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*Yana Roshchina, Sergey Roshchin,  
Ksenia Rozhkova*

# **DETERMINANTS OF COVID-19 VACCINE HESITANCY AND RESISTANCE IN RUSSIA**

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## **DETERMINANTS OF COVID-19 VACCINE HESITANCY AND RESISTANCE IN RUSSIA<sup>4</sup>**

Vaccination is the main tool available to handle the COVID-19 pandemic globally. Though no vaccine is proven to be 100% effective, vaccination secures against getting seriously ill and dying from the disease. Russia announced the development of its first domestic vaccine back in August 2020 and launched the nationwide immunization campaign at the beginning of 2021. Despite these achievements, as for mid-October 2021, only 36% of the population got at least one shot of the vaccine. Massive vaccination hesitancy and refusal pose a great threat to public health and postpone social and economic recovery. Using nationally representative data from the general adult population of Russia, this study explores the scope of vaccination hesitancy and refusal as well as the determinants of vaccination attitudes. The results suggest that only 45% of Russian population demonstrated positive attitudes towards COVID-19 vaccination prior the launch of nationwide vaccination. We analyze a wide array of demographic, socio-economic, and health-related factors in relation to vaccination intentions. We also explore the deep-rooted causes of vaccination reluctance by looking at personality traits, religiosity, and trust. The obtained results are vital for designing policy measures to promote vaccination as a “fourth wave” of COVID-19 in Russia is currently progressing.

**Keywords:** COVID-19; coronavirus; vaccination attitudes; vaccination hesitancy; vaccination resistance; risk attitudes; personality traits; Russia

**JEL Classification:** I11, I12

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<sup>1</sup> PhD, Senior research fellow at Center for Longitudinal Studies and of the Laboratory for Studies in Economic Sociology, Department of Sociology, National Research University Higher School of Economics, yroshchina@mail.ru

<sup>2</sup> PhD, Head of Laboratory for Labor Market Studies, Faculty of Economic Sciences, National Research University Higher School of Economics, sroshchin@hse.ru

<sup>3</sup> Junior research fellow at Laboratory for Labor Market Studies, Faculty of Economic Sciences, National Research University Higher School of Economics

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## **Introduction**

The world has been facing the global pandemic of COVID-19 since March 2020. As of 21 October 2021, the cumulative number of COVID-19 cases reported globally exceeded 242 million and that of deaths was already over 4.9 million. Russia demonstrates one of the highest numbers of infected individuals in the world, ranking 8<sup>th</sup> globally with over 8 million of cumulative cases or almost 55,000 cases for every 1 million of population. The death rates are also high and increasing daily with total over 223,000 confirmed deaths or 1,530 fatal cases for every 1 million of population (Ritchie et al., 2020). To date, the disease has yet no medication with proven efficacy, while treatment remains predominantly symptomatic (WHO 2020).

Under these circumstances, vaccination is viewed as the most effective tool to handle the pandemic. Russia announced its first domestic vaccine Gam-COVID-Vak, also known as “Sputnik V” in August 2020 when it was approved and registered by the Ministry of Health of the Russian Federation. Phase III trial was conducted in September-November 2020 with the results claiming 91.6% efficacy against COVID-19 (Logunov et al., 2021). Mass immunization campaign was launched in Moscow in December 2020, following with a nationwide campaign in January 2021. Vaccination is available free of charge for the whole adult population.

Despite significant achievements in developing and producing domestic vaccine as well as launching the vaccination campaign, vaccination rates in Russia remain remarkably low relative to what has been reported to date in other countries. As of mid-October 2021, ten months after the start of the national immunization program, only 36% of the population has got at least one shot of the vaccine (Our World in Data, 2021). This is an especially low figure given the fact that the vaccine has been available simultaneously for the whole population and not for the most vulnerable groups as in many European countries (Liu et al., 2021). Moreover, this rate was reached only after the implementation of administrative enforcement in June 2021, when employees of several industries were obligated to complete immunization (Dixon, 2021). One month prior to obligatory vaccination, right before the rise of the third wave of COVID-19 in Russia, only 9% of the population received at least one dose of the vaccine. At the meantime, by October 2021, 48% of the population globally has received at least one dose of a COVID-19 vaccine with the highest levels of uptake reaching over 95% in certain countries (UAE), 14 countries covering more than 70% of the population, and another 3 countries covering at least 60% of their respected population (Ritchie et al., 2020).

Vaccination resistance and hesitancy, defined as a reluctance to get vaccinated despite the availability of the vaccine (MacDonald, 2015), pose serious risks to public health. Despite the importance of the issue, there is still lack of vital representative vaccine hesitancy data for Russia. To our knowledge, there are only two cross-country studies (Lazarus et al., 2021; Solis Arce et al., 2021) which reported the scope of vaccination hesitancy and refusal in Russia. However, the factors underlying vaccine attitudes need more attention. The debate surrounding vaccination in Russia is based primarily on expert views and subjective estimates rather than objective data. In this study, we estimate the scope of vaccination hesitancy and resistance in Russia and examine a wide array of sociodemographic, health-related, and other determinants of vaccination attitudes. We also highlight the deep-rooted causes of vaccination reluctance by looking at personality traits, religiosity, and trust. Unlike a large fraction of previous studies (Machida et al., 2021; Malik et al., 2020; McElfish et al., 2021), this research is based on data from a reputable panel survey, covering a representative sample of general adult population. Identifying the factors which provoke vaccination hesitancy and resistance is vital for tailoring effective promotion and covering a larger fraction of the population as a “fourth wave” of COVID-19 is currently progressing in Russia. Rapid mass vaccination is the only possibility to avoid the grave consequences both in terms of public health and national economy.

## **Background**

Vaccine hesitancy and resistance is a common problem which existed long before COVID-19 era. Even though the invention of vaccines allowed to dramatically reduce morbidity and mortality from infectious diseases, vaccination has always faced resistance from people fearing

possible side effects (Dube et al., 2013). In recent history, vaccine hesitancy gained forces after the notoriously famous study on the relationship between MMR vaccine and autism that turned out to be falsified. Prior to COVID-19 pandemic, vaccination hesitancy has been identified as one of the top ten threats to global health (WHO 2019).

Attitudes towards vaccination are formed through complex interactions between different personal (i.e., socio-demographic, economic, psychological, health-related) and external factors. Several models were proposed to integrate the previous literature dedicated to the determinants of hesitancy. “3Cs” concept distinguishes three main elements underlying vaccination acceptance. These are complacency, which implies low perceived risks of the disease; convenience, which refers to vaccine availability and affordability; and confidence, meaning trust in vaccine safety and effectiveness as well as trust in the health system, which delivers the vaccine, and authorities (SAGE, 2014). Further studies expanded this framework to “4Cs” (Betsch et al., 2015) and “5Cs” (Betsch et al., 2018), adding to the list communications as a source of vaccine-related information and context, which refers to sociodemographic characteristics.

Hesitancy depends on the vaccine in question. In general, people are more reluctant to get vaccinated with innovative vaccine (Dube et al., 2014). COVID-19 vaccines differ from other ones in terms of the speed, at which the development was carried out, lack of informational transparency regarding the safety and effectiveness of the novel vaccines, and their innovativeness. These features naturally increase hesitancy related to COVID-19 vaccines. Surveys conducted before COVID-19 vaccines have become available to public, demonstrate large vaccination hesitancy globally (Sallam, 2021) which increased over time. Vaccination acceptance declined from 70% in March 2020 at the beginning of the pandemic to less than 50% in October 2020 when information about novel vaccines became publicly available (Lin et al., 2020).

The specificities of the novel COVID-19 vaccines also imply that the determinants of acceptance, hesitancy, and refusal may significantly differ from that discovered for other vaccines. We go on by considering several groups of factors which have consistently been shown to affect vaccination intentions.

#### *Demographic and socio-economic factors*

Research suggests that males are more inclined to get vaccinated in general and to receive a vaccine shot against COVID-19 (Ahmed et al., 2021; Khaled et al., 2021; Troiano, Nardi, 2021). However, comparative studies, analyzing evidence from different country settings, show mixed results. For instance, Lazarus et al. (2021) in a cross-country study based on data from 19 countries concludes that women are more inclined to get vaccinated for the novel coronavirus. Cultural framework, tendency to believe rumors, psychological factors specific to men and women may serve as an explanation for the gender gap in vaccine uptake (Browne et al., 2015). Moreover, women outnumber men in occupations related to health services, where vaccine acceptance is reportedly higher (Dube et al., 2013) and constitute a larger fraction in older age groups, which received early access to the vaccine during the pandemic (Barford et al., 2006). Age is another significant correlate of vaccination intentions (McElfish et al., 2021; Murphy et al., 2021). While younger groups are mainly reluctant to get vaccinated, those at risk (elderly groups 65+) generally demonstrate positive attitudes towards vaccination which is consistent across different countries (Ahmed et al., 2021; Fisher et al., 2020).

The impact of socio-economic factors differs significantly in various settings. For example, evidence concerning the impact of education on vaccination attitudes is inconclusive. In some countries higher education is associated with the reduced chances of vaccine hesitancy and refusal (Ahmed et al., 2021; Fisher et al., 2020; Reno et al., 2021; Troiano, Nardi, 2021), while in the others education either does not demonstrate any statistically significant relationship with vaccination intentions (Khaled et al., 2020) or, conversely, increases the chances of negative attitudes (McElfish et al., 2021). Education is correlated with the level of awareness in health-related issues and defines what sources of information would be chosen in the decision-

making process. Less educated individuals are more vulnerable to rumors (Lai et al., 2020). Alongside education, individual employment status and income have been shown to determine vaccination attitudes. Before the pandemic, unemployed individuals generally demonstrated negative perceptions about vaccine safety and effectiveness across countries (Larson et al., 2016). Similarly, income group appears to be one of the largest predictors of vaccine reluctance (Paul et al., 2020) with higher income being positively associated with vaccine acceptance (Lazarus et al., 2021; Machida, 2021; Murphy et al., 2021; Lin, Wang, 2020).

