Of sticks and carrots —
Effects of coercive and rewarding measures for increasing vaccination uptake

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Zusammenfassung

Der Ausbruch ansteckender Krankheiten wie Masern oder COVID-19 kann durch flächendeckende Impfung verhindert werden (Fine, Eames, & Heymann, 2011). Die Impfquoten fallen jedoch regelmäßig zu gering aus (WHO, 2019). Verschiedene Interventionsmaßnahmen versuchen deshalb, die Gründe geringer Impfbereitschaft zu adressieren. So wird beispielsweise im Rahmen von Bildungsprogrammen versucht, Falschinformationen auszuräumen und über den individuellen und kollektiven Nutzen von Impfungen zu informieren (Brewer, Chapman, Rothman, Leask, & Kempe, 2017). Die vorliegende Dissertation beschäftigt sich jedoch mit zwei alternativen Ansätzen, die Menschen mit zusätzlichen negativen oder positiven Anreizen zu einer Impfung motivieren sollen: die Sanktionierung der Nichtimpfung im Rahmen einer Impfpflicht und die Belohnung der Impfung durch Gewährung bestimmter Vorteile gegenüber Ungeimpften.

Es hat sich gezeigt, dass eine **Impfpflicht** die Impfquoten bei Kindern (Hull et al., 2019; Lee & Robinson, 2016) und Beschäftigten im Gesundheitswesen (Pitts, Maruthur, Millar, Perl, & Segal, 2014) wirksam erhöhen kann. Da verpflichtende Impfungen jedoch die Wahlfreiheit einschränken, können sie auch Reaktanz hervorrufen, ein Gefühl der Verärgerung, das zur Wiederherstellung der eigenen Freiheit motiviert (Dillard & Shen, 2005; Miron & Brehm, 2006). Dementsprechend konnten Betsch und Böhm (2016) zeigen, dass sich Menschen, die dem Impfen kritisch gegenüberstehen, über eine verpflichtende Impfung ärgern und in der Folge andere freiwillige Impfungen eher auslassen wollen, als Personen, die nicht zur Impfung verpflichtet werden. Dieser Effekt wird in der vorliegenden Arbeit näher untersucht. In fünf Artikeln werden die Ergebnisse mehrerer Online-Umfragen und Experimente zu den Ursachen und Folgen von Reaktanz sowie möglichen Gegenmaßnahmen präsentiert.

Artikel A1—*Herd immunity communication counters detrimental effects of selective vaccination mandates: Experimental evidence* (Sprengholz & Betsch, 2020)—befasst sich mit der Frage, ob Reaktanz infolge einer verpflichtenden Impfung durch Begründung der Regelung verringert werden kann. In einem Experiment zeigte sich, dass Teilnehmende, die sich eine Impfpflicht für eine fiktive Krankheit vorstellen sollten, wütender waren als Personen, die von einer freiwilligen Impfung ausgingen. Wurde den Teilnehmenden allerdings die Bedeutung umfassender Impfungen für die Sicherstellung von Herdenimmunität erklärt (d.h. der Schutz der Gemeinschaft einschließlich solcher Menschen hervorgehoben, die z.B.

noch zu jung sind, um geimpft werden zu können), so fiel die Verärgerung weniger hoch aus. Da Reaktanz wiederum mit einer geringeren Impfabsicht in einem anschließenden freiwilligen Impfszenario verbunden war, deuten die Ergebnisse darauf hin, dass die Erläuterung des prosozialen Nutzens von Impfungen potenziell nachteilige Auswirkungen verpflichtender Regelungen dämpfen kann.

Artikel A2—*Vaccination Policy Reactance: Predictors, Consequences, and Countermeasures* (Sprengholz, Felgendreff, Böhm, & Betsch, 2021)—präsentiert drei Studien. In den Studien 1 und 3 wurden individuelle Korrelate für die Unterstützung einer COVID-19-Impfpflicht untersucht. Es zeigte sich, dass die verpflichtende Impfung eher befürwortet wurde, wenn das Vertrauen in die Sicherheit der Impfstoffe hoch war und sich die Befragten für den Schutz der Gemeinschaft verantwortlich fühlten. Dagegen waren libertäre Moralvorstellungen mit einer geringeren Unterstützung der Impfpflicht verbunden. In Studie 2 wurde ein Experiment durchgeführt, das die Ergebnisse von Artikel A1 reproduzierte und erweiterte. Die Ankündigung einer verpflichtenden (vs. freiwilligen) Impfung gegen COVID-19 löste Reaktanz aus, vor allem unter Teilnehmenden, die einer Impfpflicht kritisch gegenüberstanden. Allerdings fiel der Effekt geringer aus, wenn die Bedeutung hoher Impfraten für öffentliche Gesundheit, Wirtschaft und Beschäftigung kommuniziert wurde. Es zeigte sich erneut, dass die Erklärung und Begründung von Zwangsmaßnahmen Reaktanz und damit mögliche negative Auswirkungen auf andere Impfungen zwar nicht verhindern, aber abschwächen kann. In Studie 3 wurden die Auswirkungen einer selbstrelevanten und einer nicht selbstrelevanten Impfpflicht verglichen und die Vielfalt möglicher Auswirkungen von Reaktanz weiter untersucht. In einem Experiment fiel die Verärgerung infolge einer Impfpflicht besonders hoch aus, wenn die Unterstützung der verpflichtenden Regelung gering war und sie die Teilnehmenden selbst betraf. Galt die Pflicht zur Impfung nur für andere Personen (z.B. Gesundheitspersonal), zeigten sich die Teilnehmenden ebenfalls verärgert, allerdings in geringerem Maße. Mit der Reaktanz stieg auch die Absicht, Maßnahmen gegen die Impfpflicht zu ergreifen (z.B. durch Unterzeichnung einer Petition oder Teilnahme an einer Demonstration), den neuen Impfstoff zu meiden, weniger Schutzverhalten zu zeigen (z.B. geringere Intention, in der Coronapandemie Maske zu tragen und Kontakte zu vermeiden) und eine freiwillige Grippeimpfung zu unterlassen.

