

Different interventions for different vaccinations? Effects of psychological factors and health policies on COVID-19 primary and booster vaccine uptake

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Abstract

Mitigation of the COVID-19 pandemic requires continued uptake of SARS-CoV-2 vaccines. Using experimental data collected in Germany in February 2022 ($N = 2,701$), this study investigated (a) predictors of primary and booster vaccination and (b) potential effects of policies combining vaccination mandates and monetary incentives. Compared to unvaccinated participants, those with primary vaccination were less complacent, more often understood the collective protection afforded by vaccination, and less often endorsed conspiracy-based misinformation. Compared to participants with primary vaccination, boosted individuals were even less complacent, exhibited fewer conspiracy-based beliefs, perceived fewer constraints, and more often favored compliance with official vaccination recommendations. Support for and reactance about vaccination mandates depended on vaccination status rather than policy characteristics, regardless of mandate type or incentives (up to 500 euro). While unvaccinated individuals rejected policy provisions and declined vaccination, boosted individuals indicated mid-level support for mandates and showed high vaccination intention. Among vaccinated individuals, higher incentives of up to 2,000 EUR had a considerable effect on the willingness to get boosted, especially in the absence of a mandate. The results indicate that mandates may be needed to increase primary vaccination numbers while incentives could be an alternative to promote booster uptake. However, combining both measures for the same target group seems inadvisable.

Introduction

As SARS-CoV-2 vaccines have been shown to reduce severe infection and death as well as transmission of the pathogen (Haas et al., 2021; Lopez Bernal et al., 2021), vaccination is considered an essential measure in mitigating and ultimately ending the pandemic. Most countries initiated large-scale vaccination campaigns after the first vaccines were licensed, and as of April 2022, about two-thirds of the world's population had received a first shot (Ritchie et al., 2022). While this is an unprecedented achievement in logistical terms, many low-income countries lag behind because of unequal access (Schaefer et al., 2021), and vaccine hesitancy—the refusal or delayed acceptance despite availability (MacDonald, 2015)—has hindered further uptake in many high-income regions (Yin et al., 2022). In addition to primary vaccination, booster shots are also important. As natural or vaccine-induced immunity wanes over time, repeated vaccination is necessary to extend protection against hospitalization and death (Falsey et al., 2021; Mattiuzzi & Lippi, 2022). Second, because first-generation vaccines are less effective against new variants such as Omicron (Andrews et al., 2022), vaccines will need to be updated regularly to maintain immunity (Milne et al., 2021) and so improve protection. While booster shots of first-generation vaccines have been available and recommended in many countries since autumn 2021, uptake has fallen short of expectations. In the US, for instance, less than 40% of those initially vaccinated had received a booster shot as of April 1, 2022. Rates were higher in European countries such as France (68% of the vaccinated population), the UK (73%), and Germany (77%), but these levels quickly stagnated (Ritchie et al., 2022), and possible reasons for this low booster uptake have been widely discussed, along with intervention strategies to increase both primary and booster uptake.

Psychological antecedents of vaccination intention and behavior

To understand and ultimately increase vaccination intention and uptake, it is important to begin from the known key determinants. According to the 7C model of vaccination readiness (Geiger et al., 2021), uptake increases with *confidence* (perceived vaccine safety and effectiveness), *collective responsibility* (valuing the protection of others), and *compliance* (supporting sanctions against those who do not follow official recommendations). Conversely, uptake decreases with *complacency* (perceived low risk of infection), *constraints* (structural or psychological barriers), *calculation* (high need to weigh perceived benefits and risks), and *conspiracy beliefs* (endorsing misinformation about vaccination).

Importantly, these factors may differ in their effects on primary and booster vaccination. For instance, while confidence in vaccine safety is likely to be a prerequisite in all cases, the effects of complacency and constraints may differ. As primary vaccination provides basic protection from SARS-CoV-2, assuming a low risk of infection may have a stronger negative effect on booster than primary vaccination intention, and the same may be true of perceived barriers to getting vaccinated. By identifying such differences, it may be possible to design effective interventions to improve vaccination uptake.

Indirect and direct interventions to change vaccination intention and behavior

Previous research suggests that measures to address perceptions of disease, vaccination, and related social processes—such as those described by the 7C model—have limited effects on vaccine uptake because they are indirect (see Figure 1; see also Brewer et al., 2017). For instance, a leaflet designed to increase awareness of the risks associated with contracting COVID-19 may have little impact on primary or booster vaccination intention because the available evidence suggests that risk perception is influenced less by personal knowledge than by variables that are difficult to change, including an individualist worldview, direct experience, and trust in science (Dryhurst et al., 2020). Even in cases where educational material mitigates complacency, other factors such as lack of confidence about safety may hinder vaccine uptake. Stagnating vaccination rates reflect the limitations of indirect intervention; despite extensive education and awareness campaigns, levels of primary and booster vaccination have slowed in many countries.

