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Vaccination Intention at the Time of Covid-19

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Make it or break it:
Vaccination intention at the time of Covid-19

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Abstract

This research updates early studies on the intention to be vaccinated against the Covid-19 virus among a representative sample of adults in 6 European countries (France, Germany, Italy, Spain, Sweden, and the UK) and differentiated by groups of "acceptors", "refusers", and " hesitant". The research relies on a set of traditional logistic and more complex classification techniques such as Neural Networks and Random Forest techniques to determine common predictors of vaccination preferences. The findings highlight that socio-demographics are not a reliable measure of vaccination propensity, after one controls for different risk perceptions, and illustrate the key role of institutional and peer trust for vaccination success. Policymakers must build vaccine promotion techniques differentiated according to "acceptors", "refusers", and " hesitant", while restoring much larger trust in their actions upfront since the pandemics if one wishes the vaccination coverage to close part of the gap to the level of herd immunity.

Keywords

Covid-19, vaccine strategy, deconfinement, priority groups, random-forest, tree classification

JEL-codes: I12, J22, J23, J33

1. Introduction

The Covid-19 pandemic continues unabated across the world. Official infections in the US have reached 18 million by mid-December 2020, far below the herd immunity needed to end the pandemic of the coronavirus SARS-CoV-2.

Currently the strategy set up by many countries has been to push for non-pharmaceutical measures. This strategy, while effective at flattening the curve, risks a fast rebuild of the pandemic if measures are loosened. Many countries have witnessed this issue with the second wave in most of the European countries, and a third wave emerging in yet a few countries (e.g. South Korea).

The only serious alternative is vaccination. Since April, the race has been on, with hundreds of candidates. This unprecedented effort has already led to two major vaccines being authorized by public health authorities. The vaccine set up by Pfizer/BioNTech and Moderna does not use bits of the virus; rather it leverages messenger RNA to trigger the immune system to produce antibodies. The reported protective effectiveness looks to be very promising, above 90% (See e.g. Polack et al. 2020). This level is slightly lower than measles but much more effective than traditional vaccines like the flu, at just above 60% (e.g. Osterholm et al. 2012). The technique, further, may open a totally new era for human protection.

Nevertheless, vaccination coverage must be widespread if the hope is stopping the pandemic. This is far from a "done deal". For example, compliance with the anti-H1N1 vaccine in 2009, was notoriously low. In Europe where most countries followed the vaccination recommendations of the WHO, barely 15% of the population went to be vaccinated, except for the Netherlands which initiated an aggressive vaccination campaign (Blasi et al., 2012).

One major cause of reluctance is the newness of a vaccine. The Covid-19 case is no exception, adding on top, the "newness" of the technique and the fact that the virus went into production in less than one year versus often a decade in the past for other vaccines.

In Europe, side effects/safety of the vaccine have been reported to be the largest reason for hesitating to be vaccinated against the Covid-19 (Neumann-Bohme et al., 2020, or Karlsson et al., 2020).[1] But, aside from the uncertainty around the product itself, another key worrying trend is the rise of social movements against vaccination. The rise of activists against vaccination is well documented and not new (Kata, 2012) but is booming in the case of the Covid-19 through fake news and conspiracy theories relayed online via social media (Nguyen and Catalan, 2020).[2]

The individuals receptive to those conspiracy theories are usually people with a feeling of being lost or betrayed, which reinforces the importance of transparency and trust as a key channel of influence for vaccination success (Schwartz, 2020). In this research, we are abstracting from the pure « product » effect, already well covered in Neumann-Bohme et al. (2020), and Karlsson et al. (2020), and looks at factors such as health, job, or financial risks as well as multi-dimensional trust, e.g., trust towards other individuals, and institutions such as the government and the media.

As in Neumann-Bohme et al. (2020), our research is based on an online survey with 1,000 respondents per country, among various European countries, conducted in April 2020. Differences with their study are however important. First, both studies cover France, Germany, Italy, and the UK, but we include Spain and Sweden. Second, as we are relying on respondents' statements, we adjust survey answers, by response time. This leverages the neuroeconomics principle that response time is a strong indicator of attitude strength (see Fazio et al., 1989). As we correct for this response time, we essentially recalibrate responses based on strength of survey responses and avoid noises based on answers hesitancy (we find the information bias to be important in case of vaccination leading to a reallocation of 7 points of positive answers to the category of vaccine

[1] Vaccination risk can also be anchored to recent controversies too. For example, the Pandemrix vaccine caused big controversy due to its association with an increased risk of narcolepsy (Sarkanen et al., 2018). Another controversy happened around the vaccine against measles, mumps, and rubella, as it was wrongly suggested that the vaccine could drive autism.

[2] The consequence of vaccination decline is leading to the resurgence of virus, -otherwise instinct, with high morbidity risk, like measles. In the US for instance, the share of vaccinated kids for important diseases such as MMR, Varicella, or Polio, is 6 points of a percentage lower than a decade ago in Georgia and Arkansas, as reported by Statista, based on US health testing centres.

hesitancy). Third, we contrast *three* groups, those who would accept to be vaccinated, those who will refuse, and those who are hesitating; each of the groups against the two others, so that we can determine the commonality and impact of drivers in each group.

Fourth, when it comes to risk perception, the literature on vaccination intention has primarily looked at *health* risk. However, individuals also may trade-off social distancing over-vaccination as an additional choice, and may also consider other risks such as job and finance preservation as part of their decision to get vaccinated. Our survey is rather comprehensive in covering the extent of risk *perception* during the Covid-19 crisis and demonstrates that other risks than health are to be taken into account as determinants of vaccination intention.

We also look at various trust elements. Algan et al. (2017) have for instance demonstrated that third-party trust is an important factor of vote extremism and rejection of the public authorities. This element of people trust is rarely measured in assessing vaccination intention, but maybe a relevant driver to the extent that public authorities actively promote vaccination (Jovančević and Milićević, 2020).

Last, but not least, the decision-making process of people to get vaccination is likely not linear. Game theory models of vaccination such as in Choi and Shim (2020), demonstrate that vaccination Nash strategies are a negative step function of the recovery rate of infection, and below which vaccination propensity increases in function of the opportunity costs of not being vaccinated. The latter is for instance driven by fatality rate or lockdown duration. In such a case, we may need to use non-linear techniques to determine vectors of vaccination preferences. For robustness, we use and compare typical logit, but also more complex Random Forest and Gradient Boosting Machine classification machine learning techniques as predictors of vaccination preferences.

In a nutshell, our research provides five key findings:

1) The percentage of acceptance is 65%[3] or a level that *does not guarantee herd immunity against the Covid-19.*

2) The risk of being contaminated, and given infection, the risk of large morbidity risk drive preferences for vaccination, *in contrast to job/financial risk which increases vaccination hesitancy*.

3) Institutional trust (towards health care, government, and the media) has a major influence on vaccination outcomes. *Trust in the former has the greatest influence on the undecided; confidence in the media and the government rate play on crushing the rate of refusal.* In particular, the degree of exaggeration of the media and the versatility of government actions undermine the credibility of discourse and the understanding of the disease. Trust towards *peers* also matters for vaccination choice.

4) When we control for attitudes, *only age (over 64 years of age) and very low educational attainment emerge as robust socio-economic drivers of preferences*.

5) The citizen *who respects the rules of confinement is more likely to recommend her social circle to respect them as well as to be vaccinated*. In this sense, putting citizens on the right side of the debate is also critical.

The next section discusses the research background, and high-level statistics including the will to take the vaccine. Multi-variate results are then presented and discussed. The last section concludes.

2. Research background and statistics

2.1. Research objectives

This research is a part of an extensive multinational project aimed at understanding people's attitudes, emotions, and behaviors connected with the SARS-CoV-2 pandemic, and their consequences for the adoption of protective behavior. This follows from the established fact that risk perception intensity may support a behavioral change to limit virus exposure (Wise et al., 2020; Harper et al., 2020).

[3] This number is smaller than in Neumann-Bohme et al. (2020), as we especially reweighted the sample to account for time response.

Using the same data set of this paper, a companion paper (Bughin et al., 2020) concentrates on risk perception and non-pharmaceutical protection interventions (NPIs) including quarantine, social distancing, and extra hygiene adoption. Risks include health morbidity risks, but also, risks such as job and financial stability, psychological risk, and social risks, among others. Those risks are also clear drivers of NPI compliance. In this paper, we focus on *vaccination as another Covid-19 pandemic mitigation* strategy.

