Running Head: PREFERENCES FOR VACCINATION POLICIES

Word Count: 2,992

# Individual Preferences for Voluntary vs. Mandatory Vaccination Policies: An Experimental Analysis

Nicolas W. Meier[§] and Robert Böhm

School of Business and Economics, RWTH Aachen University, Aachen, Germany

Lars Korn and Cornelia Betsch

Media and Communication Science, University of Erfurt, Erfurt, Germany

Center for Empirical Research in Economics and Behavioral Sciences, University of Erfurt, Erfurt, Germany

[§] Correspondence: Nicolas W. Meier, RWTH Aachen University, Templergraben 64, 52062 Aachen, Germany, Phone: +49 241 80 96703, E-mail: nicolas.meier@rwth-aachen.de

**Abstract**

**Background:** More and more countries are discussing the introduction of mandatory vaccination policies. Yet, little is known about individuals' actual preferences for voluntary vs. mandatory vaccination policies, and the psychological processes underlying such preferences. Objective of the present research was to investigate the development of individual preferences for voluntary and mandatory vaccination policies.

**Methods:** We conducted a controlled laboratory study ($N$ = 168) using a repeated interactive vaccination game with decision-contingent monetary incentives. In each round, participants decided in favour of either a voluntary or a mandatory vaccination policy, followed by the vaccination decision (voluntary policy) or vaccination (mandatory policy) which both resulted in actual (financial) consequences.

**Results:** We observe large heterogeneity in participants' preferences for the voluntary vs. mandatory policy. Under voluntary vaccination, the preference for the mandatory policy increased with decreasing vaccination rates (and increasing risk of infection). In contrast, experiencing vaccine-adverse events under mandatory vaccination increased the preference for the voluntary policy. The latter effect was larger for individuals with a negative (vs. positive) attitude towards vaccination. Overall, as individuals gathered experiences under both the voluntary and the mandatory policy, the preference for voluntary vaccination policy increased over time.

**Conclusions:** Individuals are more willing to accept mandatory vaccination policies when vaccination rates are low. In the long run, the occurrence of vaccine-adverse events may spark opposition to mandatory vaccination policy.

Keywords: Vaccination; Mandatory Vaccination; Experiment; Experimental Health Economics; Health Behaviour; Health Policy

## Introduction

Vaccination is one of the most successful measures of preventive medicine.[1] Despite its demonstrated success in the past, e.g., the eradication of smallpox,[2] suboptimal vaccination rates are a persistent threat to eliminating or eradicating infectious diseases. Therefore, more and more countries discuss whether to introduce selective or full mandatory vaccination policies.[3] For example, in 2017 France[4] introduced mandatory vaccination policies for standard childhood vaccines. In the US, many states require certain vaccinations for kindergarten or school entry.[5]

However, the question of whether vaccination should be voluntary vs. mandatory is a perennial issue in recent public debates[6], which are often emotional, ethically and morally challenging and divisive.[7,8] Clearly, mandatory vaccination is effective in increasing uptake of the mandatory vaccine.[9–12] Therefore, one of the most common arguments in favour of mandatory vaccination is that of promoting public health by building upon the social benefit of vaccination. According to this view, the state is permitted or even obliged to protect and promote public health by implementing a mandatory vaccination policy.[13] In contrast, mandatory vaccination is rejected from a classical libertarian point of view because it restricts the bodily integrity as well as the scope of parental control.[14–18] This is not a negligible argument, because vaccination may indeed cause harm due to potential vaccine adverse events, although in rare cases only.[19]

Beyond these normative arguments, little is known about individuals' actual preferences for either vaccination policy, and the psychological processes underlying (the development of) such preferences (for psychological reactions towards and consequences of selective mandates, see [20]). The present research aims to address this issue, which is of utmost importance for policymakers to implement vaccination policies that receive long-term public support.

We assessed individuals' preferences towards different vaccination policies, analysing endogenous choices for a voluntary vs. mandatory vaccination policy – and its determinants – in an incentivized, interactive vaccination game (I-Vax game[21]). The I-Vax game considers both the direct and indirect (via herd immunity) effect of vaccination and therefore allows investigating vaccination behaviour

under realistic epidemiological incentives. The dependent variable of our study is thus a 'revealed preference' (not a stated preference), which has important methodological advantages when studying policy preferences.[22–24] First, choices are consequential, i.e., after opting for either a voluntary vs. mandatory vaccination policy, participants engage in an interactive vaccination game with monetary incentives that are contingent to the participants' decisions. Hence, participants are likely to aim at maximizing payoffs and, therefore, socially desirable responding can be largely excluded. Second, participants face the decision between a voluntary and a mandatory vaccination policy across several rounds. Thus, we are able to observe whether and how participants' payoff experiences change their policy preferences over time.