Artikel A3—*Reactance revisited: Consequences of mandatory and scarce vaccination in the case of COVID-19* (Sprengholz, Betsch, & Böhm, 2021)—konzentriert sich nicht allein auf die Einschränkung des Nichtimpfens durch eine Impfpflicht, sondern untersucht

auch den entgegengesetzten Fall: die Einschränkung des Impfens aufgrund knapper Impfstoffe. In zwei Studien zur COVID-19-Impfung zeigten die Teilnehmenden dann mehr Reaktanz, wenn ihre Impfabsicht niedrig war und eine fiktive Impfpflicht eingeführt wurde oder wenn ihre Impfabsicht hoch ausfiel aber eine Impfung wegen Lieferengpässen nicht möglich war. In beiden Fällen stieg mit der Reaktanz die Absicht, gegen die Beschränkung vorzugehen. Im Einklang mit früheren Ergebnissen war die Reaktanz aufgrund einer Impfpflicht mit der Intention verbunden, Impfungen gegen COVID-19 und Windpocken zu vermeiden und weniger Schutzverhalten zur Eindämmung des Coronavirus zu zeigen. Gingen die Teilnehmenden allerdings davon aus, dass sie wegen knapper Impfstoffe nicht zeitnah vor COVID-19 geschützt werden können, kehrten sich die Intentionen um. In diesem Fall stiegen die Impfabsichten und die Bereitschaft zur Einhaltung der Coronaschutzmaßnahmen. Die Ergebnisse zeigen, wie gegensätzliche Situationen ähnliche psychologische Reaktionen hervorrufen können. Damit verallgemeinert und überträgt der Artikel frühere Erkenntnisse über psychologische Reaktanz auf den Bereich des Impfens.

Artikel A4—*Zero-sum or worse? Considering detrimental effects of selective mandates on voluntary childhood vaccinations* (Sprengholz & Betsch, 2021)—präsentiert die Ergebnisse eines kurzen Experiments mit Eltern von Kindern unter 18 Jahren. Wenn sich diese vorstellten, dass die Impfung gegen COVID-19 für Kinder verpflichtend wird, kam es zu Verärgerung, insbesondere wenn die Unterstützung für eine Impfplicht gering war. Gleichzeitig sank die Bereitschaft, die eigenen Kinder gegen eine Form der Meningokokken impfen zu lassen. Diese Übertragung des Reaktanzeffekts auf den Bereich der Kinderimpfung zeigt, dass Mandate nachteilige Auswirkungen auf das Impfprogramm Minderjähriger haben können.

Artikel A5—*Attitude toward a mandatory COVID-19 vaccination policy and its determinants: Evidence from serial cross-sectional surveys conducted throughout the pandemic in Germany* (Sprengholz et al., eingereicht)—beleuchtet die Veränderung der öffentlichen Unterstützung für eine COVID-19-Impfpflicht und potentielle Korrelate wie individuelle Impfabsichten und die im 5C-Modell (Betsch et al., 2018) zusammengefassten psychologischen Gründe für oder gegen eine Impfung. Zwischen April 2020 und April 2021 erhobene Daten zeigen, dass die Unterstützung für eine Impfpflicht zunächst deutlich zurückging und nach der Zulassung und Einführung der ersten Impfstoffe wieder leicht anstieg. Ende April 2021 sprach sich etwa die Hälfte der Befragten für eine verpflichtende Regelung aus. Im Allgemeinen wurde eine Impfpflicht eher von denjenigen befürwortet, die die Impfstoffe

für sicher hielten, praktische Impfbarrieren (z.B. Stress) wahrnahmen und sich für die Allgemeinheit verantwortlich fühlten. Im Gegensatz dazu fiel die Befürwortung geringer bei Personen aus, die die Impfung als unnötig ansahen und Nutzen und Risiken der Impfung umfänglich abwogen. Interessanterweise konnte eine Diskrepanz zwischen den Impfabsichten und der Befürwortung von Impfpflicht festgestellt werden: Ein beträchtlicher Teil der Teilnehmenden war bereit, sich gegen COVID-19 impfen zu lassen, befürwortete aber keine verpflichtende Regelung.

Zusammenfassend zeigen die fünf Artikel, dass eine Impfpflicht psychologische Reaktanz hervorrufen kann, auch wenn die Regelung nur andere Personen betrifft. Erklärung und Begründung der Impfpflicht können den Effekt zwar abfedern, vielfältige nachteilige Effekte auf das individuelle Gesundheitsverhalten sind jedoch wahrscheinlich. Insbesondere dann, wenn große Teile der Bevölkerung eine Impfpflicht ablehnen, ist von der Einführung einer solchen abzuraten.

Belohnungen können eine Alternative zu verbindlichen Vorschriften sein. Forschungsbefunde zur Wirkung von Belohnungen auf die Impfbereitschaft sind jedoch inkonsistent und beziehen sich meist auf etablierte Impfstoffe (Adams et al., 2015; Brewer et al., 2017). Um die Evidenz auf neue Impfstoffe zu erweitern, werden in der vorliegenden Arbeit Ergebnisse aus zwei Online-Experimenten vorgestellt, in denen die Auswirkungen monetärer und rechtlicher Anreize für eine Impfung gegen COVID-19 sowie mögliche Moderatoren untersucht wurden.