2.2. Data sampling and scope

Our focus is on six European countries: France, Germany, Italy, Spain, Sweden, and the UK, which are both representative of different socio-economic models (Esping-Andersen, 1999)[4], as well of different archetypes of policy responses to the Covid-19 crisis. Countries like France, Spain, and Italy have limited trust in their governments, exhibiting roughly half the trust expressed by Sweden, and those countries further got largely hit during the first wave of the pandemic, with citizens went centrally imposed to comply with very restrictive lockdown measures as a bold move to curb the pandemic.

The data collection was performed online[5], based on country representative samples for age (above 18 years old) and gender, and recruited via a panel agency in April 2020, with a total sample of more than 6,000 answers, or a minimum of 1,000 per country countries (see Table 1). Respondents got email invites and were informed about the study scope. The task of the respondents was to evaluate if they agree with the statements presented on the screen.[6] To avoid people being « forced » to respond, or respond with answers

[4] Esping-Andersen (1999) distinguishes a social-democratic regime to which the Nordic countries belong, a liberal regime that prevails mainly in Anglo-Saxon countries, and a conservative regime that applies to continental Europe (France, Belgium, Germany, Austria, and The Netherlands). A fourth type, the Latin regime, is a subvariant of the latter, which includes countries in Southern Europe (Italy, Greece, Spain, and Portugal). As part of the social-democratic regime, Swedish citizens are driven by a State focused on the egalitarian principle, but accountable for its actions. The model seems effective, as the Swedish population expresses the largest trust towards their governments within Europe.See Eurostat barometer 2015 for example; Trust - Our World in Data

[5] We would like to thank Neurohm and Syno for collecting the data in all the countries.

[6] See Appendix 1.

that are not reflective of actual behavior, each question was structured to respond, on a 3 point scale (yes, hesitant, no).

A caveat of surveys is the uncertainty of the fit between what people report and their actual attitudes and behaviors. This is critical in a study like this one, as results may lead to inadequate public policy implications. We thus apply response time measurement, and adjust data, in line with Fazio et al. (1989). The authors find a high correlation between report and actual behavior among people with fast reaction time when expressing their opinions. iCode Smart test was used to collect the data (Ohme et al., 2020), with response time (RT) collected for each answer. RT given with a latency lower than 500 milliseconds (ms) (suspected to be given randomly) or higher than 10,000 ms (suspected to have been given after distraction) were eliminated. In total, this amounts to only 0.96% of dubious responses.[7]

To account for individual differences in reaction speed, we standardize reaction time data measured in milliseconds, with STDRT being the z-score of log(RT), with mean = 0 and standard deviation = 1. For a question such as "do you envisage to get vaccinated', the proportion Y of citizens responding YES, is adjusted such that Y' = (1-a) x (Y) where (1-a) = max(SDRT, 2)/2. Thus $0 < a < 1$ acts as a factor that reduces the difference in positive responses in favor of hesitancy; in our sample, a = 19%, implying that gross responses on vaccination acceptance, at 72%, are over-rated by about 7 points.

[7] Furthermore, to ensure high quality of data and eliminate test biases a calibration phase and control screen have been added. Calibration preceded the test phase and consisted of 3 steps:

a. Familiarization with the scale. The task of the respondents was to press certain answer options – this task made sure respondents are aware of the position of the buttons on the screen.
b. Familiarization with the purpose of the task. A few statements were presented describing the test and the task. After each screen respondents had to press a button. This part served as a motoric warm up.
c. Increasing the focus on the task. During the study a screen appeared asking the respondent to indicate the statement that was presented last. The aim of this task was to make sure respondents focus their attention on the presented statements. Such screen was presented twice.

The control screen was introduced to eliminate the effect of the position of the mouse on the screen. It was presented before each statement, forcing a standardized position of the mouse (the distance to the yes and no answers was always the same).

2.3. High-level data statistics: Willingness to be vaccinated

Table 1 displays the number of respondents including the appetence to vaccination, after removing outliers.[8]

Table 1. Number of Covid-19 European respondents, April 2020

Countries	Total	Gender		Age	Willingness to be vaccinated		
	N	Females	Males	>64	Yes	Hesitant	No
France	1,024	51%	49%	13%	0.56	0.28	0.16
Germany	1,017	49%	51%	12%	0.63	0.20	0.17
Italy	1,021	51%	49%	10%	0.71	0.19	0.10
Spain	1,019	50%	50%	6%	0.74	0.18	0.08
Sweden	1,006	50%	50%	19%	0.56	0.28	0.16
The UK	1,068	53%	47%	24%	0.71	0.21	0.08
6 countries	6,155	51%	49%	14%	0.65	0.22	0.13

The total portion of citizens willing to be vaccinated is 65%, for about 22% "hesitant", and the balance (13%) are "refusers". The portion of "acceptors" is slightly less than other studies Neumann-Bohmer et al., 2020 estimate an intention at 74% for Europe, while in Lazarus et al. (2020), 80% would accept the Covid-19 vaccine. In our sample, we adjust for uncertainty in answers respondents, reducing positive direct responses on vaccination acceptance, at 72% by about 7 points.[9]

The difference in vaccination intention we observe per country is also visible in Neumann-Bohmer et al. (2020), with France, having the largest portion of refusers and hesitant.[10] In itself, the portion of acceptors is likely not to be sufficient to achieve herd immunity. This level is given by $1 - (1/R_0)$ where R_0 is the basic reproduction number. If only to be estimated, R_0 estimates range from 2.5 to 3.5, with a mean of 3.3 worldwide

[8] Outliers have been defined as responses with RT < 500 ms or RT > 10,000 ms. The first case implies that answers may only be random, the second case implies that people got distracted, with low confidence in the answer.

[9] People who hesitate to get vaccinated are probably more prone to see risks everywhere and trust less and respond slowlyer and more thoughtfully.

[10] Detoc et al. (2020) find a higher portion by aggregating those certainly and likely certainly to take the vaccine in France.

(Bughin, 2020).[11] For Europe, the most recent estimates make it more towards 3.9 (Flaxman et al., 2020) and 3.4 for the US (Pizter et al., 2020). At those levels of estimates, herd immunity would need a level of acceptance of a minimum of 60%, and more likely up to 75%, *which is in practice challenging out of the figures of vaccination intention above.*[12]

2.4. High-level data statistics: Socio-demographics

The general consensus regarding vaccination reluctance is the mediating effect of some socio-economic factors such as the level of education, level of income, gender, and age (Larson et al., 2014). Neumann-Bohmer et al. (2020) find differences in the will to be vaccinated in gender, and in age, with a higher portion of males willing to get vaccinated, and of people about 55 years old. Table 2 provides a picture from our sample.

We also see that men have a higher propensity to accept vaccination, with lower hesitancy and refusal than women. Age exhibits a "U" curve regarding vaccination, with the lowest acceptance rate between 36-49 years old, and acceleration after 64 years old. Given retirement at an older age, retired citizens exhibit higher acceptance too. Lower education citizens have lower acceptance as is lower-income, following the literature. A-political citizens are much less inclined to be vaccinated, and stand for the largest hesitant group, with the unemployed. Interestingly, those citizens fit the category of the citizens feeling misfit with their socio-economic system, e.g. Algan et al. (2017), and belong to a growing category of believers of alternative, even, conspiracy theories.

In total, hesitancy ranges between 17% and 30%, refusal between 7% and 16% depending on the socio-economic cut. The best case (17% and 7%) leads to a maximum acceptance

[11] For comparison the 2002 SRAS' Ro was estimated to be in the range of 2.2 to 3.6. Ebola by 2014, is said to have a reproduction rate, Ro between 1.5 to 2.3. The 1918 Spanish influenza Ro was estimated imprecisely between 1.8 to 4.

[12] A way to get an idea of herd immunity is to look at extreme case studies. E.g., at San Quentin State Prison in California, more than 60% of the population was ultimately infected before the outbreak was halted. Lewis et al. (2020) report on the Brazilian city of Manaus which was devastated by a large outbreak of Covid-19. But by early June, the number of excess deaths from around 120 per day went to nearly zero. When researchers found that citizens with antibodies were reaching 66% of total population.

of 76%, which is barely the threshold of herd immunity at 90% rate effectiveness of the vaccine and for an $R_0 > 3$. This best-case however concentrates only on the retired, older age group, a group with the largest morbidity and mortality risks linked to the Covid-19, but also a small portion of the total European population.