We focus on two potential determinants of individuals' preferences for vaccination policies: First, there might be differences in individuals' personal characteristics that could cause differences in policy preferences, such as vaccination attitude and desire for control over one's environment. And second, policy preferences might underlie adaptations based on experience-based beliefs about others' vaccination behaviour as well as based on personal experiences with the different policies, i.e., infections or vaccine adverse events (see supplementary material for detailed hypotheses).

## Methods

We conducted an experimental laboratory study with $N$ = 168 participants (44.6% female, aged 18 to 58, $M_{age}$ = 24.4, $SD$ = 5.5). For the vaccination decision task we used a modified version of the I-Vax game[21,25,26] for details and predictions, see supplementary material). The game is played in randomly assigned groups of 12 members over 20 rounds; groups remained stable over rounds. It is structured into four phases: (I) policy choice, (II) vaccination decision, (III) incubation phase, and (IV) payoff phase. In the policy choice phase (I), participants decide whether they want to be part of a group with a voluntary or a mandatory vaccination policy in the current round. The sizes of the policy groups, i.e., voluntary vs. mandatory policy group, vary depending on the endogenous policy choice of all players of the overall group in phase I. In the vaccination decision phase (II), participants have to decide in favour of or against vaccination in the case of voluntary vaccination policy, or are vaccinated automatically in the case of mandatory vaccination policy. In the incubation phase (III), it

is determined whether participants will contract the disease (in the case of non-vaccination) or will experience vaccine adverse events (in the case of vaccination). The probability of contracting the disease depends on the number of vaccinated individuals in the group (the higher, the lower the probability, see supplementary material). The probability for vaccine adverse events was fixed. In sum, given the parameters of the game (specified in the supplementary material), the optimal selfish-rational situation is reached when 39% of the participants vaccinate; the social optimum (elimination of the disease) is reached, when 67% vaccinate. In the final payoff phase (IV), the consequences are determined using outcome-contingent monetary incentives (contracting the disease and vaccine adverse events cause losses of money).

**Interindividual Difference Measures**

We focus on three personal characteristics that might affect individual's preferences for a voluntary vs. mandatory vaccination policy: the attitude towards vaccination, the preference towards others' welfare (operationalized via social value orientation), and the desire for control over one's environment.

**Attitude towards vaccination.** Before the actual decision making task, participants' attitude towards vaccination was measured with three 5-point Likert-type scale items (e.g., "It is a good idea to get vaccinated"), adapted from Askelson and colleagues,[27] with greater values indicating a more positive vaccination attitude. The scale had good internal consistency (Cronbach's $\alpha = 0.88$), therefore, we used the mean value for the analyses ($M = 4.11$, $SD = 0.87$).

**Social value orientation.** Participants' social value orientation was assessed with the Social Value Orientation (SVO) Slider Measure.[28] The measure consists of six constant sum and non-constant sum dictator game-like decisions in which participants have to allocate points between themselves ("sender") and an unknown other participant ("recipient"). In these allocation decisions, distributing more points to the recipient captures positive other-regarding preferences, i.e., fairness, altruism and/or social welfare concerns. Responses can be scored to yield a single angle-index of a

participant's social value orientation between -16.26° and 61.39°. Greater values indicate more positive other-regarding preferences.

**Desire for control.** We measured participants' desire for control over one's environment with five 7-point Likert-type scale items (e.g., "Sometimes I'm afraid to lose control.") by Rijsdijk and Hultink,[29] with greater values indicating a higher desire for control. For the analysis, we used the mean value of all 5 items ($M$ = 5.33, $SD$ = 0.80, Cronbach's $\alpha$ = 0.68).

**Procedure**

Participants were students at a large German university; they were recruited with the online registration software ORSEE[30] to participate in experimental sessions of 24 participants each, divided into 2 groups of 12 participants. The study was programmed with z-Tree.[31] Upon arrival at the laboratory, participants drew an index card that determined their individual cubicle number. Printed instructions (see supplementary material) were handed out and read out loud by the experimenter. The measures of interindividual differences were assessed either before participants learned about the nature of the subsequent decision task (vaccination attitude and social value orientation) or after they learned about the task but before they made decisions herein (desire for control).