Direct intervention strategies such as sanctions (through mandates) and incentives (through financial rewards), avoid these problems by addressing vaccination intention without seeking to influence what people think and feel (Figure 1). Vaccination mandates are regulations that require individuals to get vaccinated, imposing fines or other restrictions as penalties for non-compliance. Over the last decade, many European countries have implemented selective mandates for specific vaccines to increase uptake and prevent outbreaks (Lévy-Bruhl et al., 2018; Signorelli et al., 2018). As previous research indicates that mandates effectively increase childhood immunizations (Hull et al., 2019; Lee & Robinson, 2016) and levels of vaccination among healthcare workers (Pitts et al., 2014), mandates have also been discussed in relation to COVID-19. Several countries require healthcare workers to be vaccinated (Paterlini, 2021; Wise, 2021), and the same requirement has been introduced in Italy and Greece, respectively, for people aged 50 or 60 and above. Policymakers in Germany and Austria have also debated the introduction of general mandates (Druml & Czech, 2022). In Germany, policy proposals included (1) mandated primary and

booster vaccination for adults, (2) mandated primary and booster vaccination for people aged 50 or above (who are more vulnerable to infection), and (3) a mandate combining vaccination for people aged 50 or above and mandatory consultation for younger adults to promote vaccination and to rebut misinformation (without sanctioning non-vaccination).

While mandates can improve vaccine uptake, they also have some limitations and downsides. Mandates attract ethical and legal objections because they constrain individual liberty (Frielitz et al., 2021; Reiss & Caplan, 2020). There is also evidence that mandated vaccination against SARS-CoV-2 can trigger psychological reactance—feelings of anger that prompt individuals to act against regulation (e.g., by joining a demonstration or signing a petition), to avoid mandated vaccination (e.g., by seeking medical exemption), or to preserve other freedoms (e.g., by declining voluntary vaccination against other diseases) (Sprengholz, Felgendreiff, et al., 2021). Previous studies have also reported that psychological reactance to mandated vaccination is more pronounced among vaccination skeptics (Betsch & Böhm, 2016). As vaccinated individuals (especially those who have received a booster) should exhibit more positive attitudes to vaccination in terms of greater confidence, less complacency, and stronger feelings of collective responsibility), they seem less likely to exhibit negative behaviors or reactance to mandates.

To summarize, while sanctioning non-vaccination may be effective, the associated social and psychological (and potentially behavioral) costs warrant careful consideration, and policymakers should weigh these against other less intrusive strategies. One possible alternative is to incentivize vaccination through payments, gift cards, or tax deductions. However, existing findings regarding the real and potential impacts of monetary incentives on primary vaccination against SARS-CoV-2 are inconclusive. Some studies report positive effects on intention and uptake (Campos-Mercade et al., 2021; Robertson et al., 2021; Serra-Garcia & Szech, 2021), but others differ (Chang et al., 2021; Sprengholz, Eitze, Felgendreiff, et al., 2021).

While the impact of monetary incentives undoubtedly depends on the offered amount (Sprengholz, Henkel, et al., 2021), the effect may also differ for primary and booster vaccinations. In high-income countries at least, a majority of unvaccinated individuals exhibit low vaccination intention on the grounds that they consider vaccination unsafe and perceive their vaccination status as an important element of their self-concept (Henkel et al., 2022). Being offered several hundred Dollars for vaccination is unlikely to increase confidence in vaccination or diminish conspiracy beliefs; indeed, such incentives can prove detrimental

when people feel they are being “paid off” for potentially adverse events (Jecker, 2021). This suggests that financial incentives may not increase primary vaccination intention.

However, for individuals who have already been vaccinated, incentives may encourage booster vaccination. As argued above, skipping a booster may be more likely for vaccinated individuals who see no need for a booster (because they assume that primary vaccination alone offers sufficient protection), those who perceive constraints (such as everyday stress), and those for whom compliance with vaccination recommendations is not a value in itself. Incentives may help to mitigate such barriers by prioritizing booster vaccination above other behaviors. This assumption is supported by previous evidence of the positive effects of incentives on recurring vaccination for influenza (Yamin & Gavius, 2013). A recent crowdsourcing study provides further support for this view; international experts and representative samples from the US and the UK identified financial incentives and tax benefits as among the most effective and acceptable interventions for increasing booster uptake (Böhm et al., 2022).

While mandates and incentives are often considered distinct, vaccination policies may combine these interventions. In Austria, for example, it was planned to combine a vaccination mandate with a lottery offering a one-in-ten chance of winning a voucher worth 500 EUR (about 550 USD) (Tagesschau, 2022). However, little is known about the effects of combining legal sanctions and financial incentives in this way.