Artikel A6—*Money is not everything: Experimental evidence that payments do not increase willingness to be vaccinated against COVID-19* (Sprengholz, Eitze, Felgendreff, Korn, & Betsch, 2021)—präsentiert die Resultate eines ersten Experiments. Darin wurde Teilnehmenden eine hypothetische Belohnung von 0 bis 200 Euro für die Impfung gegen COVID-19 angeboten und schließlich die Impfbereitschaft erfasst. Es zeigte sich, dass die Belohnung keinen Einfluss auf die Impfbereitschaft hatte. Auch für finanziell schlechter gestellte Teilnehmende konnte kein Effekt gefunden werden. Dieses Ergebnis widerspricht ethischen Bedenken hinsichtlich wirtschaftlich benachteiligter Gruppen, die sich durch monetäre Anreize zur Impfung gezwungen fühlen könnten (Jecker, 2021).

Artikel A7—*Payments and freedoms: Effects of monetary and legal incentives on COVID-19 vaccination intentions in Germany* (Sprengholz, Henkel, & Betsch, im Review)—betrachtet die möglichen Auswirkungen höherer monetärer Belohnungen sowie rechtlicher Anreize. In einem Experiment sollten sich die Teilnehmenden entweder vorstellen, dass

die Impfung gegen COVID-19 zu mehr Rechten und Freiheiten führt oder dass dies nicht der Fall ist. Anschließend mussten sie in einer Reihe von Entscheidungen zwischen zwei Optionen wählen: sich nicht impfen lassen oder sich impfen lassen und dafür einen bestimmten Betrag zwischen 0 und 10.000 Euro erhalten. Während kein positiver Effekt für rechtliche Anreize beobachtet werden konnte, stieg der Anteil impfwilliger Personen mit der Höhe der Zahlung. Eine signifikante Steigerung war jedoch nur bei hohen Belohnungen von 3.250 EUR oder mehr zu beobachten. Im Vergleich zu denjenigen, die bereit waren, sich ohne Bezahlung impfen zu lassen, waren Teilnehmende, die einen finanziellen Anreiz bevorzugten, jünger, hatten weniger Vertrauen in die Sicherheit des Impfstoffs, empfanden die Impfung eher als nicht notwendig und fühlten sich weniger verantwortlich für die Allgemeinheit. Dies deutet darauf hin, dass hohe Anreize zur Impfung motivieren und Gründe gegen eine Impfung überstimmen können. Im Einklang mit früheren Erkenntnissen waren die finanziellen Sorgen zwischen den genannten Gruppen vergleichbar und entsprachen denen impfunwilliger Personen.

Zusammenfassend lässt sich feststellen, dass die positiven Effekte von Belohnungen auf die Akzeptanz neuer Impfstoffe begrenzt sind. Unter Berücksichtigung anderer Forschungsergebnisse sollten sich Entscheidungsträger auf einen Mix von Maßnahmen zur Steigerung der Impfquoten konzentrieren. Dabei ist es besonders wichtig, praktische Barrieren zu beseitigen, die einer Impfung entgegenstehen (Gerend, Shepherd, & Shepherd, 2013). Darüber hinaus braucht es Bildungsprogramme, die über die individuelle und gesellschaftliche Bedeutung von Impfungen informieren (Betsch, Böhm, Korn, & Holtmann, 2017). Reichen Aufklärung und ein einfacher Zugang zur Impfung nicht aus, um die Impfquoten auf das erforderliche Niveau zu steigern, kann die Einführung intrusiverer Maßnahmen diskutiert werden. Dazu können Belohnungen und, als letztes Mittel, eine Impfpflicht für bestimmte Populationsgruppen gehören. Entscheidungen sollten sich dabei auf empirische Forschungserkenntnisse stützen, wie sie in der vorliegenden Arbeit präsentiert werden. Wissenschaftliche Evidenz kann dabei helfen, wirkungsvolle Maßnahmen auszuwählen und erfolgreich umzusetzen.

Summary

To prevent outbreaks of contagious diseases such as measles or COVID-19, the uptake of available vaccines needs to be high (Fine et al., 2011). Intervention programs often try to reduce vaccine hesitancy by changing individuals' thoughts and feelings about vaccination (Brewer et al., 2017). Instead, this thesis examines the effects of two strategies that seek to bypass attitudes by providing additional reasons for vaccination: *mandates* that sanction non-vaccination and *incentives* that reward vaccination.

Vaccination mandates requiring individuals to get vaccinated have been shown to effectively increase coverage rates among children (Hull et al., 2019; Lee & Robinson, 2016) and healthcare workers (Pitts et al., 2014). However, as mandates restrict freedom of choice, they may also elicit reactance—a feeling of anger that motivates efforts to regain that freedom (Dillard & Shen, 2005). As a consequence, the individual may take action against the restriction or seek to preserve other freedoms (Miron & Brehm, 2006). Betsch and Böhm (2016) showed that mandating a particular vaccination caused anger among those exhibiting a negative attitude to vaccination. In a subsequent voluntary vaccination decision, vaccination intention declined significantly among those individuals as compared to control group participants who assumed there was no mandate in place. The present thesis investigates reactance toward mandatory vaccination policies in greater depth, exploring its causes and consequences, as well as possible countermeasures. Five articles report the results of multiple online surveys and experiments.

