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Acceptability of mandatory vaccination: a survey experiment on the effects of thresholds and justifications

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ABSTRACT

Mandatory vaccination mightseem like a straightforward solution for reaching a sufficient vaccine coverage during a pandemic. However, the effectiveness of mandatory vaccination is undermined if the public does not perceive such a compulsory policy as acceptable. We report a population-based survey experiment ($n = 1{,}131$), conducted in Finland, that addresses the effects that different ways of framing a mandatory vaccination program have on three outcome variables: (1) the perceived acceptability of the program, (2) the willingness to take the vaccine voluntarily, and (3) the preparedness to refuse the mandatory vaccine. In the 2×3 factorial experiment, the respondents were presented with one of three justification alternatives that stressed the benefits of the program for either the economy, health, or basic rights. The justification was accompanied with one of two thresholds for herd immunity (70 or 90 percent). We found that the justification and the threshold for herd immunity interact when it comes to the acceptability of the program and the willingness to take the vaccine voluntarily. Importantly, justifications drawing on health were ineffective at the lower threshold level but very effective when the threshold was high. The preparedness to refuse a mandatory vaccine was low and reacted weakly with the experimental treatments.

KEYWORDS

mandatory vaccination; pandemics; health policy; survey experiment; vaccine hesitancy

Introduction

The COVID-19 pandemic has made vaccines an intensely debated topic among experts and the public alike. Governments and private businesses have invested large amounts of resources in the development of functioning vaccines. However, an effective vaccine alone does not solve the problem; a sufficiently high vaccination coverage needs to be reached at a relatively quick pace to help prevent damages caused by further spread of the virus.

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But what if public health officials cannot rely on voluntarism to be enough to reach the necessary coverage for herd immunity? In these kinds of situations, decision makers could try to rely on mandatory vaccinations to ensure sufficiently high vaccination coverage. Although many countries have at least one mandatory vaccine in their national vaccination programs (Gravagna et al. 2020), vaccines developed against unexpected pandemics and government actions to achieve herd immunity in such a situation are a different matter (Savulescu 2021). So far only a handful of governments, most notably those of Austria, Ecuador, Indonesia, Tajikistan and Turkmenistan, has opted for mandatory vaccinations for the whole population to fight the COVID-19 pandemic (Reuters 2021; Davis 2021; MercoPress 2021).

In medical ethics, mandatory vaccines are usually defended on the grounds that state coercion and restrictions of civil liberties are justified if one individual risks harming others through their actions, for example, by abstaining from getting vaccinated (see (Savulescu 2021)). Still, mandatory vaccination policies might be perceived as illegitimate among the public, and could lead to public outcry, heighten distrust toward authorities, and even a backlash in the form of increased anti-vaccination sentiments and heightened civil disobedience (Omer, Betsch, and Leask 2019). The COVID-19 pandemic has demonstrated that the question of mandatory vaccines has potentially great significance for the future handling of similar pandemics. Despite the gravity and global scale of the COVID-19 pandemic, the level of vaccine hesitancy in many countries threatens to severely undermine the efforts to rid the world of the virus (e.g. Paul, Eberl, and Partheymüller 2021; Edwards et al. 2021), although vaccines that have proven effective and safe are increasingly available.

In this study, we present evidence from a 2×3 factorial survey experiment that examines how different ways of justifying a mandatory vaccine by public authorities affect the acceptability of such a compulsory policy measure and individual intention to get vaccinated at different thresholds of vaccine coverage for herd immunity. The study was conducted in Finland in February 2021, with a population-based sample of respondents ($N = 1131$). The experiment depicted a hypothetical contagious disease, whose properties are such that herd immunity is achievable through vaccination. Respondents were presented with scenarios concerning mandatory vaccination policy, where both the threshold for herd immunity and the justifications provided by the authorities were manipulated.

Our experiment had two objectives. Firstly, we wanted to examine whether and how different thresholds for herd immunity, and justifications based on public health, national economy or civil rights affects public support for mandatory vaccinations. Highlighting the collective benefits of herd immunity has been shown to increase intent to vaccinate (Betsch et al. 2017; Sprengholz and Betsch 2020; Arnesen et al. 2018). Still, reaching herd immunity poses a collective action problem where individuals have an incentive to free-ride (Siegal, Siegal, and Bonnie 2009). Thus the level of difficulty to attain herd immunity (low vs. high threshold) is likely to impact individuals' assessments about a hypothetical vaccine mandate. Providing justifications could, in turn, either increase policy support or cause a backfire effect, leading to decreased support (Nyhan and Reifler 2010; Towfigh et al. 2016; Nyhan and Reifler 2015). In our case, different justifications were drawn from public discourse concerning the harms caused by COVID-19 pandemic, basing the rationale of the hypothetical vaccine mandate on real life events.

Secondly, whereas most of the existing literature on vaccine attitudes concentrates on anti-vaccine attitudes, vaccine-related misinformation, and how vaccine attitudes can be

manipulated (e.g. Nyhan and Reifler 2010; Nyhan et al. 2014; MacDonald, Butler, and Dubé 2018; Trujillo et al. 2021; Vrdelja, Učakar, and Kraigher 2020), we address attitudes toward mandatory vaccines using a population-based survey experiment, which has seldom been done before. As the extensive, systematic review by Gualano et al. (2019) demonstrates, among the handful of studies that examine attitudes toward mandatory vaccines, only a few exceptions use population-based data (for more recent exceptions see also Graeber, Schmidt-Petri, and Schröder 2021; Juen et al. 2021; Smith, Attwell, and Evers 2022; Sprengholz et al. 2022). In most studies, the focus is typically on how specific groups, such as pregnant mothers, healthcare workers or parents to young children, perceive compulsory vaccinations. Moreover, our population-based survey experiment contributes to understanding how attitudes toward pandemic-related compulsory vaccines vary in different scenarios, rather than simply documenting those attitudes.