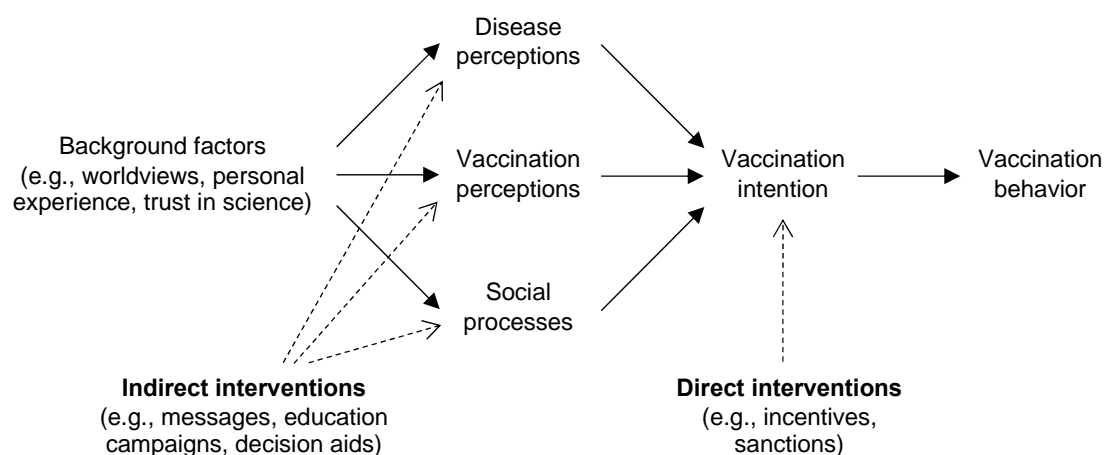


Figure 1. Determinants of vaccination intention and behavior.

Note: Interventions to increase vaccine uptake can affect vaccination intention *indirectly* by influencing perceptions of the disease and vaccination and social processes or *directly* by providing additional reasons (incentives, sanctions) for vaccination without changing disease- or vaccination-related perceptions.

The present research

The present study explores the interplay of sanctions and incentives and seeks to identify the psychological factors that distinguish unvaccinated individuals from those with primary and booster vaccination. Drawing on survey data collected in Germany in February 2022, we identify differences in the psychological antecedents of vaccination among these three groups. We further report the results of an experiment that asked individuals to imagine different mandates and incentives, based on regulations that were under discussion in several countries at that time. Our findings regarding policy support, psychological reactance, and vaccination and avoidance intentions serve to clarify the potential effects of different policies combining sanctions and incentives. The results enhance existing understanding of differences in primary and booster vaccination uptake and can help policymakers to design more effective regulations.

Methods

Participants

The study was completed as part of an online panel between February 11-23, 2022. Participants were recruited and remunerated by an independent panel provider. To secure as many participants as possible from the three target groups (unvaccinated, vaccinated, boosted), no sociodemographic inclusion criteria were specified. The study was completed by $N = 2,701$ participants from Germany (915 unvaccinated, 316 with primary vaccination, and 1,470 with booster vaccination). Mean participant age was 48.96 years ($SD = 16.46$), 48% were female, and most (52%) reported high educational attainment (i.e., university entrance qualifications).

Design

The first part of the experiment employed a 3 (mandate: general mandate vs. mandate above 50 years vs. combination of mandate above 50 years and mandatory consultation for adults younger than 50 years) \times 3 (incentive: no incentive vs. 100 EUR vs. 200 EUR) factorial between-participant design. In the second part of the experiment, participants were offered various incentives ranging from 0 EUR to 2,000 EUR (detailed below).

Materials and measures

All measures were assessed in the following order.

Antecedents of vaccination

Antecedents were assessed using the short version of the 7C scale (Geiger et al., 2021), which included statements about confidence (*I am convinced the appropriate*

authorities only allow effective and safe vaccines), complacency (*I get vaccinated because it is too risky to get infected*), constraints (*Vaccinations are so important to me that I prioritize getting vaccinated over other things*), calculation (*I only get vaccinated when the benefits clearly outweigh the risks*), collective responsibility (*I see vaccination as a collective effort to prevent the spread of diseases*), compliance (*It should be possible to sanction people who do not follow health authority vaccination recommendations*), and conspiracy beliefs (*Vaccinations cause diseases and allergies that are more serious than the diseases they seek to protect us from*). In each case, participants were asked to indicate their agreement on a 7-point scale ranging from *very strongly disagree* to *very strongly agree*.

Experiment part 1

Participants were randomly assigned to one of the three mandate and one of the three incentive conditions.

In the *general mandate* condition, participants were asked to imagine that vaccination against COVID-19 would soon become mandatory for all adults. In the *mandate above 50 years* condition, the mandate applied only to people aged 50 years or older, and in the *combination* condition, unvaccinated adults below this age were required to seek advice from a physician. Across all three conditions, participants were told that failure to comply with the specified regulation would result in a fine of up to 2,500 EUR (about 2,750 USD).

In the *no incentive* condition, participants received no further information. In the other two incentive conditions, they were asked to imagine that a vaccination bonus would be introduced immediately and that they would receive 100 EUR (about 110 USD) or 500 EUR (about 550 USD) for every past and future vaccination (including booster shots).

