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An Experimental Study of Public Support for COVID-19 Vaccine Donations

MA Thesis

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Abstract

The rapid development of vaccines brought hope to end the COVID-19 pandemic, but the lack of access to vaccines in low-income countries causes the emergence of new variants of concern (VOC), which pose a risk to high- and low-income countries alike. Due to the global nature of the pandemic, vaccine-rich countries have to choose between stocking vaccines for their own citizens' use or contributing to the global eradication effort through vaccine donation. Lampert et al. (2022) developed a game-theoretic model that evaluates the potential for vaccine donation under a range of pandemic parameters and from a self-interested point of view. The current research tests the model by examining public support for vaccine donation, through an internet-based representative survey experiment among 2,569 German citizens.

The results present a strong public support for vaccine donation, with a mean support of 42.36%. Women (1.99%, $p<.025$) and unvaccinated respondents (5.09%, $p<.001$) show higher willingness to donate vaccines. The findings however, weakly support the game-theoretic model, suggesting that citizens of vaccine-rich countries consider donating COVID-19 vaccines mainly for other reasons. Policy implications propose to either enhance citizens' understanding of the vaccine donation dilemma or alternatively frame the vaccine donation question from a moral point of view. Further research is needed to evaluate vaccine donation preferences among experts in related fields.

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Introduction

The emergence of the COVID-19 pandemic in early 2020 shook the world from many angles. Reoccurring waves of the Coronavirus caused a seemingly never-ending challenge to national decision-making questing to end the pandemic. National economies experienced a large-scale set-back, due to the implementation of strict lock downs. The loss of life due to the Coronavirus has been estimated by the WHO at more than 6.57 Million deaths.[1] The fast-tracked development of vaccines, brought hope to end the pandemic, but unequal distribution of vaccines caused the emergence of new variants of the virus (Ghebreyesus 2021, Wouters 2021). Since a variant may develop in any person who has not been vaccinated, the lack of access to vaccines in low-income countries, did not affect vaccine-poor countries only, but continued to threaten high-income countries as well. Vaccine-rich nations stocked up to two additional excess doses per capita, after the national population had received immunization (Mathieu et al. 2021). The excess doses aimed to protect citizens against new variants, through the administration of booster shots. Vaccine-poor nations, on the other hand were left waiting in line for months and even years for the vaccine, due to a global shortage and the vaccine hoarding of high-income nations. The WHO, through its COVAX strategy aimed to achieve a more equal global distribution of vaccines, but was not able to succeed (Hogan et al. 2020). Contrary to COVAX's attempt to equally distribute vaccines, high-income nations opted for vaccine-nationalism, by signing unilateral deals with vaccine producers and stocking many vaccines (Hafner et al. 2020). The global nature of the pandemic, however, showed that even when vaccine-rich nations had received immunization, new variants jeopardised the sense of national health security. A more global approach was needed to address the multifaceted challenges of the COVID-19 pandemic. Vaccine-rich nations were thus faced with a dilemma between prioritizing their national interest of stocking vaccines or contributing to the global effort through vaccine donation. Studies from previous pandemics, such as Barrett's (2007) research on smallpox, show that under certain conditions it is in the self-interest of high-income countries to finance immunization in low-income countries. While in the case of smallpox there was no shortage of vaccines and no new variants emerged, the concept of reaching a global optimal strategy for vaccine donation, was introduced (Barrett 2007). Lampert et al. built on Barrett's findings, by developing a game-theoretic model for constructing a global approach to combat the COVID-19 pandemic (Lampert et al. 2022). The model identifies optimal strategies for vaccine-rich countries under a range of pandemic parameters. The following four parameters are considered: (1) the effectiveness of the donation, which is measured

[1] https://covid19.who.int (Data retrieved on 07/11/2011)

by the share of the unvaccinated poor population that can be vaccinated in the event of full donation of all vaccine-rich countries (Vmax); (2) the annual rate of emergence of a new COVID-19 variant of concern (λ); (3) the effectiveness of stocking the vaccine for the use of the country's own population (α), or the unavoidable share of the cost of future outbreaks given stocking, estimated by the time it takes to vaccinate the population; and (4) the number of vaccine-rich countries (N). Based on a range of values of these four pandemic parameters, Lampert presents optimal strategies for vaccine donation. Two solution concepts, Nash Equilibrium and self-enforcing international agreement (SEA), present the cumulative optimal outcome of all vaccine-rich countries from a self-interested decision-making point of view.

The likelihood of a nation to act according to the demonstrated model is largely based on the willingness of its citizens to donate their surplus vaccine doses. The current research comes to test the game-theoretic model, based on the notion of policy representation, which stresses the need for public support in using financial resources outside of a country's borders (Soroka & Wlezien 2010; Bechtel, Hainmueller and Margalit 2017). Studies on the public support for COVID-19 vaccine donation have shown that the public in Germany, the US and other vaccine-rich countries support vaccine donation. This depends, however, on the amount that is being donated. The studies also show that vaccine nationalism is prominent, especially when citizens have to give up scarce resources or have to finance the vaccines that are being donated (Vanhuysse 2021; Klumpp, Monfared and Vollmer 2022). Existing studies have not evaluated the self-interested nature of vaccine donation. The COVAX initiative and other donation quests are based on global equity and humanitarian efforts. The current research aims to assess whether citizens of vaccine-rich countries comply with Lampert's game theoretic model, which suggests vaccine donation to be supported by self-interested decision-making. The sensitivity of citizens in vaccine-rich countries to the four pandemic parameters, in forming their donation opinions, is evaluated. Based on respondents' estimations of the aforementioned parameters, they are asked to state their support for vaccine donation. The research hypothesises that higher estimations of (1) the support for donation, (2) the time it takes until a new variant emerges, (3) the time it takes to vaccinate 50% of the national population, and (4) the greater the number of vaccine-rich countries are - the higher the support for vaccine donation. An empirical survey experiment among a representative sample of German citizens was obtained to assess public support for vaccine donation. Results of this study suggest policies for governments of vaccine-rich countries to be implemented during the current COVID-19 pandemic and in future global health crises.

The following chapter introduces literature on the background of the vaccine donation dilemma, by presenting existing studies on the question of vaccine donation, the need for booster shots and individual level decisions in vaccine uptake. Following the general background, examples of disease eradication during the smallpox and the H1N1 pandemics are elaborated on, and Lampert's game-theoretic model introduced. Next, the role of public opinion in making financial contributions and its role for the donation of vaccines in the current COVID-19 pandemic, is presented. The subsequent section includes the research question, hypotheses and methods of this research. Finally, the results and a discussion thereof conclude this work. The following section includes a more detailed explanation of the motivation of the current research.

Literature Review

Motivation

The emergence of the Coronavirus at the beginning of 2020 has brought with it a new set of challenges for national and international policy decisions. The tensions between local governance and global cooperation were highlighted more and more. Even within the EU, countries closed their borders and hoarded vaccines and medical equipment. Travel restrictions and the implementation of national Non-Pharmaceutical Interventions (NPIs) hindered trade and caused global economic losses. The successful development of vaccines against COVID-19 brought hope to end the epidemic, but without a coordinated effort the emergence of new variants brings recurring spikes in COVID-19 cases. The quest for global herd immunity supported by initiatives such as the World Health Organization's (WHO) COVAX program were countered by vaccine nationalism and self-interested behaviors of countries with the most resources.

The global initiatives and donation commitments by the G7 and other multilateral diplomatic efforts have been based on humanitarian concerns aiming to counteract the inequality in vaccine access. Nevertheless, current trends do not show a move towards more equal vaccine distribution, leaving low-income countries that make up about 85% of the world population, to wait for access to vaccines according to estimations, at least until mid-2023 (Padma 2021). While low-income countries received just 0.9% of available vaccines by June 2021, a set of few high-income countries have stocked large amounts of vaccine doses that could vaccinate all their population more than two additional times (Ghebreyesus 2021). In this situation, not only low-income countries come to pay the cost, but due to globalization the economy and public health in all countries is affected (Çakmaklı 2021). The emergence of new variants poses a risk even to the richest of countries. Due to the global nature of the pandemic, a coordinated effort is the only way to eradicate the

Coronavirus (Fontanet 2021). Considering the interplay between national and global interests the question arises as to how alliances could further vaccine donations and under what circumstances self-interested actors would be willing to take part in such an initiative (Lampert et al. 2022).

This research considers the dilemma that vaccine-rich nations face due to the emergence of new variants, given the nature of the pandemic. Since the COVID-19 virus appeared, it spread rapidly infecting many and causing millions of deaths globally. The wide spread of the virus increases the likelihood of mutations that result in new variants. Even though rapidly developed COVID-19 vaccines have proven to be effective in reducing risk of mortality and infection, since large populations, mainly in mid- and low-income countries, are not vaccinated, new variants spread globally causing reoccurring waves of the pandemic. Since travel restrictions can not be maintained long-term, those new variants infect large parts of populations, even in vaccine-rich countries where the majority of the population had been vaccinated. In order to mitigate the spread and harm of new variants in vaccine-rich countries re-vaccination (boosters) is required. To prevent the emergence of new variants, the populations in vaccine-poor nations need to receive access to the vaccine. Vaccine-rich nations are thus faced with the choice between stocking vaccines to administer booster shots for their own population's protection against new variants, or alternatively donating their surplus vaccine stock and thus reducing the risk of new variants emerging in vaccine-poor nations. In the following section literature involving the question of vaccine donations is presented.

The question of COVID-19 vaccine donations

Vaccine nationalism is described by Fidler as the self-interested outcome-oriented behavior of countries with the most resources regarding vaccine allocation. Wealthy countries prioritize their own citizens over global vaccine distribution, as advocated by the COVAX initiative. Willingness to support global equitable vaccine distribution follows only after their own citizens have received protection from the virus (2020). Hafner et al. (2020) presents the dilemmas countries face and how they lean towards vaccine nationalism. Based on the obligation towards their own citizens, high-income countries acquire as many vaccines as deemed necessary for the protection against COVID-19. This comes to contrast international efforts to allocate vaccines in such a way that enables a more equal global distribution. On the one hand the production of vaccines is based on global cooperation, requiring a global supply chain for their manufacturing. On the other hand, when it comes to the use of vaccines, global distribution is countered by geopolitical competition for acquiring the COVID-19 vaccine for one's own population. Most countries of the developed

world have signed direct deals with the manufacturers, wherewith the price of the doses is not revealed. While most high-income countries sign unilateral agreements with vaccine producers, the WHO attempts through an internationally coordinated effort to enable low-income countries to receive vaccine doses as well. The WHO Access to COVID Tools (ACT) Accelerator, named the COVAX Facility, developed a model of international cooperation in which vaccines will be distributed according to population size. COVAX's plan is based on the WHO's global allocation framework constituting of four parts: 1. benefits of the resources are maximized 2. priority is given to those who would be worst-off in the absence of the resource 3. individuals are treated equally 4. social benefit is maximized (Hogan et al. 2020). According to the model, high-income countries self-finance their vaccinations and low-income countries receive assistance in financing. While this approach might be more effective in the long-run, high-income countries are confronted with the needs of their population, causing them to opt for vaccine nationalism. Even though some of the rich countries did join COVAX and committed to fund the initiative, they arranged for unilateral deals to provide the vaccines for their own population (Hafner et al. 2020). Considering that the self-interested nature in policy making is stressed during times of crisis, alliances that are solely based on humanitarian efforts do not yield substantial results (Ghebreyesus 2021, Wouters 2021). In this research the international vaccine donation alliance considered, assumes that vaccine-rich countries are strictly self-interested.

The need for vaccine doses

Effectiveness of vaccines in decreasing death from COVID-19

COVID-19 vaccines were developed in record time. While it usually takes around 10 years to develop safe and effective vaccines, manufacturers were able to develop and test vaccines against the Coronavirus within less than a year (Ghebreyesus 2021, Wouters 2021). Studies have shown that the effectiveness of the administered COVID-19 vaccines was largely in line with the estimated effectiveness in clinical trials. Vaccines have been effective in protecting vaccinated individuals from infection, from hospitalization and from death (Wouters 2021, Tregoning et al. 2021, Zheng 2022). A meta-analysis of real-world vaccine effectiveness has shown that the most commonly used vaccinations Pfizer and Moderna are more than 90% effective, given full vaccination. For partial vaccination (one shot) the effectiveness has been shown to provide protection above 60% against infection, hospitalization and ICU admission. Against death partial vaccination has proven to be effective a little less than 60% (Zheng 2022). However, while studies have shown that COVID-19 vaccines are effective, as of October 2022 only 23.3% of people in low-income countries have received at least one

dose.[2] This is an improvement since June 2021, when only 0.9% of the vaccines had been administered in low-income countries. This trend however deviates from COVAX's vaccine distribution plan. The tension between global and national interests is particularly highlighted when certain countries can access more vaccines without the internationally coordinated effort (Hogan et al. 2020).

