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Between nudges and mandates: The drivers of COVID-19 vaccination intentions and subsequent uptake in Russia

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ABSTRACT

Despite high levels of morbidity and mortality, as well as the widespread availability of domestic vaccines, Russia demonstrated significantly low rates of vaccination throughout the COVID-19 pandemic. This research explores vaccination intentions before the start of the immunisation campaign and the consequent uptake in Russia after the introduction of mandatory vaccination policy in certain industries and proof-of-immunisation for social activities. Using a nationally representative panel dataset, we analyse factors behind individual vaccination decisions using binary and multinomial logistic regressions. Special attention is given to the effect of employment in industries with vaccine mandates and personal factors which determine individual "nudgeability" to vaccination (e.g., personality traits, beliefs, vaccine alertness, self-perceived vaccine availability etc.). Our results show that 49 per cent of the population received at least one shot of COVID-19 vaccine by autumn 2021 after the introduction of mandatory vaccination. Vaccination intentions before the rollout of the nationwide immunisation campaign are correlated with the consequent attitudes and uptake, although the prediction is not perfect. 40 percent of vaccine refusers eventually got vaccinated, while 16 percent of vaccine supporters turned into refusers, revealing the lack of promotion of vaccine safety and effectiveness. To a large extent, vaccination refusal and hesitance are explained by vaccine alertness. Vaccine mandates significantly increased the uptake in several affected industries, especially education. These results offer important insights for designing information policy, relevant for future vaccination campaigns.

1. Introduction

The novel coronavirus infection COVID-19, which provoked a global pandemic from early 2020, has caused significant damage, both in terms of public health and economy. The mortality reportedly surpassed 4 million cases globally by spring 2021 [1]. In Russia, the peak of COVID-related mortality occurred from December 2021 to March 2022 [2]. By 2023, new variants of the virus reportedly became less virulent but more transmissible [3] with the case fatality rate globally decreasing from 3.74 per cent in March 2020 to 1.02 per cent in January 2023 [2]. Vaccination remains the core instrument to decrease COVID-19-related mortality and to reach herd immunity.

During the Soviet era, preventive medicine has achieved significant success in keeping the majority of infectious diseases under control. Vaccination for children was mandatory with certain medical exceptions [4,5]. There was a well-known case of smallpox outbreak in late 1959, when over 6,000,000 adults were urgently vaccinated within a month [6]. However, after the collapse of the Soviet Union, post-Soviet countries, including Russia, experienced a rapid increase in vaccine hesitancy. In 2018, Gallup World Pool surveys showed that only 53 percent of the respondents from the former Soviet Union considered vaccines safe [7]. A relatively high level of vaccine refusal in Russia prior to the pandemic likely had a negative impact on vaccination against COVID-19.

Despite the rapid development of the first domestic vaccine against COVID-19 and entirely free vaccination for the whole population, launched in January 2021, vaccination rates in Russia are remarkably low. By October 2021, or 10 months into the national vaccination campaign, only 36 percent of the population received at least one vaccine shot [8]. The figure rose to 51 percent by early

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2022 [9] and to 61 percent by January 2023 [2]. At the same time, the level of vaccination in Chile, Brazil, Italy, Spain, the US, and some other countries surpassed 80 percent by January 2023 [2].

Various policy instruments are used to increase vaccination uptake worldwide. The first common mechanism is nudging. Nudge is a concept, widely known in behavioural economics [10], which comprises certain actions aimed at adjusting individual behaviours in a predictable (and often pro-social) way without restricting options. Nudges can be subdivided into direct motivational (e.g., direct messages about the importance of vaccination, including advertising, financial incentives), indirect motivational (e.g., publishing public reports about positive effects of vaccination), and implicitly motivational (e.g., limiting access to services and activities for unvaccinated individuals) [11]. Another mechanism is mandating vaccination for certain groups of individuals (e.g., healthcare workers, seniors). Although mandates can significantly increase vaccination rates in a short period of time, they are unable to change vaccination behaviours [12] and show mixed effects on vaccine uptake [13–15]. They often result in negative reactions, including intentions to avoid vaccination at all costs [16] and individuals giving up certain activities where mandatory vaccination is applied [12]. Mandating one vaccination can also hamper other still voluntary vaccinations [16,17] and have a detrimental effect on trust [18], while previous studies showed a lack of trust to be the core reason behind suboptimal vaccination levels [8].

One of the advantages of nudges compared to mandates is that they are cheaper in terms of public trust and are less expected to provide negative feedback. However, the existing research suggests that nudges (including financial incentives [19,20], lotteries [21], messages [22,23]) revealed themselves as low effective in increasing vaccination uptake during the COVID-19 pandemic. Richard Thaler, one of the authors of the ‘‘nudge” theory, suggested that nudges were not enough to put an end to the pandemic and more decisive actions should be taken [24].

In Russia, vaccination became mandatory from July to October 2021 for the workers of certain industries (i.e., education, healthcare, services). Employers were obligated to achieve a proportion of the vaccinated employees above a certain threshold (from 60 to 100 percent) by the end of July 2021. Those employers who failed to comply with the obligation risked being fined (each fine reaching up to 1,000,000 rubles, or $13,000 at the time) or to experience business suspension up to three months [25]. Those employees who were unwilling to get vaccinated could be fired. Moreover, during the peak of morbidity in 2021, vaccine passports in the form of QR codes (proof-of-immunisation) became compulsory for attending social activities (theatres, restaurants, museums etc.). Similarly, mandatory vaccination was introduced in many countries around the globe for particular industries (for health and social care in Australia, the UK, Canada, for education in New Zealand), for attending social events (e.g., Australia, Italy, Germany, the Netherlands) and even for the whole adult population (e.g., Austria, Ecuador, Indonesia, Turkmenistan) [26].