Afterwards, participants engaged in 20 rounds of the I-Vax game including the preceding policy choice. Within the overall group of 12 players, the respective sizes of the voluntary and mandatory vaccination policy group varied depending on participants' endogenous preference for the respective vaccination policy. Upon policy decision, the I-Vax game was played separately for each policy type. Note that the policies were labelled neutrally, i.e., "Group A" (instead of voluntary group) and "Group B" (instead of mandatory group). After the policy decision but before the vaccination decision, participants were informed about the number of players in each group. After each round, participants received feedback about their outcome and the vaccination rate in the voluntary policy group.

At the end of all rounds, participants' outcomes were accumulated across rounds and converted to money (see supplementary material). Participants also learned about their payoff from the SVO Slider

Measure. Overall, participants earned on average 12.40 Euros (*SD* = 1.03; between 9.20 and 14.90 Euro) in the 75-minutes study.

## Results

The data are provided in the supplementary material. First, we report and analyse the aggregated descriptive data of the endogenous policy choices and the vaccination decisions, using non-parametric tests. Subsequently, the predictors of the individual-level policy choices are examined, using multilevel mixed-effects logistic regressions.

### Aggregated Policy Preferences

Figure 1 displays the average number of participants selecting the mandatory vaccination policy over the 20 rounds. Participants' policy decision in the first round provides insights about their "baseline" preference without having had any experiences under the respective vaccination policy in the game. In the first round, an average of $M = .61$ ($SD = .14$, $Min = .42$, $Max = .83$) of the participants opted for the voluntary vaccination policy (blue bars in Figure 1; Binomial test against equal distribution: $p = .004$). The average preference for the voluntary policy across all rounds is $M = .70$ ($SD = .10$, $Min = .56$, $Max = .87$). Over the course of the repeated game, participants' preference for the voluntary vaccination policy increased (difference between first ten vs. last ten rounds, Wilcoxon signed-rank test: $z = 2.14$, $p = .033$).

Analysing intraindividual consistency of policy preferences across all rounds reveals considerable heterogeneity: The vast majority (68%) of participants switched at least once between the two vaccination policies. Only 26% of the participants consistently chose the voluntary vaccination policy and 6% consistently chose the mandatory vaccination policy.

These results provide first evidence that the preference for a voluntary vaccination policy is more prevalent than the preference for a mandatory policy. The voluntary policy becomes even more popular over time when people had gained experiences with the policies.