#### *Behavioral patterns and personality traits*

Personality traits determine individual ways of thinking and behavioral patterns. In the context of the pandemic, personality traits may affect what sources of information people choose, whether they follow the official guidelines regarding social distancing, and eventually, what are their vaccination intentions.

There is yet no consensus about what psychological construct is more predictive of vaccine attitudes. In the current study, we rely on the well-established personality taxonomy of “the Big Five” (John, Srivastava, 1999), which suggests that an individual can be described from the point of five broad categories: conscientiousness, openness to experience, neuroticism, agreeableness, and extraversion. Previous research has stated that the Big Five significantly influences individual health behaviors (Joyner et al., 2018). However, the literature regarding the association between personality traits measured by the Big Five and the vaccination intentions remains limited. Neuroticism and conscientiousness have been shown to be related to hesitancy towards HIV and HPV vaccination (Patty et al., 2017; Johnson, 2000). Individuals high in agreeableness, conscientiousness, and emotional stability are more inclined to value vaccination as beneficial to their health (Lin, Wang, 2020). Regarding the current pandemic, individuals low in agreeableness (Salerno et al., 2021) and conscientiousness, but high in neuroticism tend to express negative attitudes towards COVID-19 vaccination (Murphy et al., 2021). Openness to experience and extraversion are reportedly unrelated to any of vaccine attitudes.

There are several mechanisms which can be underlying the relationship between vaccination intentions and personality. One of them is the choice of informational sources related to the disease. Studies show that people high in neuroticism and extraversion are more likely to fall for false rumors (Lai et al., 2020), while conspiracy beliefs have been named as an important factor hindering vaccination intentions (Salerno et al., 2021). Conscientiousness may be associated with thorough examination of all sources of information with the focus on scientific evidence. Another mechanism is obedience to rules. Higher levels of neuroticism, openness, conscientiousness, and agreeableness as well as lower levels of extraversion predict compliance with official COVID-19 guidelines (Abdelrahman, 2020; Aschwanden et al., 2021), while poor compliancy to guidelines predicts unwillingness to get vaccinated (Paul et al., 2020). Agreeableness is a psychological characteristic of prosocial behavior while willingness to protect others is associated with vaccine acceptance (Machida et al., 2021). It is also close to altruism which is shown to be positively related to getting vaccinated against COVID-19 (Rieger, 2020). People high in neuroticism are more inclined to anxiety, while COVID-19-related anxiety and fears are positively related to the intention to get vaccinated (Bendau et al., 2021).

Attitudes towards risk may serve as another psychological factor influencing vaccination intentions. Studies show that risk perceptions are biased: people tend to value natural risks, such as the probability to contract COVID-19, more favorably compared to man-made risks, such as getting side effects from the vaccination (Browne et al., 2015). In addition, people are generally more averse to risks which are associated with action (getting vaccinated) rather than inaction (getting sick). This is known as omission bias (Brewer et al., 2007). Most of prior research focuses on health-related risks and individual perceptions of risk related to COVID-19 as one of the sources of positive attitudes towards vaccination. Perceived risk of the severity of the disease and of getting ill are significantly positively correlated with the probability to get vaccinated against coronavirus (Karlsson et al., 2021; Nazli, 2021). However, these risk perceptions are different compared to general risk preferences which are less researched.

Lastly, there is a vast literature dedicated to the link between religious beliefs and vaccine hesitancy. In the context of COVID-19 pandemic, religiosity is reportedly positively associated with vaccine hesitancy and refusal (Murphy et al., 2021; Troiano, Nardi, 2021). The effect is partially mediated through locus of control (Olagoke et al., 2020). Belief in external forces affecting individual state, which is common among religious individuals, translates into external locus of control and vaccination hesitancy. Moreover, religious beliefs are strongly correlated with trust in conspiracy and informal sources of information (Cacciatore et al., 2018) which are shown to be negatively correlated with vaccine acceptance. However, we do not expect this factor to be significantly relevant for the Russian case since only a small proportion of population reports incompatibility between religion and vaccination (Larson et al., 2016).

### *Trust*

Unwillingness to get vaccinated is strongly associated with lack of trust in the vaccine safety and efficacy. Establishing this kind of trust requires also trust in the authorities, which promote immunization, trust in the official sources of information as well as trust in the health system and health professionals who deliver the vaccine to the public. Those individuals who claim to trust the government demonstrate higher levels of vaccine acceptance (Lazarus et al., 2021). Trust in the government and health authorities is related to confidence in the vaccine and, therefore, positively affect vaccination intentions (Wismans et al., 2021). In contrast, those resistant to COVID-19 vaccine show lower levels of trust and use alternative sources of information (Murphy et al., 2021).

Social media represent one of the alternative sources of information. Research suggests that frequent social media use is positively correlated with hesitancy towards different kinds of vaccines (Gunaratne et al., 2019). The relationship further revealed itself during the COVID-19 pandemic. Those individuals who use social media as the main source of information are more inclined towards vaccination hesitancy (Reno et al., 2021; Puri et al., 2020; Hughes et al., 2021). Social networks provide a platform for anti-vaccination activist to spread their views to wider audiences (Keelan et al., 2010). The content of social media and networks regarding vaccination is mostly of low quality and carries negative connotations (Dube et al., 2013).

Finally, health professionals represent the most trusted source of information regarding vaccination safety and efficacy. In many countries health-care practitioners generally support vaccination. Physicians and medical students are more inclined to get vaccinated against COVID-19 (Petraovic, 2021). Opinion of health professionals matters for vaccine hesitancy as hesitant individuals rarely refer to health professionals as their primary source of information (Salerno et al., 2021).

### *Health-related factors and COVID-19 experience*

The danger of COVID-19 is multiplied in the presence of other chronic diseases. Moreover, those individuals who experienced the disease either personally or in someone close are supposed to be more aware of the risks associated with getting sick. However, some research states that neither chronic diseases nor COVID-19 related experience (i.e., quarantine status, infection, or deaths of someone close) are statistically significant for vaccination attitudes (Khaled et al., 2021). International data prove this finding suggesting that being sick or having family members sick with COVID-19 is associated neither with vaccination hesitancy, nor with vaccination acceptance (Lazarus et al., 2021).

### *Russian context*

Negative attitudes towards vaccines are a major public health concern in Russia and a massive barrier to vaccination uptake during the pandemic. Compared to other countries in the European region, Russia demonstrated the highest proportion of people who disagreed with vaccines being important for children, finding vaccines unsafe and ineffective (Larson et al. 2016). Previous cross-country studies that explored data on COVID-19 vaccine hesitancy in Russia, among other countries, showed that the acceptance rate was less than 55% (Lazarus et al., 2021). Russia was

placed among the countries with the lowest COVID-19 vaccine acceptance rates (54.9), next to Italy (53.7), Poland (56.3) and US (56.9) by December 2020 (Sallam, 2021). This rate is insufficient to achieve herd immunity which would require at least 60-75% immune individuals (Billah et al., 2020; Britton et al., 2020), especially with the spread of the Delta Variant.

The lower COVID-19 vaccine acceptance rate in Russia is a result of general vaccine skepticism that has evolved due to the negative informational context prevailing in the Russian society and in media. The list includes exaggeration of possible side effects, inconsistent quarantine measures, the growing prevalence of antivaccine attitudes among health professionals, and lack of confidence in domestic vaccines and medications which was observed long before COVID-19 outbreak. All these factors simultaneously undermine the success of the national immunization campaign.

## Data

For this study, data were drawn from a national panel household survey “Russia Longitudinal Monitoring survey”, RLMS-HSE<sup>5</sup>, which is the most reputable non-state source of data widely used in social science research. The survey is conducted annually and uses multistage probability sampling with primary sampling units selected from geographically determined strata, making it nationally representative. The dataset covers a wide spectrum of individual demographic, socio-economic, health-related, psychological, behavioral, and other characteristics. We use the most recent data which were collected from October to January 2021 prior to vaccine rollout. The resulting representative weighted sample consists of 9,705 adult individuals aged 18 or more (8,533 in regression due to missing value).

## Measures

### *Dependent variable - vaccination intentions*

In 2020, a special block of questions dedicated to individual behavior during the pandemic was introduced to the survey. One of the questions covers the intentions to get vaccinated against COVID-19. Since the survey was conducted prior to the launch of the immunization campaign, vaccination intentions were assessed with the following question: “Are you planning to get vaccinated against COVID-19 once the vaccine becomes available?”. The answer choices were: “I will certainly get vaccinated in any case”, “I will get vaccinated but only if I am sure about vaccine safety and reliability”, “I will not get vaccinated”, “I have already recovered from COVID-19 and I find it unnecessary to get vaccinated”, “I have already got vaccinated”, “Not sure whether I will get vaccinated”.

We explore the link between vaccination intentions and four broad groups of explanatory variables, in accordance with previous research. These groups are: 1) demographic and socio-economic factors; 2) behavioral patterns and personality traits; 3) trust; and 4) health-related factors.

### *Demographic and socio-economic factors*

The first group of factors includes gender, age divided by 10 and its square divided by 100 to capture possible non-linearities, marital status (a binary variable that equals 1 if the respondent is married either formally or informally, and 0 otherwise), number of children younger than 18 years old, the presence of elderly family members (65 years old and above), the type of settlement (a categorical variable, including Moscow and Saint-Petersburg, regional center, city, or village as a reference category), level of education (a categorical variable, including university degree, vocational college, or no professional education as a reference category), employment status (a categorical variable, including employed, unemployed, studying, or inactive as a reference category), and the logarithm of the household’s per capita income.