Article A1—*Herd immunity communication counters detrimental effects of selective vaccination mandates: Experimental evidence* (Sprengholz & Betsch, 2020)—investigates whether the reactance elicited by mandatory regulation can be buffered by communicating the concept of herd immunity (in which the proportion of vaccinated individuals in a population is sufficiently large to prevent the spread of a pathogen to those who are not or cannot be vaccinated). In an experiment involving fictitious diseases, individuals who were asked to imagine mandatory vs. voluntary vaccination exhibited greater anger, especially when herd immunity was not explained. This anger was in turn associated with lower vaccination intention in a subsequent voluntary vaccination scenario. These results indicate that explaining the prosocial benefits of vaccination can prevent reactance, so buffering the potentially detrimental effects of selective mandates.

Article A2—*Vaccination Policy Reactance: Predictors, Consequences, and Countermeasures* (Sprengholz, Felgendreff, et al., 2021)—describes three studies of potential COVID-19 vaccination mandates. Studies 1 and 3 investigated individual correlates of support for mandatory vaccination against COVID-19. Confidence in vaccine safety and collective responsibility were identified as main drivers of support for a mandate while libertarian morality was associated with low support. In Study 2, which reproduced and extended the findings of Article A1, announcing a vaccination mandate for COVID-19 elicited reactance, in turn reducing willingness to be vaccinated against influenza. However, reactance was buffered by individual support for the mandate and communication interventions that explained the importance of high vaccination rates for public health and the economy. This finding confirms the value of explaining the rationale underpinning a coercive policy. Study 3 further compared the effects of self-relevant and non-self-relevant mandates and investigated the detrimental consequences of mandatory regulations. In an experiment, reactance was higher when support for the mandate was low, especially when the mandate affected the participants themselves, but also to a lesser extent when the mandate was not self-relevant as it affected only health professionals. Furthermore, individuals who expressed more reactance toward a mandate, indicated stronger intention to take action against the regulation (e.g., by signing a petition or joining a demonstration); to avoid the new vaccine; to adopt fewer protective behaviors (e.g., wearing a mask, avoiding close contacts); and to skip voluntary flu shots.

Article A3—*Reactance revisited: Consequences of mandatory and scarce vaccination in the case of COVID-19* (Sprengholz, Betsch, et al., 2021)—investigates does not only focus on the limitation of non-vaccination by mandates but also investigates effects of limited vaccination due to scarce vaccine supplies in the case of COVID-19. In the two reported studies, reactance was elicited when vaccination intention was low and a mandate was introduced or when vaccination intention was high but vaccine supplies were scarce. In both cases, reactance increased intention to take action against the restriction. In line with previous findings, mandate-related reactance was positively associated with the intention to avoid vaccination for COVID-19 and an unrelated vaccination for chickenpox while it was negatively associated with the intention to adopt protective behaviors limiting the spread of the coronavirus. Importantly, reverse intentions were observed when vaccination was scarce. By showing how opposing situations can elicit similar psychological reactions, the article

extends and generalizes previous findings about psychological reactance in the domain of vaccination.

Article A4—*Zero-sum or worse? Considering detrimental effects of selective mandates on voluntary childhood vaccinations* (Sprengholz & Betsch, 2021)—presents the results of a short experiment with parents of children younger than 18 years. When asked to imagine that vaccination against COVID-19 was to become mandatory for children, the parents exhibited anger, especially when support for such a mandate was low. Meningococcus vaccination intention was also lower when compared to parents who were asked to imagine voluntary vaccination. The findings confirm detrimental effects of selective mandates on parents' decisions about voluntary childhood immunization.

Article A5—*Attitude toward a mandatory COVID-19 vaccination policy and its determinants: Evidence from serial cross-sectional surveys conducted throughout the pandemic in Germany* (Sprengholz et al., under review)—investigates changes in public support for a COVID-19 vaccination mandate and examines individual correlates such as vaccination intention and the 5C antecedents of vaccination. Data collected between April 2020 and April 2021 show that support for a vaccination mandate declined in 2020 and increased slightly following approval and rollout of the first vaccines. However, at the end of April 2021, only half of respondents favored mandatory regulation. In general, mandates were endorsed by those who considered the vaccines to be safe, anticipated practical barriers, and felt responsible for the collective. Conversely, perceiving vaccination as unnecessary and weighing the benefits and risks of vaccination was associated with lower support. Interestingly, a gap was observed between vaccination intention and the support for a mandate—a considerable proportion of participants were willing to get vaccinated against COVID-19 but did not support mandatory regulation.

In summary, the thesis findings demonstrate that mandatory vaccination can elicit psychological reactance, even where regulations are not self-relevant. While explaining the rationale behind the measure can buffer this effect, a mandate will likely have detrimental consequences. In particular, it is not advisable to implement a mandate for a given vaccine when large parts of the population oppose it.

Vaccination incentives may offer a viable alternative to mandatory regulations. However, research on the effectiveness of rewards is inconclusive and usually refers to established vaccines (Adams et al., 2015; Brewer et al., 2017). To extend the evidence to new vaccines, the present thesis reports the findings of two online experiments investigating the

impact of monetary and legal incentives for vaccination against COVID-19, along with potential moderators.

Article A6—*Money is not everything: Experimental evidence that payments do not increase willingness to be vaccinated against COVID-19* (Sprengholz, Eitze, Felgendreff, et al., 2021)—reports results from an initial experiment in which a hypothetical reward of up to 200 EUR did not alter vaccination intention. This did not change when controlling for participants' financial situation, therefore challenging concerns that monetary incentives might compel economically disadvantaged groups to consent to vaccination (Jecker, 2021).