COVID-19 variants and the need for booster shots

It can be observed in many vaccine-rich countries that as long as there is no global herd immunity, the need for re-vaccination and booster shots, caused by new variants of the Coronavirus continues to persist. A study in New York State showed waning vaccine effectiveness after the emergence of the Delta variant, with a 10% decline in immunity against hospitalisation for recipients aged 65+ of the Pfizer vaccine. These findings suggest the need for booster shots in order to regain the lost immunity (Rosenberg et al. 2021). A study conducted on the vaccine effectiveness in Israel showed a similar trend (Bar-On et al. 2021). While there were less than two cases per million by June 2021, after the influx of the Delta variant, a rise in infections could be observed. By the end of August 2021 there were more than 10,000 confirmed COVID cases and a high number of hospitalized patients. A study about the third vaccination among people aged 60+, showed that the booster recipients had a lower infection rate than non-recipients by a factor of 7-20 (Bar-On et al. 2021). These findings on the waning effectiveness of vaccines, when new COVID-19 variants emerge, reflect the need for administering booster shots and thus the national interests of countries in stocking the vaccines for the use of their own populations. On the other hand, as long as there are countries without sufficient vaccine intake, new variants are created, thus stressing the need for international cooperation to end the pandemic. The current research comes to address this dilemma, by researching the support for vaccine donation in vaccine-rich countries.

The economic cost of COVID-19

Çakmaklı et al. present the need for global distribution of vaccines from an economic point of view. Due to the global nature of supply and demand chains, the COVID-19 crisis has affected the economies of all countries, regardless of the national level of vaccination. Even if a country vaccinated most of its citizens, allowing the opening of the local market, the decrease in demand in an unvaccinated country, affected the exports of the inoculated country. Demand has been affected by changing consumer preferences. Since products are internationally manufactured and during COVID-19 there has been a noted shortage of

[2] https://ourworldindata.org/covid-vaccinations (Data retrieved on 01/10/2022)

skilled workers, global supply chains have been disrupted. Çakmaklı et al. estimates that due to a lack of equal distributions of vaccines, advanced economies might bear up to 49% of global losses (2021).

The quest for global distribution of vaccines has different reasons behind it that are not merely based on humanitarian and moral norms. Against this goal stands vaccine nationalism that aims to protect the nation's own citizens against new COVID-19 variants. However, considering the economic and health costs incurred, it might be in the interest of high-income countries to donate their surplus doses to advance the effort to globally vaccinate. In order for vaccine-rich nations to be able to reach national herd immunity and donate vaccines to other countries, the behavior of the vaccine-rich country's citizens in choosing to get vaccinated has to be evaluated. In the following section individual-level decisions in vaccine uptake are presented, through a game-theoretic approach which evaluates the vaccination behavior of individuals in connection with their social network.

Individual-level decisions in vaccine uptake

Fu et al. (2011) uses a game-theoretic approach to study the vaccine uptake of individuals dependant on their social network. The study was conducted to better understand the vaccination behaviour of individuals under flu-like infection conditions. The more people get the vaccine the closer to herd immunity the society converges. Individuals however, evaluate the costs versus the benefits of getting vaccinated. The cost that is considered in Fu's research is the uncertainty about contracting the disease when unvaccinated. Free riding has been observed in England when the measles-mumps-rubella vaccine became voluntary. Fu shows that under conditions of voluntary vaccination convergence towards a social optimal vaccination behaviour is dependent on the structure of the society. A well-mixed population converges towards a Nash Equilibrium, which is not so if the population structure is more homogenous. Individuals may choose not to get vaccinated, if they see enough people in their social network taking the vaccine. The public good is thus not always provided for if vaccination is voluntary.

Similarly to Fu's research, Tanimoto evaluates the decision making of individuals with regards to vaccine up-take (2021). In both studies vaccine access is assumed for all individuals. In the current COVID-19 pandemic a scarcity in the supply of vaccines has been observed and thus not all individuals have equal access to vaccine doses. Therefore in the current research the collective decision making of a country is evaluated, not the individual-level choice. Even when a minority of individuals in a society chooses not to get vaccinated, vaccine-sceptics usually do not make up a substantial part of the population. Additionally, the vaccine up-take in a society largely depends on public policies of that nation. However,

when not enough doses are available and global equity is lacking, a global approach to vaccine distribution is needed. The current research evaluates the conditions under which such a global approach may emerge, based on the support for vaccine donations among citizens of a vaccine-rich country. Under which circumstances self-interested nations would align with other nations and form an alliance for donation, will be discussed in the following section by presenting examples from previous global health crises.

Previous examples of disease eradication

Eradication of smallpox

Similar to COVID-19, smallpox could only be successfully eradicated if it was done in all countries. In 1979 smallpox was successfully eradicated, a big success that nearly failed due to lack of funding. Barrett (2007) suggests that the global challenge of eradication in this case constitutes a '*weakest link public good game'*, meaning it only succeeds if the weakest country in controlling the disease succeeds in doing so. During the wide spread of smallpox, the WHO oversaw the attempt to eradicate the disease, however lacked sufficient enforcement authority. Low-income countries did not possess enough resources for national vaccination campaigns, resulting in the need for an internationally coordinated effort that could lead to eradication. Global coordination was dependent on the interest of high-income nations to contribute to the financing of the smallpox budget sharing plan, which included allocation of contributions per country according to GDP per capita and the size of the population. For the US the cost of vaccination ($150 million a year) superseded the amount needed for eradication ($100 million) and thus it was in the interest of the US to fund the eradication effort unilaterally. In order to avoid free riding, the US needed to commit to this amount without pledging to donate more, so other countries would contribute their amounts. The US donation brought about the incentive for other countries to join in the effort to finance the public good, which lead to successful eradication. Barrett also conducted an experimental analysis to understand the dynamics of the financing game. The results show that full provision of the public good is not a default option, but rather requires coordination. He also found that public goods with lower thresholds and higher rewards are more likely to be provided for.

Barrett's research shows the dilemma between national priorities and the need for international cooperation to eradicate a disease. In the case of smallpox the quest for eradication depended on the financing of vaccines for global distribution. In the current research, evaluating potential for international cooperation to eradicate the Coronavirus, the development of vaccines has not come to the same level. While Barrett's research can serve as a model for disease eradication, it does not account for the scarcity of supply of

vaccine doses, as is the case in the current COVID-19 pandemic. The zero-sum nature of either stocking COVID-19 vaccines or donating them, adds another layer to the decision-making of vaccine-rich nations. Another added challenge in the COVID-19 pandemic is the development of new variants, which has not been the case with smallpox. This research will further evaluate an international cooperation game in which a few high-income countries decide to finance the global distribution of vaccines based on self-interested decision-making.

The 2009 H1N1 influenza pandemic

During the 2009 H1N1 influenza pandemic, scarcity of supply was coupled with unequal distribution of vaccines between countries. The pandemic was officially declared in June 2009, with developed countries ensuring their access to enough vaccine doses for their own population through advance purchasing orders, and bought practically all available vaccines from manufacturers (Fidler 2010). Even though several developed countries made pledges to donate some of their vaccines to developing countries, there was a delay between the timing of the pledges and the actual delivery (WHO 2012). For example, while the US agreed to donate 10% of vaccines to developing countries, scarcity of supply delayed the donations, which only came through when all of the at-risk people in the US had received the vaccine. Similarly, Canada announced its vaccine donation only after the second wave of the flu (Kumar 2009). While the WHO tried to ensure equitable access to vaccines for all countries, the 2009 H1N1 pandemic showed that self-interested behavior of high-income countries in securing vaccines for their own citizens superseded (Usher 2021). The lack of equity did not reflect in absence of vaccine donation, but in a large delay thereof. After a considerable development of the pandemic, the H1N1 influenza was found to be less severe than it was feared to be, thus freeing up many countries from the need to donate vaccines. In the current COVID-19 pandemic, similar trends in ensuring the access to vaccines could be observed, against which the WHO initiated the COVAX initiative (Wouters et al. 2021). The current research addresses the need for equitable vaccine distribution from the developed countries' perspective, since without cooperation and vaccine access in poor nations the pandemic continues to affect all countries. The following section presents the theoretical model, which describes optimal solutions for the vaccine donation of vaccine-rich countries during the COVID-19 pandemic, under a range of pandemic parameters. The current research is based on the theoretical background of this model.

Game theoretic model

The current research is based on a game theoretic model by Lampert et al. (2022), which examines the circumstances under which it will be in the self-interest of vaccine-rich

countries to (partially or fully) donate their surplus vaccine doses to vaccine-poor countries. The dilemma between stocking excess doses and donating them is evaluated for vaccine-rich nations, across the ranges of the four pandemic parameters. The donation of all vaccine-rich countries combined is considered from a social planner's perspective. The cooperation is based on strictly self-interested decision-making and the participation of vaccine-rich countries. The model considers three choices: no donation, donating half, or all of the excess doses. The effects of the following pandemic parameters on the optimal strategy and cooperation among countries are considered:

Effectiveness of the donation (Vmax): Vmax is measured by the share of the unvaccinated population of vaccine-poor countries that can be vaccinated given a full donation of all vaccine-rich countries. As long as Vmax is smaller than one, there is still a chance for a new variant to occur. A partial donation of the vaccine-rich countries is denoted as v, which is equal or smaller than Vmax. Depending on the excess doses that are donated by vaccine-rich countries, v will be either closer to Vmax or closer to 0. The share of the globally unvaccinated population is estimated at 4.119 billion.[3] According to the estimate of ordered doses, the US and the EU can account for Vmax=0.53, and the 10 vaccine-richest countries for Vmax=0.85.[4] The theoretical model is based on the simplifying assumption that nations are equal in size.

Estimated annual rate of variant emergence (λ): A VOC may emerge in any unvaccinated person, which is denoted as λ, if no vaccines are donated. In the research the assumption is made that variants emerge independently from each other. As of now no certain estimations have been made about the annual frequency of a new variant occurring. Experience with COVID-19 in the last two years enables to make a cautious broad estimation of $\mathbf{0} \leq \lambda \leq \mathbf{2}$.

Effectiveness of stocking the vaccine for use of own population (α): Even if vaccines are stocked there is always an unavoidable cost of the outbreak due to the time it takes to administer a booster shot to a sizable share of the population (e.g., >50%). The unavoidable share of the cost of future outbreaks given stocking (α) can therefore be estimated by the time it takes to vaccinate this share of the population. The duration of a pandemic wave has been estimated at 5.9 months, with lingering economic and health implications for up to 10 months. The time it took several vaccine-rich countries to administer the booster shot to its population varied between 3.1 months in Israel, 7 months in Germany and 7.77 months in the US. The average time it took the 5 vaccine-rich countries to administer the booster

[3] https://ourworldindata.org/covid-vaccinations. Data extracted on November 24, 2021
[4] See supplementary information in Lampert et al. 2022.

shoot amounted to 6.19 months, including delays due to vaccine shortages. Assuming no shortages in supply, the time it takes to vaccinate a nation's population with a booster shot (using one dose) can be estimated at $\mathbf{0.3} < \boldsymbol{\alpha} < \mathbf{0.6}$.[5]

Number of vaccine-rich countries (N): Given the above estimates for Vmax, the number of countries participating in the theoretical paper are $\mathbf{2} \leq \boldsymbol{N} \leq \mathbf{10}$. This research is estimating the implications of this parameter on the level of support for vaccine donations.

The optimal solution and its stability

According to Lampert the optimal solution can either be a Nash Equilibrium, or alternatively a self-enforcing international agreement (SEA). In game theory, a Nash-equilibrium "is a strategy profile s such that […] no single player, by changing his own part of s, can obtain higher utility if the others stick to their parts" (Kreps 1989). In other words a Nash Equilibrium is is an optimal solution, in which all players choose a strategy based on their self-interest and thus maximize their welfare, leaving no interest in changing the chosen strategy. A self-enforcing international agreement (SEA) is an optimal outcome, which is an agreement with signatories and non-signatories. As opposed to a Nash Equilibrium, in a SEA it is possible that party x will be better-off by changing her position (e.g., opt-out of an agreement), but it may cause another party y to change her position as well, thereby withholding the benefit of y's participation in the agreement from x. In such a scenario party x may be worse off and is thus not expected to change her original position. In an SEA no non-signatory has the interest to join and no signatory to opt-out (Barrett 1994). A Nash Equilibrium is also a SEA, but not the other way around. The research describes the conditions under which the optimal strategies are likely to be adopted, from a strategic perspective.

The results show that the optimal solution is equal donation of all countries, while the amount of donation depends on the values of the aforementioned parameters. For high values of Vmax full donation is the optimal solution, which is not strongly affected by the values of $\boldsymbol{\lambda}$. The threshold for full donation given $\boldsymbol{\alpha} = \mathbf{0.4}$ and $\boldsymbol{N} = \mathbf{6}$, is $\boldsymbol{v}_{\mathbf{max}} > \mathbf{.75}$. Below this value the optimal strategy becomes much more sensitive to the values of $\boldsymbol{\lambda}$. For high values of $\boldsymbol{\lambda}$ donation is only beneficial if either Vmax or α are large. The values for α largely affect the benefit of donating, when those are high and approximate the length of a pandemic wave, full donation becomes much more beneficial, since the efforts to vaccinate the population are not advantageous in terms of reducing the cost. For low values of α,

[5] See supplementary information in Lampert et al. 2022.

however, it is almost always beneficial to stock excess doses, since only a small cost withstands the large costs of undergoing an outbreak.

The results also show that if Vmax is held constant the size of the coalition does not change the optimal strategy, but it does affect the stability of the strategy. The more countries take part in the agreement the less stable it becomes, since the weight of the share of the country's donation diminishes with increasing number of players. The solution strategy is stable both for variable ranges that yield a Nash Equilibrium and such that do a SEA. While the Nash Equilibrium is held for high Vmax and low λ values, the SEA shows stable solutions also for wider and more realistic ranges of the parameter values. The lower the value of α, the narrower the range of values for which a stable strategy is found.