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<sup>5</sup> Russia Longitudinal Monitoring survey is conducted by National Research University “Higher School of Economics” and OOO “Demoscope” together with Carolina Population Center, University of North Carolina at Chapel Hill and the Institute of Sociology of the Federal Center of Theoretical and Applied Sociology of the Russian Academy of Sciences. (RLMS-HSE web sites: <https://rlms-hse.cpc.unc.edu>, <https://www.hse.ru/org/hse/rlms>)

### *Behavioral patterns and personality traits*

To address personality traits, we rely on the Big Five taxonomy (John, Srivastava, 1999). The survey module consists of 24 questions, each representing a facet related to one of the Big Five categories (for complete mapping, see Table 1 in the Appendix). Responses are self-evaluated on a scale from 1 to 4, depending on the frequency with which the facet is reflected in the respondent's daily behavior. Each of the five categories is calculated as an average of the corresponding facets, standardized with the mean of 0 and a standard deviation of 1.

In addition, we measure individual risk attitudes. The survey module dedicated to risk consists of 6 questions, each representing the respondent's willingness to take risks either in general or in certain situations related to health, work safety, career promotion, driving, and financial decisions. Responses are self-evaluated on a scale from 0 ("not ready to risk at all") to 10 ("always ready to take risks"). Risk attitude is calculated as an average of all the questions (if the respondent does not drive, the measure was calculated based on the remaining 5 questions) and standardized with the mean of 0 and a standard deviation of 1.

We also look at the impact of religiosity on vaccination attitudes by including the frequency of attending religious services in the model (a categorical variable, including at least once a month, several times a year or less as a reference category, and never or non-believers).

### *Trust*

We include two measures of trust into our analysis. The first measure represents general level of trust and is measured with the following question: "Do you think that most people can be trusted or that one always has to be cautious with other people?". This measure is the main and it is present in all the models. The second measure represents the level of trust in public institutions and is measured with the set of consecutive questions asked in 2018 and formulated as follows: "To what extent do you trust: 1) the government; 2) the State Duma<sup>6</sup>; 3) the courts; 4) the army; 5) the police?". Panel nature of the survey allows us to attach these data to our 2020 sample. The overall level of trust in public institutions is calculated as an average of these questions standardized with the mean of 0 and a standard deviation of 1 (results for this regression are present in Table 4 in the Appendix). Finally, we control for the frequency of social media use as a source of alternative information about COVID-19 and vaccination.

### *Health-related factors and COVID-19 experience*

We look at the link between self-rated health and vaccination intention. There are five possible options: individual health can be "very good", "good", "average, neither good nor bad" as a reference category, "bad", and "very bad". Additionally, we look at COVID-19 related experiences such as the presence of confirmed cases among family members (either a positive test or presence of antibodies - binary variable), the presence of confirmed cases among acquaintances (either a positive test or presence of antibodies - binary variable), personal confirmed case of COVID-19 in the past (either a positive test or presence of antibodies - binary variable), and self-perceived probability to get infected in the following 12 month measured on a scale from 1 to 10 and standardized with the mean of 0 and a standard deviation of 1. Since Russia is a large country with heterogeneous epidemiological situation across different regions, we additionally control for COVID-19 incidence rate in each region measured as a 7-day moving average preceding the day of the survey.

### **Statistical analysis**

We estimate multinomial logistic regression models in several specifications to examine the impact of various factors on vaccination attitudes. First, we estimate a model where the dependent variable is vaccination intention with four options: certainly accepting (the category includes those individuals who answered "I will certainly get vaccinated in any case" and those

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<sup>6</sup> The State Duma is the lower house of the Russian parliament



who have already got vaccinated), conditional accepting (those who answered they would get vaccinated in case of safety and reliability of the vaccine), resistant (those who answered they would not get vaccinated or those who find vaccination unnecessary due to previous COVID-19 experience), and hesitant (those who answered “Not sure whether I will get vaccinated”). The base outcome is conditional acceptance since it can be considered as rational behavior at the time preceding vaccination rollout. We consider it to be the baseline model for our analysis. However, it does not allow us to directly compare the group of certain acceptance to the group of certain resistance. For this reason, we additionally present the results for the model with resistance as the base outcome (see Table 5 in the Appendix).

We conducted a sensitivity analysis to test for the robustness of our models in the presence of methodological changes. First, we estimated the same models with age limitation 18-60. The results remained practically unchanged, supporting the robustness of the results. Second, we estimated separate models for men and women since it is well-established that men and women differ a lot in their health behaviors (Kandrack et al., 1991). We provide separate results for men and women in Table 6 of the Appendix.

In order to properly interpret the results, we estimated relative risk ratios (RRR) with corresponding 95% confidence intervals (CI) and robust SEs due to heteroskedasticity.  $RRR > 1$  shows that the risk of the outcome in the comparison group relative to the risk of the outcome in the referent group increases as the variable of interest increases. Similarly,  $RRR < 1$  shows the decrease of the risk as the variable of interest increases.  $RRR = 1$  indicates that the risk of the outcome in the comparison group is the same relative to the referent group.

## Results

First, we assess the scope of vaccination acceptance, hesitancy, and refusal in Russia shortly before the launch of the immunization campaign. By the time of the survey, less than 1% of the sample (0.2%) has already got vaccinated during vaccine trials, 8% were certain about getting vaccinated once the vaccine becomes available, 36% would get vaccinated if they were sure in the safety and the reliability of the vaccine, 1% has recovered from COVID-19 and found vaccination unnecessary, 42% were strongly resistant towards vaccination, while the remaining 13% were hesitant. The acceptance rate is somewhat lower compared to the results previously reported in (Lazarus et al., 2021). By the time of the survey, 22% of the respondents got tested either for the coronavirus infection or antibodies, 3% received positive test or discovered antibodies.

### *Determinants of vaccination attitudes*

Table 2 in the Appendix summarizes mean values of explanatory variables across different vaccination intention groups. Some typical patterns can be already observed at this stage. In terms of gender, there is a slightly higher proportion of males in the hesitancy group ( $M=0.47$ ) compared to the acceptance ( $M=0.44$  in both certain and conditional acceptance groups) and the resistance groups ( $M=0.45$ ). The conditional acceptance group demonstrates a slightly higher fraction of married respondents ( $M=0.61$ ) compared to the rest of the groups. Moreover, individuals with elderly family members are slightly more present in the acceptance group ( $M=0.29$  for both certain and conditional acceptance). There are no significant differences in mean age across vaccination intention groups (46 years in the total sample), but these groups seem to vary in terms of educational composition. The certain acceptance group has a higher proportion of individuals with some professional education compared to other categories – 30% of the group has a university degree, another 27% - a vocational degree. In contrast, the lowest proportion of the respondents with a vocational degree is observed in the resistance group ( $M=0.22$ ), while the lowest proportion of the respondents with a university degree is in the hesitancy group ( $M=0.24$ ). We further observe a clear pattern of relationship between vaccination intentions and states of employment. The highest proportion of employed individuals is observed in the certain ( $M=0.67$ ) and conditional acceptance groups ( $M=0.65$ ). In vaccination resistance and hesitancy groups the proportion of employed is lower ( $M=0.59$  and  $M=0.60$ ,

respectively). However, we observe no significant differences in the proportions of unemployed individuals and students across vaccination intentions groups. In terms of income, hesitant individuals demonstrate a bit lower logarithm of per capita income ( $M=9.47$ ), though no clear pattern can be derived for the acceptance and resistance categories. Finally, the data suggest that capital cities Moscow and Saint Petersburg demonstrate higher proportions of respondents in the resistance and hesitancy groups ( $M=0.15$  each) compared to certain ( $M=0.09$ ) and conditional acceptance ( $M=0.07$ ), while in regional centers, cities, and villages the largest fraction of respondents falls into acceptance categories. We assume that vaccination reluctance in the two main cities may reflect greater medical capacities and ability to provide medical assistance in case of COVID-19 infection compared to the rest of the regions.

We note clear patterns in personality traits distribution across vaccination intention groups. The certain acceptance group can be characterized by higher mean levels of openness ( $M=0.047$ ), conscientiousness ( $M=0.108$ ), and agreeableness ( $M=0.151$ ). In contrast, the lowest levels of these traits ( $M=-0.124$  for openness,  $M=-0.186$  for conscientiousness, and  $M=-0.112$  for agreeableness, respectively) are observed in the hesitancy group. Such links are well documented in other countries as well (Murphy et al., 2021; Salerno et al., 2021). Higher mean level of neuroticism is observed in the vaccine resistance group ( $M=0.068$ ), but not in the hesitancy group ( $M=-0.103$ ), contrary to previous research (Murphy et al., 2021). Surprisingly, respondents hesitant towards vaccination appear to be the most emotionally stable even compared to the acceptance group ( $M=-0.031$  in certain acceptance,  $M=-0.037$  in conditional acceptance). From all the Big Five categories extraversion is the only one which does not demonstrate any clear pattern across vaccination attitudes groups. Contrary to previous research, the highest proportion of non-religious individuals is observed in vaccine resistant individuals ( $M=0.47$ ).

Vaccination resistance group exhibits the highest mean level of risk inclination ( $M=0.074$ ). In contrast, both acceptance and hesitancy groups contain risk averse individuals ( $M=-0.070$  in certain,  $M=-0.048$  in conditional acceptance, and  $M=-0.067$  in hesitancy). However, this risk aversion reveals itself differently in these two cases. Those individuals who certainly accept vaccination against COVID-19 are risk averse towards encountering the virus and experiencing consequent health issues. For hesitant individuals the risks of infection and the risks of possible side effects are equal which prevents them from receiving a vaccine shot.