Our previous study showed that before the rollout of the nationwide vaccination campaign, by October 2020, negative attitudes towards vaccination in Russia had already reached alarming figures: 44 percent of the respondents were strongly resistant, 12 percent were hesitant [8]. We also identified determinants such as age, self-perceived health condition and risks of being infected, personality traits, and trust having influences on vaccination attitudes which was supported by other studies [27]. However, vaccination intentions may not always coincide with the resulting vaccination uptake [28,29] which is specifically true for COVID-19. For example, while in Sweden intentions appear to be very predictive of the actual vaccination [30], in the US [20], as well as Hong Kong [31], the situation is reversed. Qualitative studies conducted internationally allow to distinguish between the groups of vaccine refusers, based on their motivation. For Russia and Denmark, previous research highlights four types of hesitancy: resisting hesitancy based on mistrust, paralyzed hesitancy based on personal fear, informed hesitancy based on informed choice, and empowered hesitancy based on empowered choice [32]. In Germany, vaccine refusal is mainly provoked by low perceived benefits of vaccination, low perceived risk of contracting COVID-19, health concerns, lack of information, systematic mistrust, and spiritual reasons [33]. Interviews conducted in 7 European countries show that lack of trust and high speed of vaccine creation are the main reasons behind vaccine refusal [34].

This paper continues to explore the factors associated with vaccination attitudes in Russia, a country with high levels of vaccination hesitance. Due to the panel nature of our dataset, now we can compare previous vaccination intentions, observed before the start of the nationwide immunisation campaign, with the actual vaccination uptake. Most of the research concerning COVID-19 vaccination attitudes is conducted on cross-sectional data with longitudinal studies remaining scarce [35,36]. We explore the effect of vaccination mandates by controlling employment in the industries where vaccination enforcement was introduced (health, education, trade and services, housing and utilities, science and culture, public administration). We specifically focus on those individuals who changed their opinions about vaccination, getting a vaccine shot despite being a vaccine opposer in the past, and turning from vaccination supporter into its opposer. We do not look directly at all the introduced nudges. Instead, we control for the effect of possible individual ‘‘nudgeability”, i.e., personality traits and personal beliefs concerning vaccination. We also use a wide range of socio-demographic parameters to control for individual heterogeneity.

2. Methodology

2.1. Data

We use data from the nationally representative household survey RLMS-HSE [37]. To our knowledge, this is the only nationally representative non-state panel study extensively used in research related to Russia. The survey has been conducted annually since 1994. RLMS sample represents a split panel, combining elements of the repeated cross-section and pure panel designs. Each year, it covers roughly 10,000 individuals from 4,000 households, addressing various characteristics related to demography, socio-economic status, health, beliefs, and other individual aspects.

We primarily rely on the data from the 30th wave of the study, collected from September 2021 to January 2022. This wave contained a special block of questions related to the COVID-19 pandemic, including vaccine uptake and opinions on coronavirus and the vaccines. The resulting sample consists of 8,048 respondents. We also use data from the 29th wave of the survey containing information on vaccination intentions, for which data were collected from September to December 2020. Such information is available for 7,414 respondents. From the longitudinal sample surveyed in 2020, 91.2 percent of individuals older than 18 were surveyed in 2021. The proportion of nonresponses to vaccination-related questions was 0.1 percent in 2020 and 0.5 percent in 2021.

2.2. Dependent variable

In 2021, the respondents were asked two questions. The first one was: ‘‘How do you feel about the vaccination against the coronavirus?” with the following response options: ‘‘I am already vaccinated, at least with the first shot”, ‘‘I am going to get vaccinated if

I am sure of the safety and the effectiveness of the vaccine", "I am planning to get vaccinated with any available vaccine", "I am not planning to get vaccinated". In the case of choosing the first option, a new question was asked: "Was it your voluntary decision?" with the answer choices as follows: "Yes, it was my voluntary decision", "It was a forced decision: it is required by my job, social restrictions are imposed on the unvaccinated etc.". The resulting dependent variable contains six options: 1) vaccinated voluntary; 2) vaccinated involuntary; 3) inclined to get vaccinated in case of vaccine safety and effectiveness; 4) inclined to get vaccinated with any vaccine; 5) vaccine refusers; 6) hesitant (who failed to answer the question). Categories 3 and 4 can be regarded as hidden hesitance.

2.3. Independent variables

In order to compare the determinants of the actual uptake with those of the vaccination intention presented in the previous study [8] and to be consistent with other research on vaccination hesitance, we included three groups of explanatory variables into our models.

The first set is socio-demographic characteristics: gender, age divided by 10 and its square divided by 100, marital status (binary variable which equals to 1 if the respondent is officially married or cohabiting), presence of children younger than 18, presence of elderly family members (65+), vocational education, higher education, the natural logarithm household income per capita, type of settlement (regional centre, city, village or Moscow and Saint Petersburg as a reference category).

The second set of variables concerns individual nudgeability, understood as beliefs and behaviours, including religiosity (non-believer or not visiting religious services, visiting religious services more than once a month, visiting religious services once a month as a reference category), level of individual trust (0 = one should always be cautious with other people, 0.5 = depends on the situation, 1 = most people can be trusted), social network use (non-users, 1 time per week, 2–3 times per week, every day as a reference category), frequency of TV viewing (once a week, less than once a week, and every day as a reference category), and personality traits (the Big Five and risk attitudes). The Big Five categories are self-evaluated on a scale from 1 to 4 with a block of 24 questions which can be mapped into openness, conscientiousness, extraversion, agreeableness, and neuroticism. Each category is calculated as an average of the included questions and then standardised with a mean of 0 and a standard deviation of 1. Risk attitudes are also self-evaluated on a scale from 0 to 10 and calculated as an average of 6 questions each representing the respondent's willingness to take risks in various contexts: health, work safety, career, driving, finance, and generally. The variable is also standardised with a mean of 0 and standard deviation of 1.

The third group of variables is related to health and includes self-reported health status (very bad, bad, good, very good, and average as a reference category), COVID-19 related experiences among family members and the self-perceived risks of getting infected over the next 12 months measured on a scale from 1 to 10 and standardised with a mean of 0 and a standard deviation of 1 for the ease of interpretation.