Based on the game-theoretic model the success of alliance formations for vaccine donation under certain conditions can be predicted. Results from the model can be used during different times of pandemics, in order to understand the country-level decisions regarding vaccine donation. During the COVID-19 pandemic data shows, that around 900 million vaccine doses have been donated by the EU countries and the US.[6] While the current donations are slightly short of the model's predictions, they are largely in line given not all donations are recorded and the model's limitations. The current research will further develop the theoretical model by conducting an empirical survey experiment, which will test the public's decision-making regarding vaccine donation in vaccine-rich countries. The survey will be conducted in Germany as the largest country in the EU. The research bases its methodology on the notion that the feasibility of policies is often dependant on the level of support received in public opinion as reflected by the concept of policy representation (Soroka & Wlezien, 2010). In the following section existing studies evaluating the role of public opinion in national decision-making and with regards to COVID-19 vaccine donation, will be presented.

The role of public opinion in national decision-making

Policy representation and public opinion on financial contributions

Soroka & Wlezien define policy representation as "policymakers' active representation of citizens' (aggregated) preferences" (2010). In modern democracies representatives are dependent on electoral support, which spurs the impact of the public's ideas on policy decisions. Soroka's research shows the overlap between changes in public preferences and budgetary spending modifications. The extend of the effect of public opinion on policy outcomes depends not only on public preferences, but is also influenced by the political

[6] https://launchandscalefaster.org/covid-19/vaccinedonations (Data retrieved on 05/04/2022)

system and varies between policy domains. Based on data collected in the US, the UK and Canada, the study shows that there is a positive impact of public opinion on public policies, a finding that is relevant for the current research (Soroka & Wlezien 2010).

An example for the impact of public opinion on budgetary spending towards other nations or concerning international initiatives, can be observed in the 2008 financial crisis. Economically strong nations, especially within the Eurozone, were faced with the dilemma between financing the bailout of other economically weaker countries or letting those countries financially collapse. Bechtel, Hainmueller and Margalit (2017) present an analysis on the public support for financing bailout efforts. Their study shows that while the media presented mainly public resistance to the use of tax money for financial assistance, a survey in Germany presented that only less than a quarter fundamentally opposed financing of bailouts. In Germany, which proved to be one of the largest donor countries, the public held contingent views depending on the specific nature of the bailout packages. This study indicates that public support for financial donations during times of crises can vary depending on the nature of the program, as can be observed in the current COVID-19 pandemic.

The importance of local public support for a globally cooperated effort is also stressed in the quest towards climate cooperation. In international climate change agreements, contribution towards the global public good requires nations to cut down on emissions locally. The benefit is of global interest, but requires local action. In those agreements some nations choose to free ride and thus benefit both from local emissions production and the global emissions reduction by other countries. When emissions reduction policies stem from local priorities, however, global cooperation is much more stable. Bechtel, Genovese and Scheve (2019) present the role of the public's support for a country's participation in a global climate change agreement. In this case as in the aftermath of the financial crisis in 2008, government resources are allocated for issues that are outside of the country's borders. Since the resources stem from tax payer's money and modern democracies largely depend on public support, the public opinion on such matters is influential. The donation of vaccines during the recent COVID-19 pandemic requires decision-making that is based on public support. Existing studies on the public support for COVID-19 vaccine donation will be presented in the following section.

Public support for vaccine donations

Countries with large stocks of COVID-19 vaccines are mostly high-income industrialized countries. Studies in political economy stress the role of public opinion in shaping policies and institutions (Vanhuysse et al. 2021). Thus, the opinion of the public contributes to

shaping the decision-making of its leaders. Geissler et al. (2022) highlights the importance of public support in using government resources and donating vaccines to economically weak countries.

Based on the notion of policy representation several studies have been conducted to attempt to measure the public support for vaccine donation. Clarke et al. (2021) conducted an international internet-based survey in seven high-income countries (Australia, Canada, France, Italy, Spain, UK, and USA), in which the participants were asked whether their country should donate vaccines, how much should be donated and what the allocation prioritization principles should be. Their results show that more than double the proportion of people support donation, as opposed to those not willing to donate. In terms of allocation the first preference was to allocate vaccines according to the need in the countries, followed by affordability and lastly allocation to countries that developed the vaccine. The results were consistent in all countries. This research suggests that the quest for global approaches to the emergence of the COVID-19 virus appears to be supported by the public opinion of high-income countries (Clarke et al. 2021).

The research by Vanhuysse et al. presents public opinion regarding vaccine donations in Germany. The study shows the German public's preference when choosing international COVID-19 vaccine alliance design principles. To test the public opinion in Germany regarding vaccine donation a conjoint experiment was conducted in the summer of 2020. The period of the study was characterized with "deep ignorance, high attentiveness, and false safety". The public awareness of the stage of development of a potential vaccine was low, the public debate about the virus was high, and low numbers of COVID-19 cases caused a false sense of security. The experiment evaluated the public preference of a potential vaccine distribution alliance according to the following four parameters: 1. Composition of the alliance in terms of numbers of countries and identity of countries (EU countries, democracies). 2. The joining cost according to either population size, progressive international solidarity, or equal pay; and the international allocation criteria according to medical need or financial contribution. 3. The cost of the vaccine for Germans and the access of vaccine doses for German citizens. 4. The country of origin of the vaccine and the producer of the vaccine (public university/pharmaceutical company). The research showed that the respondents preferred alliances with other EU countries or democracies. While the size of the alliances mattered less, medium, and large alliances were preferred. Joining costs did not have a large effect, however distribution of vaccination according to financial participation was less desired than allocation according to population size or medical need. In terms of vaccine nationalism, support for alliances with lower vaccine costs and larger

coverage was clearly higher. Lastly, vaccines produced in the US and China were less preferred than Swiss and German vaccines, whereas vaccines produced in Germany were the most preferred. These results show that public opinion about the formation of alliances is shaped by EU-centrism and vaccine nationalism. When considering the formation of alliances to combat COVID-19 through vaccine donations the self-interested reasoning of a nation ingrained in the public opinion of its citizen must be considered. In the case of Germany, public opinion on vaccine donation is shaped by a preference for EU-centric alliances (Vanhuysse 2021).

Kulmpp, Monfared and Vollmer (2022) conducted a survey in Germany and the US to understand the public opinion with regards to vaccine distribution. In the research, respondents were asked to state the principle according to which they would like vaccines to be distributed. Highest support was found for distribution of vaccines based on utilitarian values, followed by egalitarian values. Even though both countries are large investors in R&D of vaccines, merit based considerations were ranked lower. Free-market principles were also not high on the list, even though vaccine access today is mainly based on this principle. Klumpp also tested how the public in both Germany and the US would distribute scares resources between a high- and a low-income country. Respondents allocated slightly more than 50% of vaccines to the high-income country. Around 20% of respondents reduced the amount allocated to the low-income country, when additional information was provided, stating that a vulnerable family member was waiting to get vaccinated. This research shows that in principle the public opinion of Germany and the US supports a more utilitarian and egalitarian approach to vaccine-distribution, than what can be observed in the vaccine allocation today. This current research will further evaluate the public support for vaccine donation including four pandemic parameters. Klumpp's research shows the element of self-interested prioritisation in decision-making, which will be further developed (Klumpp, Monfared and Vollmer 2022).

The current research

The current research empirically tests citizen's choices regarding the allocation of nationally available COVID-19 vaccines based on the theoretical study, which was developed by Lampert et al. (2022). Lampert's game-theoretic decision-making model presents a potential for vaccine donation alliances. A variety of realistic value ranges for the following parameters are used as the base-line of the research: (1) the effectiveness of donation (Vmax), (2) the likely occurrence of new variants (λ), (3) the effectiveness of own-population vaccination (α), and (4) the number of potential donating countries (N).

Vanhuysse (2011) and Geissler et al. (2022) present the importance of public opinion in national decision making. Clarke et al. (2021) and Vanhuysse (2021) conducted surveys regarding the support for vaccine donation during the COVID-19 pandemic. However, the creation of an international agreement amongst vaccine-rich countries during the Corona pandemic has not been researched from a self-interested decision-making perspective. While the COVAX initiative provides a platform for international vaccine donation, it is based on the voluntary participation of high-income nations. During an emergency, countries prioritize their own citizens, which hindered the successful implementation of COVAX's vaccine distribution efforts. The current research comes to test Lampert's theoretical study empirically. In the game-theoretic model, solution concepts regarding alliance formation of a small number of vaccine-rich countries, are considered from a social-planner's perspective. By conducting a survey experiment in Germany, which is a vaccine-rich nation, information about public opinion support for donation will be provided. The results of the empirical study will be able to point to the likelihood the decision-making of the public of a vaccine-rich country stands in line with the predictions of the optimal donation in the theoretical model.

Research question and hypotheses

The empirical research comes to test the support for vaccine donation from vaccine-rich to vaccine-poor countries. The research asks the following: *Under what circumstances is vaccine donation supported by public opinion of a vaccine-rich nation, and how many of the excess doses are citizens of vaccine-rich countries willing to donate according to the parameter estimates (IVs)?*

Drawing on the results of the theoretical propositions of Lampert et al. (2022) game-theoretic model, the hypotheses are:

H1: The expected share of the world's population that can be covered if all vaccine-rich countries donate their entire excess vaccine doses (Vmax) has a positive effect on the support for vaccine donation.

H2: The expected frequency of variants of concern (VOC) emergence (λ) has a negative effect on the support for vaccine donation.

H3: The expected time it takes to re-vaccinate a significant percentage (for example, half) of the population in case of an outbreak (α) has a positive effect on the support for vaccine donation.

H4: The expected number of potential donor countries has a negative effect on the support for vaccine donation.

H5: The effect of the frequency of VOCs on donation support (H2) will be larger under relatively low expected Vmax (<0.7) compared with high expected Vmax. In other words, a positive interaction between Vmax and λ is expected.

Methodology

Survey experiment

Based on the background of the literature review, the current research aims to test whether the theoretical propositions suggested by the 'game-theory' model are empirically supported by public opinion regarding vaccine donations in vaccine-rich countries. For this purpose the research experimentally treats the parameters discussed earlier, and estimates their effects on the level of support for vaccine donations. Through an online survey experiment, which was conducted from October 3rd to 14th 2022, a representative sample of 2,569 German citizens aged 18+ was obtained. Qualtrics was used as the survey platform and respondents were reached through a survey company (Schlesinger group). All information presented and the questionnaire was in their native language.

The survey begins by asking respondents general background questions about their age, gender, education and questions regarding the respondents' experience regarding the COVID-19 virus (questionnaire in English can be found in the appendix). Following the general introduction respondents were presented with the basic information about the vaccine donation dilemma by a two minutes video that was created for the research.[7] The purpose of the video was to give respondents a general understanding of the dilemma between donating and stocking vaccines. To ensure respondents had understood the content of the video they were asked several comprehension questions after watching it. Before watching the video they were made aware that the more comprehension questions are answered correctly the higher the chance of winning a 10 Euro bonus, which was allocated randomly to 50 participants. The three comprehension questions were (1) "What is the effect of the continuous spread of Covid-19, especially in countries with low-vaccination rates?", (2) "What role does a large stock of COVID-19 vaccines play in the pandemic and how can it be used?", and (3) "What are the benefits of stocking vaccines and what are the benefits of donating excess vaccines to vaccine-poor countries?". Respondents had to choose one of three possible answers, after which they were made aware of the correct answer.

Treating the four independent variables

After answering the comprehension questions, respondents were presented with the treatment questions for the four independent variables (model parameters). They answered

[7] Link to the video: https://youtu.be/-9St_tAYmE8

a pair of questions regarding each of the four paraments. In the first question respondents were randomly allocated to either a high or low reference value of the parameter, and were asked to choose whether the actual parameter value is above or below the reference value. Following the treatment question for each parameter, respondents were asked to give their personal estimation of the parameter. The treatment is based on the notion of anchoring bias (Tversky and Kahneman 1974), namely, that exposure to the high/low value in the previous question would bias their personal estimates upward/downward, respectively.

The independent variables are the four pandemic parameters from Lampert's theoretical paper:

- **Effectiveness of the donation**: The variable is measured by the share of the unvaccinated poor population that can be vaccinated given a full donation of all vaccine-rich countries (Vmax). The range between vaccine donations covering 20% to 90% of the world population is used as the anchors in the first part of the survey question, followed by an open estimate question.
- **Estimated annual rate of variant emergence (λ)**: The variable constitutes of two parts. The first being the high/low anchor, which includes the likelihood of the occurrence of a new variant every year or every month. Secondly, the variable is estimated in an open question. It is assumed that variants occur independently from each other, meaning the emergence of a variant does not change the probability another variant is likely to emerge.
- **Effectiveness of stocking the vaccine for use of the country's own population**: The unavoidable share of the cost of future outbreaks given stocking (α) is estimated by the time it takes to vaccinate the population in a country with a booster shot. The anchors for this variable are two and 18 months until 50% of the country's population have received a re-vaccination, which is followed by a personal estimate thereof.
- **Number of vaccine-rich countries (N)**: The variable includes five or 30 nations as anchors. The size of the country is not considered in this research. However for a small country, free riding might be a likely preferred option. Since here the public opinion in a large country is studied, free riding is assumed to be less likely.