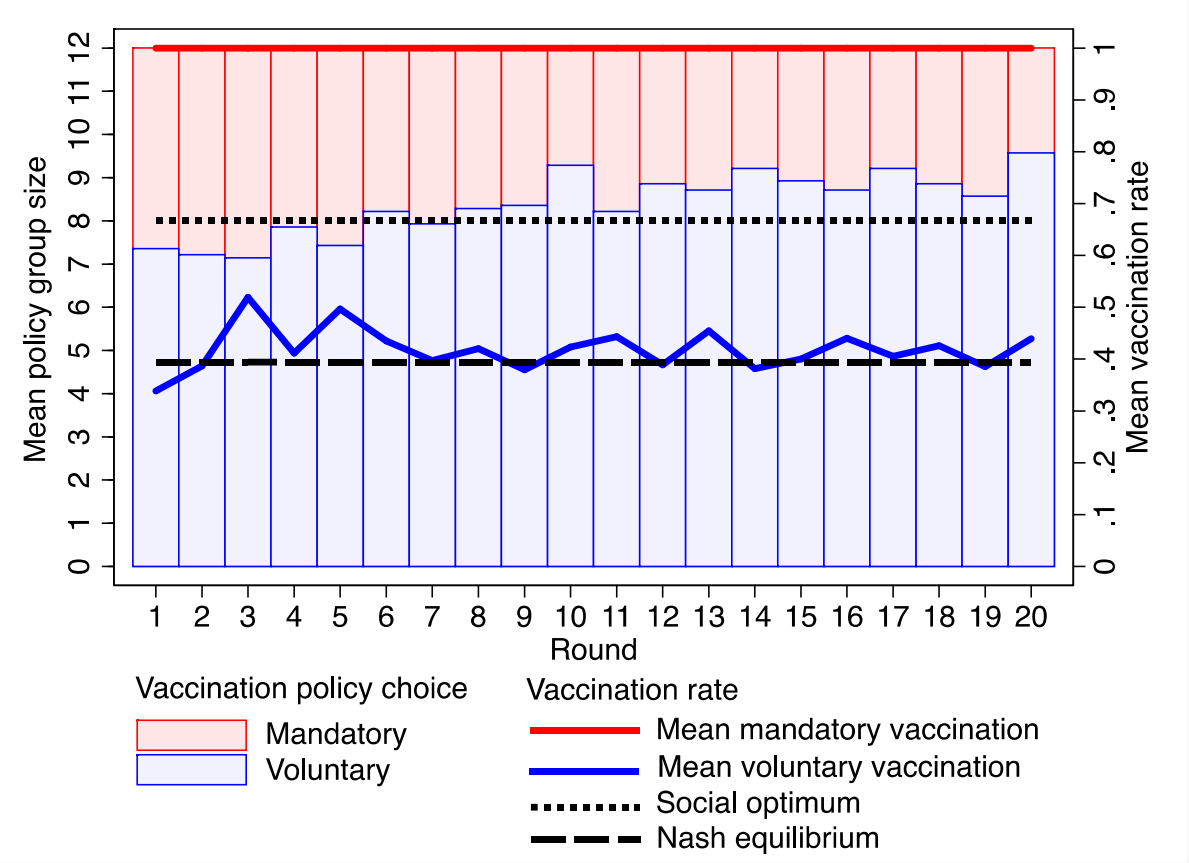


**Figure 1. Policy choices and vaccination behaviour over rounds.**

*Note. The bars show the mean number of players per overall group who opted for each vaccination policy in each round (left y-axis). The red solid line shows the mean vaccination rate (v, right y-axis) given the mandatory policy (always 1). The blue solid line shows the mean vaccination rate given the voluntary vaccination policy. The black short-dashed line shows the social optimum ($v_{SO} = 0.67$); the black long-dashed line shows the Nash equilibrium ($v_{Nash} = 0.39$).*

## Aggregated Vaccination Decisions

Figure 1 also displays the average vaccination rates under the mandatory vaccination policy (red line, which is by definition 1) and under the voluntary vaccination policy (blue line) over the 20 rounds. The average vaccination rate under the voluntary vaccination policy is *M* = .34 (*SD* = .24, *Min* = 0, *Max* = .83) in the first round and *M* = .41 (*SD* = .08, *Min* = .32, *Max* = .56) aggregated across all rounds. The average payoff in the I-Vax game under the voluntary vs. mandatory vaccination policy across all rounds is not significantly different (Wilcoxon signed-rank test: z = 0.047, *p* = .963).

Overall, the vaccination rate is fairly stable over rounds (difference between first ten vs. last ten rounds, Wilcoxon signed-rank test: z = -.031, $p$ = .975). Note that the average vaccination rate of .41 is not significantly different from the vaccination rate expected if all players were to make selfish-rational vaccination decisions; i.e., the Nash equilibrium (see supplementary material; two-sided sign test against the null hypothesis of a vaccination rate different from $v_{Nash} = 0.39$: $p > .999$). However, it falls significantly below the socially optimal vaccination rate (see supplementary material; two-sided sign test against the null hypothesis of a vaccination rate different from $v_{SO} = 0.67$: $p < .001$). These results suggest that individuals' vaccination decisions given the voluntary vaccination policy are mainly determined by individuals' maximization of self-interest rather than social welfare, replicating previous studies on vaccination decisions in this experimental setting.[21,25,26]

**Individual Policy Preferences**

To better understand the determinants of individuals' preferences for vaccination policies, we conducted multilevel mixed-effects logistic regressions using the individual policy decision as the dependent variable (voluntary vaccination policy = 0, mandatory vaccination policy = 1), see Table 1. Because each participant made repeated decisions and members of the same overall group received feedback on the vaccination rate under the voluntary vaccination policy after each round irrespective of their policy choice, we considered the participants and overall groups as random effects to account for their interdependent error terms (random intercept models[32]).

As shown in the regression models (see Table 1), none of the interindividual differences in person characteristics, i.e., attitude towards vaccination (coefficient A), social value orientation (B), and desire for control (C), predict policy preferences as a main effect. Across both models, we find a significant influence of the vaccination rate in the previous round (D) on the subsequent policy preference. In detail, the higher the vaccination rate in the voluntary vaccination policy of the previous round was, the more likely participants were to opt for the voluntary vaccination policy again in the subsequent round. This, in turn, also indicates that the preference for mandatory vaccination increased when participants experienced low vaccination rates under the voluntary

vaccination policy. Additionally, consistent with the results from the analyses of aggregated policy preferences (see above), there is a significant effect of round (H), indicating that the preference for the mandatory vaccination policy declined over time (and the preference for the voluntary vaccination policy increased, respectively).