We add a new set of explanatory variables which reflects individual attitudes towards COVID-19 vaccine and vaccination. First, it includes former vaccination intentions measured in 2020. The question was as follows: "Are you planning to get vaccinated against COVID-19 once the vaccine becomes available?". The answer choice was "I will certainly get vaccinated", "I will get vaccinated but only if I am sure about vaccine safety and reliability", "I will not get vaccinated", "Not sure whether I will get vaccinated", "I have already recovered from COVID-19 and find it unnecessary to be vaccinated", "I have already been vaccinated". Answer choice "I will certainly get vaccinated" was combined with "I have already been vaccinated" to form the group of vaccine accepting individuals. Similarly, answer choices "I will not get vaccinated" (49.2 percent) and "I have already recovered from COVID-19 and find it unnecessary to be vaccinated" (1.4 percent) are combined to form the group of vaccine opponents due to a small number of observations. Second, we used a block of questions, where the respondents were asked to express their agreement or disagreement with the following statements (0 = disagree, 0.5 = difficult to answer, 1 = a gree):"Getting vaccinated against COVID-19 is useless: the vaccine does not save from the infection or from severe cases, new variants etc.", "Getting vaccinated is dangerous because it can be harmful to health", "The vaccines were created at suspiciously high speed, the trials have not been fully conducted, it is better to wait", "Vaccination is a conspiracy of pharma companies and the governments", "It is better to obtain natural immunity than to get vaccinated", "Many medical workers do not recommend to get vaccinated", "It is difficult to get vaccinated where you live". These statements were specifically designed based on the prevalent comments of Russian-speaking social media users in spring-summer 2021. The first six questions turned out highly correlated, therefore, we conducted the Principal Component Analysis, resulting in a single latent factor of «vaccine alertness» with Eigenvalue greater than 1. This suggests that all the statements represent a similar mindset and should not be separated. The question concerning lack of access to vaccination was used separately since it can be used as one of the nudges.

Finally, the following set of dummies was included to assess employment characteristics: economically inactive, unemployed, student, employed in education, employed in science and culture, employed in healthcare, employed in trade and services, employed in housing and utilities, employed in public administration, employed in other industries. The named industries were marked with mandatory vaccination for employees under the threat of dismissal. A in the Appendix demonstrates mean values for all the explanatory variables depending on the respondents' vaccination attitudes and vaccine uptake almost 1 year after the launch of the national immunisation program.

Compared to the previous study on vaccination intentions, certain factors were excluded from the analysis. In particular, we excluded COVID-19 cases among acquaintances since, by October 2021, almost every respondent (86 per cent) had at least one friend or relative who had experienced the coronavirus. We also exclude personal COVID-19 experience because for the vaccinated individuals, we cannot identify for sure whether the illness occurred before or after vaccination. Finally, we do not control for the regional weekly moving average of incidence rate since we do not know the date of the vaccination, leading to inability to make any conclusions on causality in this case.

2.4. Method

First, we ran a multinomial logistic regression where all six vaccination attitudes are analysed simultaneously with vaccine resistance ("not planning to get vaccinated") as a base outcome. This model is considered as a baseline model[1]. Second, we run another multinomial logit on a subsample of those individuals who were not planning to get vaccinated in 2020 (before the rollout of the national vaccination campaign) with vaccine resistance as a base outcome. By this, we are trying to analyse those factors which led to the change of plans during the actual vaccination. Finally, we esti-

[1] Initially, our baseline multinomial model was estimated without including former attitudes towards vaccination, measured in 2020. The resulting coefficients were only slightly different from the subsequent models with the inclusion of the said variables. The sample was also reduced only slightly (from 8,048 to 7,450 individuals).

Table 1
COVID-19 vaccination-related statements, percent of the respondents, N = 8048.

Statement	Disagreed	Not sure	Agreed
Getting vaccinated against COVID-19 is useless: the vaccine does not save from the infection or from severe cases, new variants etc.	54.2	14.2	31.6
Getting vaccinated is dangerous because it can be harmful to health	47.1	17.7	35.2
The vaccines were created at suspiciously high speed, the trials have not been fully conducted, it is better to wait	37.3	17.2	45.5
Vaccination is a conspiracy of pharma companies and the governments	52.9	27.2	19.9
It is better to obtain natural immunity than to get vaccinated	51.1	20.5	28.4
Many medical workers do not recommend getting vaccinated	61.8	18.1	20.1
It is difficult to get vaccinated where you live	89.7	7.1	3.2

mate a multinomial logit on a subsample of those individuals who planned to get vaccinated in 2020 with being already vaccinated in 2021 as a base outcome. This will allow us to look more carefully at those factors which contributed to the eventual vaccine rejection.

3. Results

3.1. Stylised facts

By the time of the survey (October 2021-January 2022), 49 percent of the respondents aged 18 and above received at least one shot of COVID-19 vaccine. More than a third of them (or 16 percent of the whole sample) got vaccinated due to the mandate. Additionally, 11 percent were planning to get vaccinated if they were confident in the safety and the effectiveness of the vaccine, 7 percent were planning to get vaccinated with any available vaccine. 28 percent refused to get vaccinated. Almost 5 percent remained hesitant.

One of the reasons for a relatively low vaccination level in Russia can be the belief in vaccine inefficiency or even its harmfulness to health. Almost half of the respondents (46 percent) suggest that the vaccine was created at suspiciously high speeds, 35 percent believe that vaccination can harm one's health while 32 percent suppose that getting vaccinated is simply useless. Other negative beliefs concerning vaccination are less common (Table 1). Qualitative assessments confirm the prevalence of such opinions in other countries as well [32–34,38]. We also can infer that vaccine accessibility was quite high in Russia across the regions: only 3 percent of the sample claimed it difficult to get vaccinated in their place of residence.