Dependent variable

Next, respondents were asked to state how much of their country's excess vaccine dosses they are willing to donate, which as the dependent variable measures the public support for vaccination donation. In order to ensure that the answer regarding donation is based on the four parameters, each respondent was presented with her/his parameter estimations,

before stating their support for donation. Respondents were asked to choose the relative share of their country's excess stock of vaccine doses between 0 to 100%. The respondents are thus faced with the dilemma between stocking excess vaccines for the use of their own population and donating the vaccines, thus contributing to the decreased likelihood of new variants occurring. A response feature enables participants to see how much of the three stocks are available to them, after they chose to donate a certain percentage of the available vaccine doses (e.g., 50% represent a donation of 1.5 vaccination rounds for the whole population). The visualization is based on three barrels being emptied the more of the stock is donated, which is done by moving the slider towards the right (100% donation).

Exploratory variables

Finally, a set of follow-up question asked respondents to state the reasons for their donation choice, their political preferences, risk aversion, time preferences, cognitive reflection, cosmopolitan/globalist attitudes vs. nationalist attitudes, occupation in the public or private sector and income level.

Ethical standard

In order to maintain the ethical standard of the research all information presented to the respondents is from publicly available data. The content of the video was reviewed by specialists in the field of virology/ epidemiology. Prior to the full survey, a pilot was conducted, in order to test the logic and technicalities of the survey. The pilot was conducted amongst a sample of 200 German citizens. Following the pilot, the research was preregistered in "AsPredicted".

Analysis

The experimental results are analysed using Stata. To avoid deception in the experimental setting, the treatment of parameter values is obtained by employing anchoring bias (endogenous). The effect of the parameter values on the support for donation is estimated using four instrumental variable (IV) estimations, one for each parameter.

The first stage of the analysis includes descriptive statistics of the sample demographics, a randomization check of the independent variables' high- and low-anchor assignments, and an individual level analysis of the support for donation. Thereafter, a manipulation test using OLS regression assesses the casual effect of each treatment on its respective parameter estimate.

The second stage of the analysis estimates the effects of the independent variables on the dependent variable. The following analyses are used to test the hypotheses:

1) A correlational analysis of the dependent variable and the four parameter estimates as independent variables is used. The control variables gender and COVID-19 vaccination status are added to the analysis. The analysis is conducted using OLS regression presenting correlational only, non-causal results.
2) The causal effect of the independent variable treatments (low-/high anchor) on the support for donation (dependent variable) is estimated in a similar analysis like in point 1 above. In this analysis the parameter estimates are replaced with the 'high-anchor' treatment. The augmented OLS regression presents the average treatment effect (ATE) of the four treatments on the dependent variable.
3) Instrumental variable (IV) analysis is used to estimate the causal effect of the four parameters on the dependent variable. The analysis includes four IV estimations, one for each parameter. The 'high-anchor' serves as the IV, the respective parameter estimate serves as the endogenous variable, and the outcome variable as the dependent variable (using the 'ivregress' command in Stata). For each one of the estimations, the other three parameters are added as covariates to avoid potential violations of the exclusion restriction. The results provide local average treatment effect (LATE) (Angrist & Pischke 2009).
4) An interaction model is used to test hypothesis 5, regarding the effect of the interaction between the frequency of occurrence of new variants (λ) and the percentage of the world's unvaccinated that can receive a vaccine if all excess doses are donated (Vmax) on the support for donation. To obtain the results the analyses described in point 2 are re-fitted with an interaction between parameters Vmax and λ.

Finally, the relationships between respondents' comprehension level, considerations for donation, cognitive reflection, time preferences, risk aversion, solidarity/pro-social preferences, political preferences, cosmopolitan/globalist attitudes vs. nationalist attitudes, occupation in the private or public sector, and income level – and support for donation are examined as an exploratory analysis.

Results

In the following chapter the results of the survey experiment are presented, beginning with descriptive statistics of the individual characteristics and the dependent variable. A randomization check is included, which ensures the random assignment of the experimental design. In the second part of the chapter, the results of the pre-registered (in 'AsPredicted') analyses are presented. The results include a manipulation test, where the effect of each

treatment on its parameter estimate is assessed. Further, a set of OLS regressions describe (1) the correlation relationships between the dependent variable and the four independent variables (pandemic parameters); (2) the average treatment effects (ATEs) of the four high anchors on the support for donation; and (3) an interaction model refitting model 2 with a interaction between the effectiveness of the donation (Vmax) and the time until a new variant emerges (λ). The pre-registered results also include four instrumental variable estimations, one for each parameter. In the 2sls regression the high anchors serve as the instrument, the parameter estimates as the endogenous variable, and the outcome variable is the support for donation. Following the pre-registered results, a set of additional non-registered analyses are presented. The exploratory analyses include the effect of a set of considerations asked after the dependent variable on the support for donation. Further, the ATEs from model 2 are adjusted to reflect higher levels of education, comprehension and reflectiveness. Finally, the relationships between education and comprehension, and education and reflectiveness are presented.

Descriptive statistics

The survey experiment was conducted in Germany amongst 2,569 German citizens above the age of 18 (October 3-14, 2022). The sampling aimed to represent the German population in terms of gender, age, education and region. While there were slight deviations, especially in the education category, the sample closely represents the German population. Figures 1-3 compare the German population characteristic and the sample proportions (Statistisches Bundesamt 2019, 2020&2021).

Figure 1: Gender and age of German population and survey sample

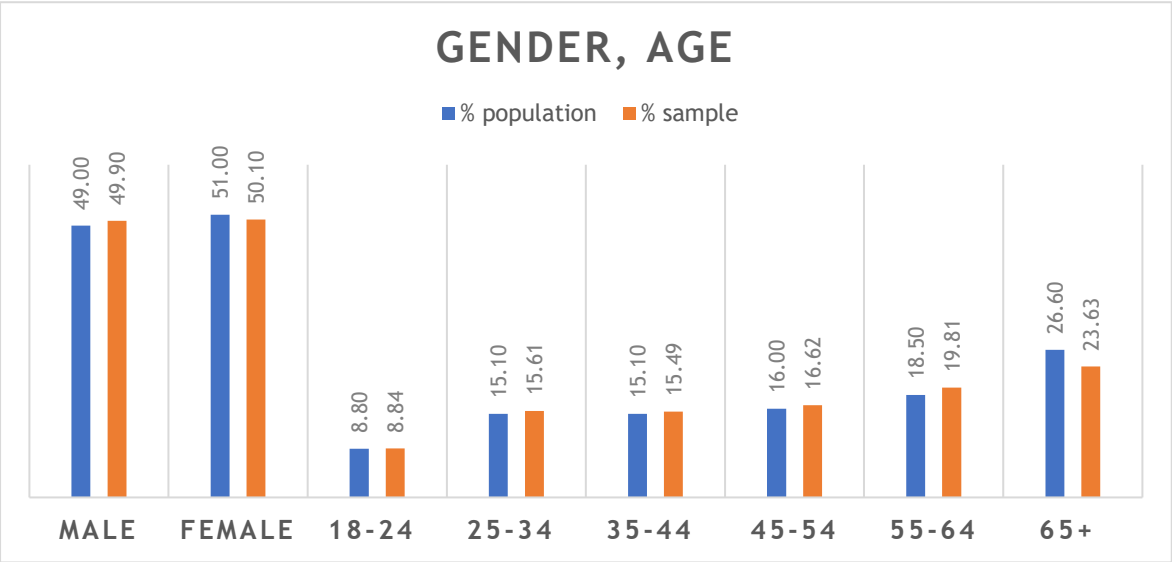


Figure 2: Education of German population and survey sample

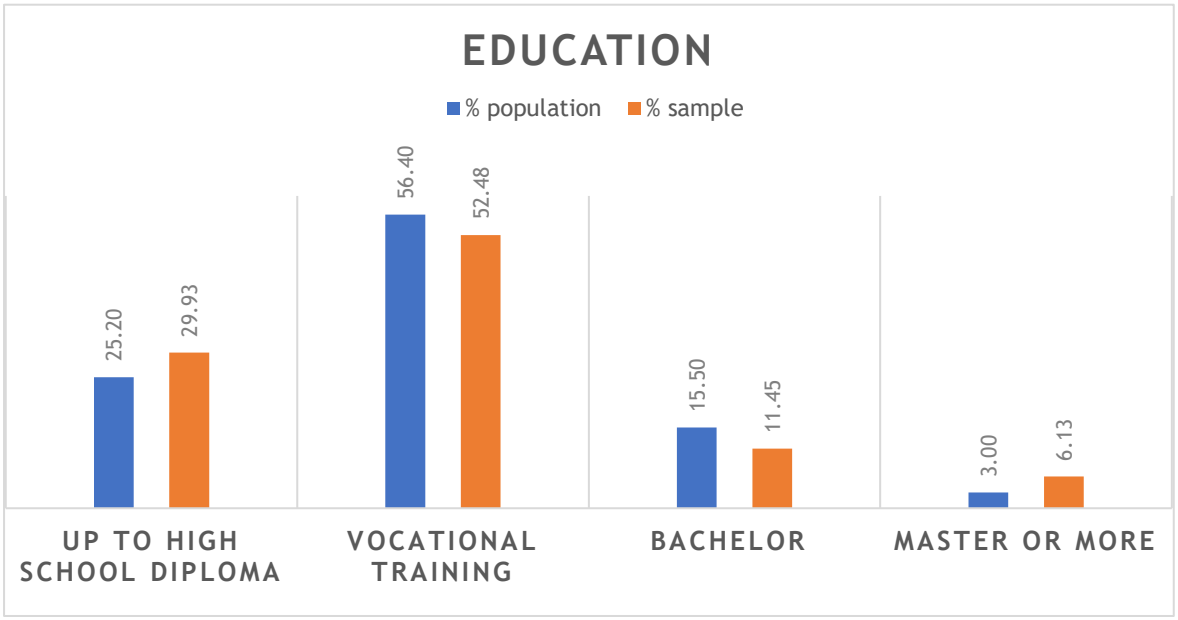
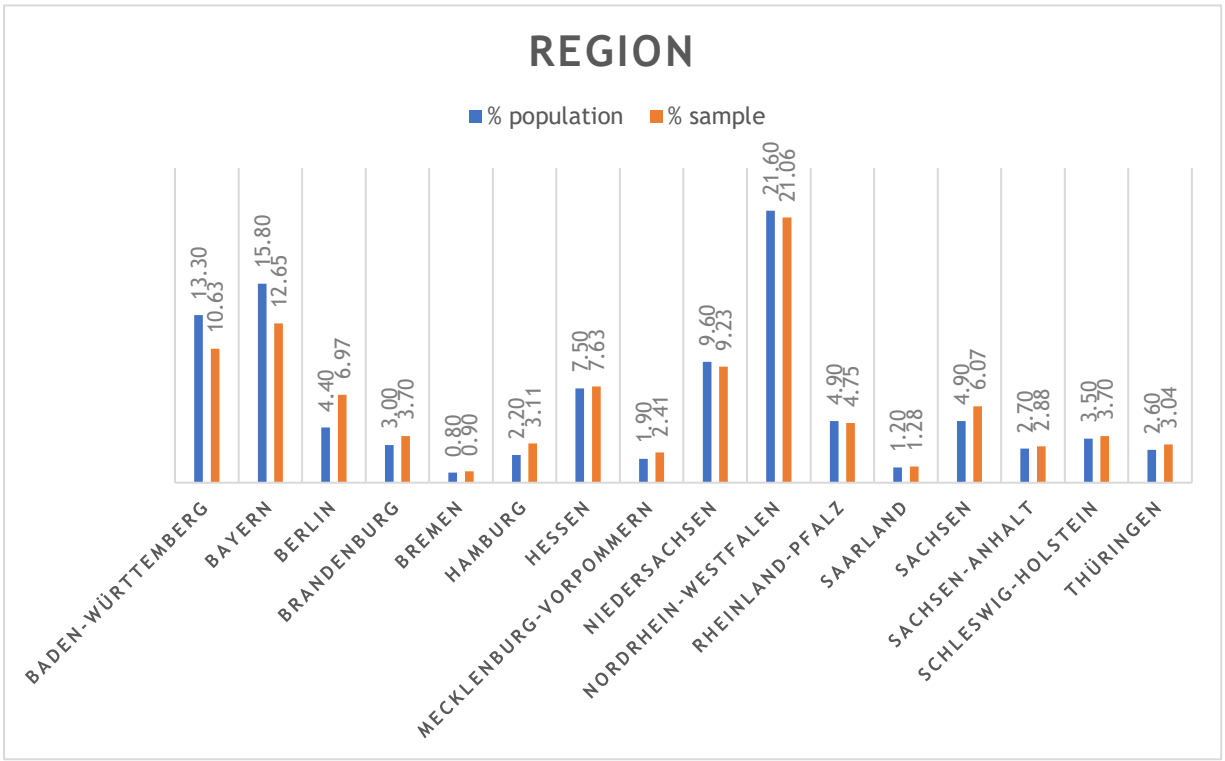