After the experimental manipulations, participants were asked to indicate their level of support for the presented regulation and their level of anger on 7-point scales ranging from *not at all* to *very much*. Unvaccinated individuals were additionally asked how likely they were to get vaccinated before the regulation came into force. Those who had had a primary or booster vaccination were asked how likely they were to accept a booster shot if available and recommended. Vaccination intention was assessed on a 7-point scale ranging from *not getting vaccinated at all* to *definitely getting vaccinated*.

Finally, unvaccinated individuals were told that vaccination could be rejected on the basis of medical exemption. Avoidance intention was assessed by asking whether they would try to obtain such an exemption, and their responses were recorded as a binary *yes* or *no*.

Experiment part 2

After a reminder about their mandate condition, participants were offered a series of cash incentives up to 2,000 EUR (about 2,200 USD), and vaccination intention was recorded for each offered amount. Using a contingent valuation approach (Carson, 2000), the presented amounts depended on the participant's original incentive condition and responses (Figure 2). Those who exhibited high vaccination intention (values of 6 or 7 on the 7-point scale) for a specific incentive (e.g., 500 EUR) were offered lower incentives (e.g., 100 EUR). Those who exhibited low to medium vaccination intention (values of 1 to 5) were offered higher incentives (e.g., 800 EUR). This method enabled us to identify individual-level incentive thresholds that would prompt a change from non-vaccination to vaccination.

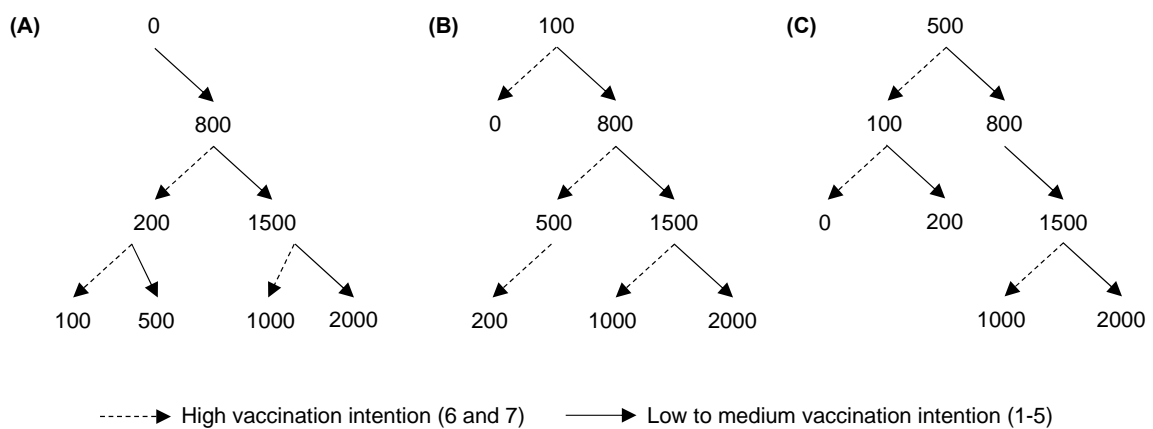


Figure 2. Contingent valuation decision trees.

Note: Participants were asked to indicate vaccination intentions for different incentives ranging between 0 and 2,000 EUR (about 2,200 USD) on a scale from 1 (*not getting vaccinated at all*) to 7 (*definitely getting vaccinated*). The incentives offered depended on initial intentions in the first part of the experiment when presented with (A) no incentive, (B) an incentive of 100 EUR, or (C) an incentive of 500 EUR. Higher amounts were presented when vaccination intention was low to medium (values 1-5, solid line); lower amounts were offered when vaccination intention was high (values 6-7, dashed line).

Results

Psychological antecedents of primary and booster vaccination

A multinomial regression was performed to identify differences in the psychological antecedents of vaccination intention and behavior across the three target groups (Table 1). Compared to unvaccinated participants, vaccinated individuals were less complacent, felt more collective responsibility, and believed less in misinformation. The results were similar for boosted participants, who also reported more confidence in vaccine safety and efficacy, fewer perceived constraints, and greater compliance with vaccination recommendations than unvaccinated individuals. Comparison of boosted and primary vaccination groups showed

that the former were less complacent and reported lower conspiracy thinking, fewer perceived constraints, and greater compliance (see Δ in Table 1). Interestingly, while confidence in authorities was more likely among those who had received a booster shot (compared to the non-vaccinated) but not among the primary vaccination group, no significant difference was observed between the two effects.

Table 1. Predictors of group membership.