Table 2. Socio-demographics of vaccination

When a COVID-19 vaccine is available I'd like to be vaccinated				
Typology	Details	Acceptor	Hesitant	Refuser
Gender	Female	0.62	0.25	0.13
	Male	0.69	0.19	0.12
Age	18-25	0.65	0.23	0.12
	26-35	0.61	0.24	0.15
	36-49	0.60	0.24	0.16
	50-64	0.66	0.23	0.11
	>64	0.78	0.15	0.07
education	Primary schools	0.62	0.25	0.13
	Middle school	0.64	0.22	0.14
	Vocational	0.62	0.23	0.15
	High school	0.67	0.22	0.11
	Bachelor or higher	0.67	0.22	0.11
kids	0 children	0.62	0.24	0.13
	1 child	0.68	0.19	0.13
	2 children	0.71	0.20	0.10
	3 children	0.63	0.21	0.16
	>3 children	0.60	0.25	0.15
occupations	Student	0.67	0.20	0.12
	Employed	0.64	0.23	0.13
	Entrepreneur	0.59	0.25	0.16
	Unemployed	0.60	0.27	0.14
	Retired	0.74	0.17	0.08
location	<100000 inhabitants	0.63	0.23	0.14
	>100000 inhabitants	0.65	0.21	0.13
income	<20000€	0.61	0.25	0.14
	>20000€	0.67	0.20	0.13
	don't want to answer	0.57	0.28	0.15
politics	Left	0.73	0.18	0.10
	Right	0.68	0.20	0.13
	Other	0.61	0.22	0.16
	Don't associate with politics	0.54	0.30	0.16
	Don't want to answer	0.62	0.26	0.11

2.5. High-level statistics: beyond socio-demographics

Appendix 2 further provides the univariate correlation matrix of respondents' statements from Appendix 1, with vaccination intention. The matrix gives a glimpse at the role of institutional trust and health risk, as vaccination intention is a) highly negatively correlated with factors such "Media exaggerate the situation with Covid-19"

and b) highly positively correlated with "I am worried …about my health… about the health of my children…about the health of my older family members"; as well as "Coronavirus is dangerous for my health".

Heath and other Covid-19 risks

If agents are fully informed, voluntary vaccination arises when the relative benefit of vaccination becomes greater than the cost of vaccination. This relative benefit is greater when direct protection is greater (via high resistance to the pathogens) but is also lower when indirect protection is lower (via a lower portion of people being a transmitter of the disease). Thus, it implies that major health risks would correlate positively with the will to get vaccinated, as well as possibly with the perception of additional risk linked to lasting lockdown. In general, also, there is a typical "free rider" problem where vaccination propensity may marginally decline when more and more other individuals get the vaccine (Choi et al., 2020).

In our sample, we measure four types of worries mostly, health (henceforth, H), economic (E), social (S), and psychological (P). Table 3 provides the worries' propensity ranked from the most frequently expressed worry to the lowest, and for the 16 constructs allocated to H, E, S, and P.

Except for the job situation, more than 1 out of 2 respondents worry about any matter. Health worries are the largest ones (average = 65.6%), while the lowest is financial worries (55.3%). Psychological and social risks are clearly important too (58% and 62% respectively).

We also describe the worries for the socioeconomic groups, with apparently lower vaccination propensity in Table 2. We notice that women are the most worried on all dimensions, and the reverse for the low-income segment. Lower education expresses lower worries than average except when it comes to their own and children's health; while those in the 36-49 years old brackets generally are more worried than average, except for social violence. In general, those patterns do not demonstrate that worries

correlate necessarily with lower vaccination expression by socio-demographic group, as it emerged from high-level data. Clearly other factors explain vaccination preferences.

Table 3. European citizens worry during the 1st wave of the covid-19 pandemic

		Vaccine "a priori less acceptors" groups				
Statement	**Yes**	**Women**	**Low education**	**36-49 years old**	**Low income**	**Do not associate with politics**
I am worried about the health of my older family members (H)	0.71	0.73	0.68	0.76	0.73	0.74
COVID-19 increases domestic violence (S)	0.64	0.66	0.66	0.63	0.64	0.62
The COVID-19 outbreak will make society more unequal (S)	0.61	0.61	0.60	0.63	0.63	0.62
I am worried that our country will run out of money (E)	0.63	0.66	0.58	0.65	0.66	0.67
I am worried about not being able to meet with my family (P)	0.63	0.65	0.62	0.65	0.64	0.68
COVID-19 will increase divorce rates (S)	0.60	0.61	0.60	0.61	0.60	0.61
I am anxious about not being able to meet with friends (P)	0.59	0.60	0.59	0.59	0.61	0.60
Living in isolation negatively impacts my wellbeing (P)	0.56	0.56	0.54	0.57	0.57	0.56
I am worried about my own health (H)	0.66	0.68	0.68	0.69	0.69	0.70
I am worried about the health of my children (H)	0.60	0.62	0.65	0.62	0.59	0.64
Being together all the time increases family tensions (S)	0.55	0.56	0.55	0.57	0.55	0.55
I worry how living in isolation will affect me (P)	0.55	0.57	0.53	0.58	0.58	0.58
I am worried about my financial situation (E)	0.56	0.59	0.52	0.62	0.64	0.61
I am worried about my job situation (E)	0.47	0.49	0.38	0.56	0.53	0.53

Note: all variables are adjusted for time response.

The role of institutional and peer trust

Under a new vaccine, like in this case of Covid-19, the assumption of perfect information on the effectiveness of the vaccine may evidently not hold. When uncertainty may then become a deterrent to accepting to be vaccinated, institutions may play an important role in transparency and information dissemination to support risk-averse people to take vaccination (Lazarus et al., 2020). This is even more important as there has been large documentation of cases of anti-vaccination groups promoting misinformation and

conspiracy theories, in order to create division, and aimed at sowing mistrust of experts' voices and government actions during a pandemic (Kata, 2010 and Fisher et al., 2020).

We have collected responses linked to trust around how the Covid-19 has been managed, along with three components, government/media, healthcare system, and people in general (Table 4).

Table 4. European citizens third party trust during the Covid-19 pandemic

Statement		Vaccine acceptor				
	Yes	**Women**	**Low education**	**36-49 years old**	**Low income**	**Do not associate with politics**
Trust in institutions						
I am satisfied with how my government is handling this crisis	0.59	0.59	0.60	0.57	0.58	0.51
The government is doing a good job dealing with Covid-19	0.58	0.59	0.61	0.57	0.57	0.51
The government discloses real numbers of coronavirus infections and deaths	0.54	0.53	0.54	0.53	0.53	0.49
[President] is doing a good job dealing with Covid-19	0.54	0.54	0.54	0.54	0.54	0.51
Media provide reliable information about the pandemic	0.57	0.58	0.57	0.57	0.57	0.54
Trust in Healthcare						
In case of coronavirus infection, I will get appropriate medical help	0.63	0.63	0.59	0.63	0.63	0.61
I am satisfied with how our healthcare system is handling this crisis	0.66	0.66	0.70	0.65	0.63	0.60
Trust in people						
Covid-19 reveals the best in people	0.57	0.57	0.58	0.56	0.56	0.55

Note: all variables are adjusted for time response.

Trust is far from being complete. This lack of trust likely is likely to drive down the acceptance of control measures, as already demonstrated in other pandemics (Gellin, 2020). Trust is larger towards healthcare than for institutions, and towards peers in general. Trust is notably low for the group that does not associate with politics, and except for the low-income segment, is rarely above the average for any other group, leading to the idea that low trust may build large hesitancy about vaccination.

3. Multi-variate analysis

3.1. Techniques used

We now resort to various formal multivariate analyses of potential acceptance of the Covid-19. The first technique is a simple logit regression model, the second is a classification tree model, the third one is a random forest classification model, and the last two ones are a Neuronal Network and a Gradient Boosting Machine classification models.[13] No model is better than the other, but we aim to have a comparison of multiple techniques for robustness.

In particular, it has been claimed that the Random Forest technique is important as an alternative to the traditional logit model, given likely non-linearity (e.g. threshold effect in health risk impact on control preferences), and high-order interaction effects. For example, Random Forest techniques have exhibited superior predictive power for H5N1 influenza outbreaks (see Herrick et al., 2013; or Kane et al., 2014), and recently Covid-19 infections (Iwendi et al., 2020).