In line with the previous literature, those respondents who report higher levels of trust in public institutions are more inclined towards vaccination: the mean level of trust in institutions increases from to  $M=-0.205$  in the resistance group to  $M=0.245$  in the certain acceptance group. However, this clear relationship disappears once we consider the general level of trust. The highest mean value of general trust is observed in the hesitancy group ( $M=0.461$ ), while the lowest is in the resistance group ( $M=0.379$ ). Moreover, the highest mean frequency of social media use is present in the vaccine resistance group ( $M=16.9$ ) which means that social media may indeed serve as an alternative source of information with predominantly antivaccine sentiments.

The highest proportion of individuals with bad health is concentrated in the hesitancy group ( $M=0.12$ ) while the lowest is in the certain acceptance group ( $M=0.07$ ). Bad self-rated health may imply that people are more focused on possible side effects associated with vaccination. Interestingly, individuals with COVID-19 experience are more present in both certain acceptance and resistance groups ( $M=0.04$  each). Our guess is that attitudes towards vaccination in recovered populations may depend on the severity of the case with more severe cases demonstrating inclination towards vaccination. Finally, individuals from the resistance and hesitancy groups come from the regions with worse epidemiologic situation, meaning that they underestimate the risks of infection in the region.

We continue by estimating the multinomial logit model for the determinants of vaccination attitudes. Table 3 in the Appendix shows the results of the model comparing willingness to receive COVID-19 vaccination depending on a set of demographic, socio-economic, psychological, behavioral, and health-related characteristics. First, among demographic and socio-economic factors the following variables are significantly associated

with the decreased risk of being vaccine resistant compared to being in the conditional acceptance group: presence of elderly family members (RRR=0.859), vocational (RRR=0.820) and university education (RRR=0.873) compared to no professional education, and living in a regional center (RRR=0.641), a city (RRR=0.562) or a village (RRR=0.586) compared to living in Moscow or Saint-Petersburg. The decreased risk of being vaccine hesitant compared to being conditionally accepting is brought by the number of underaged children (RRR=0.838), presence of a university diploma (RRR=0.837), being a student (RRR=0.619), and living in a regional center (RRR=0.445), a city (RRR=0.454) or a village (RRR=0.454) compared to living in Moscow or Saint-Petersburg. The results also demonstrate the existence of a non-linear U-shape relationship between age and willingness to get vaccinated: increasing age reduces the risks of being either vaccine resistant or vaccine hesitant compared to conditional acceptance but after certain age the effect turns around. Number of underaged children (RRR=0.817) as well as living in a city (RRR=0.533) also reduce the chances of certain vaccine acceptance compared to conditional acceptance, while employment (RRR=1.310) increases these chances. Gender, marital status, unemployment, and income are statistically unrelated to vaccination attitudes.

Second, among behavioral and personality factors, the increased risk of being vaccine resistant compared to conditional acceptance is associated with higher levels of agreeableness (RRR=1.066), neuroticism (RRR=1.150), risk loving (RRR=1.168), being both a non-believer (RRR=1.397) and a believer (RRR=1.355) compared to occasionally going to religious services. At the same time, conscientiousness (RRR=0.841) and neuroticism (RRR=0.910) are the only psychological factors associated with the risks of being vaccine hesitant compared to conditional acceptance: both higher levels of conscientiousness and neuroticism reduce the risk of hesitancy. Being more agreeable (RRR=1.261), less extraverted (RRR=0.903), and a non-believer (RRR=1.200) increases the chances of certain acceptance compared to conditional acceptance. In line with previous research, openness to experiences turned out to be statistically insignificant for willingness to receive vaccination.

Third, general trust and frequency of social media use are both associated with the risks of being vaccine resistant compared to conditionally accepting: trust in people reduces the risks (RRR=0.741), while spending time in social networks weakly increases the risks of resistance (RRR=1.004). General trust also increases the risk of vaccination hesitancy (RRR=1.381) but is statistically insignificant for certain acceptance. On the contrary, social media use reduces the chances of being certainly accepting (RRR=0.984) but is insignificant for hesitancy compared to conditional acceptance. The model with trust in public institutions further suggests that trust in government increases the chances of certain acceptance (RRR=1.144) and reduces the risks of both resistance (RRR=0.721) and hesitancy (RRR=0.898) compared to conditional acceptance.

Ultimately, self-related health ended up being an important predictor of vaccination attitudes. The increased risk of being vaccine resistant compared to conditional acceptance is associated with very bad (RRR=2.216) or very good (RRR=2.183) state of health. While having experienced COVID-19 in the past (RRR=1.846) as well as living in a region with worse epidemiologic situation (RRR=1.146) increase the risk of vaccine resistance compared to conditional acceptance, having a friend or a relative who has experienced COVID-19 (RRR=0.819) or perceiving high risks of COVID-19 infection (RRR=0.850) reduce this risk. Having bad (RRR=1.245) and very bad health condition (RRR=2.074) as well as perceiving high risks of infection (RRR=1.065) increase the risks of being vaccine hesitant compared to conditional acceptance, though the links are relatively weak. Being in a very good health condition (RRR=4.351) as well as experiencing COVID-19 in the past (RRR=2.169) both increase the chances of certain vaccine acceptance compared to conditional acceptance.

#### *Gender differences in factors*

Although previous studies state that gender is associated with vaccination intentions, little attention is given to gender differences in determinants of vaccination attitudes. We further highlight the most notable results (see Table 6 in Appendix for full results).

Unlike the overall sample, age is not significant for vaccination resistance among males. Number of children is only significantly correlated with vaccination intentions among females, reducing the chances of certain acceptance (RRR=0.804) and hesitancy (RRR=0.813) compared to conditional acceptance. Presence of elderly family members is positively associated with health-protective behavior in both genders, however, for men it reduces the chances of any attitudes other than conditional acceptance, while for women it increases the chances of certain acceptance (RRR=1.266) compared to conditional acceptance. Interestingly, education turned out to be significant only on female subsample – both vocational and higher education reduce the chances of vaccination resistance (RRR=0.796 and RRR=0.844, respectively) compared to conditional acceptance. Behavioral and psychological factors appear to have similar associations with vaccination attitudes in both genders. Extraversion is only significant in male sample reducing the chances of certain acceptance compared to conditional acceptance (RRR=0.854), while agreeableness among men is only related to certain acceptance and not to resistance as observed in the overall sample (RRR=1.294). Being religious appears to be more strongly correlated with vaccination attitudes in females increasing risks of vaccination resistance compared to conditional acceptance (RRR=1.550). Higher general level of trust is associated with increased risks of vaccine hesitancy compared to conditional acceptance only for females (RRR=1.560), simultaneously decreasing risks of vaccination resistance both in males (RRR=0.697) and females (0.766). Frequency of social media use slightly reduces certain acceptance for females (RRR=0.979) and increases resistance for males (RRR=1.008), which in both cases mean reduction in healthy and rational behavior. Finally, very bad health increase chances of resistance only for females (RRR=2.715), very good increases resistance for males and both certain acceptance (7.575) and resistance (RRR=1.886) for females, though the positive effect is stronger both in terms of the size and statistical significance.

## **Discussion**

This is the first nationally representative study conducted in Russia which explores the scope of vaccine acceptance and the potential determinants of vaccine hesitancy and resistance. By focusing on vaccine hesitancy and resistance, we look at the part of the population which is the hardest to persuade to get a vaccine shot. We find that prior to COVID-19 vaccination rollout in Russia, vaccination acceptance was quite low (45%) and resistance was quite high (43%) compared to other countries (Lazarus et al., 2021). The layer of hesitant individuals who can be persuaded through targeted information policy is rather low (13%), leaving very little room for policy maneuver.

We find that education is positively related to vaccination acceptance in Russia, while age demonstrates a non-linear relationship with vaccination intentions. Higher levels of education were previously reported to be significantly correlated with positive attitudes towards vaccination in other countries (Fisher et al. 2020;), while multiple studies also highlighted that younger groups of individuals are less determined to get vaccinated (Fisher et al. 2020; Lazarus et al. 2021; McElfish et al. 2021). Family composition, namely number of children and presence of elderly family members predict lower risks of hesitancy relative to acceptance. Gender, marital status, and income are not related to vaccination intentions. Previous literature is inconsistent, sometimes showing females and low-income individuals being more hesitant towards vaccination (Lazarus et al. 2021).

Health-related factors appear to be strong predictors of vaccination intentions with better health simultaneously increasing the probability of acceptance and vaccination resistance. Individuals with bad self-rated health tend to overestimate the importance of side effects and have high risks of being resistant and hesitant. Perceived risk of infection appeared to be an important factor reducing the risks of being vaccine resistant. Experiencing COVID-19 in the past simultaneously increases the risks of vaccine resistance and acceptance probably depending on the severity of the case. Previous studies indicated that COVID-19 related experiences are not associated with any vaccination attitudes (Khaled et al. 2021; Lazarus et al. 2021), however, perceived risks of infection appear to be consistently positively related to vaccination intentions

against various diseases, including coronavirus (Fisher et al. 2020; Brewer et al. 2007; Karlsson et al. 2021). Finally, we explored gender differences in vaccination determinants. Although some factors appear to be significant for vaccination attitudes in one gender and not significant in another, the effects in both genders tend to head in the same direction, either being associated with protective health behaviors (i.e., increasing the chances of certain acceptance or/and decreasing the chances of resistance and hesitancy) or with risky health behavior (i.e., decreasing the chances of certain acceptance or/and increasing the chances of resistance and hesitancy).