While it is unlikely that the notion of herd immunity is relevant in the context of COVID-19, in a population-based study it provides a means of depicting vaccine coverage targets that are easy to understand. Even when herd immunity is not attainable, the level of vaccine coverage may affect a number of things, such as hospitalization rates and individuals' risk of falling seriously ill. Achieving desirable outcomes in these respects is a collective action problem similar to achieving herd immunity. Therefore, our results are relevant even in settings where herd immunity is not possible.

We examined the impacts of justifications at two levels of herd immunity, one of them moderate (70 percent of the population) and the other quite high (90 percent). We found that, generally speaking, presenting health-, economy- or rights-based justifications in addition to information concerning the threshold for herd immunity had a positive impact on the acceptability of the measure, compared with the control group. We also found that the effectiveness of justifications is linked to the threshold for herd immunity. Thus, our results suggest that authorities seeking to convince the public of the benefits of a vaccination policy must pay close attention to the contents of the justifications.

Background

Attitudes toward mandatory vaccination

The purpose of this study is to examine how the thresholds for herd immunity and the justifications provided affect the acceptability of mandatory vaccines and the readiness to get a (voluntary or a mandatory) vaccine. So far, research has mainly approached mandatory vaccinations either from the perspective of medical ethics (Savulescu 2021) or from a purely practical viewpoint (Omer, Betsch, and Leask 2019), while less attention has been paid to how they could be implemented in an acceptable manner. Still, there is evidence that curtailing individuals' freedom of choice can result in anger, negative sentiments toward the vaccine in question, and increased reluctance to take any vaccine in the future (see, for example, Sprengholz et al. 2022; Betsch and Böhm 2016).

While governmental coercion through formal sanctions gives strong incentives for individuals to get a vaccine, such solutions are often regarded as unfeasible (Ahlskog 2017) or even ethically questionable in Western democracies (Haire et al. 2018). Opposition to a mandatory vaccine policy can be related to general opposition toward coercive government (health) policies and support for individual autonomy in questions of public health

instead of, or in addition to, mere vaccine opposition (Betsch and Böhm 2016). Socio-economic background variables explain part of the variation in people's attitudes toward mandatory vaccination (Graeber, Schmidt-Petri, and Schröder 2021; Smith, Attwell, and Evers 2022). Political orientation can also have an effect, as Juen et al. (2021) show.

Vaccine hesitancy is one important reason for negative reactions to mandatory vaccines. According to Macdonald and the Sage Working Group on Vaccine Hesitancy (MacDonald 2015, 4163), '[v]accine hesitancy refers to delay in acceptance or refusal of vaccination despite availability of vaccination services.' Vaccine hesitancy is complex and context specific, varying across time, place, and vaccines (e.g. Trujillo et al. 2021; Larson et al. 2014; Larson et al. 2018; van der Linden, Clarke, and Maibach 2015; Bigman, Cappella, and Hornik 2010; Gesser-Edelsburg et al. 2015). Factors contributing to vaccine uptake and intentions to vaccinate are multifaceted and include personal attitudes and risk perception, social norms, trust in the healthcare system and decision makers, confidence in vaccine safety and efficiency, and the availability and affordability of the vaccine in question (MacDonald 2015; Larson et al. 2014; Larson et al. 2018; Karlsson et al. 2021). Vaccine hesitancy is widespread, even in industrialized, Western democracies (Larson 2016), which calls into question how efficiently public health officials are able to fight pandemics through voluntary vaccinations.

Mandatory vaccination proposals can be seen as treating people unequally, as not everyone has similar access to vaccines and information related to vaccines, while the sanctions for not complying treat different groups disproportionally (Gravagna et al. 2020; Omer, Betsch, and Leask 2019). Opposition to mandatory vaccination is thus not equivalent to vaccine hesitancy, even though rejection of voluntary vaccination is an important predictor of opposition to mandatory vaccination policy (Smith, Attwell, and Evers 2022; Taylor-Clark et al. 2005).

This is further supported by the findings of Graeber, Schmidt-Petri, and Schröder (2021), who recently studied German opinions about (hypothetical) mandatory vaccination and individual willingness to get vaccinated in the context of the COVID-19 pandemic. While the approval of mandatory vaccination is higher among those who would get vaccinated voluntarily, a non-negligible proportion of the population indicates support for mandatory vaccination despite declaring unwillingness to take the vaccine voluntarily. At the same time, many of those who would voluntarily get vaccinated do not approve mandatory vaccination. Such findings confirm that attitudes toward mandatory vaccination must be kept analytically separate from attitudes toward vaccines themselves. Still, it is worth noting that when vaccine mandates are a common and widely accepted policy, these attitudes seem to be more in parallel (Smith, Attwell, and Evers 2022).

Thresholds, justifications and acceptability of mandatory vaccines

Achieving herd immunity is an example of a collective action problem (Siegal, Siegal, and Bonnie 2009; Graeber, Schmidt-Petri, and Schröder 2021). In collective action problems, individual rational behavior is not sufficient for achieving a collectively optimal outcome. For example, the costs of getting vaccinated as well as the potential side effects are suffered by the individual, whereas herd immunity can be enjoyed by everyone independently of their own actions. Consequently, individuals have an incentive to free ride, i.e. take advantage of public goods achieved through collective efforts without contributing to those efforts themselves (Sandler 2015).

There are various coercive and non-coercive solutions to collective action problems. Coercive solutions include governmental sanctions that incentivize cooperative behavior. The structures of collective action problems vary, which affects the efficiency of various types of coercive and non-coercive solutions. Making vaccines mandatory under the threat of punishment is a coercive solution to the problem of achieving herd immunity to infectious diseases. In order to be efficient, coercive solutions such as mandatory vaccines need to be acceptable, i.e. perceived to be legitimate. Perceived legitimacy has been regarded as the key to people's willingness to comply with coercive policies (Tyler and Jackson 2014). Acceptability of coercive policy measures such as mandatory vaccines depends on a variety of factors. Previous research shows that the perceived legitimacy of policies is dependent on factors such as outcome favorability (Arnesen 2017) and the fairness of the decision-making procedures (Tyler and Caine 1981; Tyler 2001).