Table 2 demonstrates the relationship between past vaccine intentions, measured before the rollout of the national vaccination campaign, and the attitudes one year after the initial survey. 55 percent of those who were willing to get vaccinated under any circumstances got at least one shot within a year. In contrast, only 36 percent of those who were conditionally accepting (planned to get vaccinated in case of vaccine safety and reliability) got vaccinated. Moreover, 25 percent of those respondents who initially expressed negative attitudes towards vaccination eventually got vaccinated. Similarly, COVID-19 vaccination intentions were found to be strongly but imperfectly associated with subsequent uptake in a panel study for the US [29,39] and Hong Kong [31]. In California, 49 percent of those, expressing uncertainty, and 21 percent of those expressing willingness in February 2021, were vaccinated within a year [29]. Russian data demonstrate a smaller difference between hesitant and resistant in the proportion of the eventually vaccinated.

3.2. Regression results: Baseline model

Table 3 further reveals the effects of various explanatory variables on vaccination intentions and the actual vaccine uptake. We present relative risk ratios (RRRs) for the ease of interpretation. RRR greater than 1 signifies the increased risks of the event, RRR < 1 signifies the decreased risks. The reference category is vaccination refusal.

First, we assess the effects of the socio-demographic factors. There is a quadratic relationship between actual vaccination (both performed mandatorily and voluntarily) and age, which peaks in middle age. Having a vocational diploma increases the chances of voluntary (RRR = 1.449) and mandatory vaccination (RRR = 1.314), as well as the chances of hidden (i.e., still planning to get vaccinated with any vaccine, RRR = 1.327) and direct hesitance (RRR = 1.337). Similar results are observed for higher education diplomas. Individuals coming from the households with a higher per capita income demonstrate higher chances of voluntary (RRR = 1.268) or mandatory (RRR = 1.293) vaccination and decreased chances of hesitance (RRR = 0.848). Those living in a regional centre, compared to Moscow and Saint Petersburg demonstrate lower chances of mandatory vaccination (RRR = 0.656) and hesitance (RRR = 0.514), in a town – reduced chances of hesitance (RRR = 0.571), and in a village – reduced chances of voluntary (RRR = 0.611) and mandatory vaccination (RRR = 0.622) compared to vaccination refusal. Statistically significant results are associated with family composition. We observe a positive effect of marital status on vaccination uptake compared to vaccination refusal. Contrary to intuition, the presence of senior family members is not statistically associated with voluntary vaccination but decreases the chances of mandatory vaccination (RRR = 0.788) and planning to get vaccinated conditional on vaccine confidence (RRR = 0.817). We suppose that senior family members are more often present in the households of other senior respondents, who also fear possible side effects. Such factors as gender, presence of children turned out to be statistically insignificant for vaccination uptake.

Second, we assess the effect of employment status and working in certain industries where mandatory vaccination was imposed. A highly significant effect is observed for those employed in education with an increase in the chances for both voluntary (RRR = 2.249) and mandatory (RRR = 3.036) vaccination compared to resistance. Being employed in science and culture shows a similar positive effect on vaccination uptake, although the level of statistical power is significantly reduced. Surprisingly, no effect is associated with employment in healthcare. Employment in trade and services increases the chances of planning to get vaccinated conditional on vaccine confidence (RRR = 1.384), which can be considered a form of hidden hesitance. Economic inactivity reduces the chances of being vaccinated either voluntarily (RRR = 0.413) or mandatorily (RRR = 0.0526), as well as hesitance compared to vaccination resistance. Similar reduction in the chances of mandatory vaccination (RRR = 0.171) is provided by unemployment status.

Third, we explore the effect of factors associated with individual nudgeability, such as personality and behaviours. From the Big Five, higher levels of agreeableness reduce the chances of mandatory vaccination (RRR = 0.858), while neuroticism increases the chances of hidden hesitance (RRR = 1.152). Risk inclined individuals have reduced chances of vaccination, both voluntary (RRR = 0.792) and involuntary (RRR = 0.839), as well as reduced chances of hidden hesitance compared to vaccination refusal. Having higher levels of openness to experience, conscientiousness, and extraversion is statistically insignificant for actual vaccination and

Table 2
Vaccination intentions 2020 and vaccination intentions 2021 (including actual uptake), percent of the respondents, N = 7450.

2021 2020	Have been voluntary vaccinated	Have ben involuntary vaccinated (mandate)	Will get vaccinated if sure in vaccine safety and reliability	Will get vaccinated with any vaccine	Will not get vaccinated	Hesitant
Will get vaccinated under any circumstances	54.9	13.9	5.8	7.6	15.5	2.3
Will get vaccinated if sure of vaccine safety and reliability	35.5	16.2	13.5	8.4	22.7	3.8
Will not get vaccinated	25.2	15.2	11.3	6.2	37.5	4.6
Hesitant	34.1	12.8	9.8	8.5	24.8	10.0
Total	32.6	15.2	11.4	7.4	28.6	4.7

any other vaccination attitudes. In contrast, individual trust increases the chances of vaccination (for voluntary RRR = 1.501, for mandatory RRR = 1.598), but also increases different forms of hesitance compared to vaccination resistance (planning under the condition of vaccination confidence RRR = 1.352, planning to get vaccinated with any vaccine RRR = 1.421, hesitance RRR = 2.141). Being a non-believer reduces the chances of the actual uptake (voluntary RRR = 0.831, mandatory RRR = 0.774) and that of planning (RRR = 0.723) compared to vaccination refusal. Individuals never using social media are less likely to get vaccinated voluntarily or to have any vaccination plans compared to vaccination refusers. Rarely watching TV decreased the chances of voluntary vaccination (RRR = 0.455).