Figure 3: German population and survey sample by region

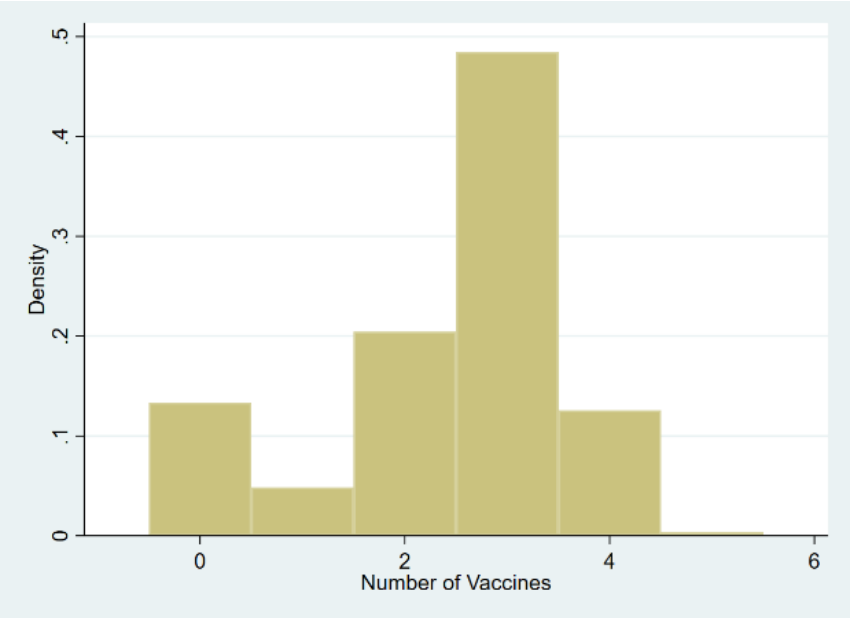


Experience during the COVID-19 pandemic

Following the demographic questions respondents were asked a set of questions regarding their experience during the COVID-19 pandemic. Amongst the 2,569 respondents, 87.1% have received at least one vaccination shot. The most common vaccine was Pfizer-BioNTech with 75.9% of respondents who received at least one shot of the vaccine. 34.0% of respondents

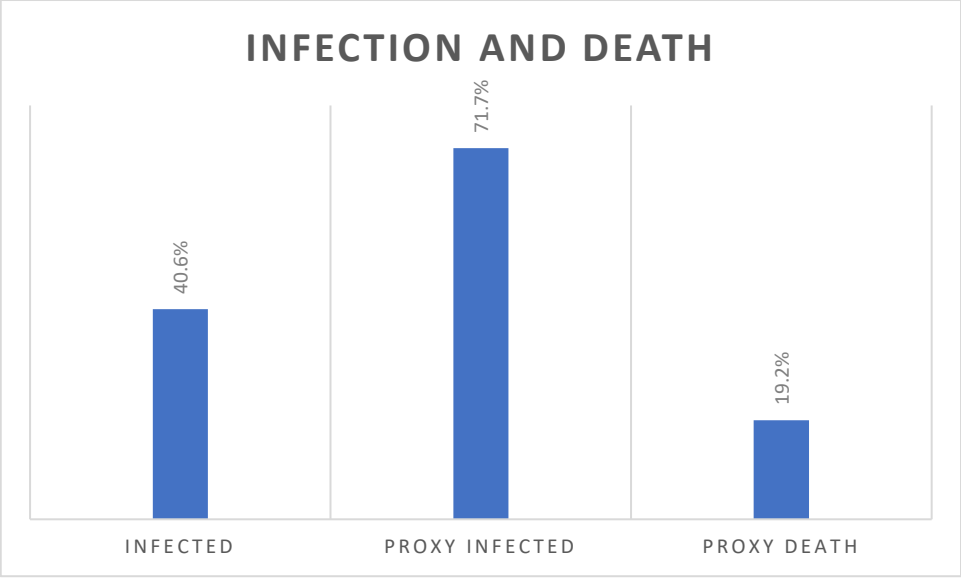
received at least one shot of the Moderna vaccine and 21.9% at least one shot of the AstraZeneca vaccine. 33.5% of respondents received a combination of different vaccines. Among respondents who were vaccinated, 49.5% received three shots, with the other half of respondents receiving one, two, four or five vaccine shots. For a distribution of received vaccine doses see the Figure 4 below.

Figure 4: Number of vaccine doses received



In another set of questions respondents reported whether they have been infected with COVID-19, and whether a family member or a closer friend of theirs has been infected (proxy infected) or died (proxy death) from COVID-19. See in Figure 5 below for the reported answers.

Figure 5: Reported infection, and infection or death of a close person



All the above mentioned questions were presented to the respondents before the treatment, and therefore can serve as control variables in the analysis.

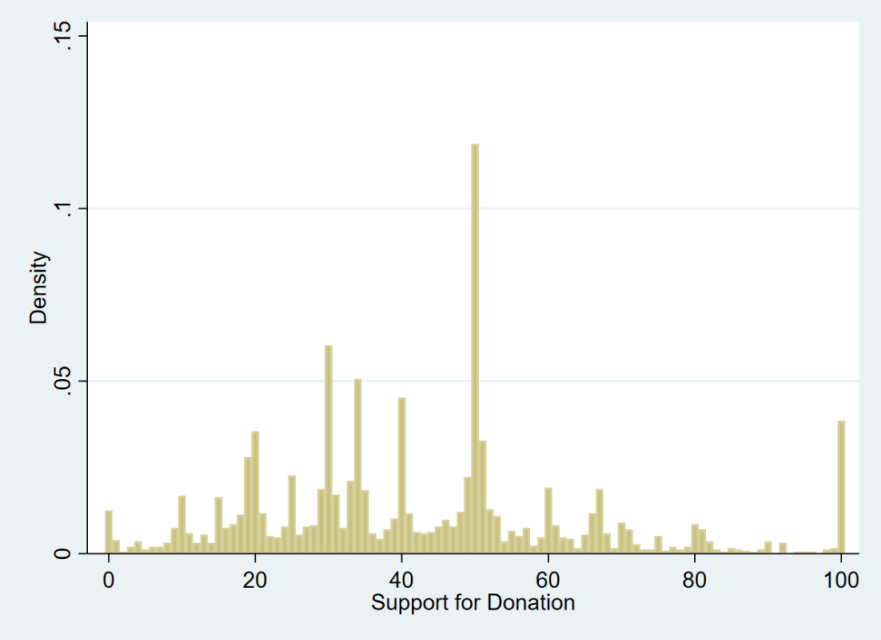
Randomization check

To assess the randomized allocation to the four experimental conditions (high/low anchor values) a randomization check was conducted. Four regression analyses included each of the high anchor variables (effectiveness of donation (Vmax), frequency of variants (λ), duration of vaccination (α), and number of nations (N)) as the dependent variables, predicted by the entire set of control variables. None of the four models are statistically significant, providing no indication that treatment assignment was not random (see Table 5 in the appendix).

Dependent variable: Support for vaccine donation

The dependent variable is the level of support for vaccine donation, which was measured on a scale of 0 to 100%, assuming a national stock that can cover the national population three times. Figure 6 presents the distribution of support. The mean level of donation suggested was 42.36% (SD=21.98%) of available excess doses. A large number of respondents (11.87%) were willing to donate 50% of the country's excess doses; 6.03% were willing to donate 30% of the available doses. Remarkably, only a small number of respondents were not willing to donate any dose (1.25%), whereas 3.85% showed support for donating 100% of the country's excess doses. As shown in the graph below, round numbers were a preferred choice (20, 30, 40 etc.).

Figure 6: Support for donation on a scale of 0 to 100%



Individual-level predictors of support for vaccine donations

Table 1 presents the results of regressing the level of support for vaccines donations on individual characteristics, which shows that women were willing to donate 1.99% more than men (p<.025). Respondents who have been vaccinated with one dose or more were willing to donate 5.09% less doses than non-vaccinated respondents (p<.001). No other variables were found to predict the level of vaccine donation. Interestingly, even people's experiences of the pandemic (e.g. a family member or close friend died of the COVID-19 virus) were not associated with their support for vaccine donation.

Table 1: Support for donation by control variables

VARIABLES	(1) Demographics
Gender (Female=0)	-1.988* (0.888)
25-34 years old	1.392 (1.896)
35-44 years old	1.957 (1.947)
45-54 years old	2.382 (1.977)
55-64 years old	-1.938 (1.953)
65+ years old	-1.290 (1.923)
Intermediate maturity	-1.846 (2.498)
High school diploma	-1.828 (2.528)
Vocational training	-2.199 (2.277)
Bachelor's degree	-3.222 (2.542)
Master or more	-3.273 (2.847)
Bayern	-2.186 (1.804)
Berlin	-2.583 (2.128)
Brandenburg	-6.033* (2.608)
Bremen	-3.043 (4.816)
Hamburg	-1.541 (2.785)
Hessen	-0.900 (2.063)
Mecklenburg-Vorpommern	-0.121 (3.093)
Niedersachsen	0.302 (1.956)
Nordrhein-Westfalen	1.449 (1.635)
Rheinland-Pfalz	1.448 (2.388)
Saarland	-2.726 (4.062)
Sachsen	-1.457 (2.227)
Sachsen-Anhalt	-0.372 (2.906)
Schleswig-Holstein	-5.057+ (2.615)
Thüringen	-3.866 (2.826)
Vaccinated (Not vaccinated=0)	-5.094*** (1.348)
Infected (Not infected=0)	0.807 (1.005)
Family member/close friend infected (Not infected=0)	-0.146 (1.092)
Family member/close friend died (No death=0)	1.225 (1.121)
Constant	50.049*** (3.259)
Observations	2,508
R-squared	0.028

Standard errors in parentheses *** p<0.001, ** p<0.01, * p<0.05, + p<0.1 (two-tailed test). The reference categories are for Age '18-24', for Education 'Secondary school certificate or less', and for *Region* 'Baden-Württemberg'.

Manipulation tests

Manipulation tests for each of the treatments of the four pandemic parameters were conducted. These tests are based on simple OLS regressions, in which the open response estimates for each of the parameters are regressed on dummy variables that indicate allocation to the respective high-value anchor. For example the high anchor of Vmax increased the parameter estimate of Vmax. See Figure 7 below for an illustration of the effect of the four treatments on their respective parameters. To ensure the selectiveness of the treatments the three non-related high anchors were included as control variables. As can be seen in Figure 7 the treatment affected only the parameter it was meant to.

Figure 7: Effect of treatments on four pandemic parameters

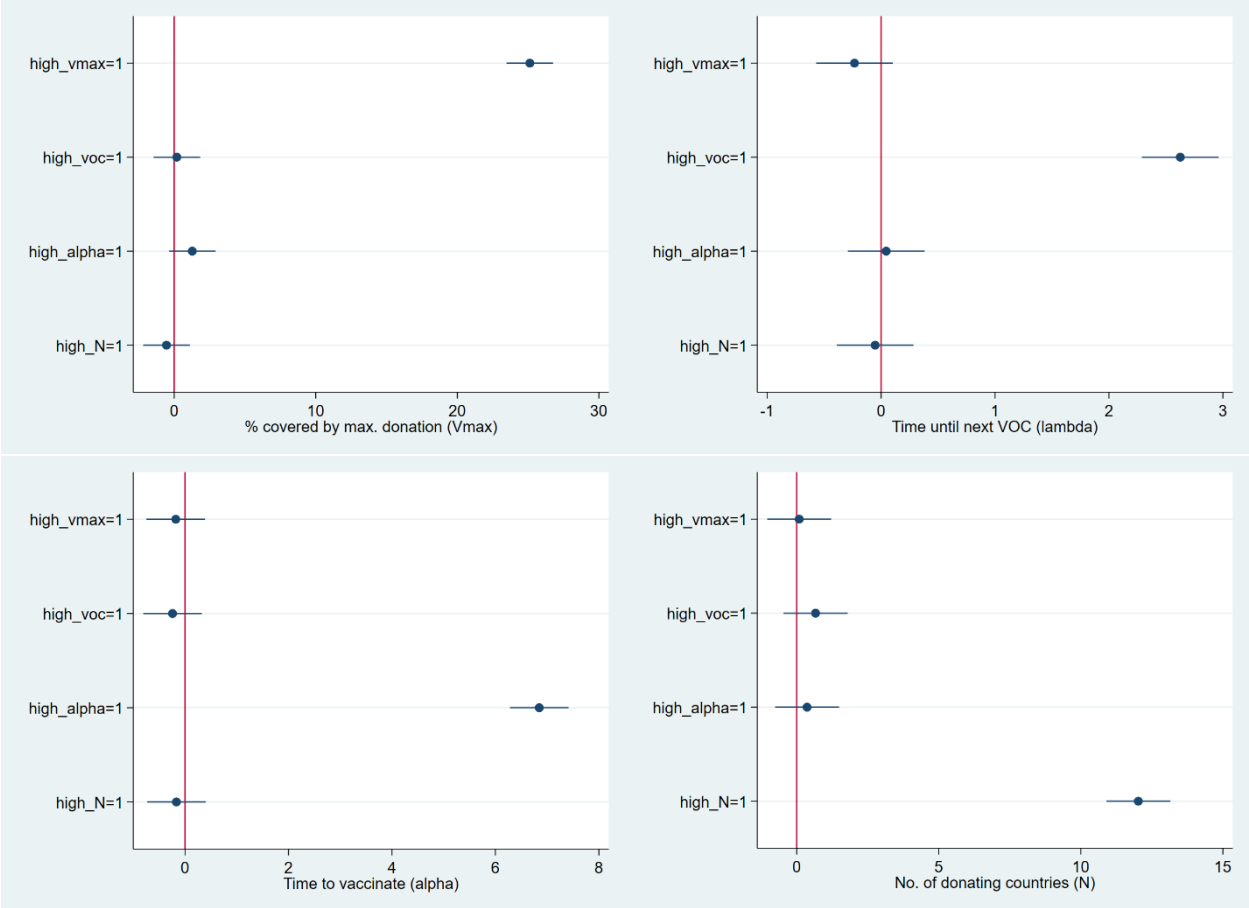


Table 2 presents the results of the anchor treatments on the parameters. Column 1 shows that the assignment to the high anchor of Vmax increased the estimated effectiveness of the donation (Vmax) by 25.13 percentage points (p<.001, N=2,602) compared with respondents who were assigned to the low-value anchor. Assignment to the high anchor of the time until the next variant (column 2) increased the estimated occurrence of a new variant of concern by 2.63 months (p<.001, N=2,580). For α (column 3), the high anchor increased the estimated time it takes to re-vaccinate 50% of the population by 6.85 months

(p<.001, N=2,590). Finally, the estimated number of vaccine-rich nations (column 4) was estimated higher by 12.26 nations (p<.001, N=2,589), if respondents were exposed to the high anchor of N. All results were significant at p<.001, showing a large effect for the four treatments. The high anchor of α and of N doubled the estimate as opposed to the low anchor condition. Vmax and λ were increased by 40% as a result of the exposure to the high anchor condition.