Predictors	Primary vaccination (vs. unvaccinated)			Boosted (vs. unvaccinated)			Δ
	<i>OR</i>	<i>CI</i> –	<i>CI</i> +	<i>OR</i>	<i>CI</i> –	<i>CI</i> +	
(Constant)	2.62	0.65	10.58	19.83	5.19	75.76	+
Confidence	1.11	0.99	1.26	1.20	1.06	1.35	
Complacency	0.74	0.66	0.84	0.67	0.60	0.76	–
Constraints	0.87	0.74	1.01	0.72	0.62	0.84	–
Calculation	1.07	0.99	1.16	1.03	0.95	1.12	
Collective responsibility	1.31	1.15	1.48	1.39	1.23	1.57	
Compliance	1.12	0.97	1.29	1.34	1.17	1.54	+
Conspiracy beliefs	0.79	0.71	0.87	0.61	0.55	0.67	–

Note. Results from multinomial logistic regression (reference group: unvaccinated individuals, $N = 2,701$, Cox' & Snell's $R^2 = .61$, Nagelkerke's $R^2 = .72$). Bold predictors are statistically significant for $p < .05$. *CI*– and *CI*+

Effects of mandates and minor incentives

To investigate the effects of different policies on support, reactance, and vaccination intention, each of the three outcomes was regressed on policy characteristics (mandate and incentive conditions from the first part of the experiment), participant age (up to 50 years or 50 years and older, as these were relevant for policy conditions), and vaccination status (not vaccinated, primary vaccination, or boosted), as well as all possible interactions. In the following account, only significant relationships ($p < .05$) are reported; for details, see the online supplement. For all dependent variables, the main finding was that vaccination status exerts a strong influence on how policies are evaluated and whether people wish to get vaccinated (again). These findings are visualized as descriptive statistics in Figure 3.

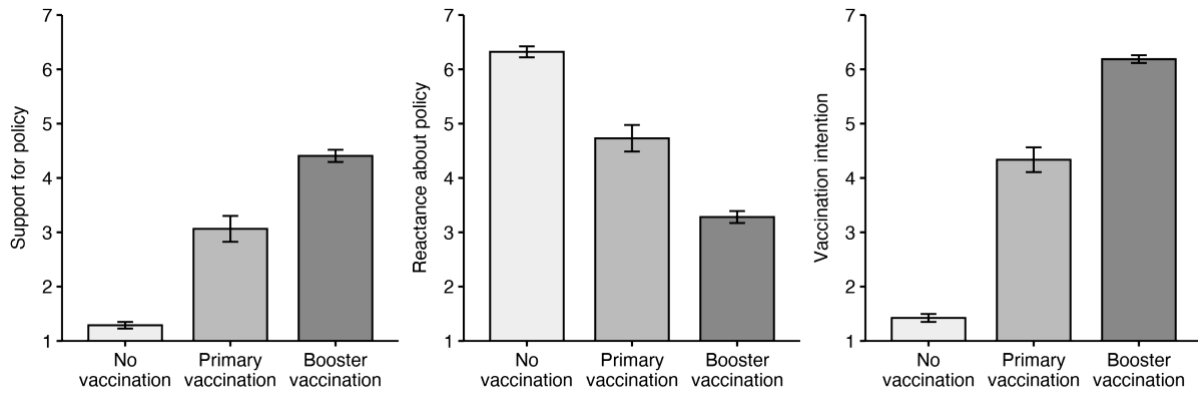


Figure 3. Policy support, reactance, and vaccination intention.

Note: Participants were presented with different policies combining vaccination mandates and incentives. While policy characteristics had little or no effect on support, reactance, or vaccination intention, individual vaccination status was a strong predictor. Bars denote means; error bars indicate 95% confidence intervals.

Policy support ($R^2 = .39$) was related only to vaccination status. Compared with the unvaccinated, those who had received primary vaccination exhibited greater support for the presented regulation ($b = 1.28$, 95% CI = [0.38; 2.18]), and this difference was even stronger among boosted individuals ($b = 3.33$, 95% CI = [2.64; 4.03]). No significant effects were observed for mandate and incentive characteristics, age, or potential interactions.

Reactance ($R^2 = .36$) also related solely to vaccination status. Boosted individuals were less angry than the unvaccinated about the presented regulations ($b = -3.55$, 95% CI = [-4.27; -2.82]). However, there was no significant difference between unvaccinated and primary vaccination participants ($b = -0.79$, 95% CI = [-1.74; 0.15]). Again, policy characteristics, age, and potential interactions played no significant role. Overall, a strong correlation could be observed between policy support and reactance ($r = -.79$).