Moreover, there are significant main effects of experienced costs (E) and mandatory vaccination policy (G), qualified by a significant interaction effect of costs and mandatory vaccination policy (E*G, Model 1): experiencing vaccine adverse events after mandatory vaccination decreased the preference for this policy in the subsequent round; this effect was less pronounced under voluntary vaccination. Specifically, in 76% of the cases, participants chose the mandatory vaccination policy again when they experienced no vaccine adverse events. In contrast, when experiencing vaccine adverse events after mandatory vaccination, only 63% of the participants chose the mandatory vaccination policy again.

To test whether the negative reaction in response to vaccine adverse events after mandatory vaccination is larger than the reaction to negative consequences after voluntary (non-)vaccination (vaccine adverse events or infection with the disease), we run an additional regression analysis in which we predict a change in policy preference (0 = opting for the same policy again, 1 = policy change). We use the subset of observations in which participants experienced costs (1,552 out of 3,192 observations) and predict policy change after voluntary non-vaccination (costs due to disease) vs. after voluntary vaccination vs. after mandatory vaccination (in both cases: costs due to vaccine adverse events). The model specification is otherwise identical to Model 1. We find that participants switched more often to the other policy after experiencing vaccine adverse events under mandatory vaccination compared to experiencing costs under voluntary vaccination ($B = 1.48$, $SE = 0.22$, $p < .001$, $OR = 4.37$). Thus, participants changed their preference for policies more frequently after experiencing negative consequences under the mandatory vaccination policy than under the voluntary vaccination policy.

**Table 1. Multilevel mixed-effects logistic regressions predicting preferences for vaccination policies in rounds 2-20.**

| Independent variable | Dependent variable: Vaccination policy choice | | | | | |
|---|---|---|---|---|---|---|
| | Model 1 | | | Model 2 | | |
| | *B* | *SE* | *OR* | *B* | *SE* | *OR* |
| Constant | -1.18 | 1.08 | 0.31 | -2.45 | 1.41 | 0.09 |
| Vaccination attitude (A) | 0.14 | 0.21 | 1.15 | 0.44 | 0.30 | 1.56 |
| SVO angle (B) | -0.01 | 0.01 | 0.99 | -0.01 | 0.01 | 1.00 |
| Desire for control (C) | > -0.01 | 0.06 | 1.00 | < 0.01 | 0.06 | 1.00 |
| Vaccination rate (D) | -1.13 | 0.33*** | 0.32 | -1.15 | 0.34*** | 0.32 |
| Costs in previous round (E) | 0.27 | 0.24 | 1.30 | 1.05 | 1.24 | 2.86 |
| Voluntarily non-vaccinated in previous round (F) | -0.20 | 0.25 | 0.82 | -0.19 | 1.32 | 0.825 |
| Mandatorily vaccinated in previous round (G) | 1.72 | 0.23*** | 5.61 | 5.15 | 1.23*** | 172.40 |
| Round (H) | -0.06 | 0.01*** | 0.94 | -0.06 | 0.01*** | 0.94 |
| A*E | | | | -0.19 | 0.289 | 0.83 |
| A*F | | | | < 0.01 | 0.31 | 1.00 |
| A*G | | | | -0.82 | 0.29** | 0.44 |
| E*F | 0.27 | 0.31 | 1.31 | 1.47 | 1.61 | 4.33 |
| E*G | -0.87 | 0.30** | 0.42 | -4.36 | 1.55** | 0.01 |
| A*E*F | | | | -0.29 | 0.38 | 0.75 |
| A*E*G | | | | 0.84 | 0.36* | 2.30 |
| Observations / subjects / groups | 3,192 / 168 / 14 | | | 3,192 / 168 / 14 | | |

*Note. B = unstandardized regression coefficient; SE = standard error; OR = odds ratio. * p < 0.05, ** p < 0.01, *** p < 0.001.*