Since we use data that were collected in September-January 2020 before the launch of the nationwide vaccination campaign, the obtained results reflect the baseline attitudes towards COVID-19 immunization which significantly affect the advancement of the vaccination process. Our aim was to measure the root causes and mental attitudes associated with vaccination such as psychological traits, religiosity, and trust in other people and public institutions. These factors do not depend neither on the availability, nor on the characteristics of a particular vaccine and have nothing to do with scientific evidence. These root causes are the hardest to control and to shape, especially in case of emergency such as COVID-19 pandemic. We find that behavioral and psychological factors are very important predictors of vaccination intentions. The key element of vaccination acceptance is trust in other people and in public institutions since trust in a particular vaccine cannot be developed on its own without proper environment. Lack of trust is a systematic problem explaining why Russia remains reluctant towards COVID-19 vaccination. We found that trust in public institutions increases the chances of vaccine acceptance, reducing the risks of resistance and hesitancy which is a result supported by the empirical literature (Lazarus et al. 2021) and theoretical framework (Betsch et al., 2018): trust in vaccination supplier (i.e., the government and the public system) increases the probability of vaccination no matter what vaccine is in question. We also find that frequent use of social networks is negatively associated with certain acceptance of vaccination suggesting that mistrust pushes people to search for independent sources of information such as social networks with prevalence of antivaccination rhetoric. Finally, our analysis suggests that personality traits, primarily agreeableness, neuroticism, and risk attitudes increase the chances of vaccine resistance, while conscientiousness as a productive characteristic reduces the risk of hesitancy compared to conditional acceptance. While the results concerning the Big Five are in line with the existing literature (Murphy et al., 2021), the relationship between risk attitudes and vaccination intention has not been previously assessed for general population. However, we do not find strong evidence for the association between religiosity and vaccination resistance as suggested by previous literature (Olagoke et al., 2020). Both individuals never visiting religious services and visiting them regularly demonstrate higher risks of being vaccine resistant compared to the average group of people who occasionally visit religious services.

The factors associated with vaccine hesitancy and resistance are not unique to COVID-19. There are systematic problems in vaccine attitudes that are vital not only for current situation but for years to come as well. The main question is what policy interventions should be implemented in order to achieve larger vaccine coverage. These interventions should be divided into short-run and long-run measures. We recognize several groups at risk that should be targeted by the vaccination campaign in the short run. These are individuals with bad health, risk loving and with low perceived risks of getting COVID-19 at the same time, living in Moscow and Saint Petersburg or other regions with high morbidity rates, and frequently using social media. The issue is that vaccine resistant and hesitant groups do not consider COVID-19 a severe illness and do not perceive themselves susceptible to the disease. These health beliefs (severity and susceptibility) should be influenced by targeted interventions. The long-run solution to vaccination hesitancy and resistance requires the development of trust in public institutions in general.

### **Limitations**

There are several limitations to the current study that can be addressed in the future work. Firstly, our data cover an early pre-vaccination period when neither vaccine itself, nor vaccine-

related information was yet available to the public. However, our study explores the general mindset and captures the attitudes important for the development of policy measures. Secondly, since the respondents were asked about their intent to get vaccinated at the time when neither vaccination, nor information about future vaccines were available, learning more details about the vaccines potentially could change their attitudes. Therefore, our estimates of vaccination intention might differ from the real uptake. Third, our data lack information about important factors which can affect hesitancy and resistance in case of the COVID-19 vaccine. These are trust towards vaccines in general, trust in health professionals, previous experiences with vaccines, and self-valuation of health.

### **Conclusion**

High and rising levels of COVID-19 vaccination hesitancy and refusal pose a threat to public health amidst the emergence of new contagious variants of the coronavirus. It is necessary to understand the reasons behind negative attitudes to vaccination to tailor communication and vaccination campaigns. In Russia, one of the countries most affected by the pandemic in terms of the public health, rapid vaccination-related actions are crucial. Our findings suggest that 43% of the Russian adult population is resistant towards vaccination, while 13% is hesitant. Vaccination attitudes depend on age, family composition, education, type of settlement, employment, self-perceived health condition, previous COVID-19 experience, and self-perceived risk of getting infected. The results also state that personality traits, risk attitudes, and trust reflect the deep-rooted causes of vaccination attitudes and predict vaccination intentions.

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### **Conflict of interests**

None to declare

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## Appendix

**Table 1. The Big Five Questionary**

|  |
|--|
| <b>Openness</b>  |
| Do you come up with ideas other people haven't thought of before?                                |
| Are you very interested in learning new things?  |
| Do you enjoy beautiful things, like nature, art and music?                                       |
| <b>Conscientiousness</b>   |
| When doing a task, are you very careful?   |
| Do you finish whatever you begin?  |
| Do you work very hard? For example, do you keep working when others stop to take a break?        |
| Do you prefer relaxation more than hard work?*   |
| Do you enjoy working on things that take a very long time (at least several months) to complete? |
| Do you work very well and quickly?   |
| Do you think carefully before you make an important decision?                                    |
| <b>Extraversion</b>  |
| Are you talkative?   |
| Do you prefer to keep your opinion to yourself?*   |
| Are you outgoing and sociable, for example, do you make friends very easily?                     |
| <b>Agreeableness</b>   |
| Do you forgive other people easily?  |
| Are you very polite to other people?   |
| Are you generous to other people with your time or money?  |
| Do you ask for help when you don't understand something?   |
| <b>Neuroticism</b>   |
| Do people take advantage of you?   |
| Do you tend to worry?  |
| Do you think about how the things you do will affect you in the future? *                        |
| Are you relaxed during stressful situations?*  |
| Do you get nervous easily?   |
| Are people mean/not nice to you?   |
| Do you think about how the things you do will affect other?*                                     |

Note: (\*) the scale in the marked questions was not reversed for the sake of coherence with other components of the category

**Table 2.** Mean values for explanatory variables across vaccination intentions

|  | <b>Certain<br/>acceptance<br/>(N=881)</b> | <b>Conditional<br/>acceptance<br/>(N=3473)</b> | <b>Resistance<br/>(N=4069)</b> | <b>Hesitancy<br/>(N=1274)</b> | <b>Total<br/>(N=9697)</b> |
|--|---|--|--------------------------------|-------------------------------|---------------------------|
| <b>Demographic and socio-economic factors</b>          |   |  |                                |                               |                           |
| Male   | 0.44                                      | 0.44   | 0.45                           | 0.47                          | 0.45                      |
| Age /10  | 4.56                                      | 4.50   | 4.65                           | 4.63                          | 4.59                      |
| Age squared /100                                       | 23.8                                      | 23.0   | 24.9                           | 25.1                          | 24.2                      |
| Married  | 0.57                                      | 0.61   | 0.57                           | 0.56                          | 0.58                      |
| Number of children under 18                            | 0.38                                      | 5.71   | 5.50                           | 0.36                          | 4.48                      |
| Presence of elderly family members 65+                 | 0,29                                      | 0,29   | 0,25                           | 0,24                          | 0,26                      |
| Vocational college                                     | 0.27                                      | 0.25   | 0.22                           | 0.24                          | 0.24                      |
| University education                                   | 0.30                                      | 0.29   | 0.27                           | 0.24                          | 0.28                      |
| Employed   | 0.67                                      | 0.65   | 0.59                           | 0.60                          | 0.62                      |
| Unemployed   | 0.02                                      | 0.02   | 0.02                           | 0.02                          | 0.02                      |
| Student  | 0.07                                      | 0.06   | 0.07                           | 0.07                          | 0.06                      |
| Ln household per capita income                         | 9.61                                      | 9.50   | 9.60                           | 9.47                          | 9.55                      |
| Moscow and Saint-Petersburg                            | 0.09                                      | 0.07   | 0.15                           | 0.15                          | 0.12                      |
| Regional center  | 0.35                                      | 0.31   | 0.31                           | 0.29                          | 0.31                      |
| City   | 0.20                                      | 0.27   | 0.24                           | 0.25                          | 0.25                      |
| Village  | 0.36                                      | 0.35   | 0.30                           | 0.31                          | 0.32                      |
| <b>Behavioral patterns and personality traits</b>      |   |  |                                |                               |                           |
| Openness to experience                                 | 0.047                                     | 0.016  | 0.015                          | -0.124                        | 0.000                     |
| Conscientiousness                                      | 0.108                                     | 0.041  | 0.001                          | -0.186                        | 0.000                     |
| Extraversion   | -0.014                                    | 0.023  | 0.007                          | -0.075                        | 0.000                     |
| Agreeableness  | 0.151                                     | -0.022   | 0.025                          | -0.112                        | 0.000                     |
| Neuroticism  | -0.031                                    | -0.037   | 0.068                          | -0.103                        | 0.000                     |
| Risk loving  | -0.070                                    | -0.048   | 0.074                          | -0.067                        | 0.000                     |
| Never visits religious services/non-believer           | 0.43                                      | 0.39   | 0.47                           | 0.44                          | 0.43                      |
| Visits religious services several times a year or less | 0.53                                      | 0.57   | 0.48                           | 0.52                          | 0.52                      |
| Visits religious services once a month or more         | 0.04                                      | 0.04   | 0.05                           | 0.04                          | 0.05                      |
| <b>Trust</b>   |   |  |                                |                               |                           |
| Trust in public institutions                           | 0.245                                     | 0.175  | -0.205                         | 0.009                         | 0.000                     |
| General trust  | 0.419                                     | 0.433  | 0.379                          | 0.461                         | 0.412                     |
| Frequency of social media use (times a month)          | 14.8                                      | 16.8   | 16.9                           | 15.5                          | 16.5                      |
| <b>Health and COVID-19 experience</b>                  |   |  |                                |                               |                           |
| Self-rated health - very bad                           | 0.00                                      | 0.00   | 0.01                           | 0.01                          | 0.01                      |
| Self-rated health - bad                                | 0.07                                      | 0.08   | 0.09                           | 0.12                          | 0.09                      |
| Self-rated health - average                            | 0.47                                      | 0.46   | 0.49                           | 0.46                          | 0.48                      |
| Self-rated health - good                               | 0.41                                      | 0.44   | 0.38                           | 0.40                          | 0.41                      |
| Self-rated health - very good                          | 0.05                                      | 0.01   | 0.03                           | 0.01                          | 0.02                      |
| Had positive COVID-19 bodies or antibodies             | 0.04                                      | 0.02   | 0.04                           | 0.02                          | 0.03                      |
| COVID-19 case among family members                     | 0.03                                      | 0.03   | 0.04                           | 0.04                          | 0.04                      |
| COVID-19 case among acquaintances                      | 0.58                                      | 0.58   | 0.55                           | 0.56                          | 0.56                      |
| Regional 7-day moving average of incidence rate        | 0.934                                     | 0.954  | 1.125                          | 1.076                         | 1.042                     |
| Self-perceived probability to get infected             | 0.111                                     | 0.100  | -0.137                         | 0.107                         | 0.000                     |