Table 2: Effect of high anchor treatments

VARIABLES	(1) Vmax	(2) Lamda	(3) Alpha	(4) Number of Nations
High anchor Vmax	25.125***	-0.234	-0.178	0.087
	(0.839)	(0.172)	(0.289)	(0.574)
High anchor Lamda	0.184	2.626***	-0.241	0.663
	(0.840)	(0.172)	(0.289)	(0.574)
High anchor Alpha	1.274	0.045	6.848***	0.365
	(0.840)	(0.172)	(0.289)	(0.575)
High Anchor N	-0.546	-0.052	-0.166	12.023***
	(0.839)	(0.172)	(0.289)	(0.574)
Constant	34.643***	3.833***	6.481***	12.262***
	(0.953)	(0.195)	(0.328)	(0.652)
Observations	2,602	2,580	2,590	2,589
R-squared	0.257	0.084	0.180	0.146

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Hypotheses testing

Correlational relationship

A correlational analysis of the four pandemic parameters (Vmax, λ, α and N) and the support for donation was conducted using regression analysis, which is presented in column 1 in Table 3. Gender and vaccination status were added as control variables. The relationship between the variables is not of causal nature, given the potential for omitted covariates. The results show no association for α and N. Both Vmax and λ are positively associated with the level of support for donation, suggesting that one unite increase in the effectiveness of donation increases the support for donation by 9.1% (p<.001), and a change in a month for the emergence of a new variant increases the support for donation by 23.9% (p=.012). These results are in line with H1 and H2, but are not able to support a causal relationship as stated in the hypotheses.

Average Treatment Effects (ATEs)

The average treatment effects show the causal effect of being assigned to the high-value anchor (compared with being assigned to the low-value anchor) on the level of support for donation. The results show that there is a marginally significant positive effect only of the

high anchor of Vmax (p=.055). All other treatments did not have a significant effect on the dependent variable, as detailed in column 2 in Table 3.

Table 3: Correlational relationship and ATEs on support for donation

VARIABLES	(1) Correlational relationships	(2) ATEs	(3) ATEs Interaction Model
Vmax	0.091***		
	(0.017)		
Lamda	0.239*		
	(0.095)		
Alpha	-0.014		
	(0.053)		
Number of Nations	0.011		
	(0.027)		
High anchor Vmax		1.657+	2.159+
		(0.864)	(1.226)
High anchor Lamda		-0.977	-0.478
		(0.865)	(1.224)
Interaction high anchor Vmax / high anchor Lamda			-0.997
			(1.729)
High anchor Alpha		0.126	0.117
		(0.865)	(0.866)
High Anchor N		0.135	0.128
		(0.864)	(0.864)
Gender (Female=0)	-1.598+	-2.017*	-2.023*
	(0.857)	(0.864)	(0.865)
Vaccinated (Not vaccinated=0)	-5.976***	-6.082***	-6.060***
	(1.320)	(1.290)	(1.291)
Constant	42.516***	48.103***	47.841***
	(1.738)	(1.538)	(1.603)
Observations	2,498	2,546	2,546
R-squared	0.023	0.013	0.013

Standard errors in parentheses *** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Instrumental Variable estimation

Two stage least squares (2sls) regression analysis was used to estimate the causal effect of each of the four pandemic parameters on the support for donation, using the high anchor treatment as the instrument for each respective parameter estimate. The other parameter estimates as well as gender and vaccination status were added as control variables. All the first stage analyses qualify the requirements of the instrument. The first stage equation for Vmax indicated that the high anchor of Vmax has a significant positive effect (t=30.04, p<.001), and is sufficiently strong (F(6, 2491) = 154.47, p<.001) (Sovey & Green 2010). For λ, the first stage equation indicated that the high anchor of λ has a significant positive effect (t=15.55, p<.001), and is sufficiently strong (F(6, 2491) = 53.37, p<.001). Similarly did the first stage equation of α indicate that the high anchor of α has a significant positive effect (t=23.71, p<.001), which is sufficiently strong (F(6, 2491) = 99.72, p<.001). Finally,

the first stage equation of the number of nations (N) indicated that the high anchor of N has a significant positive effect (t=20.72, p<.001), and is sufficiently strong (F(6, 2491) = 74.51, p<.001) (Sovey & Green 2010).

The results in Table 4 show the second stage analyses. The findings show a weak positive effect (p=.053) of the effectiveness of the donation (Vmax) on the support for donation, in line with hypothesis H1. The results however provide no support for an effect of the frequency of a new variant emerging (λ), the effectiveness stocking vaccines (α) and the number of vaccine-rich nations (N) – offering not to support the hypotheses H2, H3 and H4.

Table 4: Second-stage Instrumental Variable (IV) estimations

VARIABLES	(1) Vmax	(2) Lamda	(3) Alpha	(4) Number of Nations
Vmax	0.065+	0.091***	0.091***	0.091***
	(0.034)	(0.018)	(0.017)	(0.018)
Lamda	0.240*	-0.435	0.232*	0.240*
	(0.095)	(0.323)	(0.098)	(0.095)
Alpha	-0.014	0.026	0.023	-0.013
	(0.053)	(0.056)	(0.124)	(0.053)
Number of Nations	0.013	0.013	0.011	-0.003
	(0.027)	(0.028)	(0.027)	(0.071)
Gender (Female=0)	-1.643+	-1.473+	-1.585+	-1.590+
	(0.858)	(0.866)	(0.857)	(0.857)
Vaccinated (Not vaccinated=0)	-5.881***	-7.186***	-5.984***	-5.947***
	(1.323)	(1.442)	(1.318)	(1.326)
Constant	43.633***	46.473***	42.203***	42.711***
	(2.152)	(2.520)	(1.986)	(1.978)
Observations	2,498	2,498	2,498	2,498
R-squared	0.023	0.004	0.023	0.023

Standard errors in parentheses *** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Interaction model

To test the fifth hypothesis (H5) model 2 in Table 2 was elaborated, by adding an interaction term between the high-value Vmax anchor and high-value λ anchor (see column 3 in Table 2). The results are not significant, therefore not supporting the hypothesis of a positive interaction between Vmax and λ.

Additional analyses

Post response characteristics

As noted in the methods section, a set of questions after the dependent variable were included.[8] They were used in several exploratory analyses.

[8] Risk aversion, time preferences, political preferences, cosmopolitan/globalist attitudes vs. nationalist attitudes, occupation in the public sector and income level did not have a significant effect on the dependent variable.

Considerations

Following the vaccine donation question respondents were asked to choose three of the below considerations, stating the reason of their donation choice. The considerations respondents could choose from were:

1. I am not sure about the effectiveness of the health system in poor countries and don't think vaccines can be transported there safely.
2. Everyone should have equal access to the COVID-19 vaccine.
3. My country doesn't need so many vaccines.
4. I think the UN should manage the equal distribution of all vaccines, since only a global approach can end the pandemic.
5. I am not sure about the effectiveness of the vaccine.
6. Vaccinating my own fellow citizens is most important to me and I would want to know who gets the vaccine outside of my country
7. I didn't think much about my answer.

A regression analysis assessed the effect of the seven considerations on the dependent variable. Gender and vaccination status were added as control variables. Two of the seven considerations, that respondents could choose from, showed to significantly predict the support for donation. The consideration "my country doesn't need so many vaccines" was associated with a 3.73 percentage points increase in donation (p<.001). "Vaccinating my own fellow citizens is most important to me and I would want to know who gets the vaccine outside of my country" was associated with a 3.42 percentage points decrease in donation (p=.002). All other considerations were not significantly associated with support for donation.

Average Treatment Effects (ATEs) among relatively high educated, more reflective and high comprehension respondents

The robustness of the ATEs was evaluated by estimating them on sub-samples of respondents with relatively high education level, higher reflectiveness (correlated with intelligence) and comprehension of the dilemma. The education levels that were included in the analysis are 'Vocational training', 'Bachelor's degree', and 'Master's degree or more'. To attain a measure for respondent's reflectiveness, the commonly used Cognitive Reflection Test (CRT) was used[9], which tests people's cognitive ability. The CRT is moderately associated

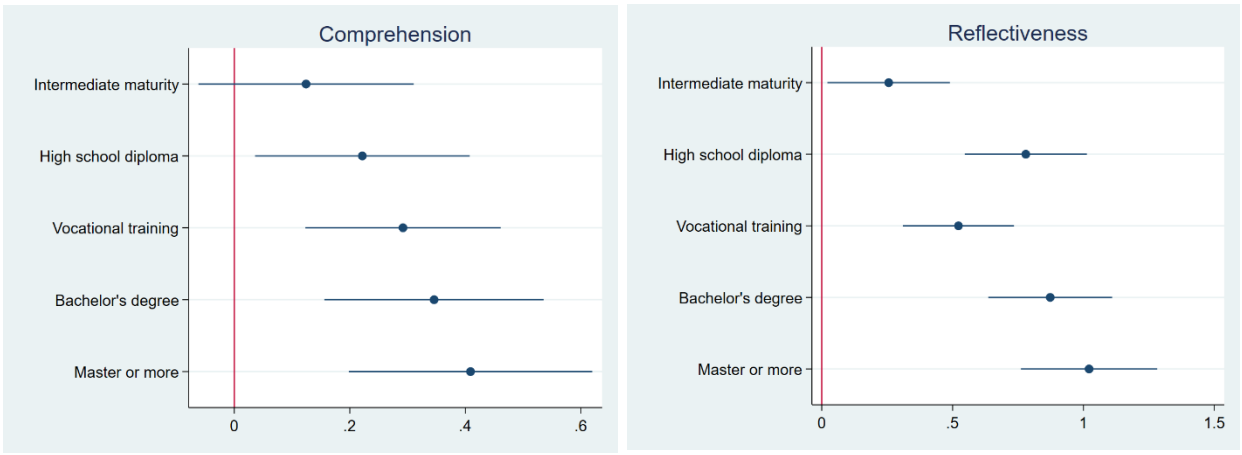
[9] (1) A bat and a ball cost 1.10 Euro in total. The bat costs 1.00 Euro more than the ball. How much does the ball cost? (2) If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? (3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?

with intelligence measures (Frederick 2005). While the CRT is a general measure, the comprehension questions tested respondent's direct understanding of the topic (see methods section for elaboration). To select respondents with higher levels of education, those who had a high school diploma or less were excluded from the ATEs analyses. To select respondents with higher levels of reflectiveness, only those who answered at least one of the three CRT questions correctly were included in the analysis. To select respondents with higher levels of understanding of the COVID-19 vaccine donation dilemma, those with only one or less correct answers of the comprehension questions were excluded. The three analyses did not largely deviate from the original findings. The exclusion of respondents with low levels of education resulted in a larger ATE of the high-valued Vmax anchor of 2.10 percentage points (p=.043). Both higher levels of reflectiveness and comprehension yielded non-significant results. These results are reported in Table 6 in the appendix.

Cognitive reflection and comprehension by education level

The following analysis attest to the validity of the comprehension measure, by estimating the relationship between education level and comprehension. The results showed a gradual increase in comprehension the higher the levels of education – as depicted in the left panel of Figure 8. The validity of reflectiveness was similarly assessed. A slight deviation from the trend was found, since respondents with a 'high school diploma' scored higher than absolvents of 'vocational training', but other than that, higher education level was predictive of the level of reflectiveness – as shown in the right panel of Figure 8.

Figure 8: Comprehension of the dilemma and reflectiveness by education



The results of the survey conducted among 2,569 German citizens did not support four of the five hypotheses (H2,H3,H4,H5). H1 was supported, though not a very strong effect of the effectiveness of the donation on the support for donation was found. The results showed higher support for donation amongst women and non-vaccinated respondents. Excluding

respondents with education below 'vocational training' increased the effect of Vmax on the dependent variable. In the following chapter the main results will be discussed along the exploratory findings and in light of the aforementioned literature.

Discussion

The COVID-19 pandemic has brought with it new challenges with regards to national decision-making. To combat the health and economic implications of the pandemic, governments were faced with dilemmas between national prioritization and global cooperation. Lampert et al. (2021) developed a game-theoretic model, which presented optimal strategies for COVID-19 vaccine donation under a set of pandemic parameters. Based on this theoretical study and given the importance of public opinion for national decision-making, the current research examined public support for COVID-19 vaccine donation. The current study hypothesized that citizens of vaccine-rich countries increase their support for donation if (1) the effectiveness of the donation (VMAX) was higher; (2) variants of concern were likely to appear less frequently (λ); (3) the time it takes to vaccinate the national population (α) was longer; and (4) there were less vaccine-rich countries (N). The study evaluated whether the preferences of citizens of a vaccine-rich country (Germany) comply with the predictions of the self-interested decision-making model.