First or further vaccination intention ($R^2 = .72$) were most strongly predicted by vaccination status. Compared to the unvaccinated, those in the primary vaccination group reported higher vaccination intention ($b = 2.79$, 95% CI = [2.12; 3.46]), and the difference was even greater between unvaccinated and boosted participants ($b = 4.30$, 95% CI = [3.78; 4.81]). Four minor interaction effects indicated that policy characteristics and age exert some influence on vaccination intention. Being 50 years or older increased vaccination intention among those in the primary ($b = 1.71$, 95% CI = [0.53; 2.90]) and booster vaccination groups ($b = 1.01$, 95% CI = [0.30; 1.72]). However, for individuals aged 50 or older in the primary vaccination group, being assigned to the *combination* condition (compared to the *general mandate* condition) had a negative effect on vaccination intention ($b = -1.87$, 95% CI = [-3.59; -0.15]). Those in the primary vaccination group also reported somewhat lower

vaccination intention when offered 100 EUR than when offered no payment at all ($b = -1.28$, 95% CI = [-2.28; -0.28]).

Among unvaccinated individuals, 63% indicated that they would seek medical exemption from vaccination. A binary regression revealed no significant influence of policy characteristics (mandate and incentive conditions) or age (up to 50 years, or 50 years and older) on the avoidance intention (see supplement for further detail).

Effects of mandate self-relevance and major incentives

The above analyses focused on the effects of dedicated policies proposed by German policymakers. As policy characteristics and participant age played little or no role in explaining the different outcomes, we decided to aggregate mandate characteristics and age information as an indicator of policy self-relevance. For participants assigned to the *general mandate* condition and those aged 50 or older, the regulation was considered self-relevant, otherwise it was coded not self-relevant. This way, statistical power and interpretability of findings could be increased.

Based on their responses in the second part of the experiment, likelihood of getting vaccinated (again) was calculated for each participant and incentive. Adopting a conservative coding approach, vaccination intention values between 1 and 5 were coded as low likelihood (0), and vaccination intention values of 6 or 7 were coded as high likelihood (1). For incentives that were not presented, likelihood was estimated by assuming monotone decision making—that is, individuals indicating a high (low) chance of vaccination for a specific incentive would do the same for any higher (lower) incentive.

As shown in Figure 4, the share of people indicating high likelihood of vaccination depended not only on vaccination status but also on policy self-relevance and the size of incentive offered. To investigate these effects for each group, we performed linear mixed effects regressions as recommended by Gomila (2021). Likelihood of vaccination was regressed on policy self-relevance (between participants), incentive size (within participants, treated as a numeric value between 0 and 2 for incentives from 0 to 2,000 EUR), and their interaction (Table 2). As the different intercepts indicate, future vaccination was more likely among vaccinated individuals, especially when they had received a booster shot. The effect of mandate self-relevance was significant only for boosted individuals, who exhibited higher intention to get vaccinated if required to do so. Importantly, greater incentives increased vaccination intention in all three groups, especially when the mandate was not self-relevant. In such cases, offering participants the maximum 2,000 EUR rather than no incentive increased the share of willing individuals from 0% to 7% (7 pp) for unvaccinated

participants, from 23% to 53% (30 pp) for those in the primary vaccination group, and from 57% to 82% (25 pp) for boosted individuals. When participants were affected by the mandate, incentives had less impact. In this case, offering 2,000 EUR rather than no incentive increased the share of willing individuals from 1% to 5% (4 pp) for unvaccinated participants, from 34% to 53% (19 pp) for participants in the primary vaccination group, and from 79% to 90% (11 pp) for boosted individuals. To that extent, the overall positive effect of incentives was much smaller for unvaccinated individuals than for vaccinated participants and for those affected by mandatory regulations than for those not affected.