This is still to be seen for vaccination choice, however. Table 5 presents a comparison of the fit accuracy of the various models, using a K-fold cross-validation (KFCV) technique (Li, 1987).[14] The accuracy is fair, at 79% for Random Forest, but at the same order of magnitude as other techniques.[15]

[13] The Random Forest algorithm is an ensemble learning method combined with multiple decision tree predictors that are trained based on random data samples and feature subsets (Breiman, 2001). Deep learning approaches are getting more and more used in complex non-linear predictive models. In the case of the Covid-19, it has been used successfully to predict Covid-19 infection development (Yeşilkanat, 2020), Covid-19 fatality rates (Pourhomayoun and Shakibi, 2020), or Covid-19 pulmonary damages (Sun et al., 2020).

[14] Formally, we keep aside a portion of the entire dataset, which is not used to train the models, and later use this sample for testing/validating the models. Formally, we split the dataset randomly into 10 folds, then fit the model using the K - 1 folds and validate the model using the remaining K^{th} fold. We repeat this process until every K-fold serves as the test set and then we take the average of the recorded scores for each validation.

[15] The total variance explained is 18.3%, and the mean square residuals is 18%.

Given likely non-linearity, at higher order, hierarchical effects, assumed, we focus here on Random Forest regression technique to discuss the results. We present a high-level comparison of the four techniques. Appendix 3a and 3b present the results of the logistic and tree regression for perusal examples.

Table 5. Performance (10-fold cross-validation) comparison of models

Model		Accuracy
Logistic regression on	acceptors	71.49%
	hesitant	77.38%
	refusers	87.08%
Classification tree on	acceptors	64.85%
	hesitant	76.59%
	refusers	86.85%
Random forest on	acceptors	70.56%
	hesitant	77.58%
	refusers	87.37%
Neuronal Network	acceptors	67.77%
	hesitant	72.51%
	refusers	83.88%
Gradient Boosting Machine	acceptors	71.54%
	hesitant	77.43%
	refusers	87.30%

3.2. Random forest tree results

We have configured the Random Forest algorithm with 5,000 trees in the forest, and including statements and demographics, 88 variables were tried at each split. Figures 1.1 to 1.3 exhibit the results for the three segments of "acceptors", "hesitant", and "refusers", ranked by decreasing importance on node purity (a measure of contribution fit) and on mean square error (a measure of predictive accuracy). The following insights emerge.

The first observation is that the two measures provide the same, but not fully equal, picture. As an illustration, Figure 2 ranks the top 20 most important factors (100% is the most important, and 0% the least important) for the acceptors. The rank fit exhibits a positive correlation, r = 0.83, with in general, the most important factors are slightly less predictive, and vice versa. Among factors relatively *more* predictive than anticipated by the pure regression fit, *those linked to attitude towards the healthcare system and healthcare professionals stand out, and rank among the top 10 most important factors to predict vaccination preferences*.

Figures 1a-1c. Random forest correlates and predictors of Covid-19 vaccination preferences (based on adjusted responses rate, RTC)

Figure 1.a. Random forest on acceptors

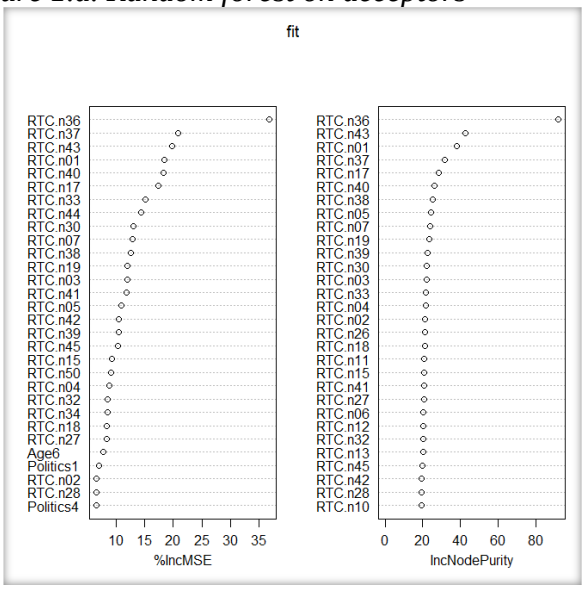


Figure 1.b. Random forest on hesitant

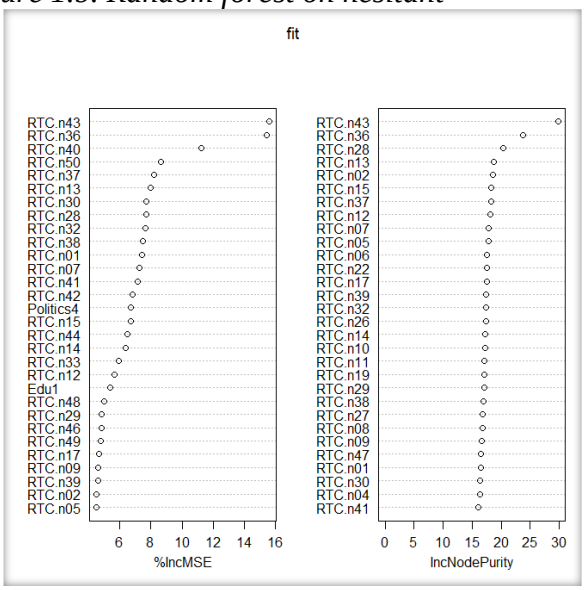
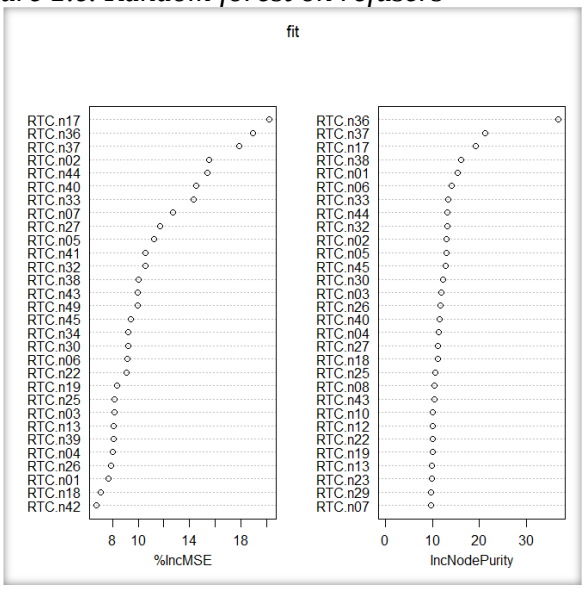
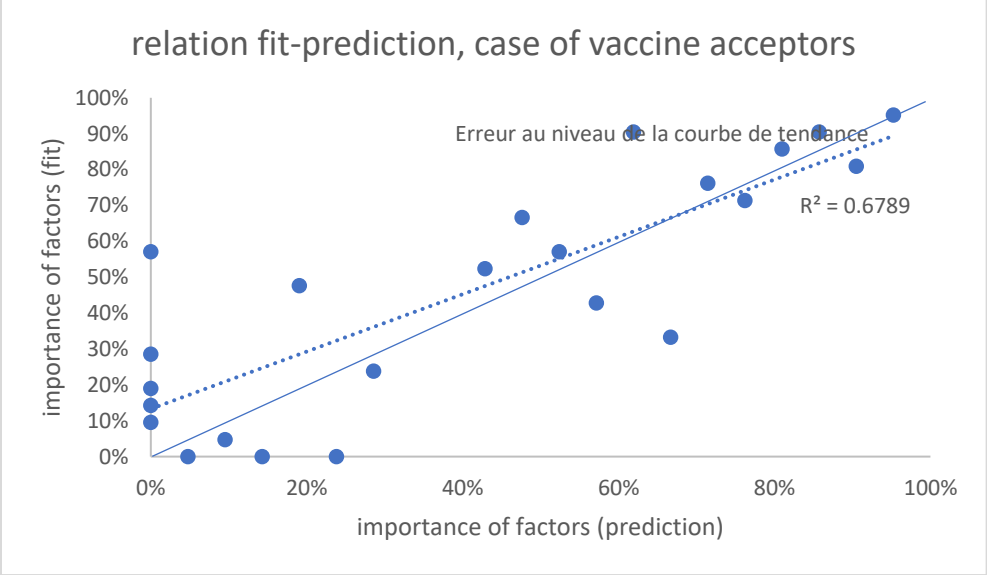


Figure 1.c. Random forest on refusers



The second observation is that the list of predictors is not the same for the different groups (will accept, hesitate to take, or refuse the vaccine). Ranking all factors by importance, the largest correlation observed is only r = 0.36 between acceptors and refusers. The correlation with the hesitant is neither significant for the acceptors, nor the refusers.