Fourth, we discuss the effect of health-related factors. Although COVID-19 experiences among family members have little effect on actual vaccination (weak negative effect for mandatory vaccination, RRR = 0.826), it increases hesitance compared to vaccination opposition. Moreover, we observe a non-linear relationship between self-assessed health and vaccination. Very bad health reduces the chances of voluntary uptake compared to vaccination refusal (RRR = 0.288). Bad health compared to average also reduced the chances of voluntary (RRR = 0.471) and mandatory uptake (RRR = 0.594), as well as plans to get vaccinated (RRR = 0.585). Good health reduces the chances of voluntary uptake (RRR = 0.742), while very good health reduces the chances of voluntary vaccination (RRR = 0.262) and various forms of hesitance (planning under vaccine confidence condition RRR = 0.0988, planning with any vaccine RRR = 0.170, hesitance RRR = 0.401). A highly significant factor is the so-called vaccine alertness or individual lack of vaccine confidence – it decreases the chances of voluntary (RRR = 0.142) and mandatory vaccination (RRR = 0.576), as well as plans to get vaccinated (RRR = 0.567, conditional on vaccine efficacy and safety, and RRR = 0.222 with any vaccine) and direct hesitance (RRR = 0.610) compared to vaccination resistance. Self-perceived vaccine unavailability is associated with the reduced chances of mandatory vaccination (RRR = 0.910) and plans to get vaccinated conditional on vaccine confidence (RRR = 0.902) but with a slightly increased direct hesitance (RRR = 1.093). Finally, self-perceived risks of infection increase individual chances of vaccine uptake (RRR = 1.111 for voluntary and RRR = 1.145 for mandatory) and hesitance (RRR = 1.151 for plans under the condition of vaccine confidence, RRR = 1.540 for other plans, RRR = 1.233 for hesitance) compared to vaccination refusal.

Finally, vaccination intentions in the past are predictive of the actual uptake. Former plans to get vaccinated are highly significant for actual voluntary vaccination (RRR = 2.871) and for mandatory uptake (RRR = 1.736). They also increase hidden hesitance (RRR = 1.903) compared to vaccine resistance. Those who planned to get vaccinated under the condition of vaccine confidence also have higher chances of being vaccinated (voluntarily RRR = 1.593 or mandatorily RRR = 1.511) or to have vaccination plans (RRR = 1.699 and RRR = 1.616) compared to refusal. Previously hesitant individuals eventually had higher chances of voluntary vaccination (RRR = 1.743) and hesitance (RRR = 2.704) compared to refusal.

3.3. Multinomial logit model for vaccination refusers

A in the Appendix specifically focuses on the determinants of the actual uptake among the group of people who reported negative attitudes towards vaccination before the start of the immunisation campaign. These results allow us to understand the reasons for the opinion switch which is important for designing a successful promotion policy. The reference group are vaccine refusers in 2021.

From the socio-demographic factors, we still observe the quadratic effect of age, positive effect of marital status (RRR = 1.898 for voluntary, RRR = 1.622 for mandatory uptake), and higher education (RRR = 1.678 for voluntary uptake). Higher household per capita income increases the chances of voluntary and mandatory vaccination among past vaccination opposers with a slightly larger effect for voluntary uptake (RRR = 1.693 and RRR = 1.562, respectively). We also observe reduced chances of voluntary vaccination in villages compared to Moscow and Saint Petersburg (RRR = 0.625).

Being employed in education increases the chances of actual vaccination among previous vaccination opposers (RRR = 2.020 for voluntary, RRR = 2.698 for mandatory) compared to refusal. However, the effect of being employed in other industries is statistically negligible. Economically inactive individuals demonstrate dramatically reduced chances of voluntary (RRR = 0.384) and mandatory (RRR = 0.0555) uptake compared to refusal which suggests that work mandates rather than other social restrictions were a more effective tool for vaccination promotion. There are also reduced chances of mandatory vaccination for unemployed (RRR = 0.0922) and increased chances for voluntary uptake among students (RRR = 3.782) compared to vaccination refusal.

From the factors of nudgeability, we observe an emerging positive effect of extraversion (RRR = 1.144) for mandatory vaccination. Risk inclination retains the same effect as that in the original model – among last years' vaccination refusers, risk inclination significantly reduced the chances of vaccination uptake (voluntary RRR = 0.787, mandatory RRR = 0.817). In contrast, individual trust increased the chances of uptake compared to vaccination refusal (RRR = 1.570). Moderate social media use (2–3 times a week) increased the chances of voluntary vaccination among former vaccine refusers (RRR = 1.476), while rare TV viewing decreased it (RRR = 0.422).

Self-assessed health shows a stable, non-linear relationship with voluntary vaccination on the subsample of former vaccination refusers. Vaccine alertness reduces the chances of voluntary (RRR = 0.124) and mandatory vaccination (RRR = 0.567), plans to get vaccinated (RRR = 0.530, RRR = 0.211) and hesitance (RRR = 0.508) compared to vaccination refusal. At the same time,

Table 3
Multinomial logit regression results, reference category = Not vaccinated and not planning to get vaccinated (vaccination opposer), RRR.