Article A7—*Payments and freedoms: Effects of monetary and legal incentives on COVID-19 vaccination intentions in Germany* (Sprengholz, Henkel, & Betsch, under review)—investigates the potential effects of higher monetary rewards and legal incentives. Participants in the experiment were told either that vaccination led to more rights and freedoms or that it did not. Afterwards, they had to decide between two options in a series of repeated decisions: not getting vaccinated vs. getting vaccinated and being paid a hypothetical amount ranging from 0 EUR to 10,000 EUR. While no effect was observed for legal incentives, the proportion of participants willing to be vaccinated increased with payment amount. However, a significant increase was only observed for larger rewards of 3,250 EUR or more. Compared to those who were willing to get vaccinated without payment, participants who favored a monetary incentive were younger, expressed less confidence in vaccine safety, perceived vaccination as rather unnecessary, and felt less responsible for the collective. This suggests that high incentives can motivate vaccination when there are reasons for not doing so. In line with article A6, financial worries did not differ between the groups and were comparable for participants unwilling to get vaccinated.

In summary, the thesis findings indicate that incentives have only a limited impact on the uptake of new vaccines. The available evidence to date suggests that policymakers should employ a mix of measures. Most importantly, practical barriers to vaccination need to be removed (Gerend et al., 2013). Vaccination programs should also be accompanied by educational campaigns highlighting the individual and social importance of vaccination (Betsch et al., 2017). If vaccination rates remain below target thresholds following the introduction of such measures, more intrusive policies might include incentives and, as a last resort, mandatory vaccination for specific subgroups. However, when deciding which vaccination policies to implement and how to communicate them to the public, policymakers should defer to empirical evidence such as presented here.

Contents

Please note that the numbering of figures and tables starts anew in each chapter.

Introduction

Vaccination is among the most successful and cost-effective public health interventions (Rémy, Zöllner, & Heckmann, 2015), protecting individuals against viral and bacterial diseases by training the immune system to detect and suppress pathogens. In the case of contagious diseases like measles or influenza, vaccination protects both vaccinated individuals and their contacts by reducing the spread of the disease (Doherty, Buchy, Standaert, Giaquinto, & Prado-Cohrs, 2016). According to the World Health Organization (WHO, 2019), vaccination prevents up to five million deaths every year, but more lives could be saved if vaccination coverage was improved. For contagious diseases, the proportion of immune individuals within a population needs to exceed the disease-specific herd immunity threshold to prevent the pathogen from circulating (Fine et al., 2011). However, vaccine hesitancy—the refusal or delayed acceptance despite vaccine availability (MacDonald, 2015)—can hinder immunization efforts, resulting in ongoing outbreaks that endanger public health and expend significant resources. Examples:

(1) Measles. Measles is a highly contagious airborne disease that typically causes a high fever, cough, and a red flat rash. Infection can cause secondary health problems such as diarrhea, pneumonia, seizures, or inflammation of the brain (Bester, 2016). Childhood vaccines against the disease have been available for more than fifty years, but uptake rates rarely exceed the herd immunity threshold of 95% (Patel et al., 2019). Because of delayed immunization and sudden drops in vaccination rates, the disease has not been eliminated (Kuehn, 2021). In 2018, in the WHO European Region alone, more than 80,000 individuals were infected with measles (Thornton, 2019), and in 2019/2020, an outbreak in Samoa caused more than eighty deaths, mainly of children (Craig, Heywood, & Worth, 2020).

(2) COVID-19. The coronavirus disease COVID-19 is a contagious airborne disease with variable symptoms, including fever, cough, headache, and breathing difficulties (Cevik, Kuppalli, Kindrachuk, & Peiris, 2020). The disease was first identified in China in December 2019 and subsequently spread across the world in an ongoing pandemic. By August 2021, more than four million people were known to have died from COVID-19-related causes (Johns Hopkins University, 2021). In an unprecedented development

effort, the first vaccines against the disease were rolled out in the US and EU at the end of 2020 (European Commission, 2020). While supplies were scarce at the beginning of 2021, availability improved steadily in these regions and eventually exceeded demand. For instance, in the first half of 2021 in Germany, more than half of the adult population were vaccinated against COVID-19, but uptake subsequently slowed down (Bundesministerium für Gesundheit, 2021). Based on calculations by the Robert Koch Institute, at least 85% of those aged between 12 and 59 years and 90% of those aged 60 years and older need to be immunized in order to control infections and mitigate future pandemic waves (Wichmann et al., 2021). However, estimates that take account of both actual uptake and vaccination intention among unvaccinated individuals suggest that we may fail to reach these levels soon. For instance, by the end of June 2021, only 81% of those aged between 18 and 74 years in Germany reported being or intending to be vaccinated (Betsch et al., 2022).

Understanding and eventually improving vaccination intention and uptake requires a closer look at key determinants. Previous research has shown that vaccination intention is affected by thoughts and feelings as well as by social context (Brewer et al., 2017). According to the 5C model (Betsch et al., 2018), vaccination increases with *confidence* (perceiving a vaccine as safe and effective) and *collective responsibility* (valuing the protection of others) but decreases with *complacency* (assuming a low risk of infection), *constraints* (encountering structural or psychological barriers), and *calculation* (weighing the perceived benefits and risks of vaccination). However, vaccination interventions based on these antecedents have produced mixed results. For instance, one meta-analysis (Sheeran, Harris, & Epton, 2014) revealed moderate effects of messages that increase risk appraisal on tetanus and influenza vaccination intention and uptake while multiple reviews have reported uncertain effects of parent-centered information and education on early childhood vaccination (Kaufman et al., 2018; Sadaf, Richards, Glanz, Salmon, & Omer, 2013). In similar vein, laboratory research indicates the influence of social networks and social norms on vaccination behavior, but evidence from field studies is scarce (Brewer et al., 2017). For instance, game-based studies have shown that vaccination is perceived as a social contract (Korn, Böhm, Meier, & Betsch, 2020) and that acceptance is more likely among prosocial individuals (Böhm, Betsch, & Korn, 2016). However, it remains unclear whether these observations generalize to actual vaccination behavior. In this regard, Brewer et al. (2017) assumed that interventions that