Figure 2. Comparison fit and prediction, Covid-19 vaccine acceptance



The hesitant are *more worried about their health* (and in accordance comply more strongly with social distancing measures), doubt more about media and government *transparency* than the two other groups, and on how covid may impact *their peers*. Regarding the refusers, they are much *less worried about their health* and their older family members' health than all other segments. They also are relatively *more worried about their personal and family tensions during Covid-19, and their finance*. And while they look at the government to be effective, they *consider the current actions to be largely not adequate*. Finally, regarding the acceptors, they are likely more prone to influence others to comply with control measures, they are confident in the healthcare treatment if infected while being worried about the virus.

Third, the importance of trust in predicting vaccination preferences is relatively material. We aggregate the top 20 most predictive factors along the dimensions of worries and trust, such that total = 100% in Table 6. *Trust factors in the aggregate are the largest predictors of vaccination preferences*. As we further split trust by constituents, and risk/worries by nature, health is evidently the most important predictor, but *institutional trust and psychological worries are also material*. As to be anticipated, health factors are relatively less important for refusers than for other vaccination preference categories, while refusers overweight economic worries and lower trust in people and government institutions. Hesitant overweight on psychological versus economic worries.

Fourth, only age (> 64 years) plays a predictive role in vaccination intention. This is indeed the age where the fatality risk linked to the Covid-19 increases significantly. Non-association to mainstream politics is also associated (but negatively) with vaccination acceptance, in line with this segment likely less trustful in institutions, as mentioned here-before. Low education predicts vaccination hesitancy, but no socio-economic variable seems to be exclusively linked to vaccine "refusers".

Table 6. Comparison fit and prediction, Covid-19 vaccine preferences

Dimensions		Importance			
		total	Acceptors	Refusers	Hesitant
risk/worries	Health	46%	53%	29%	49%
	psychological	36%	27%	54%	46%
	economic	26%	17%	65%	0%
	total worries	37%	36%	40%	40%
trust	heathcare	80%	75%	49%	71%
	government	57%	57%	61%	55%
	Media	86%	86%	80%	81%
	people	27%	41%	63%	33%
	total trust	63%	65%	61%	60%

3.3.Comparison with other predictive models

As other models used (pure logistic, and regression trees) are as / if not more, informative as / than Random Forest, we complete this section by highlighting common results. Table 7 presents the top 10 common factors that come out as predictors of increased vaccination rates.

Table 7. Top 10 common factors that come out as determinants of increased vaccination rates

	Method (rank)			Effect on the will to vaccinate
statements	Random Forest	Regression Tree	Logistic	
Coronavirus is dangerous for my health	1	3	3	+
In the case of Covid-19, I will receive appropriate health	3	1	2	+
Media exaggerate the situation	2	4	1	-
I am satisfied with how the government handles the crisis	4	7	9	+
Government discloses real numbers of coronavirus	5	n.a	5	+
I am grateful to healthcare professionals	6	n.a	16	+
I actively ask people to follow measures against the virus	8	6	11	+
I am worried about my own health	11	2	4	+
I comply with measures of staying home	17	n.a	8	+
Covid-19 reveals the best in people	16	5	n.a.	+

Notes:
Rank based on predictive power averaged for “acceptors”, “refusers” and “hesitant”;
Only 7 statements are significant predictors in the case of a simple regression tree.

The common list of predictors is rather robust, with a rank correlation between 0.5 to 0.6 between pairs of statistical techniques. But differences also prevail. In practice:

1. *Health risk elements stand as a key opportunity cost* of not being vaccinated, as well as does health care quality- this again fits with existing literature and with the logic of optimal individual strategies for protective measures adoption (e.g. Choi and Shim, 2020)

2. *Trust also appears to be the key determinant of vaccination intention* in all techniques, as we anticipated. Among others, institutional trust is ranked higher within Random Forest than with the two other techniques. This is of major importance as the government effective prevention and rescue during the pandemic crisis are essential to get the full cooperation with their citizens (Zang, 2013, Li et al., 2018, Duan et al., 2020).

3. All techniques demonstrate *the importance of some individuals to actively seek others to comply with control measures.* This is consistent with other research highlighting that word of mouth is rather effective in previous vaccination campaigns (Tchuenche et al., 2011; Bhattacharyya et al., 2015).

4. Random Forest and logistic regression spot some extra factors, but not in the top 10 most important ones predicting vaccination preferences. Among others, Random Forest highlights the importance of the citizens' financial and personal situation. This shows the relevance of also securing wealth and social structure on top of health in a pandemic crisis.

5. Socio-demographics are not playing a major direct important role in predicting vaccination preferences, in any technique. This reinforces the point that attitudes and beliefs are much more crucial than anything others, to secure large vaccination potential.

3.4 . By the way, does all the above matter?

All the above points out that an important foundation that underpins vaccination acceptance is trust and sufficient consideration of the risks and worries of the population.

Here we use the estimates collected to see how big those effects are. If one takes for instance the results of the three regressions in Appendix 3, the best case leads to up to 12 extra points of vaccination intention, of which about 8 points is linked to trust improvement and tackling additional worries. Table 8 computes the average of the methods and shows that the total effect is about 14.5 points gross, and corrected for response time, 12 points extra.

At this indicative level, the vaccination rate may become close to 80% and may lead to close to the gap needed for herd immunity, if the effectiveness of vaccines is as expected to be above 90%, and vaccination intention fully materializes. This again re-emphasizes the importance of getting barriers removed for a future without Covid-19 morbidities.

Table 8. Marginal impact of fixing trust and other worries
Estimates on vaccination intention

Levers	marginal effect	population Coverage	total
Trust improvement	28%	31%	8.6%
Reduce media exageration	11%	39%	4.0%
Promote best in people	3%	29%	0.9%
Improve government actions	14%	26%	3.6%
fix additional worries	15%	41%	6.0%
Secure Job and finance	3%	50%	1.5%
secure appropriate medical help	12%	39%	4.5%
Total			14.5%

Source: Regression estimates weighted by nodes

3.5. Country effects

We close this section by reporting on country effects, in Table 9.

Table 9. Country effects on vaccination preferences (after controlling for risk, trust, and sociodemographics)

Country	acceptors	hesitant	refusors
Spain	74%	19%	6%
France	57%	25%	17%
Italy	68%	26%	6%
Sweden	46%	30%	23%
Germany	77%	14%	9%
The UK			7%

Note: only significant effects at 5% are reported. Germany as the reference case.

Those effects in Table 9 suggest that Sweden is the least inclined to accept the vaccination but the will is much larger in countries most affected by the Covid-19 pandemic by April 2020, such as Spain and Italy. Remember that those are marginal probability estimates, i.e. after taking into consideration trust and perception risk. Sweden's perception risk has been actually lower than other countries, in the first wave of the Covid-19, given its limited lockdown strategy, even if Swedish citizens have had a large trust in its institutions. The reversal is true for Spain for example. In general, the figures suggest that country effects linked to vaccination preferences are rather strong and relatively larger than for non-pharmaceutical compliance propensity (Bughin et al., 2020).

4. Conclusions

This research has provided a view on European citizens' vaccination preferences for the SARS-CoV-2 and how those preferences are shaped by socio-demographics, risk perception of the pandemics, as well as trust in institutions and peers. Using multiple regression and classification techniques, all converge to the findings that vaccination preferences are shaped more by attitudes than by socio-demographics. In particular, it is critical to improving trust extensively in media, governments, healthcare, and peers if one hopes to be as close as to herd immunity with enough vaccination acceptance.

The research has some clear shortcomings, e.g. perceptions were collected in wave 1 of the pandemic, and may have changed since the evolution towards wave 2 (and even wave 3 in some countries), and the discovery and rollout of mRNA vaccines since late December 2020.

Furthermore, in our research, preferences were simply stated, but not forced against a plausible alternative like done in conjoint techniques. For example, asking whether people would want to be vaccinated or continue to be under lockdown, may lead to more optimistic results in favor of vaccination. We aim for those extensions in further research. Meanwhile, we believe our results have emphasized four core actions in the rollout of vaccination strategies.