Additionally, interindividual differences moderated individuals' behavioural responses to experiences of vaccine adverse events under different vaccination policies. In Model 2, there were significant interactions of experienced costs and vaccination attitude (A*E) as well as of mandatory vaccination policy and vaccination attitude (A*G), both qualified by a significant three-way interaction (A*E*G). As shown in Figure 2, individual responses to experiencing vaccine adverse events differed among people with different attitudes towards vaccination. Individuals with a more positive vaccination attitude were less affected by vaccine adverse events, whereas individuals with a rather negative vaccination attitude were more likely to change their policy preference after experiencing vaccine adverse events given the mandatory vaccination policy (Figure 2, left panel). Thus, given the mandatory vaccination policy, individuals with a rather negative vaccination attitude were particularly sensitive to vaccine adverse events and, in turn, reacted negatively towards this policy. Given the voluntary vaccination policy, attitudes did not moderate the effect of experiencing vaccine adverse events (Figure 2, right panel). Note that when adding interaction terms with individuals' social value orientation and desire of control, none of these effects reached significance.

## Discussion

The present study investigated individuals' preferences for voluntary vs. mandatory vaccination policies. We applied a behavioural game method to assess policy preferences using real consequences in a controlled laboratory setting.

We found that policy preferences were partly determined by individuals' experiences under such policies. On the one hand, in the case of voluntary vaccination individuals' preference for mandatory vaccination increased with decreasing vaccination rates (i.e., when the risk of infection was high). On the other hand, when individuals gained experiences with both voluntary and mandatory vaccination policies, the preference for voluntary vaccination increased over time. This was due to an increased sensitivity to negative events after mandatory vaccination, i.e., vaccine adverse events. The effect applied especially to individuals with a rather negative attitude towards vaccination.