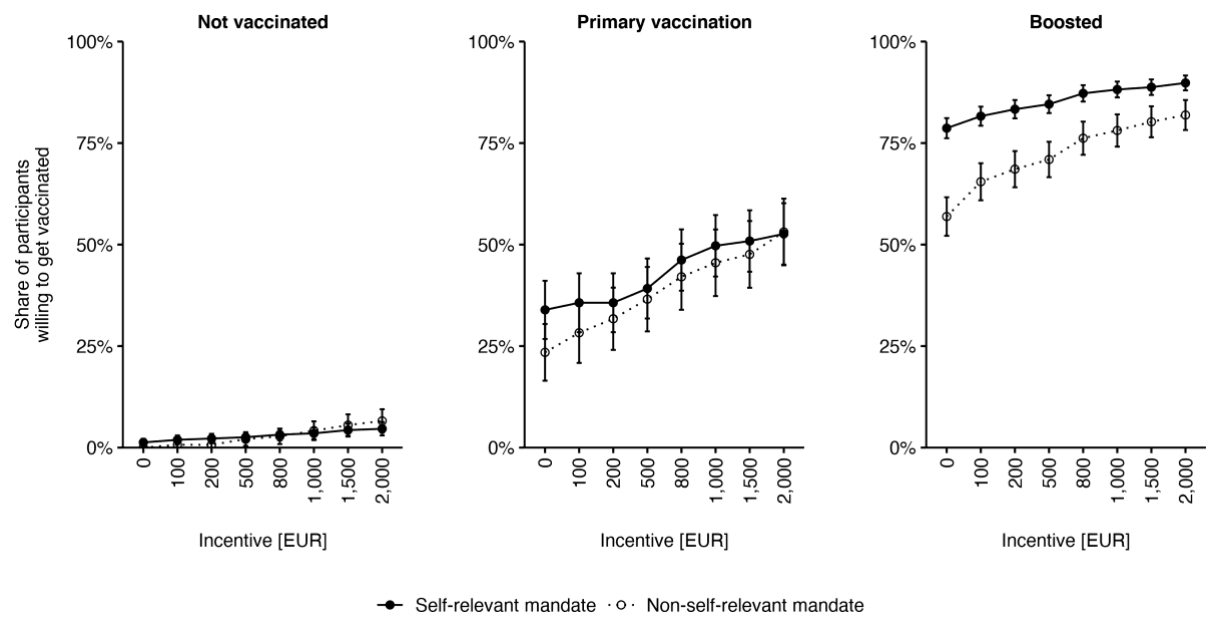


Figure 4. Effects of incentives and policy self-relevance.

Note: Share of participants willing to get vaccinated (i.e., vaccination intention above 5 on a scale from 1 to 7), depending on vaccination status, incentive offered, and self-relevance of presented vaccination mandate.

Table 2. Predictors of vaccination likelihood.

Predictor	Unvaccinated				Primary vaccination				Boosted			
	<i>b</i>	<i>SE</i>	<i>CI</i> −	<i>CI</i> +	<i>b</i>	<i>SE</i>	<i>CI</i> −	<i>CI</i> +	<i>b</i>	<i>SE</i>	<i>CI</i> −	<i>CI</i> +
(Constant)	0.00	0.01	-0.01	0.02	0.28	0.04	0.21	0.35	0.64	0.02	0.61	0.67
Policy: self-relevant (baseline: not self-relevant)	0.01	0.01	-0.01	0.04	0.07	0.05	-0.03	0.17	0.17	0.02	0.13	0.21
Incentive (x1,000 EUR)	0.03	0.00	0.03	0.04	0.14	0.01	0.12	0.16	0.11	0.00	0.10	0.12
Interaction effect	-0.02	0.00	-0.02	-0.01	-0.04	0.01	-0.06	-0.01	-0.06	0.01	-0.07	-0.05
Marginal R^2 /Conditional R^2	0.01/0.68				0.03/0.81				0.04/0.81			

Note. Results from mixed effects regressions investigating the effects of self-relevant (compared to non-self-relevant) mandates and incentives (0 to 2,000 EUR) on likelihood of vaccination (vs. non-vaccination) for unvaccinated individuals and participants in primary and booster vaccination groups. Bold predictors are statistically significant for $p < .05$. *CI*− and *CI*+ denote lower and upper bounds of the 95% confidence interval.

Discussion

Unvaccinated individuals and those in the primary and booster groups differ in terms of how they think and feel about COVID-19 vaccination and how they perceive and react to direct interventions that seek to change their vaccination intention. Compared to unvaccinated participants, those in the primary vaccination group were less complacent, more likely to understand the issue of collective protection, and less likely to believe in conspiracies. It follows that future campaigns to persuade unvaccinated individuals to get vaccinated should focus on communicating individual and collective risks of non-vaccination and on debunking misinformation. Compared to those in the primary vaccination group, boosted individuals were less complacent, believed less in conspiracy-based misinformation, perceived fewer constraints, and were more likely to favor compliance with official vaccination recommendations. These observed differences have important implications for future booster campaigns. First, vaccinated individuals should be reminded that protection can wane over time and that getting vaccinated again can help to prevent severe infection and death. Second, getting a booster shot should be made as easy as possible. In many countries, booster vaccinations are available locally (e.g., in community centers and pharmacies) without having to make an appointment, and this approach should be more widely implemented. Finally, information campaigns to correct conspiracy-based beliefs should target unvaccinated as well as vaccinated individuals. Therefore, misinformation circulating within both groups must be monitored closely.

Lowering barriers and enhancing education may help to increase vaccination intention in some cases. However, pre-pandemic evidence of the ineffectiveness of these indirect measures (Brewer et al., 2017) and the observed slowing of vaccination uptake in many countries in autumn 2021 (despite easy access and extensive information campaigns) highlights their limited impact on future uptake, especially among unvaccinated skeptics. For that reason, we focused on the potential of direct interventions such as vaccination mandates and financial incentives to increase uptake of primary and booster vaccines. Based on real policy proposals in Germany and Austria at the time of data collection, we investigated the combined effects of different mandates and payments.