	Vaccinated voluntarily (1)	Vaccinated due to mandate (2)	Planning to get vaccinated conditional on vaccine confidence (3)	Planning to get vaccinated with any vaccine (4)	Hesitant (6)
Gender (male = 1)	1.018	0.960	1.078	0.883	1.021
	(0.0912)	(0.0950)	(0.107)	(0.108)	(0.144)
Age/10	1.875***	1.862***	1.102	1.468*	0.763
	(0.280)	(0.399)	(0.181)	(0.301)	(0.169)
$Age^2/100$	0.951***	0.920***	0.983	0.961**	1.028
	(0.0131)	(0.0216)	(0.0153)	(0.0184)	(0.0211)
Marital status (married = 1)	1.539***	1.418***	1.264**	1.327**	1.204
	(0.137)	(0.144)	(0.125)	(0.165)	(0.174)
Presence of children younger than 18	0.959	0.930	0.957	1.079	0.948
	(0.0579)	(0.0556)	(0.0544)	(0.0851)	(0.0948)
Presence of senior family members	0.913	0.788**	0.817**	0.881	1.001
	(0.0809)	(0.0832)	(0.0829)	(0.109)	(0.137)
Education					
Vocational education	1.449***	1.314**	0.983	1.327**	1.337**
	(0.140)	(0.140)	(0.105)	(0.172)	(0.193)
Higher education	1.884***	1.250*	1.102	1.408**	1.181
	(0.193)	(0.143)	(0.127)	(0.194)	(0.191)
Employed in mandatory vaccination industry (base = employed in other industries)					
Employed in education	2.249***	3.036***	1.473	0.900	0.727
	(0.504)	(0.626)	(0.417)	(0.306)	(0.342)
Employed in science, culture	2.036*	1.888*	1.296	0.711	0.330
	(0.789)	(0.686)	(0.602)	(0.433)	(0.334)
Employed in healthcare	1.179	1.427	0.940	0.651	0.396*
	(0.298)	(0.327)	(0.291)	(0.231)	(0.221)
Employed in trade and services	0.943	1.052	1.384**	0.857	1.046
	(0.139)	(0.140)	(0.224)	(0.175)	(0.251)
Employed in housing and utilities	0.991	1.092	1.080	1.339	0.439
	(0.255)	(0.247)	(0.314)	(0.428)	(0.222)
Employed in public administration	0.666	1.438	1.225	0.431	0.721
	(0.263)	(0.465)	(0.506)	(0.259)	(0.475)
Economically inactive	0.413***	0.0526***	0.956	0.602***	0.555***
	(0.0510)	(0.0102)	(0.129)	(0.0971)	(0.107)
Unemployed	0.645	0.171***	0.776	0.926	1.369
	(0.216)	(0.0719)	(0.273)	(0.388)	(0.497)
Student	1.610*	0.665	1.102	0.794	0.977
	(0.463)	(0.179)	(0.329)	(0.304)	(0.366)
Logarithm of household per capita income	1.268***	1.293***	0.997	1.128	0.848*
	(0.113)	(0.120)	(0.0662)	(0.0982)	(0.0730)
Type of settlement (base = Moscow and Saint Petersburg)					
Regional center	0.871	0.656***	0.844	0.973	0.534***
	(0.119)	(0.101)	(0.132)	(0.188)	(0.113)
Town	0.876	0.778	1.037	0.944	0.571***
	(0.126)	(0.122)	(0.163)	(0.194)	(0.123)
Village	0.611***	0.622***	0.916	0.797	0.723
	(0.0879)	(0.0981)	(0.142)	(0.159)	(0.149)
The Big Five					
Openness to experience	1.067	1.026	1.051	1.030	1.019
	(0.0509)	(0.0530)	(0.0546)	(0.0659)	(0.0748)
Conscientiousness	1.014	1.030	1.020	0.888*	0.951
	(0.0483)	(0.0560)	(0.0515)	(0.0579)	(0.0678)
Extraversion	1.054	1.069	0.989	0.988	0.961
	(0.0435)	(0.0482)	(0.0452)	(0.0557)	(0.0648)
Agreeableness	1.003	0.858***	0.945	1.084	1.028
	(0.0463)	(0.0446)	(0.0483)	(0.0676)	(0.0718)
Neuroticism	0.962	1.029	0.982	1.152**	0.994
	(0.0397)	(0.0475)	(0.0437)	(0.0664)	(0.0628)
Risk inclination	0.792***	0.839***	0.894**	0.809***	0.940
	(0.0350)	(0.0379)	(0.0391)	(0.0491)	(0.0600)
Visiting religious services (base = rarely)					
Non-believer or never visiting religious services	0.831**	0.774***	0.723***	1.033	0.786*
	(0.0690)	(0.0711)	(0.0664)	(0.116)	(0.102)
Visiting religious services once a month and more often	0.993	0.978	0.902	1.252	0.816
	(0.174)	(0.205)	(0.187)	(0.302)	(0.245)
Individual trust	1.501***	1.598***	1.352**	1.421**	2.141***
	(0.165)	(0.194)	(0.162)	(0.213)	(0.350)
Social media use (base = every day)					

Table 3 (*continued*)

	Vaccinated voluntarily (1)	Vaccinated due to mandate (2)	Planning to get vaccinated conditional on vaccine confidence (3)	Planning to get vaccinated with any vaccine (4)	Hesitant (6)
Never using social media	0.813*	0.816	0.660***	0.761*	0.928
	(0.0881)	(0.103)	(0.0786)	(0.114)	(0.160)
Using social media less than once a week	0.724	0.693	0.833	0.901	1.240
	(0.176)	(0.182)	(0.225)	(0.272)	(0.428)
Using social media 2–3 times a week	1.079	0.981	0.982	1.255	1.221
	(0.141)	(0.135)	(0.140)	(0.216)	(0.251)
Frequency of TV viewing (base = every day)					
Once a week	0.922	1.135	0.916	1.094	0.852
	(0.0961)	(0.121)	(0.108)	(0.153)	(0.143)
Less than once a week	0.455***	0.780	0.857	0.909	0.645*
	(0.0731)	(0.124)	(0.141)	(0.178)	(0.163)
Self-assessed health condition (base = average)					
Very bad	0.288***	0.237	0.508	0.575	0.459
	(0.111)	(0.223)	(0.218)	(0.252)	(0.257)
Bad	0.471***	0.594**	0.851	0.585***	0.886
	(0.0591)	(0.131)	(0.115)	(0.104)	(0.158)
Good	0.742***	0.898	0.837*	0.962	0.879
	(0.0729)	(0.0898)	(0.0899)	(0.126)	(0.134)
Very good	0.262***	0.757	0.0988***	0.170***	0.401**
	(0.0637)	(0.174)	(0.0439)	(0.0738)	(0.162)
COVID-19 experience among family members	0.948	0.826*	1.309**	1.581***	1.541***
	(0.0981)	(0.0952)	(0.143)	(0.203)	(0.238)
Vaccine alertness	0.142***	0.576***	0.567***	0.222***	0.610***
	(0.00778)	(0.0282)	(0.0271)	(0.0159)	(0.0378)
Self-perceived vaccine unavailability	0.939	0.910**	0.902**	0.997	1.093**
	(0.0446)	(0.0412)	(0.0399)	(0.0615)	(0.0467)
Self-perceived risk of infection	1.111***	1.145***	1.151***	1.540***	1.233***
	(0.0440)	(0.0511)	(0.0493)	(0.0830)	(0.0686)
Vaccination intentions before the immunization campaign (base = vaccination opposer)					
Planned to get vaccinated (vaccination supporter)	2.871***	1.736***	1.120	1.903***	1.077
	(0.456)	(0.312)	(0.238)	(0.412)	(0.321)
Planned to get vaccinated conditional on vaccine confidence	1.593***	1.511***	1.699***	1.616***	1.221
	(0.140)	(0.145)	(0.160)	(0.194)	(0.176)
Hesitant	1.743***	1.183	1.180	1.749***	2.704***
	(0.216)	(0.175)	(0.174)	(0.289)	(0.433)
Constant	0.0178***	0.0465***	0.570	0.0311***	2.319
	(0.0182)	(0.0511)	(0.490)	(0.0350)	(2.613)
Observations	7,414				