**Table 3.** Determinants of vaccination attitudes, base outcome – conditional acceptance, RRR

|  | Certain acceptance          | Resistance                  | Hesitancy                   |
|--|-----------------------------|-----------------------------|-----------------------------|
| <b>Demographic and socio-economic factors</b>                |                             |                             |                             |
| Male   | 0.900<br>(0.0899)           | 0.959<br>(0.0567)           | 0.996<br>(0.0870)           |
| Age/10   | 0.840<br>(0.148)            | <b>0.806**</b><br>(0.0835)  | <b>0.503***</b><br>(0.0713) |
| Age squared /100   | 1.016<br>(0.0175)           | <b>1.032***</b><br>(0.0103) | <b>1.072***</b><br>(0.0143) |
| Married  | 0.950<br>(0.0930)           | 0.973<br>(0.0578)           | 1.055<br>(0.0968)           |
| Number of children under 18                                  | <b>0.817***</b><br>(0.0564) | 1.000<br>(0.000100)         | <b>0.838***</b><br>(0.0525) |
| Presence of elderly family members 65+                       | 1.013<br>(0.0841)           | <b>0.859***</b><br>(0.0455) | <b>0.835**</b><br>(0.0647)  |
| Vocational college   | 1.162<br>(0.127)            | <b>0.820***</b><br>(0.0554) | 0.900<br>(0.0866)           |
| University education   | 1.118<br>(0.128)            | <b>0.873**</b><br>(0.0587)  | 0.837*<br>(0.0831)          |
| Employed   | <b>1.310**</b><br>(0.159)   | 0.944<br>(0.0710)           | 1.143<br>(0.126)            |
| Unemployed   | 0.960<br>(0.357)            | 0.971<br>(0.194)            | 0.930<br>(0.281)            |
| Student  | 1.066<br>(0.292)            | 0.854<br>(0.145)            | 0.619*<br>(0.152)           |
| Ln household per capita income                               | 1.005<br>(0.0349)           | 1.009<br>(0.0194)           | 0.972<br>(0.0249)           |
| Regional center (base outcome – Moscow and Saint Petersburg) | 0.850<br>(0.187)            | <b>0.641***</b><br>(0.0772) | <b>0.445***</b><br>(0.0746) |
| City   | <b>0.533***</b><br>(0.121)  | <b>0.562***</b><br>(0.0701) | <b>0.454***</b><br>(0.0778) |
| Village  | 0.813<br>(0.179)            | <b>0.586***</b><br>(0.0735) | <b>0.454***</b><br>(0.0797) |
| <b>Behavioral patterns and personality traits</b>            |                             |                             |                             |
| Openness to experience                                       | 0.953<br>(0.0521)           | 1.008<br>(0.0332)           | 1.028<br>(0.0472)           |
| Conscientiousness  | 1.027<br>(0.0577)           | 1.016<br>(0.0338)           | <b>0.841***</b><br>(0.0398) |
| Extraversion   | <b>0.903**</b><br>(0.0457)  | 0.974<br>(0.0280)           | 0.947<br>(0.0411)           |
| Agreeableness  | <b>1.261***</b><br>(0.0677) | <b>1.066**</b><br>(0.0333)  | 0.961<br>(0.0443)           |
| Neuroticism  | 1.069<br>(0.0523)           | <b>1.150***</b><br>(0.0334) | <b>0.910**</b><br>(0.0377)  |
| Risk loving  | 1.006<br>(0.0495)           | <b>1.168***</b><br>(0.0333) | 1.008<br>(0.0450)           |
| Never visits religious services/non-believer                 | 1.200*<br>(0.115)           | <b>1.397***</b><br>(0.0800) | 1.139<br>(0.0945)           |
| Visits religious services once a month or more               | 0.945<br>(0.198)            | <b>1.355**</b><br>(0.164)   | 0.860<br>(0.167)            |
| <b>Trust</b>   |                             |                             |                             |
| General trust  | 0.827                       | <b>0.741***</b>             | <b>1.381***</b>             |

|   |                 |                 |           |
|---|-----------------|-----------------|-----------|
|   | (0.103)         | (0.0544)        | (0.142)   |
| Frequency of social media use (times a month)   | <b>0.984***</b> | 1.004*          | 0.998     |
|   | (0.00382)       | (0.00227)       | (0.00339) |
| <b>Health and COVID-19 experiences</b>          |                 |                 |           |
| Self-rated health - very bad                    | 0.837           | <b>2.216**</b>  | 2.074*    |
|   | (0.672)         | (0.773)         | (0.899)   |
| Self-rated health - bad                         | 0.815           | 0.909           | 1.245*    |
|   | (0.139)         | (0.0852)        | (0.163)   |
| Self-rated health - good                        | 1.059           | 0.915           | 0.940     |
|   | (0.110)         | (0.0582)        | (0.0897)  |
| Self-rated health - very good                   | <b>4.351***</b> | <b>2.183***</b> | 0.578     |
|   | (1.251)         | (0.502)         | (0.269)   |
| Had positive COVID-19 bodies or antibodies      | <b>2.169***</b> | <b>1.846***</b> | 0.905     |
|   | (0.564)         | (0.311)         | (0.238)   |
| COVID-19 case among family members              | 1.018           | 1.144           | 1.218     |
|   | (0.272)         | (0.183)         | (0.267)   |
| COVID-19 case among acquaintances               | 0.903           | <b>0.819***</b> | 0.881     |
|   | (0.0840)        | (0.0462)        | (0.0728)  |
| Regional 7-day moving average of incidence rate | 0.881           | <b>1.146***</b> | 1.086     |
|   | (0.0826)        | <b>(0.0523)</b> | (0.0723)  |
| Self-perceived probability to get infected      | 1.019           | <b>0.850***</b> | 1.065*    |
|   | (0.0459)        | <b>(0.0233)</b> | (0.0394)  |
| Constant  | 0.597           | 2.415**         | 3.704***  |
|   | (0.383)         | (0.887)         | (1.868)   |

N = 8.533

Wald chi2(102) = 706.33

Prob > chi2 = 0.0000

Log pseudolikelihood = -9671.8264

Pseudo R2 = 0.0400

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

**Table 4.** Determinants of vaccination attitudes, including trust in public institutions, base outcome – conditional acceptance, RRR

|  | Certain acceptance          | Resistance                  | Hesitancy                   |
|--|-----------------------------|-----------------------------|-----------------------------|
| <b>Demographic and socio-economic factors</b>                |                             |                             |                             |
| Male   | 0.913<br>(0.0984)           | 0.905<br>(0.0593)           | 0.940<br>(0.0909)           |
| Age/10   | 0.811<br>(0.163)            | <b>0.766**</b><br>(0.0899)  | <b>0.504***</b><br>(0.0815) |
| Age squared /100   | 1.017<br>(0.0199)           | <b>1.038***</b><br>(0.0116) | <b>1.072***</b><br>(0.0160) |
| Married  | 1.012<br>(0.112)            | 0.988<br>(0.0655)           | 1.032<br>(0.106)            |
| Number of children under 18                                  | <b>0.832**</b><br>(0.0635)  | <b>1.000</b><br>(9.82e-05)  | <b>0.831***</b><br>(0.0596) |
| Presence of elderly family members 65+                       | 1.012<br>(0.0903)           | 0.918<br>(0.0534)           | 0.908<br>(0.0758)           |
| Vocational college   | 1.196<br>(0.142)            | <b>0.828**</b><br>(0.0618)  | 0.905<br>(0.0960)           |
| University education   | 1.094<br>(0.136)            | 0.906<br>(0.0682)           | 0.858<br>(0.0947)           |
| Employed   | <b>1.375**</b><br>(0.185)   | 0.956<br>(0.0798)           | <b>1.232*</b><br>(0.153)    |
| Unemployed   | 0.620<br>(0.313)            | 0.903<br>(0.208)            | 0.756<br>(0.278)            |
| Student  | 1.018<br>(0.328)            | 0.953<br>(0.192)            | 0.650<br>(0.190)            |
| Ln household per capita income                               | 1.010<br>(0.0394)           | 1.007<br>(0.0229)           | <b>0.954*</b><br>(0.0264)   |
| Regional center (base outcome – Moscow and Saint Petersburg) | 0.901<br>(0.239)            | <b>0.687**</b><br>(0.106)   | <b>0.442***</b><br>(0.0933) |
| City   | <b>0.511**</b><br>(0.139)   | <b>0.664**</b><br>(0.106)   | <b>0.488***</b><br>(0.109)  |
| Village  | 0.841<br>(0.220)            | <b>0.706**</b><br>(0.111)   | <b>0.448***</b><br>(0.0997) |
| <b>Behavioral patterns and personality traits</b>            |                             |                             |                             |
| Openness to experience                                       | 0.976<br>(0.0611)           | 0.970<br>(0.0354)           | 1.018<br>(0.0519)           |
| Conscientiousness  | 0.991<br>(0.0607)           | 1.009<br>(0.0374)           | <b>0.816***</b><br>(0.0435) |
| Extraversion   | <b>0.886**</b><br>(0.0498)  | 0.968<br>(0.0311)           | 0.944<br>(0.0454)           |
| Agreeableness  | <b>1.271***</b><br>(0.0726) | <b>1.096***</b><br>(0.0384) | 0.982<br>(0.0503)           |
| Neuroticism  | 1.058<br>(0.0571)           | <b>1.145***</b><br>(0.0369) | <b>0.913*</b><br>(0.0429)   |
| Risk loving  | 0.950<br>(0.0502)           | <b>1.193***</b><br>(0.0390) | 1.048<br>(0.0526)           |
| Never visits religious services/non-believer                 | <b>1.298**</b><br>(0.137)   | <b>1.368***</b><br>(0.0873) | <b>1.186*</b><br>(0.110)    |
| Visits religious services once a month or more               | 1.085<br>(0.249)            | <b>1.427***</b><br>(0.190)  | 0.816<br>(0.186)            |
| <b>Trust</b>   |                             |                             |                             |