1. **Build the urgency of vaccination.** The (adjusted) acceptance rate for vaccination (assuming the product is not controversial) is around 65%. Knowing that official contamination of the order of 5% of the population to date in Europe, the possible effective immunization rate would therefore be at best 64% under voluntary vaccination. This will lead to herd immunity if a basic Covid-19 reproduction rate, Ro < 2.8. While most estimates suggest Ro > 3 (and most likely Ro = 3.9 in Europe). Taking point estimates from other studies that uncertainty about the vaccine results could reduce the willingness to vaccinate, by 5-10 points (average 7), current voluntary vaccination may still imply (1 - (1/3.9)) - (64% - 7%) = 17% of the population still to be infected to get to herd immunity, or still three times the current level of infections.[16]
2. **Launch segment-specific campaigns on the no as well on the undecided.** Adjusting for response time in our survey, the non-vaccination rate is 12% while the portion of hesitation is 23%. In other words, the undecided are the most important class to convert. As seen above, the campaigns are however to be segmented. The hesitant must be reassured about how health institutions may support their own health and more transparency must be warranted by media

[16] Given asymptomatic cases, and absence of tracking, the figures of currnt infections may be two times higher. Than would still make the current shortfall to herd immunity to be as large as current infections, under no additional control measures.

and government alike. Refusers are relatively more worried about family tensions and finance, while they want to see governments that are much more effective in their actions, namely embracing more than health issues only.

3. **Reset the institutional factor**. Trust in Health care, government, and the media are more important than health risk perceptions if one wants to convert the undecided to accept the vaccine. In particular, it is crucial that media provides a true fact base on the pandemic challenges, while the government actions are simple, consistent in order to build the credibility of discourse
4. **Use the citizen force of persuasion**. In all cases, as in any social system, the citizen is also an important vector of influence. The importance of social media is often seen from the negative side, that is, social media may propagate fake news that increase the confusion in citizen mind, and thus reduce the will to get vaccinated. But the positive story is also that the citizen who is willing to vaccinate is also likely to recommend to her social circle to accept the vaccination. Given that acceptance is dominating today, the positive word of mouth must be much more systematically harnessed in order to make the undecided shift their mind, and possibly limit the contagion of refusers into the undecided population. For everyone's sake, and to get rid of the virus.

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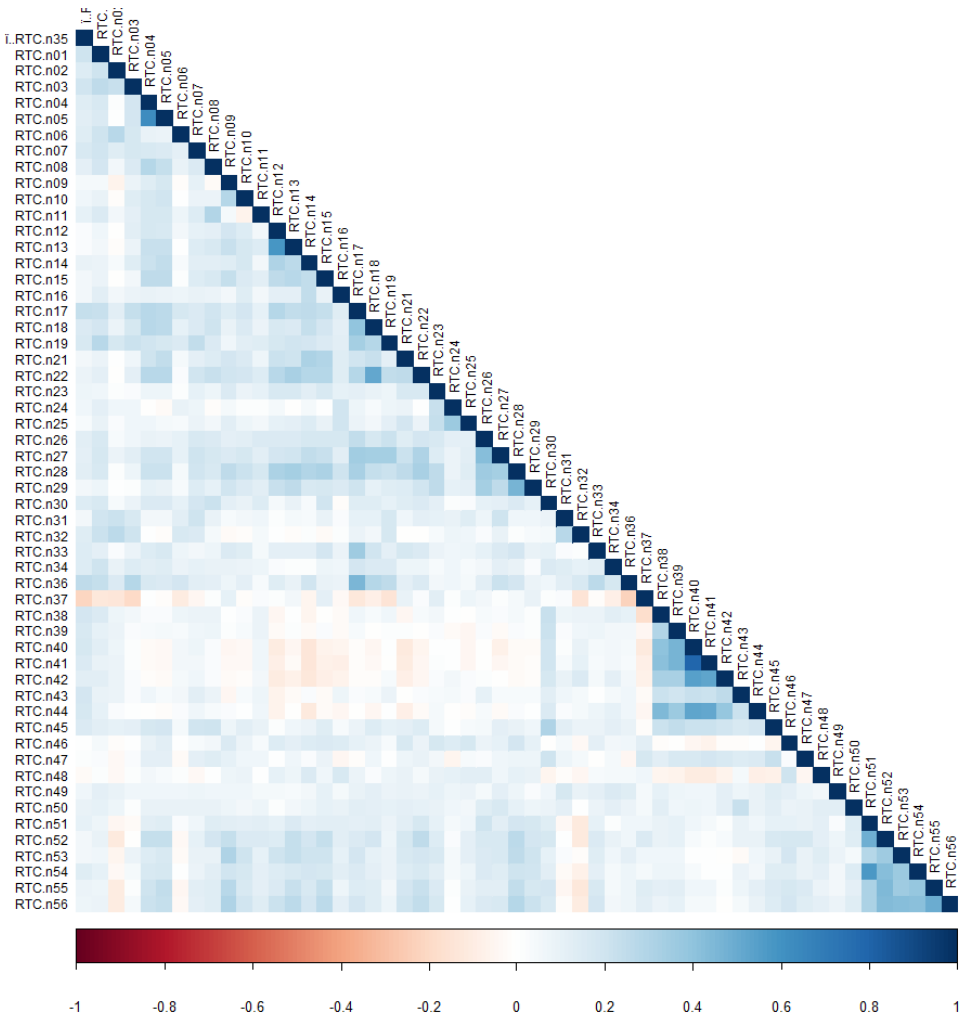
APPENDIX 1. Tested statements

Variable	BEHAVIOR
RTC.n1	I actively encourage others to follow the restrictions and guidelines
RTC.n2	I comply with the recommendations for physical distancing
RTC.n3	I comply with the restrictions to stay home
RTC.n4	I disinfect groceries before putting them away
RTC.n5	I disinfect mail and deliveries before opening them
RTC.n6	I wash hands for 20 seconds when necessary
RTC.n7	I would like to help people who are more vulnerable to COVID-19
RTC.n8	Since COVID-19 I eat healthier
RTC.n9	Since COVID-19 I eat unhealthier
RTC.n10	Since COVID-19 I exercise less
RTC.n11	Since COVID-19 I exercise at home more
RTC.n12	When a COVID-19 vaccine is available, I'd like to be vaccinated
	EMOTIONS
RTC.n13	I'm worried about my financial situation
RTC.n14	I'm worried about my job situation
RTC.n15	I'm worried that our country will run out of money
RTC.n16	I'm worried that there will not be enough basic necessities in the stores
RTC.n17	I am worried about my own health
RTC.n18	I am worried about the health of my children
RTC.n19	I am worried about the health of my older family members
RTC.n20	I am worried about the health of people in my country
RTC.n21	I worry that there will be an increase in break-ins and thefts
RTC.n22	I'm worried about my children's education
RTC.n23	I am anxious about not being able to meet with friends
RTC.n24	I am worried about not being able to meet with my family
RTC.n25	I worry how living in isolation will affect me
RTC.n26	Living in isolation negatively impacts my wellbeing
	OPINIONS
RTC.n27	The COVID-19 outbreak will make society more unequal
RTC.n28	Being together all the time increases family tensions
RTC.n29	COVID-19 increases domestic violence
RTC.n30	COVID-19 will increase divorce rates
RTC.n31	COVID-19 will bring countries closer
RTC.n32	I am grateful to our essential workers
RTC.n33	I am grateful to our healthcare professionals
RTC.n34	My chance of getting COVID-19 is high
RTC.n35	Slowing the spread of COVID-19 is more important than the economy
RTC.n36	Coronavirus is dangerous for my health
RTC.n37	Media exaggerate the situation with COVID-19
RTC.n38	Media provide reliable information about the pandemic
RTC.n39	[The President] is doing a good job dealing with COVID-19
RTC.n40	I am satisfied with how my government is handling this crisis
RTC.n41	The government is doing a good job dealing with COVID-19
RTC.n42	I am satisfied with how our healthcare system is handling this crisis
RTC.n43	In the case of coronavirus infection, I will get appropriate medical help
RTC.n44	The government discloses real numbers of coronavirus infections and deaths
RTC.n45	COVID-19 reveals the best in people
RTC.n46	COVID-19 reveals the worse in people
RTC.n47	I believe we will beat COVID-19 soon
RTC.n48	People will stop following the restrictions soon

APPENDIX 2. Correlation matrix with vaccination acceptance



Notes:

The correlation matrix shows that vaccination intention is highly negatively correlated with “Media exaggerate the situation with COVID-19” and highly positively correlated with the following statements:

- I actively encourage others to follow the restrictions;
- I comply with the restrictions to stay home;
- I‘d like to help people who are more vulnerable to COVID-19;
- I am worried about my own health;
- I am worried about the health of my children;
- I am worried about the health of my older family members;
- COVID-19 will bring countries closer;
- Coronavirus is dangerous for my health;
- In case of an infection, I will get appropriate medical help.