*** p < 0.01, ** p < 0.05, * p < 0.1.
Wald chi2(230) = 2994.80.
Prob > chi2 = 0.0000.
Log pseudolikelihood = −9174.3925.
Pseudo R2 = 0.2241.

self-perceived risks of infection increase the chances of switching from vaccination refusers to vaccination supporters (voluntary uptake RRR = 1.205, mandatory uptake RRR = 1.235).

3.4. Multinomial logit model for vaccination supporters

Similar to the previous example, we run an additional multinomial logit model to explore the drivers of vaccination attitudes after the start of the immunisation campaign (Table 3A in the Appendix). We specifically focus on those who planned to get vaccinated before vaccination became available but changed their opinion afterwards. The reference category is being already vaccinated (either voluntarily or involuntarily).

From socio-demographic factors, age reduces the risks of vaccination refusal compared to voluntary and mandatory vaccination (RRR = 0.660), so does marital status (RRR = 0.770), vocational (RRR = 0.591) and higher education (RRR = 0.492). Higher household per capita income is associated with the reduced chances of hidden (RRR = 0.788) and direct hesitance (RRR = 0.666). Living in a village, compared to Moscow and Saint Petersburg, increases the chances of resistance (RRR = 1.828) and hidden hesitance among former vaccination supporters (RRR = 1.990).

The positive relationship with being employed in education and vaccination uptake is also observed on the sample of former vaccination supporters: it reduces the chances of any form of hesitance (RRR = 0.111, for planning to get vaccinated RRR = 0.390 and RRR = 0.259, respectively), and refusal (RRR = 0.256). Economically inactive individuals demonstrate increased chances of hidden hesitance (RRR = 3.965, RRR = 1.909) and refusal (RRR = 4.526).

Among personality and behaviour-related characteristics, neuroticism from the Big Five increases hidden hesitance (RRR = 1.181), while risk inclination has positive effects on switch-

ing position from vaccination supporters to refusers (RRR = 1.171). Being a non-believer is associated with higher chances of hidden hesitance (RRR = 1.504) and vaccination refusal (RRR = 1.376). On the contrary, trust reduces the chances of refusal (RRR = 0.467). Rare social media use increases individual chances of refusal (RRR = 2.235 and RRR = 1.754), while being a moderate TV viewer is associated with less hesitance compared to the group of already vaccinated (RRR = 0.439). Rare TV viewing increases hidden hesitance (RRR = 1.932) and refusal (RRR = 2.216).

A stable non-linear relationship is found for self-assessed health: those with worse or better health are more likely to switch to vaccination refusers and hesitance despite being vaccine accepting in the past. COVID-19 among family members increases vaccination hesitance (RRR = 1.724). Vaccine alertness increases hesitance (RRR = 2.689, RRR = 2.099 for conditional planning) and refusal (RRR = 3.529) compared to getting vaccinated among former vaccination acceptors. Finally, those who planned to get vaccinated, conditional on vaccine confidence, in the past have higher hesitance (RRR = 1.853) and refusal (RRR = 1.732) compared to those who intended to get vaccinated under any condition.

4. Discussion

First, our results suggest that past vaccination attitudes are correlated with the consequent uptake, although the prediction is not perfect which is also reported in previous studies [39,29]. This could be explained by social desirability bias in self-reporting acceptance [29]. Still, those who expressed positive attitudes towards vaccination and planned to get a shot as soon as any vaccine became available were more likely to receive at least the first dose of the vaccine. We believe that initial vaccination attitudes significantly affect the success of the vaccination campaign before its launch, and this is relevant for any vaccine-preventable disease, including COVID-19 [34]. In Russia, when no information about any vaccine was yet available in 2020, half of the population had no intentions to get vaccinated in the future. Therefore, policy interventions at this stage and framing the illness as serious, risks of the infection as high, and the vaccine under development as effective and safe could reduce the risks of further hesitance and refusal. Research on various media messages and social media content in Russia show that the messages used during the pandemic were inconsistent, such methods of influence as framing, priming, indoctrinating, and imitating were used. Intense information campaign was aimed at emphasizing the dangers of the coronavirus but was accompanied with the rise of social tension and mistrust [40]. In spring 2021, three months after the start of the immunisation campaign, the progress of vaccination staggered with a declining speed of uptake. At the same time, discussions about vaccine unsafety and conspiracy theories became widely distributed in social media. At this stage, an extensive explanatory campaign (e.g., advertising, special television programs, public talks involving health specialists etc.) could be helpful but was not undertaken. Official media favoured placing more emphasis on the dangers of the disease, while at this point it could be promising to use more positive narratives [40]. In contrast, healthcare workers expressed vaccination hesitance with only 29 per cent being ready to recommend the COVID-19 vaccine to patients [41] and such opinions were overrepresented in social media narrative. As a result, the group of hesitant individuals was large and heterogeneous: it united those who had doubts concerning the quality of the vaccine and its side effects, those who lacked trust and believe in conspiracy. Different types of hesitant individuals needed different types of media influence [32].

