract factors are originated from the gaps between community, information, and levels of trust in these sources of information. There are safety concerns, but these concerns are overcome by the efficacy of vaccination. Higher education levels among the individuals also aid WTV to decipher valuable information related to the pandemic and vaccines. Moreover, WTV is assisted and aided by medical advice in terms of elderly people as risky citizens (55 and +). Our research is novel and has implications for evidence-based policy debate. The current study offers authorities in-depth insights into the anticipated challenges and solutions regarding the COVID-19 pandemic and to its end via stimulation of the WTV.

In terms of study limitations, data availability for other countries was a subject of concern, which might be addressed in future research by external validation of our findings with a different group of countries. Moreover, because our control variables provide varied outcomes, further focused study, and statistical evidence on them may be conducted. Furthermore, the results of this study may have generalizability limits because it deals with behavioral aspects of individuals, which can be verified and adjusted in future vaccination studies based on post-crisis behavior.

5. Methods

5.1 Data and variables

For our empirical analysis, we use the latest Flash Eurobarometer survey data from the European Commission on: “attitudes on vaccination against COVID-19” (European Commission, 2021). The survey interviewed 26,106 EU citizens aged 15 and above between the 21st of May 2021, and the 26th of May 2021. The survey was conducted in the national language via computer assistance. We focus on a sample of 11,932 observations by looking at the WTV of those who are planning to be vaccinated against those who have decided to never be vaccinated. Therefore, our empirical evidence sheds light on potential drivers and determinants of the future demand of the COVID-19 vaccination.

Our binary dependent variables are constructed from the survey question: “You would be more eager to get vaccinated against COVID-19 if...”. There are multiple answers possible for this question, which causes a potential joint determination, hence, a multivariate model is employed (see next section). Our main binary independent variable is constructed from the survey question: “When would you like to get vaccinated against COVID-19?”. It takes the value of 1 if the respondent is willing to be vaccinated “As soon as possible”, “sometime in 2021”, “later”. The value is 0 if the response is “never”. A 37% of survey participants are already vaccinated, hence these responses are not of interest for our analysis. Our control variables are vaccine strategy satisfaction employed by the institutions, fear, and perception of the pandemic, and vaccines. In addition, we control for the demographic variables such as being in a risky age group, gender, and higher education. Finally, we control for the country-specific effects. A description of our constructed variables is available in table 5.

Table 5: Description of variables

Dependent variables (<i>Drivers</i>)		
Social pressure	You see more people around you do it	1 if mentioned 0 otherwise
Positive perception	More people have been vaccinated and we see that it works and that there are no major side effects.	1 if mentioned 0 otherwise
Social adoption	The people that recommend the vaccines are vaccinated themselves	1 if mentioned 0 otherwise
Medical advice	Your doctor(s) recommend(s) you to do so	1 if mentioned 0 otherwise
EU produced	Vaccines are developed in the EU	1 if mentioned 0 otherwise
R&D info	There is full clarity on how vaccines are being developed, tested and authorized	1 if mentioned 0 otherwise
Independent variable		
Willingness to be vaccinated (<i>WTV</i>)	When would you like to get vaccinated against Covid-19?	1 if As soon as possible; sometime in 2021; Later 0 if Never

Control variables		
Satisfaction in government vaccination strategy	Following institutions have handled the vaccination strategy	1 if very satisfied; fairly satisfied 0 Fairly dissatisfied; not satisfied at all
Satisfaction in the EU vaccination strategy		1 if very satisfied; fairly satisfied 0 Fairly dissatisfied; not satisfied at all
Social fear	Tell if it applies: You know people who have been ill because of COVID-19	1 Yes 0 No
Personal fear	Tell if it applies: You have been ill because of COVID-19	1 Yes 0 No
Family perception	Tell if it applies: You have been vaccinated as a child	1 Yes 0 No
Vaccine safety attitude	What extent agree or disagree: Vaccines are safe	1 Totally agree; tend to agree 0 Tend to disagree; totally disagree
Vaccine efficacy attitude	What extent agree or disagree: Vaccines are effective	1 Totally agree; tend to agree 0 Tend to disagree; totally disagree
Gender	-	1 Male 0 Female
Higher education (in years)	-	1 20 years and older; Still in full time education 0 Up to 15 years; 16-19 years; Never been in full time education
Risky age group	-	1 55 years and older 0 15 to 54 years old
Country dummy	-	Yes