address thoughts and feelings or the social context may have limited effects because of their indirect nature (Figure 1). For instance, a leaflet designed to increase awareness of the risks associated with contracting COVID-19 may have little impact on vaccination intentions because the available evidence suggests that risk perception is influenced less by personal knowledge than by variables that are difficult to change, including individualist worldview, direct experience, and trust in science (Dryhurst et al., 2020). Even in cases where educational material reduces complacency, other factors such as concerns about safety or efficacy may hinder a significant increase in vaccination intention. Direct intervention strategies work around these problems by addressing vaccination intention without seeking to influence what people think and feel (Brewer et al., 2017). Examples include measures for converting favorable vaccination intentions into uptake, such as reminders (Jacobson Vann, Jacobson, Coyne-Beasley, Asafu-Adjei, & Szilagyi, 2018) and on-site vaccination (De Sarro et al., 2021). This thesis explores two strategies that bypass vaccine hesitancy by providing additional reasons for vaccination: mandates that sanction non-vaccination and incentives that reward vaccination.

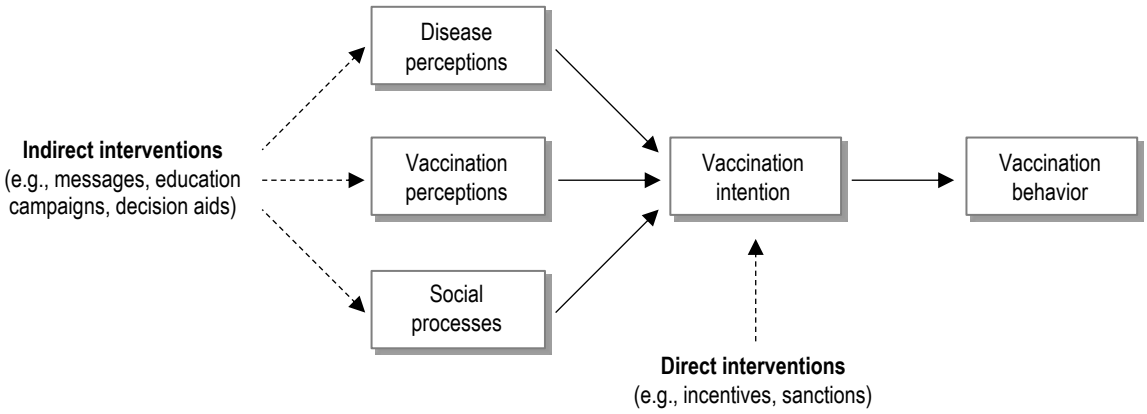

Figure 1. Determinants of vaccination intention and behavior.

Note: Interventions to increase vaccination uptake can affect vaccination intention *indirectly* by influencing disease and vaccination perceptions and social processes, or *directly* by providing additional reasons for vaccination (Brewer et al., 2017).

Vaccination mandates

Vaccination mandates are regulations that require individuals to get vaccinated, imposing fines or other restrictions to penalize non-compliance. During the last decade, many European countries have implemented selective mandates for specific vaccines to increase uptake

and prevent outbreaks (Lévy-Bruhl, Desenclos, Quelet, & Bourdillon, 2018; Signorelli, Odone, Cella, & Iannazzo, 2018). For instance, Germany's Measles Protection Act, introduced in March 2020, requires children, asylum seekers, and staff in healthcare and childcare facilities to be vaccinated twice against measles. Parents who refuse to allow vaccination of their children face fines of up to 2,500 EUR and a ban from daycare (Makoski & Netzer-Nawrocki, 2020). Previous research indicates that mandates effectively increase coverage for childhood immunizations (Hull et al., 2019; Lee & Robinson, 2016) and vaccination of healthcare workers (Pitts et al., 2014). For instance, one study comparing data from 29 European countries reported that mandatory vaccination policies were associated with higher vaccination rates for measles and pertussis than voluntary approaches (Vaz et al., 2020). Consequently, vaccination mandates have been discussed for COVID-19 as well. Italy was the first European country mandating the new vaccine for healthcare workers (Paterlini, 2021), followed soon after by France and Greece (Wise, 2021).

Despite promising uptake rates, mandates attract ethical and legal objections because they limit individual liberty (Frielitz, Wagner, Schewe, & Bothe, 2021; Reiss & Caplan, 2020). For instance, Savulescu (2020) argued that coercive policies are only justified if (1) the disease is a grave threat to public health; (2) the vaccine is safe and effective; (3) mandatory vaccination has a better cost-benefit profile than alternative interventions; and (4) penalties are proportionate. Based on these requirements, mandatory vaccination for COVID-19 may be justified for adults, and especially for healthcare workers, but not for younger children, given the low disease severity and uncertainties around vaccine efficacy and safety in this age group (Savulescu, Giubilini, & Danchin, 2021).