Second, voluntary vaccination is more common among middle-aged people with average health, higher levels of education and higher income. This is in line with the previous study of vaccination intentions [8], as well as Grossman theoretic model of health demand [42]. Higher level of education implies better health-related awareness, more positive attitudes towards vaccination, and future orientation. The Grossman model also suggests that individuals with higher income take better care of their own health, since their potential losses from temporary absence from work are more significant. The chances of voluntary vaccination are also higher among risk averse individuals, working in education, with higher levels of trust, frequently watching TV, and occasionally participating in religious services. They are less alert towards the vaccine and perceive the risks of getting infected as high. While younger cohorts with better health may tend to over-rely on natural immunity, avoiding vaccination as redundant, older cohorts and individuals with bad and very bad health may worry about possible side effects. Low perceived benefits, low subjective risks, and health concerns were also important factors of vaccine refusal in Germany [33]. Such attitudes can be changed with targeted nudges: for the first group, it is necessary to stress the importance of vaccination to protect others; for the second group, information should heavily promote vaccine safety supported by extensive clinical trials. The necessity to promote vaccine safety and effectiveness has been extensively reported in research [43] since the lack of confidence in the vaccine became the core driver behind vaccine hesitance and refusal in different countries [34,44,45,]. In European countries, reaching herd immunity was an important pro-vaccination argument, while social environment and an open discussion by the media, decision-makers, and experts had a positive impact on individual vaccination decisions [34].

Third, mandatory vaccination appeared to be quite effective, with employer mandates being vital to promote immunisation in Russia. This result is also supported by studies for other countries [46,47]. By summer 2021, the vaccination promotion policy had intensified, resorting to employer mandates (for those who work in education, healthcare, trade and services etc.) and indirect motivational nudges, imposing necessary proof-of-immunisation for social activities. Although we cannot divide these two reasons in our study and consider both of them as mandates, our results show that being involuntarily vaccinated was negatively associated with economic inactivity and unemployment but positively with working in education. Lower figures of mandatory vaccination among economically inactive and unemployed individuals implies the proof-of-immunisation for social activities was less effective in promoting vaccination than direct employer mandates. Previous research on Russia also showed the positive association between working in certain industries and vaccination uptake [25].

Another important contribution of our paper is the possibility to explore those individuals who got vaccinated despite previously negative attitudes and those individuals who eventually refused to get vaccinated while being previously vaccination supporters. 25 percent of former vaccination refusers eventually got voluntarily vaccinated, while an additional 15 percent were obliged to get vaccinated. Individuals with an appetite for risk, bad health, and high level of vaccine alertness demonstrated lower chances of changing their minds and getting a vaccine shot. Developing targeted informational policy, stressing the dangers of the infection for individuals with bad health conditions could be beneficial for increasing vaccine uptake. In contrast, 16 percent of those who planned to get vaccinated under any circumstances and 23 percent of conditionally accepting individuals turned into vaccination refusers. We suggest that these two groups represent those who were not convinced in the safety and the effectiveness of the vaccine despite initially positive attitudes. A negative change in vaccination intention was more common among economically inactive and unemployed individuals (therefore, employer mandates were

not applicable to them) with higher level of risk inclination, non-believers and rarely using social media, with high self-assessed health. Given an exceptionally large negative effect of vaccine alertness as one of the main predictors of vaccination refusal, this could signify a lack of an efficient promotion campaign, leading to low levels of vaccine uptake.

Finally, we observe a significant effect of personality traits, beliefs, and behavioural patterns on vaccination. Neuroticism from the Big Five is negatively associated with voluntary uptake but positively with some types of hesitance (such as still planning to get vaccinated one year after the start of the immunisation campaign) and switching from vaccination support to hesitance. Being a risk lover is consistently associated with anti-vaccination attitudes, reducing the chances of uptake: they are less likely to be vaccinated voluntarily, mandatorily, or to have any vaccination plans in the future. Risk inclination is also negatively associated with turning into vaccination supporters but positively with turning into vaccination opponents. Previous research also suggests that personality can significantly contribute to health-related decisions [48], including vaccination attitudes [49]. We believe that personality affects individual susceptibility to vaccination policy (i.e., "nudgeability", receptivity of mandates, social approval) and, therefore, serves as an important factor to target vaccination policy. Moreover, individual trust is negatively associated with being a vaccination opposer. Individuals with higher values of trust are more likely to get voluntarily vaccinated despite their negative attitudes before the vaccination rollout and are less likely to turn from vaccination supporters to opposers. This finding is generally in line with the previous literature, stressing the importance of trust for successful vaccination campaigns [50].

5. Limitations

Our study has several limitations. First, we do not possess any data on the time of the actual uptake, and therefore, cannot control for the regional morbidity and mortality rates which were quite predictive of vaccination attitudes in previous research [8]. Second, some of the variables might be subject to endogeneity. For instance, vaccination mandates in certain industries could serve as a reason for leaving a job [12]. Third, we cannot divide whether mandatory vaccination was caused by employer mandates or proof-of-immunisation for social activities. However, our results indicate that the effect of employer mandates is more significant. Fourth, we only have a limited set of controls for nudges which does not allow us to properly compare the effect of mandates to nudges.

6. Conclusion

This paper explores the vaccination intentions before the start of the immunisation campaign and the consequent uptake in Russia after the introduction of mandatory vaccination policies in certain industries and proof-of-immunisation for social activities. Vaccination intentions before the rollout of the nationwide immunisation campaign are correlated with the consequent attitudes and uptake, although the prediction is not perfect. To a large extent, vaccination refusal and hesitance are explained by vaccine alertness. Vaccine mandates significantly increased the uptake in several affected industries, especially education.

Declaration of Competing Interest

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

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Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2023.06.067.

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