In the first part of our experiment, we found that support for and reactance to different policies depended on vaccination status alone rather than on policy characteristics. In other words, it did not matter what kind of mandate was presented or whether vaccination was incentivized with up to 500 EUR per shot. In general, unvaccinated participants rejected every policy and declined vaccination while boosted individuals showed mid-level policy

support and high vaccination intention; people with primary vaccination fell somewhere between. Given that overall support for the presented policies was low and that even boosted individuals indicated no clear preference for mandatory vaccination, introducing any of these policies seems likely to backfire. Indeed, we observed considerable reactance, especially among the unvaccinated, and there is evidence that reactance to mandatory vaccination relates to an intention to fight or avoid regulation and resist voluntary vaccination against other diseases (Sprengholz, Betsch, et al., 2021). In line with earlier findings (Sprengholz, Felgendreiff, et al., 2021), reactance was not confined to self-relevant mandates; as age and mandate characteristics played no role in predicting anger about the regulations, potential backfire effects must be anticipated and mitigated even among those who are not affected by a given mandate. Previous research suggests that reactance can be reduced by explaining the rationale for a vaccination mandate (Sprengholz, Felgendreiff, et al., 2021; Sprengholz & Betsch, 2020). Although this issue was not explored in the present study, explaining a mandate's benefits for public health or the economy may prove effective for those who have already been vaccinated. However, unvaccinated individuals may oppose coercive measures regardless of explanation because of their stronger conspiracy-based beliefs and low confidence in vaccine safety.

While the incentives of up to 500 EUR offered in the first part of the experiment did not increase vaccination intention, higher incentives of up to 2,000 EUR proved more effective. By reclassifying policies as self-relevant or non-self-relevant, we were able to show that higher incentives prompted a stronger increase in vaccination intention, especially when individuals were not affected by the mandate. Among unvaccinated individuals, however, any such difference was negligible, and vaccination intention remained low even for higher payments. This aligns with earlier evidence from Germany, showing that payments of up to 3,000 EUR are unlikely to increase primary vaccination uptake (Sprengholz, Eitze, Felgendreiff, et al., 2021; Sprengholz, Henkel, et al., 2021). It seems that negative effects of low confidence and belief in conspiracy-based misinformation cannot be reversed by offering financial incentives. Consequently, policymakers should not seek to incentivize primary vaccination. However, for vaccinated individuals a different picture emerged. When not being affected by a given mandate, an incentive of 2,000 EUR increased vaccination intention among individuals in the primary (booster) vaccination groups by 30 (25) percentage points. To that extent, payments seem an effective means of increasing booster uptake by helping to prioritize vaccination over other behaviors and possibly overruling the influence of complacency and constraints. Clearly, appropriate mandates can also be

expected to achieve high uptake rates. For instance, the percentage of boosted individuals willing to get vaccinated was comparable for those who were unaffected by a mandate but were offered a 2,000 EUR incentive (82%) and those who were mandated but not incentivized (79%). However, as summarized above, mandates are more likely to elicit reactance and detrimental effects.

Importantly, little support could be found for policies combining incentives and mandates (as proposed in Austria) to foster booster uptake. As the positive effect of incentives seems to decrease with mandatory vaccination, policymakers should focus on one intervention or the other. However, different strategies seem optimal for promoting primary and booster vaccination. While mandates are more likely to increase primary vaccination, incentives could be implemented to sustain booster uptake. In general, our findings suggest that financial incentives can promote uptake among those who consider vaccination useless or inconvenient but not in cases where vaccination is perceived as dangerous. In short, while incentives may compensate for inconvenience, money cannot overcome low confidence in vaccine safety and conspiracy-based fears for one's health.

Limitations

While our findings contribute to the design of effective vaccination policies, they cannot be readily generalized. In order to oversample unvaccinated individuals, we dispensed with sociodemographic inclusion criteria, and while the sample was reasonably diverse in terms of age, gender, and education, it cannot be considered representative of the general German population. In addition, our results relate to a specific time and context; the data were collected during the less severe Omicron wave, and vaccination intention and support for mandatory regulation may change when more severe strains of SARS-CoV-2 emerge or new vaccines are approved (Sprengholz, Eitze, Korn, et al., 2021). Importantly, too, all variables were self-reported, and our findings may differ from actual behavior. For instance, unvaccinated participants may have understated vaccination intention in the face of mandates and fines. Nevertheless, while vaccine uptake might be higher if mandatory policies were actually implemented, the observed relationships between policy characteristics and vaccine uptake can be considered robust.

Conclusions

The present findings suggest that unvaccinated individuals and people with primary and booster vaccinations form distinct groups. For that reason, indirect interventions to improve vaccination intention by raising risk awareness, debunking misinformation, or highlighting collective responsibility must be tailored accordingly. Similarly, direct

interventions such as financial incentives or fines are likely to prove effective for some target groups but not for others. Financial incentives are unlikely to persuade unvaccinated individuals but may become an important cornerstone of health policies that seek to improve booster uptake. However, our results indicate that reasonable payments need to be offered. Importantly, policymakers should refrain from combining mandates and incentives as this means realizing multiple disadvantages (backfire effects due to the mandate and high implementation costs) while only achieving a marginal improvement in vaccination uptake as compared to either measure alone.

Online supplement

Materials, data, and the data analysis script are available at <https://osf.io/ngxtq/>

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