Acceptability of vaccine and health policies are sometimes observed through the concept of *framing*, i.e. how the way(s) issues are presented influences the perceptions and views of the listener concerning the given issue. Such presentations create a situation where a 'speaker' encourages listeners to consider the issue in certain terms instead of others, in order to arrive at a specific conclusion (Chong and Druckman 2007). The ways in which a policy is framed also have an impact on public support and potentially the willingness to comply with the policy (Tyler and Jackson 2014). Framing has been shown to have an effect on vaccine perceptions and support for vaccine and health policies (Bigman, Cappella, and Hornik 2010; Gesser-Edelsburg et al. 2015; Tversky and Kahneman 1981). For example, when the effectiveness of a vaccine is expressed in a positive way (80 percent success rate), it provokes more positive perceptions than a negative framing with logically equal information (20 percent failure rate) (Bigman, Cappella, and Hornik 2010).

In this study, we examine how the *level of vaccine coverage required for herd immunity* and the *contents of justifications* provided for the mandatory vaccination affect the acceptability of such a measure. Several studies suggest that communicating the collective benefits of herd immunity increases people's willingness to get a vaccine, even more so than information about individual benefits of being immunized (Betsch et al. 2017; Sprengholz and Betsch 2020; Arnesen et al. 2018). It is likely that the impact of the level of vaccine coverage required for herd immunity is an important component in justifying mandatory vaccines. The higher the threshold for herd immunity, the harder it is to ensure that a sufficient number of individuals will voluntarily contribute to collective action to achieve it. In other words, herd immunity becomes increasingly difficult to attain because of free riding, antisocial behavior or vaccine hesitancy among individuals or particular groups of society, which in turn might increase the support for mandatory vaccines among the public at large. Although the research on the effect of the vaccine coverage needed for herd immunity is scarce, it seems reasonable to expect that the higher the threshold for herd immunity, the higher the acceptability of mandatory vaccines.

In addition, we are interested in how the *contents of justifications* affect the acceptability of mandatory vaccines at different levels of herd immunity. From the perspective of political and administrative decision making, the quality and the contents of justifications given for policies are potentially crucial factors. The way in which policies are justified to the public is likely to affect their acceptability and the public's willingness to comply with

them. Previous studies show that the impact of justifications is complex, especially when it comes to decisions that are unfavorable from an individual perspective. Justifications may curb reactance and cushion the blow caused by an unfavorable policy decision (Towfigh et al. 2016; Sprengholz et al. 2022). Other studies suggest that justifications may produce a backfire effect, i.e. activate a negative response in people who do not agree with the outcome (Nyhan and Reifler 2010; Nyhan and Reifler 2015; Irmak, Murdock, and Kanuri 2020), although this effect may be limited (Haglin 2017; Wood and Porter 2019). In this respect, providing general justifications that do not address citizens' concerns may even be counter-productive for decision-making legitimacy (Christensen, Himmelroos, and Setälä 2020).

Public discourse around the COVID-19 pandemic helps identify arguments used to justify mandatory vaccines. Restriction strategies and policy responses to the COVID-19 pandemic have mostly been justified in terms of the negative impacts of the pandemic on individual and public health. Oana, Pellegata, and Wang (2021) show that health-related concerns are indeed key drivers of policy preferences when it comes to health-economy trade-offs during the COVID-19 pandemic. Yet, strict restrictions have also caused heightened economic anxiety (e.g. van der Wielen and Barrios 2021) and provoked fears of losing individual rights and freedoms (Macfarlane 2020). Mandatory vaccination, which would effectively contain the spread of an infectious disease and limit the need for restrictions, could thus be justified in terms of preserving economic wellbeing as well as basic rights and freedoms. Avoiding fatalities and human suffering caused by the disease is an obvious justification for mandatory vaccination, as well.

In our experiment, a mandatory vaccination policy is presented with a scenario combining (a) a description of the vaccine coverage needed for herd immunity, or the herd immunity *threshold*, and (b) a *justification* for mandatory vaccines. We refer to the combinations of justifications and thresholds as 'scenarios' rather than as 'frames'. While required vaccine coverage is likely to have an effect on public views of the matter (Betsch et al. 2017), it can be regarded as a description of a goal that needs to be achieved rather than just as a frame, i.e. an encouragement to think the matter from a certain viewpoint.

Because there are very few previous studies on this topic, our study has an explorative character. However, given the challenges of achieving sufficient vaccine coverage when the threshold for herd immunity is high, we form two hypotheses: (1) the higher the threshold for herd immunity, the more acceptable mandatory vaccines are and the more willing people are to take the vaccine, regardless of the justification given. At the same time, (2) we hypothesize that the effects of justifications are conditional on the threshold for herd immunity.

Material and methods

Case selection

The experiment was conducted in Finland using a population-based data sample. In Finland, with a population of 5.5 million, the amount of cases and fatalities caused by COVID-19 was at a relatively low level compared to many other countries. The survey experiment took place in February 2021. At the time the experiment was conducted,

fewer than 50,000 cases and 700 deaths had been recorded since the outbreak of the pandemic (Finnish Institute for Health and Welfare 2021). Despite this, several restriction measures concerning, e.g. public events, gyms, bars, and restaurants had been imposed, causing economic damage, especially in the service sector, and constraining the scope of actions of many individuals.

In the beginning of 2021, Finland had passed the pandemic's second wave that had its peak in November, and was experiencing a moderate increase in daily reported cases (Finnish Institute for Health and Welfare 2021). The COVID-19 vaccination program had recently started, and before that, the possibility to make the vaccine mandatory had also been publicly debated (Hanhivaara 2020). Acceptance of the COVID-19 vaccine had declined from 70 percent to 64 percent between April 2020 and late November 2020 (Hammer et al. 2021a), but later on in April 2021 rose to 74 percent when the vaccination program had already been in operation for some time (Hammer et al. 2021b). From the viewpoint of the experiment, the circumstances were favorable since the theme was topical and people had already experienced the impacts of containment measures. In addition, the virus situation was rather stable, and the public sphere was not dominated by demands for either stricter or looser government measures.