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259 The recent literature (Bargain & Aminjonov, 2020) on compliance to COVID-19 measures suggests
260 that pre-pandemic high-trust levels play an important part in the EU region. The countermeasure
261 strategies to manage pandemic has been found influential on trust in government (Rieger & Wang,
262 2021; Shereen et al., 2020). The implications of trust in institutions are also studied in healthcare (Ozawa
263 & Sripad, 2013) and how pandemics can be best managed with trust in government (Woskie & Fallah,
264 2019). Importantly, viable countermeasures such as vaccine-related denial are mainly affected by a lack
265 of trust in institutions (Vinck et al., 2019). Following this, we control for satisfaction attitudes towards
266 governments and the EU's vaccination strategy in our model. The fear of infection and mortality is an
267 anthropological fact that erupts in several forms and shapes related to any disease, more so, in today's
268 interconnected world (see e.g., Ahorsu et al., 2020; Pakpour et al., 2020). It may not be a psychological
269 state that may allow for rational decision-making. Furthermore, a willingness cannot be determined by
270 forced personal or social fear rather should be determined based on motivation from positive
271 perceptions and attitudes. Therefore, we control for personal and social levels of fear that may
272 influence WTV. The perception of parents, as decision-makers is crucial for vaccinating their children

(Austvoll-Dahlgren & Helseth, 2010; Brunson, 2013). We proxy this perception as a family perception towards vaccination safety, effectiveness, and its implications on WTV. It is plausible to expect that a family's health literacy as set by the parents, in such a novel health crisis will be of relevance to make appropriate decisions. Furthermore, a general perceived safety and efficacy of vaccination plays a role in the acceptance of vaccination (Sarathchandra et al., 2018). This general attitude is perhaps resistant to COVID-19 WTV as vaccinations for COVID-19 are developed with an abnormal process due to the global urgency. Moreover, conflicting information on COVID-19 vaccines is also an underlying reason to control for it. Considering gender, we take into account the medical evidence that COVID-19 is more infectious to men as compared to women (Ahmed & Dumanski, 2020; Jin et al., 2020). Similar justification follows into controlling for the risky age group. The motivation to control for higher education results from an ongoing and ever-increasing debate, that low levels of education are responsible for rejecting COVID-19 vaccinations (see e.g., Khubchandani et al., 2021) on social media. This control also allows for any family perceptions driven by a lack of education (Rammohan et al., 2012). Following the research ethics standards followed by the European Commission in data collection, the study is conducted in line with the Helsinki Declaration.

5.2 *Econometric approach*

To consider the binary and jointly determined nature of our dependent variables, we employ a multivariate probit model. A general formulation of univariate probit model requires estimation of normal probability distribution functions:

$$\Pr(Y = 1 | X, Z) = \Phi(\beta_1 X' + \beta_2 Z')$$

Where, X is a vector of independent variables, Z is a vector of control variables. Φ is a standard normal distribution function (Greene, 2012). For a multivariate nature of the probit model, normal probability distribution functions are calculated for each of the equations with error terms correlated across the equations. The system of equations is jointly determined by model design. For each of the equations:

$$y_{im}^* = \beta_m' X_{im} + \varepsilon_{im}, \quad m = 1, \dots, 6$$

$$y_{im} = 1 \text{ if } y_{im}^* > 0 \text{ and } 0 \text{ otherwise}$$

Where ε_{im} , $m = 1, \dots, 6$ are errors terms distributed as multivariate normal (Cappellari & Jenkins, 2003). Based on the cross-sectional nature of our data y_{im} represents different choices at a given time. For a system of equation $M > 2$ (here: $M=6$), the software computation is based on a simulation-based method (Cappellari & Jenkins, 2003). Using the properties of Geweke–Hajivassiliou–Keane (GHK) simulator a multivariate normal distribution function can be accurately estimated for a log-likelihood function. The fundamental premise of the simulator is that a multivariate normal distribution function is a product of sequentially conditioned univariate normal distribution functions. In a tri-variate case where $M = 3$