APPENDIX 3a. Logistic regression by "acceptors", "hesitant", and "refusers"

VARIABLES	(1) accepting	(2) se	(3) hesitates	(4) se	(5) refuses	(6) se
Spain	0.298**	(0.151)	-0.0704	(0.160)	-0.469**	(0.214)
France	-0.503***	(0.135)	0.447***	(0.143)	0.229	(0.181)
Italy	0.360***	(0.139)	-0.146	(0.146)	-0.388*	(0.202)
Sweden	-0.628***	(0.135)	0.509***	(0.142)	0.357**	(0.181)
The UK	0.054	(0.131)	0.206	(0.140)	-0.457***	(0.180)
Female	-0.0359	(0.464)	0.352	(0.440)	-0.478	(0.526)
Male	0.292	(0.464)	0.0786	(0.441)	-0.603	(0.528)
26-35	-0.289	(0.200)	0.433**	(0.212)	-0.0139	(0.285)
36-49	-0.583***	(0.174)	0.491***	(0.189)	0.333	(0.252)
50-64	-0.662***	(0.164)	0.490***	(0.180)	0.429*	(0.237)
>64	-0.519***	(0.148)	0.502***	(0.163)	0.131	(0.217)
Primary school	0.0551	(0.214)	-0.0951	(0.222)	0.0766	(0.285)
Vocational	-0.0490	(0.125)	0.0148	(0.133)	0.0522	(0.167)
High school	-0.142	(0.125)	0.245*	(0.133)	-0.140	(0.170)
Bachelor or higher	-0.0328	(0.129)	0.146	(0.138)	-0.170	(0.176)
Kids 1	-0.268	(0.301)	0.400	(0.332)	-0.205	(0.320)
Kids 2	-0.0777	(0.306)	0.135	(0.336)	-0.128	(0.325)
Kids 3	-0.164	(0.306)	0.282	(0.337)	-0.189	(0.329)
Kids>3	-0.272	(0.338)	0.173	(0.368)	0.0965	(0.371)
Employed	-0.159	(0.178)	0.267	(0.183)	-0.109	(0.241)
Entrepreneur	-0.256	(0.214)	0.322	(0.221)	-0.0788	(0.293)
Unemployed	-0.176	(0.185)	0.250	(0.189)	-0.0756	(0.253)
Retired	0.146	(0.212)	0.0717	(0.222)	-0.386	(0.297)
<100,000 habitants	-0.0592	(0.0733)	0.0598	(0.0776)	0.00929	(0.102)
<2000 euros/month	-0.0198	(0.120)	-0.0397	(0.122)	0.0399	(0.164)
>2000 euros/month	0.184	(0.120)	-0.247**	(0.123)	-0.0144	(0.166)
Exposed to Cov	0.159	(0.150)	-0.345**	(0.150)	0.320	(0.224)
Not exposed	-0.0120	(0.139)	-0.208	(0.136)	0.420**	(0.208)
Does not know	0.156	(0.428)	-0.213	(0.428)	0.281	(0.522)
Left	0.265*	(0.144)	-0.351**	(0.145)	0.0547	(0.215)
Right	0.346**	(0.147)	-0.341**	(0.147)	-0.0667	(0.216)
Other	-0.153	(0.143)	-0.0248	(0.143)	0.304	(0.207)
Don't associate with politics	-0.202	(0.141)	0.112	(0.139)	0.168	(0.208)

APPENDIX 3a. Logistic regression by "acceptors", "hesitant", and "refusers"

VARIABLES	(1) accepting	(2) se	(3) hesitates	(4) se	(5) refuses	(6) se
rtcn07	0.734***	(0.231)	-0.660***	(0.233)	-0.235	(0.321)
rtcn08	0.0658	(0.144)	-0.0810	(0.151)	0.0657	(0.197)
rtcn09	0.144	(0.168)	0.148	(0.175)	-0.448*	(0.239)
rtcn10	-0.00312	(0.142)	-0.131	(0.149)	0.243	(0.202)
rtcn11	0.133	(0.140)	0.0247	(0.147)	-0.260	(0.198)
rtcn12	-0.184	(0.157)	0.0451	(0.159)	0.225	(0.220)
rtcn13	0.0608	(0.162)	-0.124	(0.170)	0.0991	(0.220)
rtcn14	0.218	(0.200)	-0.387*	(0.206)	0.117	(0.288)
rtcn15	0.197	(0.190)	-0.142	(0.198)	-0.105	(0.267)
rtcn16	-0.289	(0.232)	0.0547	(0.241)	0.512	(0.325)
rtcn17	0.316**	(0.150)	0.0381	(0.159)	-0.728***	(0.217)
rtcn18	0.0388	(0.166)	0.124	(0.172)	-0.156	(0.223)
rtcn19	0.313	(0.192)	0.00555	(0.201)	-0.336	(0.247)
rtcn21	-0.169	(0.173)	0.156	(0.177)	0.0511	(0.237)
rtcn22	-0.210	(0.163)	0.243	(0.166)	-0.0530	(0.230)
rtcn23	0.318	(0.197)	-0.278	(0.203)	-0.0635	(0.279)
rtcn24	0.0122	(0.180)	0.235	(0.184)	-0.379	(0.246)
rtcn25	0.160	(0.196)	-0.250	(0.198)	0.152	(0.275)
rtcn26	0.336**	(0.167)	-0.162	(0.173)	-0.327	(0.227)
rtcn27	0.0884	(0.177)	-0.0427	(0.184)	-0.0739	(0.245)
rtcn28	0.409**	(0.206)	-0.392*	(0.211)	-0.164	(0.305)
rtcn29	-0.0613	(0.186)	-0.276	(0.190)	0.455*	(0.255)
rtcn30	0.268	(0.182)	0.0919	(0.186)	-0.644**	(0.276)
rtcn31	0.245	(0.233)	-0.0511	(0.241)	-0.282	(0.312)
rtcn32	0.652***	(0.242)	-0.00140	(0.253)	-0.794***	(0.298)
rtcn33	0.284	(0.195)	0.123	(0.197)	-0.726**	(0.306)
rtcn34	1.109***	(0.270)	-0.748***	(0.280)	-0.681*	(0.374)
rtcn36	0.839***	(0.167)	-0.290*	(0.175)	-0.809***	(0.211)
rtcn37	-0.830***	(0.158)	0.165	(0.167)	1.122***	(0.215)
rtcn38	0.413**	(0.197)	0.0572	(0.205)	-0.781***	(0.274)
rtcn39	0.199	(0.184)	-0.0672	(0.190)	-0.120	(0.257)
rtcn40	0.117	(0.235)	0.0634	(0.243)	-0.342	(0.321)
rtcn41	-0.239	(0.228)	0.170	(0.232)	0.207	(0.321)
rtcn42	-0.0101	(0.196)	0.251	(0.210)	-0.347	(0.271)
rtcn43	1.187***	(0.253)	-0.707***	(0.247)	-0.976***	(0.356)
rtcn44	0.494**	(0.239)	0.156	(0.249)	-1.091***	(0.334)
rtcn45	0.171	(0.184)	-0.0298	(0.192)	-0.207	(0.283)
rtcn46	0.0645	(0.173)	-0.224	(0.177)	0.230	(0.258)
rtcn47	-0.152	(0.164)	-0.0631	(0.168)	0.235	(0.227)
rtcn48	-0.218	(0.210)	-0.0653	(0.210)	0.500*	(0.297)
rtcn49	0.299	(0.252)	-0.225	(0.259)	-0.158	(0.342)
Constant	-3.265***	(0.831)	-0.395	(0.800)	2.254**	(1.014)
Observations	6,155		6,155		6,155	

Notes: See Table 1 and Appendix 1 for default and label of statements.
Prob > F= 0.000, root mean square error = 0.15, pseudo R^2 = 0.23.