The public debate around COVID-19 containment measures that was taking place in Finland in early 2021 provided fruitful conditions for exploring perceptions on mandatory vaccines. While the experiment was not about a COVID-19 vaccine per se, the situation described in the experiment text was largely parallel to the ongoing pandemic. The experiment text stated that, so far, the COVID-19 pandemic had not been considered severe enough for a mandatory vaccination to be introduced. The scenarios were thus relatable to the respondents, which likely contributed to more genuine answers than if a purely hypothetical scenario had been given. As previously stated, mandatory vaccination is enforced in many countries (Gravagna et al. 2020). In Finland, vaccinations are, as a rule, voluntary according to the Communicable Diseases Act (1227/2016). However, mandatory vaccination can be issued by a government decree if reaching a comprehensive vaccination coverage is necessary to prevent the spread of a generally hazardous communicable disease. So far, neither the ongoing COVID-19 pandemic nor any previous pandemic have been seen as threatening enough to introduce such a decree, but it is important to note that mandatory vaccination could be carried out if the government so chose. Consequently, the scenarios of the survey experiment were realistic.

Data

The data for the experiment were collected using the online panel *Kansalaismielipide* (in English: *Citizen Opinion*). The panel is part of the Finnish Research Infrastructure for Public Opinion (FIRIPO). At the time of the experiment, the panel consisted of a pool of 4,215 respondents. The majority of the respondents were recruited using random samples and mail invitations, the rest of the respondents through advertisements on social media. In order to correct for sampling-bias, the pool of respondents was divided into three strata based on level of education. A random sample was then drawn from each strata, and 1,721 respondents were invited to participate in the study.

The experiment was administered in both official languages of the country (Finnish and Swedish) using the online survey platform Qualtrics, and it ran for a period of 10 days in February 2021. A total of 1,146 respondents completed the survey, yielding a response rate of 67 percent. Non-response was to some extent associated with background variables, notably education, age, and occupational status. Those with tertiary education were more likely to respond, compared with those with lower levels of education. Younger age groups were less likely to respond than older ones and, relatedly, persons who had retired due to old age responded more actively than students or those working either part-time or full-time. Moreover, interest in politics was positively associated with proneness to respond. For more details on non-response, please see the Supporting Material (S1 Table).

To maximize data quality, we excluded 15 respondents who spent less than one minute or more than one hour completing the survey, resulting in a final sample of 1,131 respondents. In order to further correct for sampling bias and non-response, we calculated weights using raking that adjusted for gender, language, education, age, and region (see S2 Table in the Supporting Material). These weights are used in all analyses reported in the next section.

Experimental design

Upon opening the survey, the respondents were randomly placed into one of the six treatment groups or the control group. All respondents were presented with a scenario introduction, consisting of a short description of a fictive disease and its vaccine:

> It is likely that pandemics will also erupt after the coronavirus. We now ask you to imagine the following situation:
>
> The world has a new widespread viral disease that causes severe symptoms across all age groups. There is a working vaccine against the disease that is widely available.
>
> Studies conducted in accordance with the normal vaccine development process claim that the vaccine is safe. The vaccine has already been introduced in several countries and there have been no serious side effects.

The control group received no further depiction of the situation. The treatment groups were shown two additional items. The first was a statement specifying the proportion of the population that needs to be vaccinated in order to stop the spread of the disease – either 70 or 90 percent (the parts of the statements that varied between groups are in bold for clarity):

> To stop the spread of the disease in Finland, at least **70%** of the population need to be vaccinated against the disease.
>
> To stop the spread of the disease in Finland, at least **90%** of the population need to be vaccinated against the disease.

The lower threshold can be considered relatively moderate, the second one substantially higher.

The second item presented to those in the treatment groups was one of three justifications for the mandatory vaccine. The first justification referred to the functioning of the economy (referred to as the 'economy' justification later in this article):

> In this situation, mandatory vaccinations would **ensure that normal economic activity can continue**, prevent **unemployment** and **increased government debt**, and allow **economic wellbeing** despite the disease.

The second justification referred to the sustainability of the healthcare system and the avoidance of suffering caused by the disease (the 'health' justification):

> In this situation, mandatory vaccinations would **ensure that healthcare capacity is not exceeded**, prevent **human suffering** and **harm caused by the disease**, and allow **health-care services to function normally** despite the disease.

The third justification referred to individual rights and freedoms (the 'rights' justification):

> In this situation, mandatory vaccinations would **secure citizens' right to life and health**, prevent **the need to limit freedoms**, and allow **civil-society to function normally** despite the disease.

In the control group as well as in the treatment groups, the scenario description concluded with a statement saying that 'In consultation with experts, the government has decided to make it mandatory for all persons living in Finland to take the vaccine, under threat of being fined.' The respondents were then asked to indicate how acceptable mandatory vaccinations would be on an eleven-point scale ranging from zero to ten, zero indicating 'not at all acceptable' and ten indicating 'fully acceptable' (the wording of the question was 'In your opinion, how acceptable would a mandatory vaccine be?'). The structure of the experiment is presented in Figure 1.

After completing the experimental section of the survey, the respondents were asked to fill in a short questionnaire. It contained questions about perceived vaccine safety and confidence in various actors. We use responses to these questions when evaluating the robustness of our results to the inclusion of plausible covariates (see section 4.3 below and the Supporting Material (Appendices S5 and S6)).