$$= \begin{bmatrix} Y_1 & Y_2 & Y_3 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

the above matrix outlines eight joint probabilities corresponding to the possible combinations of successes ($y_{im} = 1$) and failures ($y_{im} = 0$). In the case of $\Pr(y_1 = 1, y_2 = 1, y_3 = 1)$ than

$$\begin{aligned} &= \Pr(\varepsilon_1 \leq \beta'_1 X_1, \varepsilon_2 \leq \beta'_2 X_2, \varepsilon_3 \leq \beta'_3 X_3) \\ &= \Pr(\varepsilon_3 \leq \beta'_3 X_3 \mid \varepsilon_2 \leq \beta'_2 X_2, \varepsilon_1 \leq \beta'_1 X_1) \times \Pr(\varepsilon_2 \leq \beta'_2 X_2 \mid \varepsilon_1 \leq \beta'_1 X_1) \times \Pr(\varepsilon_1 \leq \beta'_1 X_1) \end{aligned}$$

The expression shows conditioning on error terms (unobservable variables) that are correlated with each other (Cappellari & Jenkins, 2003). For seven other outcomes conditionality is similar, and for $M = 6$ where 2^6 as many combinations are possible. For an approximation of conditional distribution, using Cholesky decomposition for the estimation of the log-likelihood function, decomposed unconditional probabilities are defined of standard normal variates. This simplifies the calculation of likelihood function to the simulated estimation of decomposed univariate standard normal distributions by taking random draws that further compute multivariate probability (Cappellari & Jenkins, 2003). The simulator removes the potential for small sample and simulation biases by suggesting that a square root of the number of observations (here: $N = \sqrt{11,932} \approx 110$) is provided as number of draws. The process is computationally intensive and requires several hours where draws $(110) \times$ number of equations (6), temporary variables (660) are created. Using post estimation options, we calculate the marginal success probability for each equation. Following this we estimate a system of equations:

$$\begin{aligned} \text{Social pressure} &= \alpha_1 + \beta_1 WTV + \delta_1 Controls + \varepsilon_1 \\ \text{Positive perception} &= \alpha_2 + \beta_2 WTV + \delta_1 Controls + \varepsilon_2 \\ \text{Social adoption} &= \alpha_3 + \beta_3 WTV + \delta_3 Controls + \varepsilon_3 \\ \text{Medical advice} &= \alpha_4 + \beta_4 WTV + \delta_4 Controls + \varepsilon_4 \\ \text{EU produced} &= \alpha_5 + \beta_5 WTV + \delta_5 Controls + \varepsilon_5 \\ \text{R\&D info} &= \alpha_6 + \beta_6 WTV + \delta_6 Controls + \varepsilon_6 \end{aligned}$$

332 **Data availability**

333 The survey data used in this article can be freely downloaded from the GESIS Data Archives of the
334 Flashbarometer launched by the European Commission (European Commission, 2021). All data used
335 in this study can be downloaded from the relevant cited sources. Specific country datasets are contained
336 in references (European Commission, 2021).

337 **Code availability**

338 The codes used to generate these analyses are available for use and can be accessed with formal request
339 to the corresponding author (Arslan Austin).

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Author Contributions

A.A.: original research design and conceptualization, acquisition, exploration and preparedness of the data, data coding, selection and execution of formal analysis, visualization, writing of original draft and interpretation of results. I.U.R.: conceptualization, investigation, writing, review, editing and visualization. N.N.: conceptualization, formal analysis, data curation, writing of original draft and visualization. All authors contributed to the final draft.

Competing interests

The authors declare no competing interests.

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