To test the hypotheses a pre-registered nationally representative survey experiment amongst 2,569 German citizens above the age of 18 was conducted. Respondents were asked to estimate the four pandemic parameters, after which they stated their level of support for vaccine donation. Very few individual characteristics were predictive of this preference. The results showed that women and un-vaccinated citizens supported higher levels of vaccine donation. The results also demonstrated that the public tends to support vaccine donation programs of more than 0% and less than 100% donation, thus stressing support for vaccine donation, dependent on the amount that is being donated. With regards to the hypotheses, there was a moderate effect of the effectiveness of the donation (Vmax) on the support for donation. All other parameters did not influence lay people's support for donation. Higher levels of education slightly enhanced the found effect, but did not change the other findings. Selective analyses among respondents who comprehended the dilemma better, or among more reflective individuals (CRT) yielded similar results. Further exploratory findings showed a positive effect of the belief in global equality and a negative effect of vaccine nationalism on the support for donation.

The results show that the decision-making of lay people in Germany only very partly reflect the game-theoretic model developed by Lampert et al. (2021). The results did reflect an

understanding of the effectiveness of the donation, which is the dominant parameter in the theoretical model as well. The slightly stronger effect amongst respondents with higher education, suggests that the topic is of complex nature, and therefore requires higher analytical understanding. The lack of extreme answers of 0 or 100% donation of vaccines supports Bechtel, Hainmueller and Margalit's study, who found that the public support for the use of tax money for financial bailouts in other countries is dependent on the nature of the program (2017). Clarke et al. showed that more than double the proportion of people supported vaccine donation, as opposed to those who didn't (2021). The findings of the current study stand in line with Clarke, showing only 5.45% supporting the donation of 10% or less of the available vaccines. The results also support Klumpp's findings, who showed that German citizens allocated slightly more than 50% of vaccines to the high-income nation, as opposed to the low-income nation. In the current research the mean level of support for donation lies at 42.36%, which is comparable to Klumpp's finding of less than 50% allocation to a low-income country. The results of the current study, however do not support Klumpp's findings of a decrease in support for donation if a vulnerable family member was affected. While the questions were formulated differently, as opposed to Klumpp there was no association in the current study between reports regarding the infection or death of a family member or close friend and the support for donation. The association between gender and vaccination status and the support for donation, are also not reflected in Klumpp's study, where no such effect was reported (Klumpp, Monfared and Vollmer 2022). A lack of significant results for the number of vaccine-rich countries in the current research, stands contrary to Vanhuysse's findings among German citizens, who showed a preference for medium/large vaccine donation alliances, suggesting a positive effect of N on the support for donation (2021).

The results do not support four out of the five hypotheses, suggesting that lay people in Germany consider vaccine donation for other reasons than the self-interested decision-making model predicts. One possible reason could be that vaccine donation is considered to be a moral question. The exploratory analysis shows that both beliefs in global equality and vaccine nationalism significantly predicted the support for donation. These findings suggest that global empathy and nationalistic attitudes influence people's behavior, rather than utilitarian thinking, as proposed by the model. The diverse presentations of the COVID-19 pandemic in the media as well as a large stream of un-official news could have prevented a more scientific understanding of the vaccine donation dilemma. Additionally, the German culture could have affected citizens desire to donate or keep vaccine doses.

In light of the above discussion several policy steps can be taken by governments of vaccine-rich countries in order to implement the donation strategy. The game-theoretic model suggests a way to evaluate under what conditions it is in the best interest of vaccine-rich nation's governments to donate COVID-19 vaccines. The current research has shown that German citizens weakly respond in line with the model's vaccine donation dilemma. Suggested policy implications can either enhance citizen's understanding of the COVID-19 vaccine donation dilemma or alternatively the policy could be presented in terms of citizen's vaccine allocation principles. Public information campaigns (PICs) can be used to present the dilemma of vaccine donation to citizens of vaccine-rich nations. The policy tool aims to explain the scientific model highlighting the effect of the four pandemic parameters on the support for donation. In those campaigns citizens are informed about possible optimal policy implications depending on the development of the COVID-19 pandemic. To maintain the democratic nature of the conversation and avoid deception, a deliberate presentation of only one side – either donating or keeping all vaccines – should be avoided. The use of PICs may enable governments of vaccine-rich nations to engage in democratic deliberation, thus expanding the understanding of self-interested decision-making beyond vaccine-nationalism (Weiss & Tschirhart 1994). An alternative policy that can be implemented by vaccine-rich governments pertains to the framing of the dilemma. As suggested earlier, citizens think less in utilitarian terms when considering vaccine donation, but rather see it as a moral responsibility to donate vaccines or to protect their own fellow citizens. Tversky & Kahneman (1981) suggest the framing of decisions to have an effect on the choice outcome. In the current dilemma of vaccine donation, the question can be framed from a moral or humanitarian point of view, rather than a scientific deliberation. Klumpp's findings support the notion that the support for vaccine donation varies, depending on the way it is presented (Klumpp, Monfared and Vollmer 2022).

There are several limitations to the current study that suggest the need for further research on this topic. The research was conducted among citizens of one vaccine-rich nation (Germany). In order to draw conclusions of the public opinion support for COVID-19 vaccine donation in vaccine-rich countries, a cross-country analysis is required, suggesting an expansion of the current study to two to five other vaccine-rich countries (e.g. the US, China, Canada, the UK). An additional limitation is that the motivations for respondent's donation choice were only briefly examined (considerations question). To be able to point to the principles driving citizens decision-making, a more detailed study of the considerations could be conducted. Finally, as suggested earlier the current research examines lay citizen's support for vaccine donation. Since the vaccine donation dilemma requires more complex reasoning, the target group of the study might have not been

estimated correctly. Citizens might have estimated the topic as a moral question and not from a utilitarian stand point, which explains the lack of support for the game-theoretic model. Alternatively, a survey among experts in the fields related to COVID-19, such as public health policy experts, epidemiologists, health economics and medical professionals, could be conducted. A survey among experts in fields relevant to the COVID-19 pandemic could serve as an estimate for the implementation feasibility of the game-theoretic model in the current COVID-19 and in future pandemics.

Conclusion

The current study assessed the decision-making of the German public with regard to COVID-19 vaccine donation. By conducting a representative survey, Lampert's game-theoretic model was tested for its implementation feasibility in vaccine-rich countries. The research asked under what circumstances is vaccine donation supported by lay people. The results showed a strong support for vaccine donation, however this was only weakly in line with self-interested decision-making. Higher effectiveness of the donation positively affected the support for donation, a finding that was augmented with higher levels of education. The research also showed women and non-vaccinated citizens to support higher levels of vaccine donation.

The research suggests mainly other influences than those predicted by the game-theoretic model to shape the decision-making of German citizens. However, the effectiveness of the donation is a factor that is more easily understandable, and thus influencing the support for vaccine donation, along with other potential motivations. Suggested policy implications could either enhance citizen's understanding of the vaccine donation dilemma or alternatively frame the vaccine donation question from a moral and humanitarian point of view.

The current research contributes to the understanding of public support for vaccine donation. The findings add to existing literature by manifesting public support for COVID-19 vaccine donation, and emphasizing the nature of the donation program (Bechtel, Hainmueller and Margalit 2017; Clarke et al. 2021; Klumpp, Monfared and Vollmer 2022). The findings cast doubt on the decreased support for donation if a family member or close friend has been affected and the importance of the size of the coalition of donor countries (Klumpp, Monfared and Vollmer 2022; Vanhuysse 2021).

The study points to the need to further evaluate the motivations behind citizens' support for making financial contributions or the lack thereof. The research highlighted that on the one hand citizens of vaccine-rich countries weakly comply with the self-interested decision-

making model and, on the other hand humanitarian donation programs, such as the WHO's COVAX initiative, are not supported by the donation behavior of vaccine-rich nations. Further research is needed to assess the gap between the two. A study amongst experts in fields relevant to the COVID-19 pandemic, could shed further light on the potential for self-interested vaccine donation preferences in vaccine-rich countries.

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Appendix

Appendix 1: Additional tables

Table 5: Randomization check

VARIABLES	(1) High Vmax	(2) High Lamda	(3) High Alpha	(4) High N
Gender (Female=0)	-0.010	-0.031	-0.009	-0.006
	(0.020)	(0.020)	(0.020)	(0.020)
25-34 years old	0.030	-0.017	-0.016	0.018
	(0.043)	(0.043)	(0.043)	(0.043)
35-44 years old	-0.004	-0.064	-0.015	-0.008
	(0.044)	(0.044)	(0.044)	(0.044)
45-54 years old	0.011	-0.022	-0.035	0.003
	(0.045)	(0.045)	(0.045)	(0.045)
55-64 years old	0.010	-0.057	-0.032	0.015
	(0.044)	(0.044)	(0.044)	(0.045)
65+ years old	0.039	-0.039	-0.037	0.005
	(0.044)	(0.044)	(0.043)	(0.044)
Intermediate maturity	0.027	0.015	0.031	0.020
	(0.057)	(0.057)	(0.056)	(0.057)
High school diploma	-0.053	0.049	-0.020	0.037
	(0.058)	(0.057)	(0.057)	(0.058)
Vocational training	0.009	-0.005	0.030	0.015
	(0.052)	(0.052)	(0.052)	(0.052)
Bachelor's degree	0.008	-0.019	0.015	0.029
	(0.058)	(0.058)	(0.058)	(0.058)
Master or more	-0.045	-0.059	0.035	0.053
	(0.065)	(0.065)	(0.065)	(0.065)
Bayern	-0.039	-0.060	0.026	0.008
	(0.041)	(0.041)	(0.041)	(0.042)
Berlin	-0.033	-0.117*	0.021	-0.027
	(0.049)	(0.049)	(0.049)	(0.049)
Brandenburg	-0.034	-0.041	0.050	0.025
	(0.060)	(0.060)	(0.060)	(0.060)
Bremen	0.013	-0.189+	-0.234*	0.051
	(0.109)	(0.109)	(0.111)	(0.109)

Hamburg	-0.027	-0.082	-0.012	0.093
	(0.064)	(0.064)	(0.064)	(0.064)
Hessen	0.015	-0.072	0.042	0.029
	(0.047)	(0.047)	(0.047)	(0.047)
Mecklenburg-Vorpommern	0.047	-0.006	0.007	-0.016
	(0.070)	(0.070)	(0.070)	(0.070)
Niedersachsen	-0.000	-0.056	0.042	0.024
	(0.045)	(0.045)	(0.045)	(0.045)
Nordrhein-Westfalen	0.011	-0.048	0.061	0.041
	(0.037)	(0.038)	(0.037)	(0.038)
Rheinland-Pfalz	-0.068	-0.076	0.140**	-0.033
	(0.055)	(0.054)	(0.054)	(0.055)
Saarland	-0.022	-0.036	-0.130	0.107
	(0.093)	(0.092)	(0.092)	(0.093)
Sachsen	-0.042	-0.080	0.025	0.046
	(0.051)	(0.051)	(0.051)	(0.051)
Sachsen-Anhalt	-0.060	-0.164*	0.183**	0.012
	(0.066)	(0.066)	(0.066)	(0.066)
Schleswig-Holstein	-0.017	-0.073	0.026	0.131*
	(0.060)	(0.060)	(0.060)	(0.060)
Thüringen	0.034	-0.047	-0.110+	0.085
	(0.065)	(0.065)	(0.065)	(0.065)
Vaccinated (Not vaccinated=0)	0.022	0.026	0.020	-0.005
	(0.031)	(0.031)	(0.031)	(0.031)
Infected (Not infected=0)	-0.013	0.016	-0.015	-0.004
	(0.023)	(0.023)	(0.023)	(0.023)
Family member/close friend infected (Not infected=0)	-0.004	-0.012	-0.002	0.020
	(0.025)	(0.025)	(0.025)	(0.025)
Family member/close friend died (No death=0)	0.014	-0.029	0.001	0.004
	(0.026)	(0.026)	(0.026)	(0.026)
Constant	0.485***	0.599***	0.462***	0.436***
	(0.074)	(0.074)	(0.073)	(0.074)
Observations	2,571	2,562	2,567	2,565
R-squared	0.007	0.012	0.014	0.006

Standard errors in parentheses *** p<0.001, ** p<0.01, * p<0.05, + p<0.1 (two-tailed test). The reference categories are for *Age* '18-24', for *Education* 'Secondary school certificate or less', and for *Region* 'Baden-Württemberg'.

Table 6: ATEs among respondents with relatively high education, reflectiveness and comprehension

VARIABLES	(1) Education	(2) Reflectiveness	(3) Comprehension
High anchor Vmax	2.104*	1.742	1.366
	(1.037)	(1.136)	(0.939)
High anchor Lamda	-0.792	-0.670	-1.142
	(1.038)	(1.136)	(0.940)
High anchor Alpha	0.480	-0.874	-0.359
	(1.040)	(1.136)	(0.940)
High Anchor N	0.020	0.707	0.356
	(1.036)	(1.136)	(0.940)
Constant	40.936***	42.162***	41.818***
	(1.189)	(1.278)	(1.060)
Observations	1,802	1,370	1,985
R-squared	0.003	0.003	0.002

Standard errors in parentheses *** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Appendix 2: Questionnaire in English

Welcome,

This survey is part of an academic research project by an international group of researchers.

Participating in this survey will take you up to 20 minutes. You may end the survey at any time, however a partial completion of the survey may influence your financial compensation.