Variables

Our main outcome variable was the acceptability of mandatory vaccines. We had two additional outcome variables, measured using statements that were presented once the respondent had evaluated the acceptability of the policy. The respondents were asked to indicate the extent to which they agreed with two statements, again using a scale from zero ('strongly disagree') to ten ('strongly agree'). Because the main outcome variable did not measure (intended) behavior, we analyzed an outcome variable measuring the individual's willingness to take the vaccine even if it were not mandatory. The respective statement read, 'I would take the vaccine, even if it were not mandatory.' This variable sought to capture intended behavior and vaccine hesitancy related to the vaccine described in the experiment. Another outcome variable measured the individual's intention to refuse the vaccine even if it were mandatory ('I would not take the vaccine, even if it were mandatory with the threat of a fine.'). This was intended to capture the resistance to mandatory vaccines caused by vaccine hesitancy or backlash caused by compulsory policy (Nyhan and Reifler 2010; Nyhan and Reifler 2015; Betsch and Böhm 2016; Irmak, Murdock, and Kanuri 2020).

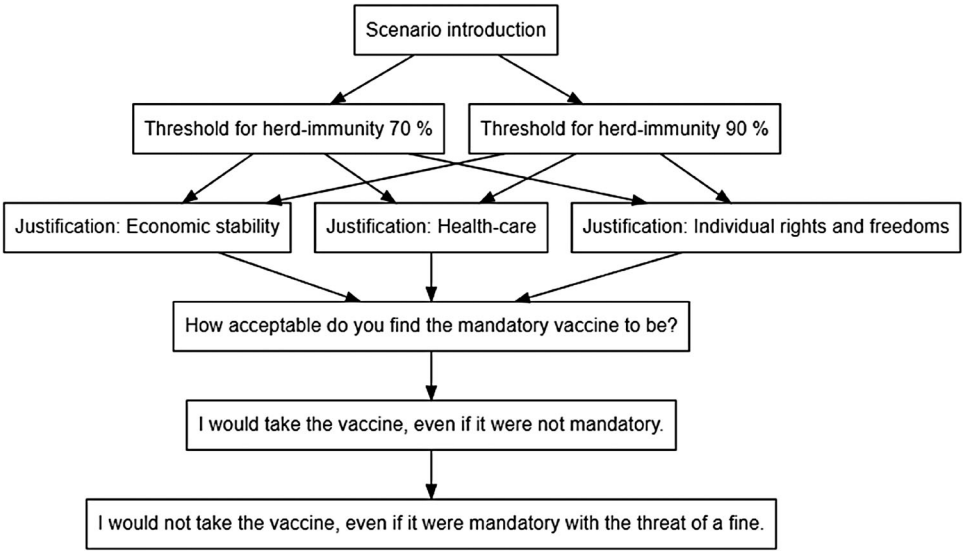

Figure 1. The structure of the experiment.

Such effects could effectively undermine attempts to attain a sufficient vaccine coverage.

Descriptive statistics of the three outcome variables are reported in Table 1. Because of some missing values, the number of observations varies somewhat between different models that address different outcome variables. The main method of analysis is two-way analysis

of variance (ANOVA). In the Supporting Material (S7 Appendix), we also report regression results and marginal effects with respect to each of the outcome variables. As they yield the same substantive conclusions as analyses of variance and are mainly intended to provide an alternative means of interpreting the results, further discussion on regression analyses is deferred to the Supporting Material.

Research ethics

The study complies with the ethical principles of research with human participants set by the Finnish National Board on Research Integrity TENK (2019). According to said guidelines, an ethical review statement must be requested from a human sciences ethics committee if the research involves at least one of the following: a deviation from informed consent; intervening in the physical integrity of research participants; minors under the age of 15; exposing participants to exceptionally strong stimuli; a risk of causing

Table 1. Descriptive statistics.

	N	Min.	Max.	Mean	Std. Deviation
Acceptability of mandatory vaccination	1030	0.00	10.00	7.34	2.95
Willingness to take a non-mandatory vaccine	1008	0.00	10.00	8.98	2.18
Refusal to take a mandatory vaccine	940	0.00	10.00	0.84	2.06

mental harm that exceeds the limits of normal daily life; or safety threats to participants, researchers or other people. Because this was not the case in this study, no ethical review statement was requested.

When registering for the online panel, the participants were informed about their rights under the European General Data Protection Regulation as well as the use of data in scientific research and publications. By registering for the panel, participants have given their informed consent to take part in studies carried out using the panel. This procedure follows the standard national guidelines in place at the time of participant recruitment. Participants were at any time able to withdraw from the study and request that the information they had provided be rectified or deleted. All participants were at least 17 years old.

Results

Figure 2 shows the means of the main outcome variable as well as the secondary outcome variables across all experimental groups, alongside the boundaries of the 95% confidence interval. For a description of standard deviations and the distribution of respondents between groups, please refer to the Supporting Material (S3 Table). Generally speaking, the respondents tended to consider the vaccination policy at least moderately acceptable and, for the most part, were willing to take a vaccine in any case, while expressing relatively little preparedness to refuse a mandatory vaccine. Nevertheless, we can see differences in the averages of each of the variables across the experimental groups. However, based on Figure 2, we cannot readily conclude that either the threshold for herd immunity or the justification for mandatory vaccination have straightforward effects.

Our first hypothesis regarding the effect of the threshold for herd immunity is not supported by this initial examination. However, there appear to be some differences when comparing the justifications between the threshold levels, which is in line with our second hypothesis.

We proceeded to test the significance of the differences between groups seen in Figure 2 using analyses of variance. When testing whether the assumptions of ANOVA were met, we found that Levene's tests produced statistically significant results indicating variance heterogeneity. However, as the ratio between the largest and smallest variance is tolerable (between approximately 2.1 and 3.1) for each of the dependent variables, and the group sizes are approximately even, we proceeded with ANOVA and F tests (Blanca et al. 2018). The randomization of the respondents should ensure that the results were not affected by other variables. However, below we also assess the robustness of our findings to the inclusion of covariates that are plausibly associated with the outcome variables.

Acceptability of mandatory vaccination

We first consider our primary dependent variable, the acceptability of mandatory vaccination. Before comparing the combinations of justifications and threshold levels with each other, we can note that the control group does not differ from the treatment groups consistently. We summarize here the substantive results from statistical comparisons of means; detailed results are reported in the Supporting Material (S4 Appendix).