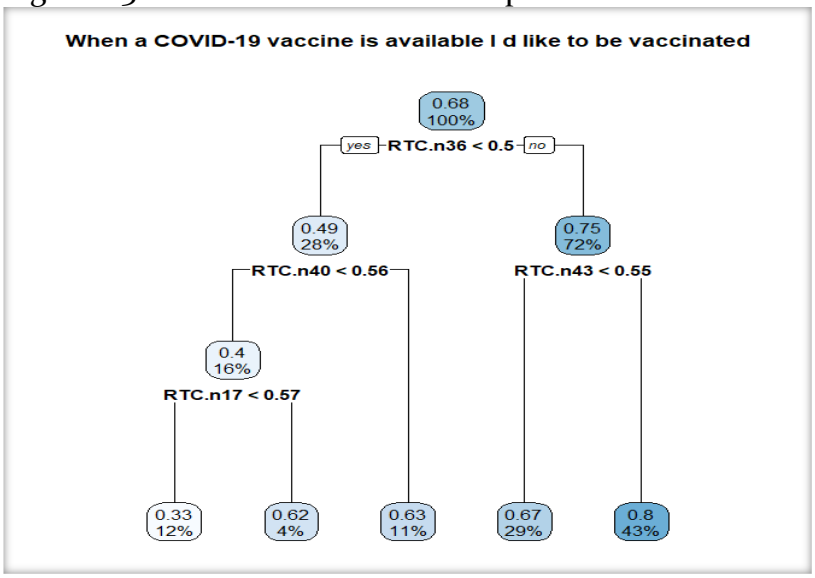
APPENDIX 3b. Computed marginal propensity to vaccinate, multi-logit estimates (non adjusted by response time)

Statements	Probability
In case of a coronavirus infection, I will get appropriate medical help	10.1%
Coronavirus is dangerous for my health	9.8%
I am worried about my health	6.7%
The government discloses real numbers of coronavirus infections and deaths	6.5%
[PRESIDENT] is doing a good job dealing with COVID-19	5.8%
I disinfect mail and deliveries before opening them	5.4%
My chance of getting COVID-19 is high	5.3%
I am satisfied with how my government is handling this crisis	5.0%
I comply with the restrictions to stay home	4.8%
I actively encourage others to follow the restrictions and guidelines	4.7%
I would like to help people who are more vulnerable to COVID	4.4%
Slowing the spread of COVID-19 is more important than the economy	3.9%
I am anxious about not being able to meet with friends	3.9%
I am grateful to our healthcare professionals	3.6%
I comply with the recommendations for physical distancing	3.6%
COVID-19 will bring countries closer	3.5%
I wash hands for 20 seconds when necessary	3.5%
I am worried about the health of people in my country	3.3%
Being together all the time increases family tensions	3.2%
I worry how living in isolation will affect me	3.2%
I am worried about my financial situation	-3.8%
I am grateful to our essential workers	-4.6%
Media exaggerate the situation with COVID-19	-13.1%

Notes: Only statistically significant parameters are shown (α<5%). Multilogit on three categories (acceptors, hesitant, and refuses). Country dummy included, as well as socio-demographics.

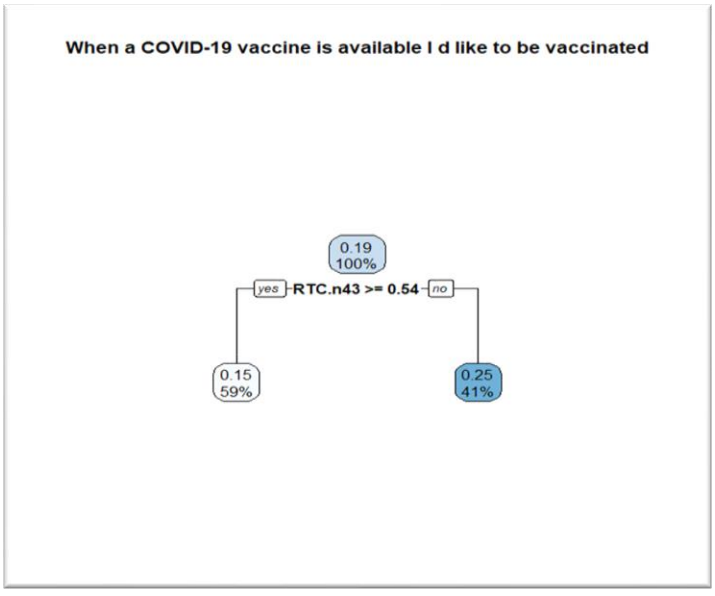
APPENDIX 4. Classification trees by "acceptors", "hesitant", and "refusers" (non-adjusted by response time)

Figure A3.1. Classification tree -Acceptor



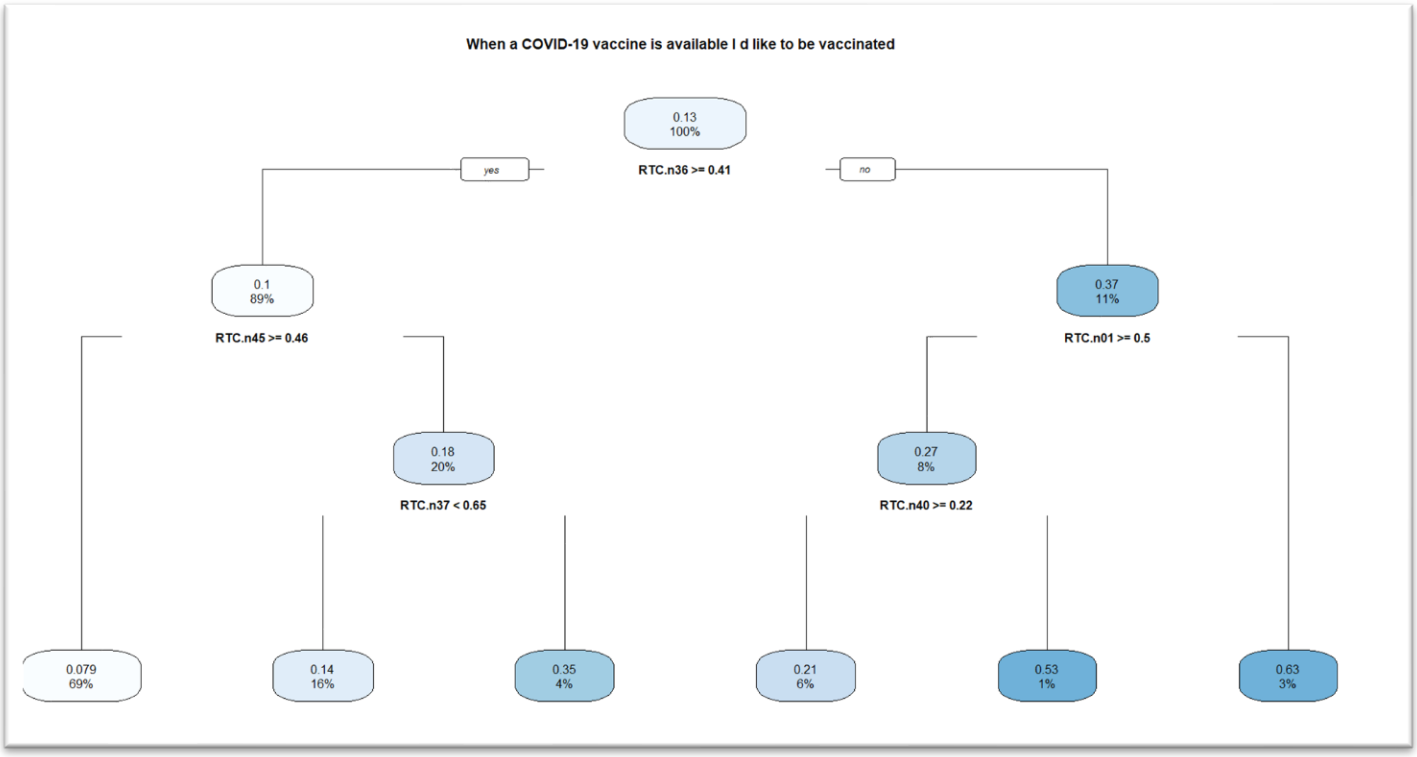
Notes:
RTC.n36: Coronavirus is dangerous for my health
RTC.n17: I am worried about my own health
RTC.n 40: I am satisfied with how my government is handling this crisis
RTC.n43: In case of a coronavirus infection I will get appropriate medical help

Figure A3.2. Classification tree - Hesitant



Note:
RTC.n43: In case of a coronavirus infection I will get appropriate medical help.

Figure A3.3. Classification tree - Refusers



Notes:
RTC.n1: I actively encourage others to follow the restrictions and guidelines;
RTC.n2: I'm worried about my children's education;
RTC.n37: Media exaggerate the situation with Covid-19;
RTC.no: The government is doing a good job dealing with Covid-19;
RTC.n46: Covid-19 reveals the worse in people.

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