|   |                             |                             |                            |
|---|-----------------------------|-----------------------------|----------------------------|
| General trust                                   | <b>0.691***</b><br>(0.0934) | <b>0.848**</b><br>(0.0692)  | <b>1.318**</b><br>(0.150)  |
| Trust in public institutions                    | <b>1.144**</b><br>(0.0612)  | <b>0.721***</b><br>(0.0233) | <b>0.898**</b><br>(0.0404) |
| Frequency of social media use (times a month)   | 0.985***<br>(0.00416)       | 1.004<br>(0.00250)          | 0.998<br>(0.00379)         |
| <b>Health and COVID-19 experiences</b>          |                             |                             |                            |
| Self-rated health - very bad                    | 0.846<br>(0.682)            | <b>2.190**</b><br>(0.786)   | 1.645<br>(0.777)           |
| Self-rated health - bad                         | 0.823<br>(0.150)            | 0.855<br>(0.0867)           | <b>1.281*</b><br>(0.181)   |
| Self-rated health - good                        | 0.969<br>(0.113)            | 0.987<br>(0.0702)           | 0.982<br>(0.107)           |
| Self-rated health - very good                   | <b>4.187***</b><br>(1.319)  | <b>2.314***</b><br>(0.631)  | 0.635<br>(0.326)           |
| Had positive COVID-19 bodies or antibodies      | <b>2.226***</b><br>(0.649)  | <b>1.697***</b><br>(0.324)  | 0.839<br>(0.265)           |
| COVID-19 case among family members              | 1.053<br>(0.313)            | 1.166<br>(0.207)            | 0.883<br>(0.244)           |
| COVID-19 case among acquaintances               | 0.981<br>(0.102)            | <b>0.807***</b><br>(0.0503) | 0.875<br>(0.0795)          |
| Regional 7-day moving average of incidence rate | 0.903<br>(0.118)            | <b>1.225***</b><br>(0.0810) | 1.063<br>(0.0996)          |
| Self-perceived probability to get infected      | 1.033<br>(0.0522)           | <b>0.859***</b><br>(0.0269) | 1.071<br>(0.0451)          |
| Constant  | 0.567<br>(0.408)            | 1.967<br>(0.860)            | <b>4.215**</b><br>(2.516)  |

N = 7.018

Wald chi2(105) = 717.83

Prob > chi2 = 0.0000

Log pseudolikelihood = -7742.2971

Pseudo R2 = 0.0515

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



**Table 5.** Determinants of vaccination attitudes, base outcome – resistance, RRR

|  | Certain acceptance          | Conditional acceptance       | Hesitancy                   |
|--|-----------------------------|------------------------------|-----------------------------|
| <b>Demographic and socio-economic factors</b>                |                             |                              |                             |
| Male   | 0.938<br>(0.0925)           | 1.042<br>(0.0617)            | 1.038<br>(0.0889)           |
| Age/10   | 1.042<br>(0.180)            | <b>1.241**</b><br>(0.129)    | <b>0.625***</b><br>(0.0853) |
| Age squared /100   | 0.985<br>(0.0166)           | <b>0.969***</b><br>(0.00968) | <b>1.039***</b><br>(0.0132) |
| Married  | 0.977<br>(0.0942)           | 1.028<br>(0.0611)            | 1.084<br>(0.0977)           |
| Number of children under 18                                  | <b>0.817***</b><br>(0.0564) | 1.000<br>(0.000100)          | <b>0.838***</b><br>(0.0525) |
| Presence of elderly family members 65+                       | <b>1.179**</b><br>(0.0972)  | <b>1.164***</b><br>(0.0616)  | 0.973<br>(0.0747)           |
| Vocational college   | <b>1.417***</b><br>(0.154)  | <b>1.220***</b><br>(0.0825)  | 1.098<br>(0.105)            |
| University education   | <b>1.280**</b><br>(0.144)   | <b>1.145**</b><br>(0.0771)   | 0.959<br>(0.0936)           |
| Employed   | <b>1.387***</b><br>(0.166)  | 1.059<br>(0.0797)            | <b>1.210*</b><br>(0.131)    |
| Unemployed   | 0.988<br>(0.362)            | 1.029<br>(0.206)             | 0.957<br>(0.285)            |
| Student  | 1.249<br>(0.336)            | 1.171<br>(0.199)             | 0.725<br>(0.173)            |
| Ln household per capita income                               | 0.996<br>(0.0346)           | 0.991<br>(0.0191)            | 0.963<br>(0.0243)           |
| Regional center (base outcome – Moscow and Saint Petersburg) | 1.325<br>(0.279)            | <b>1.559***</b><br>(0.188)   | <b>0.694**</b><br>(0.108)   |
| City   | 0.948<br>(0.207)            | <b>1.780***</b><br>(0.222)   | 0.808<br>(0.129)            |
| Village  | 1.387<br>(0.292)            | <b>1.705***</b><br>(0.214)   | 0.774<br>(0.126)            |
| <b>Behavioral patterns and personality traits</b>            |                             |                              |                             |
| Openness to experience                                       | 0.945<br>(0.0518)           | 0.992<br>(0.0327)            | 1.020<br>(0.0468)           |
| Conscientiousness  | 1.011<br>(0.0561)           | 0.984<br>(0.0327)            | <b>0.827***</b><br>(0.0384) |
| Extraversion   | 0.927<br>(0.0462)           | 1.027<br>(0.0295)            | 0.973<br>(0.0415)           |
| Agreeableness  | <b>1.183***</b><br>(0.0626) | <b>0.938**</b><br>(0.0293)   | <b>0.902**</b><br>(0.0411)  |
| Neuroticism  | 0.929<br>(0.0454)           | <b>0.870***</b><br>(0.0253)  | <b>0.791***</b><br>(0.0326) |
| Risk loving  | <b>0.862***</b><br>(0.0418) | <b>0.857***</b><br>(0.0244)  | <b>0.863***</b><br>(0.0380) |
| Never visits religious services/non-believer                 | 0.859<br>(0.0812)           | <b>0.716***</b><br>(0.0410)  | <b>0.816**</b><br>(0.0662)  |
| Visits religious services once a month or more               | <b>0.697*</b><br>(0.142)    | <b>0.738**</b><br>(0.0894)   | <b>0.634**</b><br>(0.119)   |
| <b>Trust</b>   |                             |                              |                             |
| General trust  | 1.116                       | <b>1.350***</b>              | <b>1.864***</b>             |

|   |                 |                 |                 |
|---|-----------------|-----------------|-----------------|
|   | (0.136)         | (0.0991)        | (0.188)         |
| Frequency of social media use (times a month)   | <b>0.981***</b> | <b>0.996*</b>   | <b>0.994*</b>   |
|   | (0.00374)       | (0.00225)       | (0.00332)       |
| <b>Health and COVID-19 experiences</b>          |                 |                 |                 |
| Self-rated health - very bad                    | 0.378           | <b>0.451**</b>  | 0.936           |
|   | (0.286)         | (0.157)         | (0.343)         |
| Self-rated health - bad                         | 0.897           | 1.101           | <b>1.370**</b>  |
|   | (0.150)         | (0.103)         | (0.174)         |
| Self-rated health - good                        | 1.158           | 1.093           | 1.028           |
|   | (0.120)         | (0.0696)        | (0.0971)        |
| Self-rated health - very good                   | <b>1.993***</b> | <b>0.458***</b> | <b>0.265***</b> |
|   | (0.488)         | (0.105)         | (0.118)         |
| Had positive COVID-19 bodies or antibodies      | 1.175           | <b>0.542***</b> | <b>0.490***</b> |
|   | (0.291)         | (0.0914)        | (0.122)         |
| COVID-19 case among family members              | 0.890           | 0.874           | 1.065           |
|   | (0.234)         | (0.140)         | (0.231)         |
| COVID-19 case among acquaintances               | 1.102           | <b>1.221***</b> | 1.076           |
|   | (0.101)         | (0.0688)        | (0.0871)        |
| Regional 7-day moving average of incidence rate | <b>0.769***</b> | <b>0.873***</b> | 0.948           |
|   | (0.0701)        | (0.0398)        | (0.0589)        |
| Self-perceived probability to get infected      | <b>1.199***</b> | <b>1.176***</b> | <b>1.252***</b> |
|   | (0.0549)        | (0.0322)        | (0.0474)        |
| Constant  | <b>0.247**</b>  | <b>0.414**</b>  | 1.534           |
|   | (0.155)         | (0.152)         | (0.739)         |