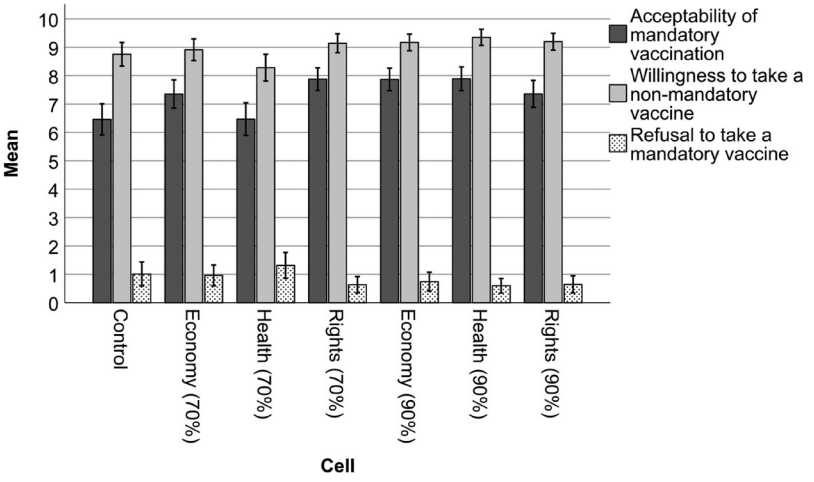

Figure 2. The means of the dependent variables across experimental treatments. Note: The error bars show the boundaries of the 95% confidence interval. The labels refer to justifications, followed by thresholds for herd immunity in parentheses.

Multiple comparisons indicate that, in terms of acceptability of mandatory vaccination, the mean difference is statistically significant between the control group and the following scenarios: the 'rights' justification at the 70 percent threshold, and the 'economy' and 'health' justifications at the 90 percent threshold.

The results from a comparison between the six treatment groups are shown in Table 2. There is a statistically significant (at the $p < 0.05$ level, two-tailed test) interaction between justification and threshold. This indicates that the relationship between the justification and acceptability is conditional on the threshold of herd immunity, as expected. To form a more detailed picture of that relationship, we performed analyses of simple effects.

We first tested the simple effect of justification at both levels of vaccine coverage. Univariate tests indicated that the average acceptability scores differed from each other in a statistically significant way across the justifications when the threshold was 70 percent ($F[945, 2] = 10.24$, $p < 0.001$). However, this was not true when the threshold was 90 percent ($F[945, 2] = 1.62$, $p = 0.199$). Taking into account the Bonferroni correction for multiple comparisons, pairwise comparisons suggest that, at the lower threshold level, acceptance was on average lower when the justification was 'health', compared to the 'economy' (mean difference = –1.07, s.e. = 0.37, $p = 0.012$) and 'rights' (mean difference = –1.56, s.e. = 0.35, $p < 0.001$) justifications. No statistically significant differences between justifications are observable when the threshold was 90 percent.

To approach the differences from a different angle, we tested the simple effect of the threshold level within different justifications. The univariate tests indicated statistically significant differences in acceptance between threshold levels when the justification was either 'health' ($F[945, 1] = 13.18$, $p < 0.001$) or 'rights' ($F[945, 1] = 5.05$, $p = 0.025$) but not when it was 'economy' ($F[945, 1] = 0.61$, $p = 0.434$). Pairwise comparisons show an average difference of 1.33 (s.e. = 0.37, $p < 0.001$) when the justification was 'health' and 0.77 (s.e. = 0.34, $p = 0.025$) when the justification was 'rights.'

Table 2. Two-way ANOVA results. Dependent variable: Acceptability of mandatory vaccination.

Source	F	df	*p*	Effect size
Corrected model	6.67	6	0.000	0.04
Justification	2.80	2	0.061	0.01
Threshold	1.90	1	0.168	0.00
Justification × Threshold	8.80	2	0.000	0.02
	SS		MS	
Error	8131.60	945	8.61	
Corrected total	8475.90	951		

Note: Effect sizes are partial eta^2. SS denotes type III sum of squares and MS mean square. *P* values are two-tailed.

These findings are summarized in Figure 3, which shows the estimated marginal means of the acceptability score. We can first note that there is no noticeable difference between the control group and the combination of the 'health' justification and the 70 percent threshold. The mean in that group is, moreover, notably lower than in the other groups with the 70 percent threshold. Furthermore, we cannot conclude that the acceptability of mandatory vaccination was uniformly higher when the threshold is 90 percent. When the justification was 'economy', there is no noticeable difference between the threshold levels. When the justification was 'health,' the acceptance is clearly higher at the higher threshold level. As for the 'rights' justification, this is reversed: the lower threshold is associated with higher acceptability.

Secondary dependent variables

We now turn to the willingness to take the vaccine even if it were not mandatory and the refusal to take the vaccine even if it were mandatory. Comparisons of means between the control group and the treatment groups show that, as for willingness to take the vaccine voluntarily, there are no statistically significant differences between the control group and

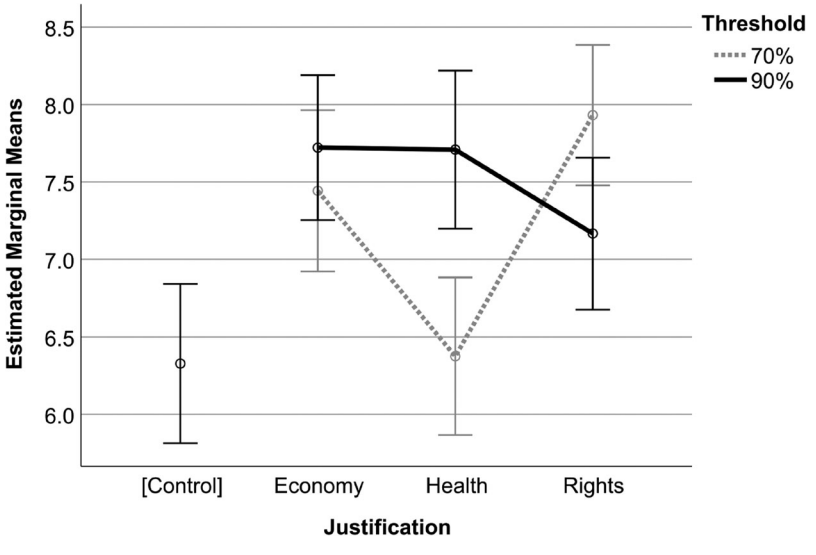

Figure 3. The estimated marginal means of the acceptability of mandatory vaccination. Note: The error bars show the boundaries of the 95% confidence interval.

any of the treatment groups; this also applies to the preparedness to refuse a mandatory vaccine (see the Supporting Material (S4 Appendix)).