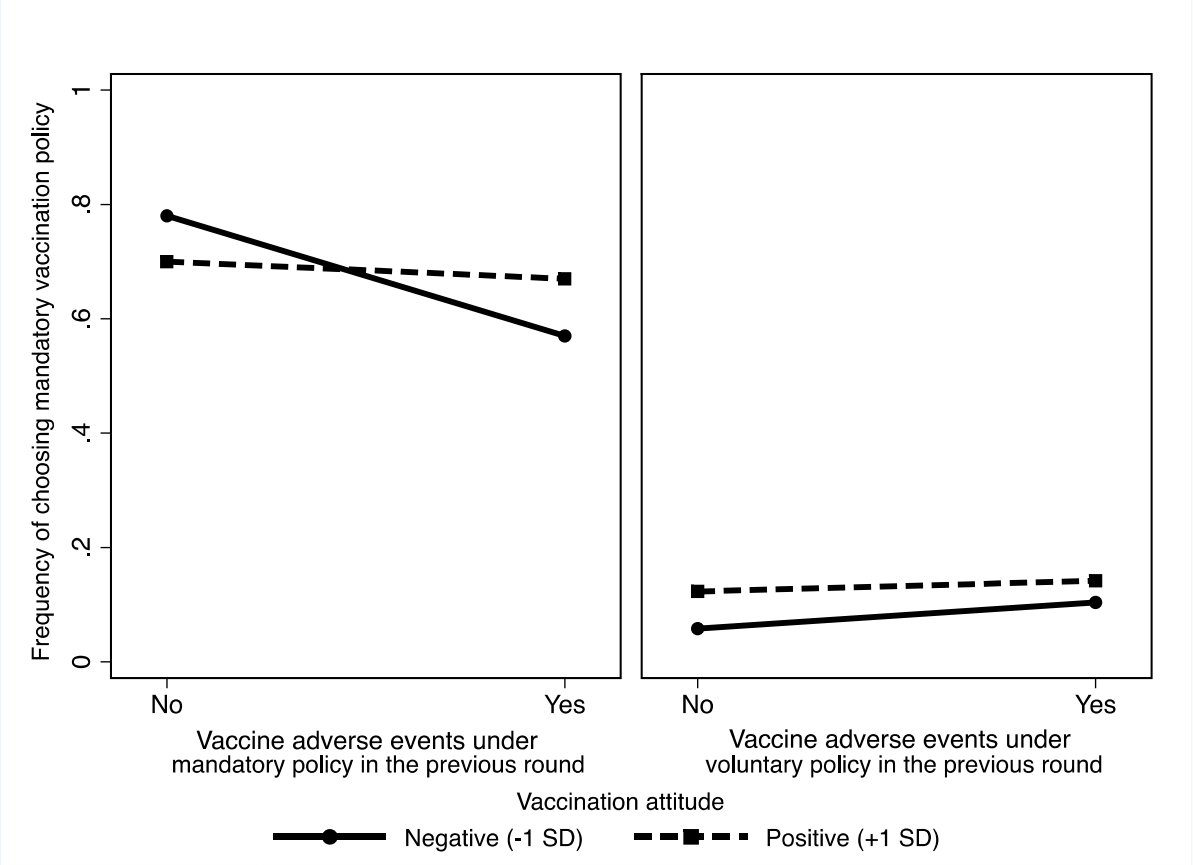


**Figure 2. Simple slope visualization of interaction effect between experienced vaccine adverse events in the previous round (x-axis) and vaccination attitude (-1 standard deviation below the mean, solid line, vs. +1 standard deviation above the mean, dashed line) given the mandatory vaccination policy (left panel) and the voluntary vaccination policy (right panel).**

*Note. The y-axis depicts the relative frequency of participants who opted for the mandatory policy in the subsequent round.*

This laboratory study has some limitations. Our sample consisted of university students and the decisions had financial rather than health consequences. Note, however, that the I-Vax game models the incentives of real-world vaccination decisions[21] and that its external validity has been established in previous research, for example, by showing a positive correlation between the participants' general vaccination attitude and their vaccine uptake in the vaccination game.[21,25,26,33] Additionally, several factors that have been shown to affect individual vaccination behaviour, such as time constraints,[34]

moral values,[35,36] and others,[37] have not been explicitly considered in this research. Such attitudes and opinions may have an additional impact or interact with the effects obtained in the present study. Moreover, it might be that immediate negative reactions towards a mandatory vaccination policy decrease over a longer time horizon. Such a potential habituation effect might be more likely when switching from mandatory to voluntary vaccination is more difficult – as it is the case in real-world settings – than it was in the present study. Despite these limitations, findings from our controlled experimental setting are valuable before testing or implementing such policies in the field.

Overall, the results provide some important insights for policymakers. Individuals might be more prone to supporting and accepting the implementation of mandatory vaccination when vaccination rates are low and the resulting risk of infection is high. To counteract the potential evolving opposition towards mandatory vaccination due to experiences with vaccine-adverse events, policymakers should aim to (a) increase individuals' positive attitude towards vaccination through public campaigns and (b) make vaccinations only mandatory when they have excellent safety profiles (yet for potential drawbacks of selective mandates, see [20]).

**Funding**

Financial support for this research was provided entirely by the German Research Foundation (DFG), grant numbers BE 3970/8-1 and BO 4466/2-1. The funding agreement ensured the authors' independence in designing the study, interpreting the data, writing, and publishing the report.

## Conflict of interests

All authors declare no conflicts of interests.

## Keypoints

- Individuals' preference towards voluntary vaccination increases after having personal experiences with both voluntary and mandatory vaccination policies.
- Preference for mandatory vaccination increases with decreasing vaccination rates under voluntary vaccination.
- Vaccine adverse events under mandatory vaccination are more likely to decrease the preference towards mandatory vaccination, more so than in the case of voluntary vaccination.

**References**


1 WHO. Global Vaccine Action Plan 2011-2020. *Glob Vaccine Action Plan 2011-2020* 2013.

2 Breman JG, Arita I. The Confirmation and Maintenance of Smallpox Eradication. *N Engl J Med* 1980;303:1263–73.

3 Arie S. Compulsory vaccination and growing measles threat. BMJ. 2017;358.

4 Ward JK, Colgrove J, Verger P. France's risky vaccine mandates. *Science* 2017;358:458–59.

5 Omer SB, Richards JL, Ward M, Bednarczyk RA. Vaccination Policies and Rates of Exemption from Immunization, 2005-2011. *N Engl J Med* 2012;367:1170–71.

6 Omer SB, Betsch C, Leask J. Mandate vaccination with care. *Nature* 2019;571:469–72.

7 Cave E. Debating the future of mandatory vaccination. *BMJ* 2017;358:j4100.

8 Day M. Doctor and MPs in Italy are assaulted after vaccination law is passed. *BMJ* 2017;358:j3721.

9 Lee C, Robinson JL. Systematic review of the effect of immunization mandates on uptake of routine childhood immunizations. *J Infect* 2016;72:659–66.

10 Jarrett C, Wilson R, O'Leary M, Eckersberger E, Larson HJ. Strategies for addressing vaccine hesitancy - A systematic review. *Vaccine* 2015;33:4180–90.