To evaluate vaccination mandates, their potential effects on the uptake of voluntary vaccines should be considered too. Brewer et al. (Brewer et al., 2017) assumed that mandates provide an opportunity to engage with healthcare providers, which may increase uptake of voluntary vaccines (Moss, Reiter, Rimer, & Brewer, 2016). However, Psychological Reactance Theory (Brehm, 1966) posits that restricting individual freedom of choice may prompt reactance—feelings of anger that motivate efforts to regain that freedom (Dillard & Shen, 2005). Reactance can manifest in various ways. Individuals may be triggered to engage in the constrained behavior, take action against the restriction, or preserve other freedoms (Miron & Brehm, 2006). Applying this principle to the domain of vaccination, one experiment demonstrated that mandating a hypothetical vaccination increased anger among individuals with a rather negative general attitude toward vaccination (Betsch & Böhm, 2016).

In a subsequent voluntary vaccination decision, those individuals' vaccination intention decreased by 39% compared to control group participants who assumed no mandates were in place. In summary, selective mandates can increase the uptake of mandated vaccines but may have a negative impact on the overall vaccination program, given that people feel reactance and, as a consequence, opt out of voluntary vaccinations (Figure 2).

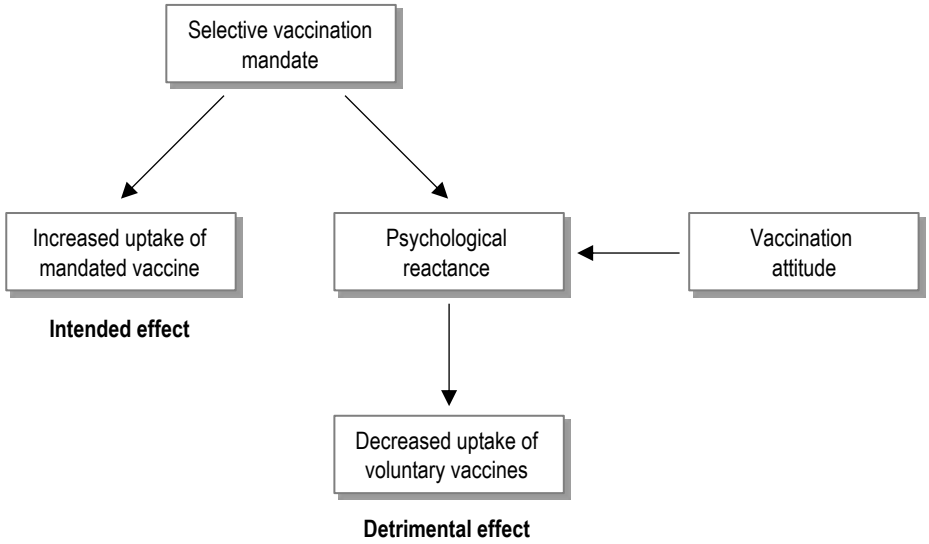

Figure 2. Effects of selective vaccination mandates.

Note: While there is some evidence that selective mandates can increase the uptake of mandated vaccines (Hull et al., 2019; Lee & Robinson, 2016; Pitts et al., 2014; Vaz et al., 2020), experimental findings indicate that reactance can reduce the uptake of voluntary vaccines (Betsch & Böhm, 2016).

Research questions

Building on initial observations of the reactance effect, the thesis seeks to clarify how attitudes and interventions affect reactance in the context of mandatory vaccination. To further investigate detrimental effects beyond the reduced uptake of voluntary vaccines and integrate the findings in a model of mandatory vaccination reactance, the following research questions are addressed.

R1	Are attitudes to vaccination and vaccination mandates interchangeable?

Negative attitudes toward vaccination foster reactance to vaccination mandates (Betsch & Böhm, 2016). While those who resist vaccination are clearly likely to feel angry about mandatory regulation, attitudes to vaccination may not be congruent with attitudes to mandates.

According to data from Australia, there is almost no disparity between these two variables, as 93% of those willing to get vaccinated against COVID-19 also favored a mandate. However, the situation may differ in countries where citizens are less accustomed to vaccination mandates (Smith, Attwell, & Evers, 2021). Strong vaccination intentions may only translate into support for mandatory vaccination when mandates align with individual moral principles. Thus, people who value freedom of choice may oppose mandates while being willing to get vaccinated. Consequently, reactance effects should be explained in terms of attitudes to mandates rather than attitudes to vaccination.

R2 Which variables underpin attitudes to mandatory vaccination?

If attitude to a mandate moderates the effect of policy on reactance, its demographic and psychological antecedents should be investigated to inform interventions that seek to increase public support for mandates. For instance, older people and males may indicate stronger support for the overarching protection offered by mandatory COVID-19 vaccination because fatality rates are higher in these groups (Davies et al., 2020; Peckham et al., 2020). The 5C can be expected to play an important role as well. For example, when vaccination intention is low because people lack confidence in vaccine safety, perceive little risk of infection, or are not concerned about collective wellbeing, support for a mandate is likely to be low as well. But individual moral should be considered too. As explained before, a strong commitment to individual freedom may reduce support for a mandate, regardless of vaccination intention.

R3 Can reactance be mitigated by explaining the rationale behind a mandate?

Previous research has shown that vaccination intention can be increased by explaining the concept of herd immunity (Betsch et al., 2017), even among individuals who value liberty and freedom of choice (Betsch & Böhm, 2018). As vaccination attitude has been found to moderate the effect of mandatory vaccination on reactance (Betsch & Böhm, 2016), explaining the collective benefits of high vaccination rates—for example, protecting those who cannot be vaccinated or safeguarding employment and the economy—could also curb reactance. This idea is supported by research showing that perspective-taking can reduce reactance (Steindl & Jonas, 2012).

R4 Can non-self-relevant mandates elicit reactance?

Previous research has shown that reactance is stronger when restrictions affect the individual but can also occur when the freedoms of others are under threat (Sittenthaler, Jonas, & Traut-Mattausch, 2016). Consequently, non-self-relevant mandates that affect only some population segments, such as healthcare workers or children, may prompt reactance and its detrimental effects as well.