The results of comparisons between the six treatment groups are shown in Table 3. When it comes to the refusal to take a mandatory vaccine, neither the model nor any of the variables are statistically significant at conventional levels. In other words, different combinations of justifications and threshold levels do not explain the variation in the intent to refuse a mandatory vaccine. This may indicate that people who have strong doubts about vaccines and are prepared to defy legal sanctions remain unaffected by authorities' appeals to any principles.

The results are somewhat different when we consider the willingness to take a non-mandatory vaccine. As in the case of the acceptability of mandatory vaccination, we observe a statistically significant interaction between justification and threshold. An analysis of simple effects suggests a pattern that resembles the one identified earlier. First, there are differences between the justifications when the threshold is 70 percent ($F[923, 2] = 6.18$, $p = 0.002$) but not when the threshold is 90 percent ($F[923, 2] = 0.39$, $p = 0.674$). For the lower threshold level, pairwise comparisons show that a statistically significant difference exists between the 'health' and 'rights' justifications (mean difference = 0.92, s.e. = 0.26, $p = 0.001$). There also appear to be differences between the threshold levels when the justification was 'health' ($F[923, 1] = 14.85$, $p < 0.001$) but not when the justification was 'economy' ($F[923, 1] = 0.78$, $p = 0.377$) or 'rights' ($F[923, 1] = 0.01$, $p = 0.932$). Pairwise comparisons show that the mean difference between the threshold levels is 1.07 (s.e. = 0.28, $p < 0.001$) for the 'health' justification.

Figure 4 summarizes these findings. On average, the willingness to take a non-mandatory vaccine is at its lowest when the 70 percent threshold is accompanied with the 'health' justification. The 'health' justification is, moreover, the only one for which the threshold of herd immunity makes a noticeable difference. Unlike in the case of the acceptability of mandatory vaccination, the marginal mean is at least as high at the 90 percent threshold level as it is at the 70 percent level for all justifications. In sum, we found no support for the hypothesis that the willingness to take the vaccine would be higher at the 90 percent level independently of the justification, while we did find that, especially at the lower threshold level, the choice of justification seems to matter.

Table 3. Two-way ANOVA results. Dependent variables: Willingness to take a non-mandatory vaccine and Refusal to take a mandatory vaccine.

	Willingness to take a non-mandatory vaccine				Refusal to take a mandatory vaccine			
Source	F	df	*p*	Effect size	F	df	*p*	Effect size
Corrected model	3.57	6	0.002	0.02	2.05	6	0.057	0.01
Justification	1.91	2	0.148	0.00	2.02	2	0.134	0.01
Threshold	7.64	1	0.006	0.01	2.50	1	0.114	0.00
Justification × Threshold	4.43	2	0.012	0.01	2.70	2	0.068	0.01
	SS		MS		SS		MS	
Error	4528.32	923	4.91		3789.52	861	4.40	
Corrected total	4633.26	929			3843.54	867		

Note: Effect sizes are partial eta^2. SS denotes type III sum of squares and MS mean square. *P* values are two-tailed.

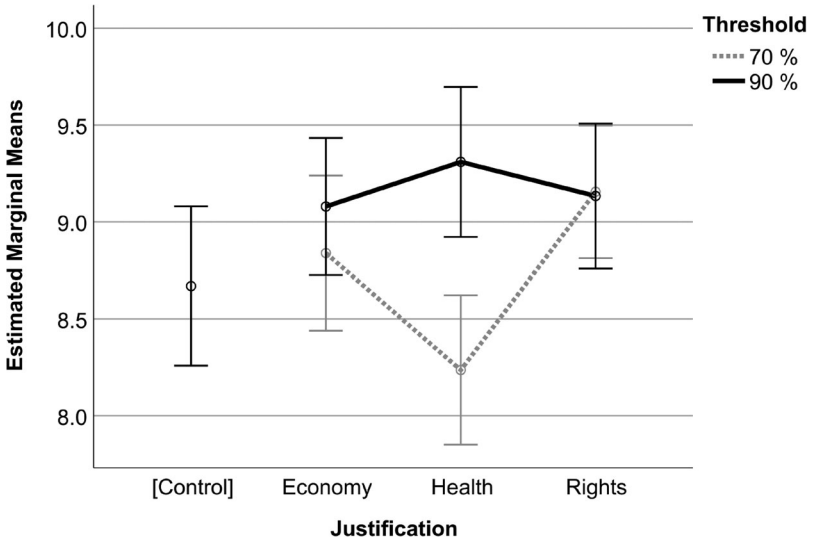

Figure 4. The estimated marginal means of the willingness to take a non-mandatory vaccine. Note: The error bars show the boundaries of the 95% confidence interval.

Robustness to the inclusion of covariates

Our experimental design should ensure that the results reported above were not driven by covariates not included in the models. Nevertheless, we performed analyses of covariance (ANCOVA) to check this. We summarize the additional analyses here and refer to the Supporting Material (Appendices S5 and S6) for detailed results.