Your answers will be kept completely anonymous. All data will be treated confidentially and will be exclusively used for statistical analyses as part of an academic research.

In the survey you will be asked for your opinion about various aspects of the Covid-19 pandemic. You will also be asked to watch a short video about the COVID-19 pandemic, after which you will be asked several comprehension questions. Participants in this survey have the chance of winning a 10 € bonus. Your chances of winning this bonus will increase depending on the number of comprehension questions you answer correctly.

If you have any questions about this study, please contact survey.inquiry.research@gmail.com.

Please press "I agree to participate in this study", to give your consent to participate in this study and to start the survey.

- I agree to participate in this study.
- I don't want to participate.

What is your gender?

- Male
- Female
- Other
- Chose not to answer

How old are you?

- Under 18
- 18-24 years old
- 25-34 years old
- 35-44 years old
- 45-54 years old
- 55-64 years old
- 65+ years old

What is the highest level of education you have completed?

- Secondary school certificate or less
- Intermediate maturity
- High school diploma
- Vocational training
- Bachelor's degree
- Master's degree or more
- Prefer not to say

In which Bundesland do you currently reside?

- Nordrhein-Westfalen
- Bayern
- Baden-Württemberg
- Niedersachsen
- Hessen
- Rheinland-Pfalz
- Sachsen
- Berlin
- Schleswig-Holstein
- Brandenburg
- Sachsen-Anhalt
- Thüringen
- Hamburg
- Mecklenburg-Vorpommern
- Saarland
- Bremen
- I do not reside in Germany

Next, we would like to ask you a series of questions about how you fared during the COVID-19 pandemic.

Are you vaccinated against COVID-19?

- Yes
- No

- Choose not to answer

Which vaccine did you get?

- Pfizer-BioNTech
- Moderna
- AstraZeneca
- Sinovac-CoronaVac
- Sinopharm
- Other _____

How many shots of the [stated vaccine] did you get?

[1-5 shots]

Were you infected with COVID-19?

- Yes
- No
- Choose not to answer

Were any of your family relatives or close friends infected with COVID-19?

- Yes
- No
- Choose not to answer

Do you personally know someone (family member or friend) who died from COVID?

- Yes
- No
- Choose not to answer

Next, we would ask you to watch a short informational video. Please take the time to follow the video carefully. You will be asked several questions about this video later. Your chances of winning a 10 € bonus will increase depending on the number of comprehension questions you answer correctly.

What is the effect of the continuous spread of Covid-19, especially in countries with low-vaccination rates?

- Global herd-immunity is reached.

- New weaker variants of the Coronavirus are created, which slowly end the pandemic.
- The likelihood of new variants of the Coronavirus increases, and these variants pose a risk to all countries, regardless of their level of vaccination.

[If the right answer was given] Congratulations, you have answered correctly. The right answer is: "The likelihood of new variants of the Coronavirus increases, and these variants pose a risk to all countries, regardless of their level of vaccination."

[If the wrong answer was given] Your answer is not correct. The right answer is: "The likelihood of new variants of the Coronavirus increases, and these variants pose a risk to all countries, regardless of their level of vaccination."

What role does a large stock of COVID-19 vaccines play in the pandemic and how can it be used?

- Nations with many excess vaccines can choose to donate their doses or use them for booster shots for their own population in future outbreaks.
- Large stocks of COVID-19 vaccines do not play a role in the pandemic, since they are not effective when new variants emerge.
- Since vaccines are effective against COVID-19, the more vaccines are available the less infectious the virus becomes, regardless of where the vaccines are administered.

[If the right answer was given] Congratulations, you have answered correctly. The right answer is: "Nations with many excess vaccines can choose to donate their doses or use them for booster shots for their own population in future outbreaks."

[If the wrong answer was given] Your answer is not correct. The right answer is: "Nations with many excess vaccines can choose to donate their doses or use them for booster shots for their own population in future outbreaks."

What are the benefits of stocking vaccines and what are the benefits of donating excess vaccines to vaccine-poor countries?

- Donating vaccines does not benefit a country, however, stocking vaccines is beneficial since it decreases the impact of a future outbreak on its own population.
- When a country donates vaccines, it helps to decrease the risk of future outbreaks caused by variants; when it stocks vaccines, it decreases the impact of a future outbreak on its own population.
- Stocking vaccines does not benefit a country, however, vaccine donation is beneficial since it helps to decrease the risk of future outbreaks caused by variants.

[If the right answer was given] Congratulations, you have answered correctly. The right answer is: "When a country donates vaccines, it helps to decrease the risk of future outbreaks caused by variants; when it stocks vaccines, it decreases the impact of a future outbreak on its own population."

[If the wrong answer was given] Your answer is not correct. The right answer is: "When a country donates vaccines, it helps to decrease the risk of future outbreaks caused by variants; when it stocks vaccines, it decreases the impact of a future outbreak on its own population."

In the following part you will be presented with further information, and will be asked for your opinion about various aspects of the Covid-19 pandemic.

The Covid-19 pandemic is characterized by the emergence of new variants of the virus. An open question regarding these variants is how frequently do they emerge.

[Randomization to low/high anchor]

Do you think that a new COVID variant is likely to occur within the next month/12 months? Or later than a month/12 months from now?

- Within the next month/12 months
- Later than a month/12 months from now

How many months from now do you expect that a new COVID-19 variant will emerge?

[write number value]

When a vaccine-rich nation considers whether to donate its surplus vaccine doses, an important question is how much of the unvaccinated world population can be covered if all the vaccine-rich countries donated their surplus vaccine doses.

[Randomization to low/high anchor]

Do you think that more or less than 20%/90% of the world unvaccinated population can receive a vaccination if all vaccine-rich countries would donate their surplus doses?

- Below 20%/90%
- Above 20%/90%

What is your estimate for the percentage of the world's unvaccinated population that can receive a vaccine if all vaccine-rich countries would donate their surplus doses?

[write number value]

The effectiveness of stocking vaccines is mainly influenced by the time it takes to re-vaccinate a significant percentage (for example, half) of the country's population. The shorter the time of re-vaccination is, the more effective it is for a country to stock vaccine doses.

[Randomization to low/high anchor]

Do you think it takes more or less than 2/18 months to re-vaccinate 50% of a nation's population?

- Less than 2/18 months
- More than 2/18 months

What is your estimate for the time it takes (in months) to revaccinate 50% of the national population?

[write number value]

The US is among the vaccine-rich nations that can potentially donate vaccines to vaccine-poor countries.

[Randomization to low/high anchor]

Do you think that the number of vaccine-rich countries (potential donor countries) is above or below 5/30?

- Below 5/30
- Above 5/30

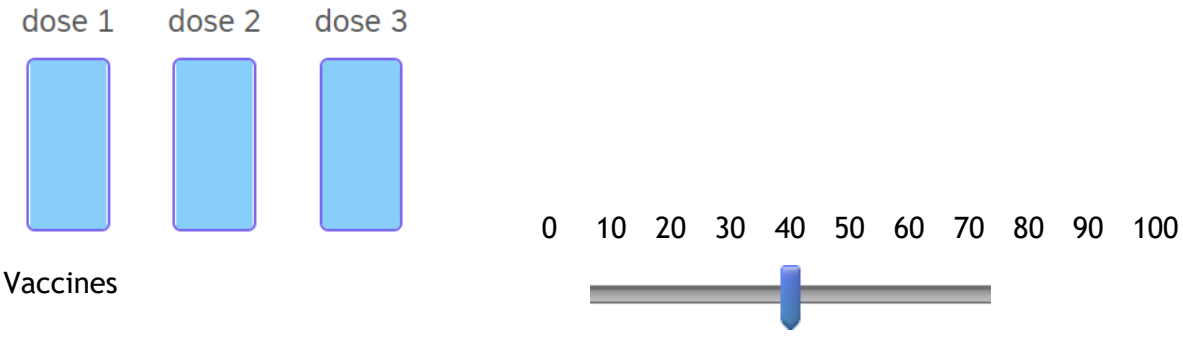
How many vaccine-rich countries (potential donor countries) do you think there are?

[write number value]

To summarize, you have given the following estimates
Please confirm each estimate below

	I confirm
A new COVID-19 variant will emerge: **in [stated number] months**	☐
The percentage of the world's unvaccinated population that can receive a vaccine if all vaccine-rich countries would donate their surplus doses: **[stated number]% of the world population**	☐
The time it takes to re-vaccinate 50% of a nation's population: **[stated number] months**	☐
Number of vaccine-rich countries (potential donor countries): **[stated number] countries**	☐

Assume your country has a stock that provides 3 additional vaccination rounds for the whole population, which can protect your country against three future outbreaks. How much of your country's stock would you be willing to donate? (Note: you can chose to donate between 0 to 100% of your country's stock. The coloured part of the barrels represents the amount of vaccines left for your country.)



Which of the following considerations influenced your decision regarding the vaccine donation?

To make your choice please drag the relevant considerations into the box.

Choose 3 considerations

_____ I am not sure about the effectiveness of the health system in poor countries and don't think vaccines can be transported there safely.

_____ Everyone should have equal access to the COVID-19 vaccine.

_____ My country doesn't need so many vaccines.

_____ I think the UN should manage the equal distribution of all vaccines, since only a global approach can end the pandemic.

_____ I am not sure about the effectiveness of the vaccine.

_____ Vaccinating my own fellow citizens is most important to me and I would want to know who gets the vaccine outside of my country.

_____ I didn't think much about my answer.

_____ Other

[Cognitive Reflection Test (CRT)]

A bat and a ball cost 1.10 Euro in total. The bat costs 1.00 Euro more than the ball. How much does the ball cost?

[write number value]

If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?

[write number value]

In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?

[write number value]

Finally, we would like to ask you a series of questions about your social preferences.

[Time Preference]

Would you rather receive 3400 € this month or 3800 € next month?

- 3400 € this month
- 3800 € next month
- I don't know

Would you rather receive 1000 € now or 100 € every year for the next 25 years?

- 1000 € now

- 100 € every year for the next 25 years
- I don't know

You bought a book for 25 €, which will arrive in two weeks. How much are you willing to add to this price in order to receive the book in the next 24 hours?

[write number value]

How willing are you to give up something that is beneficial for you today in order to benefit more from that in the future?

[scale of 0 to 10]

[Risk Aversion]

Would you rather receive 1,000 € for sure or a 75% chance of 4,000 €?

- 1,000 € for sure
- 75% chance of 4,000 €
- I don't know

Would you rather receive 500 € for sure or a 15% chance of 10,000 €?

- 500 € for sure
- 15% chance of 10,000 €
- I don't know

Would you rather lose 100 € for sure or a 50% chance to lose 300 €?

Political Ideology

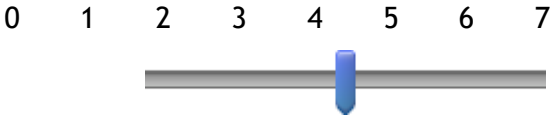
- 100 € for sure
- 50% chance to lose 300 €
- I don't know

[Political Ideology]

Did you vote in the last election?

- Yes
- No
- Choose not to answer

Here is a 7-point scale on which the political views that people might hold are arranged from extremely liberal (left) to extremely conservative (right). Where would you place yourself on this scale?



If elections were held today for which party would you vote?

- Christlich Demokratische Union Deutschlands (CDU/CSU)
- Sozialdemokratische Partei Deutschlands (SPD)
- Die Linke
- Bündnis 90/ Die Grüne
- Freie Demokratische Partei (FDP)
- Alternative für Deutschland (AfD)
- Piratenpartei
- Nationaldemokratische Partei Deutschlands (NPD)
- Other _____
- None

[Public/ Private Sector Employment]

Which of the types of organization do/did you work for?

- Central or local government
- Other public sector (such as education and health)
- A state owned enterprise
- A private firm
- Self-employed
- Other
- Not applicable

What industry / economic branch are you working in?

- Security
- Law
- Education
- Social welfare
- Administration
- Human resources
- Banking and finance
- Health
- Commerce
- Newspaper and media

- Sales and Marketing
- Food
- Cleaning and maintenance
- Infrastructure
- Agriculture
- Transportation
- Computers, Hi-Tech, and Internet
- Insurance
- Advertising
- Other ____

[Cosmopolitan/globalist attitudes vs. nationalist attitudes]

To what extent do you personally feel you are

	To a great extent	To a large extent	Somewhat	Little	Not at all
A citizen of the town where you live	○	○	○	○	○
A citizen of the region where you live	○	○	○	○	○
A German citizen	○	○	○	○	○
A European citizen	○	○	○	○	○
A citizen of the world	○	○	○	○	○

How proud are you of being German?

- Very proud
- Somewhat proud
- Not very proud
- Not proud at all
- I am not German

How much do you agree or disagree with the following statements?

	Agree strongly	Agree	Neither agree nor disagree	Disagree	Disagree strongly	Can't choose
For certain problems, like environment pollution, international bodies should have the right to enforce solutions.	○	○	○	○	○	○
Germany should follow its own interests, even if this leads to conflicts with other nations.	○	○	○	○	○	○
In general, Germany should follow the decisions of international organizations to which it belongs, even if the government does not agree with them.	○	○	○	○	○	○
International organizations are taking away too much power from the German government.	○	○	○	○	○	○

[Income]

The middle (median) monthly income in Germany is 4,253 Euro. Would you say your income is:

- Much lower
- Lower
- About the same
- Higher
- Much higher
- Prefer not to say