11 Chowell G, Miller MA, Viboud C. Seasonal influenza in the United States, France, and Australia: transmission and prospects for control. *Epidemiol Infect* 2008;136.

12 Abrevaya J, Mulligan K. Effectiveness of state-level vaccination mandates: Evidence from the varicella vaccine. *J Health Econ* 2011;30:966–76.

13 Anomaly J. Public health and public goods. *Public Health Ethics* 2011;4:251–59.

14 Colgrove J. Vaccine Refusal Revisited - The Limits of Public Health Persuasion and Coercion. *N Engl J Med* 2016;375:1316–17.

15 Bernstein J. The case against libertarian arguments for compulsory vaccination. *J Med Ethics* 2017;43:792–96.

16 Brennan J. A libertarian case for mandatory vaccination. J. Med. Ethics. 2016.

17 Kata A. A postmodern Pandora's box: Anti-vaccination misinformation on the Internet. *Vaccine* 2010;28:1709–16.

18 Kata A. Anti-vaccine activists, Web 2.0, and the postmodern paradigm – An overview of tactics and tropes used online by the anti-vaccination movement. *Vaccine* 2012;30:3778–89.

19 Institute of Medicine. *Adverse Effects of Vaccines: Evidence and Causality*. Washington, D.C.: The National Academies Press, 2012

20 Betsch C, Böhm R. Detrimental effects of introducing partial compulsory vaccination: experimental evidence. *Eur J Public Health* 2016;26:378–81.

21 Böhm R, Betsch C, Korn L. Selfish-rational non-vaccination: Experimental evidence from an interactive vaccination game. *J Econ Behav Organ* 2016;131:183–95.

22 Galizzi MM, Wiesen D. Behavioural experiments in health: An introduction. *Health Econ* 2017;26:3–5.

23 Galizzi MM, Wiesen D. Behavioral Experiments in Health Economics. Oxford Res. Encycl. Econ. Financ. 2018.

24 Gürerk Ö, Irlenbusch B, Rockenbach B. The Competitive Advantage of Sanctioning Institutions. *Science* 2006;312:108–11.

25 Böhm R, Meier NW, Korn L, Betsch C. Behavioural consequences of vaccination recommendations: An experimental analysis. *Health Econ* 2017;26:66–75.

26 Korn L, Betsch C, Böhm R, Meier NW. Social nudging: The effect of social feedback interventions on vaccine uptake. *Heal Psychol* 2018;37:1045–54.

27 Askelson NM, Campo S, Lowe JB, Smith S, Dennis LK, Andsager J. Using the theory of planned behavior to predict mothers' intentions to vaccinate their daughters against HPV. *J Sch Nurs* 2010;26:194–202.

28 Murphy RO, Ackermann KA, Handgraaf MJJ. Measuring Social Value Orientation. *Judgm Decis Mak* 2011;6:771–81.

29 Rijsdijk SA, Hultink EJ. Honey, Have You Seen Our Hamster? Consumer Evaluations of Autonomous Domestic Products. *J Prod Innov Manag* 2003;20:204–16.

30 Greiner B. Subject pool recruitment procedures: organizing experiments with ORSEE. *J Econ Sci Assoc* 2015;1:114–25.

31 Fischbacher U. z-Tree: Zurich toolbox for ready-made economic experiments. *Exp Econ*

2007;10:171–78.

32 Pinheiro JC, Bates DM. Linear Mixed-Effects Models: Basic Concepts and Examples. In: *Mixed-Effects Models in S and S-PLUS*. New York: Springer-Verlag, 2000; 3–56.

33 Betsch C, Böhm R. Detrimental effects of introducing partial compulsory vaccination: experimental evidence. *Eur J Public Health* 2016;26:378–81.

34 Betsch C, Schmid P, Heinemeier D, Korn L, Holtmann C, Böhm R. Beyond confidence: Development of a measure assessing the 5C psychological antecedents of vaccination. *PLoS One* 2018;13:e0208601.

35 Amin AB, Bednarczyk RA, Ray CE, et al. Association of moral values with vaccine hesitancy. *Nat Hum Behav* 2017;1:873–80.

36 Betsch C, Böhm R. Moral values do not affect prosocial vaccination. *Nat Hum Behav* 2018;2:881–82.

37 Citation Hornsey MJ, Harris EA, Fielding KS. The Psychological Roots of Anti-Vaccination Attitudes: A 24-Nation Investigation. Health Psychology. 2018.