First, using a set of conventional sociodemographic background variables (age, gender and education) as covariates did not lead to qualitative changes in the results. Second, the hypothetical situation depicted in our experiment involved the government issuing mandatory vaccination. The wording in the original languages clearly refers to the government in a narrow sense, that is, the politically accountable executive. It is possible that the responses reflect political trust so that those who had strong confidence in political decision makers found mandatory vaccination acceptable and were willing to take the vaccine. The responses may also reflect general attitudes toward vaccines. Based on responses to a brief post-treatment survey, we were able to control for political trust as well as conceptions of vaccine safety. The fact that the survey took place only after receiving the experimental treatment means that any connection between those responses and the dependent variables must be interpreted cautiously because they can all be affected by the scenarios. Importantly for our purposes, however, the inclusion of an index of political trust and the reported confidence in the safety of the commonly used vaccines does not substantively change the results reported above.

Third, we found no clear evidence for interactions between the level of political trust and our treatments. Although those with a lower level of trust tended to find mandatory vaccination less acceptable and were less willing to take either a mandatory or a non-mandatory vaccine, the level difference is quite similar across all treatments. Because political trust and conceptions of vaccine safety were measured in a post-treatment survey,

we cannot rule out the possibility that they were affected by the experimental treatment. We encourage scholars to address the combined effects of justifications, political trust and general vaccine attitudes using research designs that allow valid causal inferences.

Discussion

We analyzed the effects that the vaccine coverage sufficient for herd immunity and different ways of justifying a mandatory vaccination have on the acceptability of the policy, the willingness to take the vaccine even if it were not mandatory, and the preparedness to refuse even a mandatory vaccine. When it comes to the first two outcome variables, the effect that the choice of justification had was, in part, conditional on the threshold of herd immunity. Appeals to the economic benefits of mandatory vaccination seem to have produced the same effect at both threshold levels, while appeals to health and the sustainability of the healthcare system appear to have had quite different consequences depending on the required level of coverage. Our results suggest that such appeals affect the acceptability of mandatory vaccination and the willingness to take the vaccine only if the herd immunity threshold is high. By contrast, the justification stressing people's rights turned out to be especially effective in supporting the acceptability of mandatory vaccination when the herd immunity threshold was at 70 percent. We found no signs of potential backfire effects of the presented scenarios as they failed to explain variation in the preparedness to refuse a mandatory vaccine. In any case, justifications that focused on health seem to have fared relatively badly, if only a moderately high threshold of herd immunity needed to be attained.

Nevertheless, it seems that providing justifications for the decision to make vaccines mandatory has a positive impact on individuals' perceptions of the acceptability of the policy, in line with the findings of Sprengholz et al. (Sprengholz et al. 2022). Still, this impact is not fully consistent across different threshold levels of herd immunity.

However, we found no concluding evidence that a higher threshold for herd immunity would lead to higher acceptability of mandatory vaccines irrespective of the contents of the justification, since there are some noteworthy differences in how individual justifications serve in relation to the required thresholds. Notably, in the case of the 'health' justification, willingness to get vaccinated voluntarily was markedly lower at the 70 percent threshold level of herd immunity than at the 90 percent level. However, similar differences were not observed with the 'economy' or 'rights' justifications. One possible explanation could be that the health justification also triggered health-related worries about the vaccine itself (see Karlsson et al. 2021), but only the 70-percent threshold-level of herd immunity was low enough to result in expressions of hesitancy.

Limitations of the study

In our experimental design, the threshold for herd immunity and the justification for mandatory vaccination were presented to respondents always in combination, and no treatments presenting just one of the variables were carried out. Therefore, we cannot test the potential effects that justifications and thresholds have independently of each other.

Thus, the results are only indicative regarding the effect that the threshold for herd immunity or the justification might have, had they been presented to respondents separately.

Although we find that our experimental treatments have statistically significant effects on the acceptability of mandatory vaccination and the willingness to take the vaccine, the effect sizes are quite small. In other words, the empirical associations we find are not particularly strong, suggesting that the extent to which governments can affect people's attitudes and behavior by choosing the appropriate justification is limited.

In the experiment reported in this article, the respondents were presented with a hypothetical contagious disease whose spread can be stopped through vaccinations, that is, herd immunity is possible. With respect to many real-world diseases, this is not the case. Whether the effects of justifications depend on the ultimate goal of the vaccination program – herd immunity or some other objective – should be addressed in future research.

Conclusion

Fighting the COVID-19 pandemic shows that reaching a required vaccination coverage as quickly as possible is an effective strategy to save lives and lessen the harmful consequences that the pandemic has on both individuals and societies. Due to widespread vaccine hesitancy, however, reaching this threshold might be hard to accomplish (Paul, Eberl, and Partheymüller 2021; Edwards et al. 2021). Making vaccinations mandatory is a possible solution. Requiring a vaccination to participate in certain activities has raised vaccination coverage in many countries, but this kind of government coercion also carries risks (Gravagna et al. 2020; Omer, Betsch, and Leask 2019).

If mandatory vaccinations lead to widespread civil disobedience, these policies could, in fact, be detrimental to vaccine coverage. Our results suggest that both the required vaccine coverage and the contents of justifications make a difference when people evaluate the acceptability of mandatory vaccinations. Our results also indicate that health-related justifications might not lead to the greatest acceptance of mandatory or voluntary vaccinations. Therefore, in order to address vaccine hesitancy effectively and promote acceptance for mandatory vaccination, authorities could use communication strategies that take into account the benefits of high vaccine coverage to the society from multiple viewpoints. In addition to health-related benefits, authorities should appeal to the positive influences that these kinds of policies would have on the daily lives of citizens, their economic wellbeing, and the functioning of society.

Our results show that some proportion of the population would be prepared to defy a mandatory vaccination policy even if it were backed up with monetary sanctions. However, we found no clear association between the combinations of justifications and thresholds, on the one hand, and the preparedness to refuse a mandatory vaccine, on the other. It is plausible that strong doubts about vaccines or resistance to coercive policies cannot be easily overcome by the ways in which public authorities justify their decisions. In cases where widespread vaccine hesitancy or general resistance to government policies are major hurdles, other means of overcoming collective action problems related to herd immunity, such as monetary rewards for getting vaccinated, might be needed.

Disclosure statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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