N = 8.533

Wald chi2(102) = 706.33

Prob > chi2 = 0.0000

Log pseudolikelihood = -9671.8264

Pseudo R2 = 0.0400

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

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

**Table 6.** Determinants of vaccination attitudes by gender, base outcome – conditional acceptance, RRR

|  | Certain<br>acceptance     | Male<br>Resistance          | Hesitancy                   | Certain<br>acceptance      | Female<br>Resistance        | Hesitancy                   |
|--|---------------------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|-----------------------------|
| <b>Demographic and socio-economic factors</b>                |                           |                             |                             |                            |                             |                             |
| Age/10   | 0.714<br>(0.214)          | 1.054<br>(0.183)            | <b>0.644*</b><br>(0.149)    | 0.867<br>(0.197)           | <b>0.647***</b><br>(0.0862) | <b>0.426***</b><br>(0.0792) |
| Age squared /100   | 1.033<br>(0.0316)         | 1.005<br>(0.0172)           | <b>1.040*</b><br>(0.0233)   | 1.013<br>(0.0219)          | <b>1.052***</b><br>(0.0133) | <b>1.093***</b><br>(0.0187) |
| Married  | 1.014<br>(0.183)          | 1.099<br>(0.117)            | 0.991<br>(0.154)            | 0.906<br>(0.109)           | 0.883<br>(0.0668)           | 1.129<br>(0.134)            |
| Number of children under 18                                  | 0.856<br>(0.0869)         | 1.000<br>(0.000155)         | 0.861<br>(0.0809)           | <b>0.804**</b><br>(0.0753) | 1.000<br>(0.000125)         | <b>0.813**</b><br>(0.0679)  |
| Presence of elderly family members 65+                       | <b>0.733**</b><br>(0.102) | <b>0.792***</b><br>(0.0650) | <b>0.731***</b><br>(0.0884) | <b>1.266**</b><br>(0.134)  | 0.931<br>(0.0656)           | 0.946<br>(0.0969)           |
| Vocational college   | 0.861<br>(0.162)          | 0.866<br>(0.0938)           | 0.996<br>(0.152)            | <b>1.369**</b><br>(0.191)  | <b>0.796***</b><br>(0.0693) | 0.823<br>(0.102)            |
| University education   | 1.233<br>(0.213)          | 0.898<br>(0.0957)           | 1.013<br>(0.156)            | 1.055<br>(0.162)           | <b>0.844*</b><br>(0.0745)   | <b>0.716***</b><br>(0.0923) |
| Employed   | 1.087<br>(0.238)          | 0.883<br>(0.119)            | 1.042<br>(0.192)            | <b>1.490***</b><br>(0.218) | 0.975<br>(0.0897)           | 1.192<br>(0.167)            |
| Unemployed   | 0.879<br>(0.525)          | 0.959<br>(0.303)            | 1.032<br>(0.454)            | 1.032<br>(0.492)           | 0.937<br>(0.246)            | 0.788<br>(0.332)            |
| Student  | 0.896<br>(0.384)          | 1.167<br>(0.302)            | 0.702<br>(0.253)            | 1.169<br>(0.420)           | <b>0.618**</b><br>(0.143)   | <b>0.556*</b><br>(0.191)    |
| Ln household per capita income                               | 0.985<br>(0.0475)         | 1.021<br>(0.0306)           | 0.962<br>(0.0349)           | 1.032<br>(0.0517)          | 0.999<br>(0.0245)           | 0.988<br>(0.0367)           |
| Regional center (base outcome – Moscow and Saint Petersburg) | 0.699<br>(0.250)          | <b>0.588***</b><br>(0.111)  | <b>0.420***</b><br>(0.107)  | 0.977<br>(0.271)           | <b>0.676**</b><br>(0.107)   | <b>0.469***</b><br>(0.105)  |
| City   | <b>0.512*</b><br>(0.185)  | <b>0.608**</b><br>(0.119)   | <b>0.388***</b><br>(0.105)  | <b>0.559**</b><br>(0.162)  | <b>0.515***</b><br>(0.0843) | <b>0.507***</b><br>(0.113)  |

|   |                            |                             |                            |                              |                             |                             |
|---|----------------------------|-----------------------------|----------------------------|------------------------------|-----------------------------|-----------------------------|
| Village   | 0.675<br>(0.239)           | <b>0.604**</b><br>(0.119)   | <b>0.475***</b><br>(0.126) | 0.915<br>(0.255)             | <b>0.567***</b><br>(0.0928) | <b>0.437***</b><br>(0.103)  |
| <b>Behavioral patterns and personality traits</b> |                            |                             |                            |                              |                             |                             |
| Openness to experience                            | 0.906<br>(0.0806)          | 0.957<br>(0.0489)           | 0.988<br>(0.0689)          | 0.984<br>(0.0684)            | 1.054<br>(0.0456)           | 1.071<br>(0.0650)           |
| Conscientiousness                                 | 1.061<br>(0.0937)          | 1.016<br>(0.0519)           | <b>0.851**</b><br>(0.0620) | 0.999<br>(0.0731)            | 1.018<br>(0.0447)           | <b>0.830***</b><br>(0.0521) |
| Extraversion                                      | <b>0.854**</b><br>(0.0675) | 0.957<br>(0.0422)           | 0.968<br>(0.0632)          | 0.929<br>(0.0616)            | 0.982<br>(0.0373)           | 0.928<br>(0.0537)           |
| Agreeableness                                     | <b>1.294***</b><br>(0.114) | 1.055<br>(0.0498)           | 0.956<br>(0.0682)          | <b>1.250***</b><br>(0.0848)  | <b>1.081*</b><br>(0.0448)   | 0.968<br>(0.0580)           |
| Neuroticism                                       | 1.103<br>(0.0839)          | <b>1.219***</b><br>(0.0563) | 0.930<br>(0.0585)          | 1.040<br>(0.0669)            | <b>1.096**</b><br>(0.0415)  | <b>0.892**</b><br>(0.0493)  |
| Risk loving                                       | 1.015<br>(0.0752)          | <b>1.159***</b><br>(0.0499) | 0.990<br>(0.0646)          | 0.992<br>(0.0673)            | <b>1.173***</b><br>(0.0448) | 1.016<br>(0.0624)           |
| Never visits religious services/non-believer      | 1.189<br>(0.176)           | <b>1.353***</b><br>(0.116)  | <b>1.251*</b><br>(0.155)   | 1.211<br>(0.158)             | <b>1.443***</b><br>(0.112)  | 1.057<br>(0.124)            |
| Visits religious services once a month or more    | 0.543<br>(0.291)           | 0.916<br>(0.232)            | 0.863<br>(0.322)           | 1.081<br>(0.249)             | <b>1.550***</b><br>(0.215)  | 0.843<br>(0.191)            |
| <b>Trust</b>                                      |                            |                             |                            |                              |                             |                             |
| General trust                                     | 0.728<br>(0.152)           | <b>0.697***</b><br>(0.0805) | 1.158<br>(0.188)           | 0.900<br>(0.140)             | <b>0.766***</b><br>(0.0732) | <b>1.560***</b><br>(0.206)  |
| Frequency of social media use (times a month)     | 0.991<br>(0.00611)         | <b>1.008**</b><br>(0.00349) | 0.993<br>(0.00513)         | <b>0.979***</b><br>(0.00490) | 1.002<br>(0.00304)          | 1.002<br>(0.00453)          |
| <b>Health and COVID-19 experiences</b>            |                            |                             |                            |                              |                             |                             |
| Self-rated health - very bad                      | 1.195<br>(1.376)           | 1.780<br>(0.975)            | 1.985<br>(1.441)           | 0.606<br>(0.663)             | <b>2.715**</b><br>(1.240)   | 2.218<br>(1.195)            |
| Self-rated health - bad                           | 0.974<br>(0.286)           | 0.948<br>(0.157)            | 1.372<br>(0.319)           | 0.739<br>(0.155)             | 0.889<br>(0.102)            | 1.168<br>(0.187)            |
| Self-rated health - good                          | 1.157<br>(0.181)           | 0.947<br>(0.0906)           | 0.951<br>(0.132)           | 1.001<br>(0.140)             | 0.886<br>(0.0759)           | 0.932<br>(0.123)            |

|   |                          |                             |                           |                            |                             |                          |
|---|--------------------------|-----------------------------|---------------------------|----------------------------|-----------------------------|--------------------------|
| Self-rated health - very good                   | 2.094<br>(1.003)         | <b>2.370***</b><br>(0.704)  | 0.676<br>(0.387)          | <b>7.573***</b><br>(2.940) | <b>1.886*</b><br>(0.686)    | 0.429<br>(0.338)         |
| Had positive COVID-19 bodies or antibodies      | <b>2.211*</b><br>(1.035) | 1.524<br>(0.474)            | 0.598<br>(0.316)          | <b>1.971**</b><br>(0.621)  | <b>1.913***</b><br>(0.382)  | 0.984<br>(0.298)         |
| COVID-19 case among family members              | 0.823<br>(0.331)         | 0.881<br>(0.201)            | 0.923<br>(0.279)          | 1.376<br>(0.499)           | <b>1.551*</b><br>(0.356)    | <b>1.735*</b><br>(0.549) |
| COVID-19 case among acquaintances               | 0.790<br>(0.115)         | <b>0.798**</b><br>(0.0702)  | 0.853<br>(0.109)          | 1.006<br>(0.123)           | <b>0.843**</b><br>(0.0621)  | 0.915<br>(0.0998)        |
| Regional 7-day moving average of incidence rate | <b>0.745*</b><br>(0.128) | 1.073<br>(0.0765)           | 1.081<br>(0.111)          | 0.978<br>(0.108)           | <b>1.183***</b><br>(0.0714) | 1.082<br>(0.0952)        |
| Self-perceived probability to get infected      | 1.080<br>(0.0778)        | <b>0.850***</b><br>(0.0360) | <b>1.112*</b><br>(0.0657) | 0.974<br>(0.0562)          | <b>0.850***</b><br>(0.0309) | 1.035<br>(0.0488)        |
| Constant  | 1.550<br>(1.539)         | 1.137<br>(0.663)            | 3.275<br>(2.539)          | 0.299<br>(0.254)           | <b>4.710***</b><br>(2.239)  | <b>3.566*</b><br>(2.466) |
| N   | 3.444                    | 3.444                       | 3.444                     | 5.089                      | 5.089                       | 5.089                    |

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