R5 Does reactance trigger other detrimental effects besides lower voluntary uptake?

Reactance can trigger individuals to engage in the constrained behavior (boomerang effect, e.g., trying to work around the regulation) or take actions against the restriction (e.g., signing a petition, joining a demonstration). Furthermore, reactance can motivate the preservation of other freedoms (Miron & Brehm, 2006). As outlined above, reactance associated with a vaccination mandate can reduce the uptake of voluntary vaccines, but it may also affect adherence to other regulations. For instance, many countries constrained individual freedoms during the COVID-19 pandemic by implementing contact restrictions and mask mandates (Haug et al., 2020). According to Psychological Reactance Theory, support for these regulations may wane when a vaccination mandate comes into force.

R6 Can limited access to vaccines also elicit reactance effects?

While research on vaccination mandates has focused on the detrimental effects of limiting the freedom to decline vaccination (Betsch & Böhm, 2016), the consequences of limiting the freedom to be vaccinated are unknown. The COVID-19 pandemic created an example of the latter. Limited production capacities meant that vaccines were initially scarce in Europe and the US (Warren & Lofstedt, 2021). Previous research has shown that any threat to the freedom to acquire certain objects, information, or health provisions can elicit reactance (Ditto & Jemmott, 1989), motivating action to gain access to the scarce resource (Brehm, 1972). At the same time, the subjective value of that resource increases (Worchel et al., 1975). Consequently, limited supplies of COVID-19 may also trigger reactance, especially when vaccination intention is strong, prompting compensatory behavioral intentions opposite to those triggered by mandatory vaccination. In other words, vaccine scarcity may drive actions

to address the shortage (e.g., signing a petition) and increase vaccination intention. In some cases, this may even boost intentions to get vaccinated against an unrelated disease.

Overview of the studies

Several online studies were conducted to answer the research questions, yielding five articles. At the time of thesis submission, four (A1–A4) had been published in peer-reviewed journals, and one (A5) was under review. The articles are summarized below in chronological order of submission. Table 1 identifies the research questions addressed by each article.

A1 **Herd immunity communication counters detrimental effects of selective vaccination mandates: Experimental evidence**

Philipp Sprengholz and Cornelia Betsch
EClinicalMedicine, 2020

Study	N	Design
1	576	Experiment: 2 (selective mandatory vs. voluntary vaccination policy) × 2 (explaining vs. not explaining herd immunity) between-subjects design

This article investigated the extent to which communicating the concept of herd immunity can buffer reactance elicited by mandatory regulations. In a preregistered 2 (policy: selective mandatory vs. voluntary vaccination) × 2 (communication: herd immunity explanation vs. no explanation) factorial online experiment are presented ($N = 576$), participants were presented with two scenarios. In the first scenario, the concept of herd immunity was introduced or not, and vaccination against a fictitious disease was either mandatory or voluntary. The dependent variable was the intention to vaccinate in the second scenario, where vaccination against another fictitious disease was always voluntary. The mediating role of reactance between policies and intentions was explored. Results revealed that herd immunity communication increased vaccination intention in the second scenario. While selective mandates had no overall effect on the vaccination intention, they were associated with more anger when herd immunity was not explained. Anger in turn was associated with lower vaccination intention in the second scenario. These results indicate that explaining herd immunity can mitigate the potential detrimental effects of selective mandates by preventing reactance.

A2 **Vaccination Policy Reactance: Predictors, Consequences, and Countermeasures**

Philipp Sprengholz, Lisa Felgendreff, Robert Böhm, and Cornelia Betsch
Journal of Health Psychology, 2021

Study	N	Design
1	4,050	Correlational design
2	993	Experiment: 2 (selective mandatory vs. voluntary vaccination policy) × 3 (not communicating benefits of high vaccination rates vs. communicating public health vs. economic benefits) between-subjects design
3	579	Combination of correlational and one-factorial between-subjects design (self-relevant vs. non-self-relevant mandate)

This article presents results from three studies. Study 1 assessed correlates of individual preference for mandatory vs. voluntary vaccination against COVID-19 in the German population between April and October 2020. The results show that support for mandatory vaccination declined over time and that confidence in vaccine safety was the main driver of support for a mandate.

In Study 2, a preregistered experiment investigated communication strategies (highlighting the benefits of high uptake rates for public health vs. the economy vs. no information provided) for mitigating potential detrimental effects of a hypothetical COVID-19 vaccination mandate on the uptake of voluntary influenza shots, again using a German sample. Replicating and extending the findings presented in article A1, the study showed that mandating vaccination elicited reactance which in turn decreased the willingness to get vaccinated against influenza. However, both a positive attitude toward the mandate and communication about the importance of high vaccination rates buffered reactance, indicating the importance of explaining the rationale for coercive policies.

Study 3 employed a US sample to replicate previous findings and to gain a wider sense of reactance to mandatory vaccination. As a first step, the study assessed potential predictors of the support for mandatory vaccination, including the 5C and libertarian morality (as an indicator of the value assigned to freedom). The results revealed that stronger confidence and collective responsibility were associated with greater support for mandatory vaccination while calculation and libertarian morality had a negative effect. In the next step, an experiment compared the effects of hypothetical COVID-19 vaccination mandates that were either self-relevant (i.e., affecting every adult) or non-self-relevant (i.e., affecting only health professionals). Reactance was higher when support for a mandate was low, especially when that mandate was self-relevant (and, to a lesser extent, when it was not). In a final step

investigating the effects of reactance on various behavioral intentions, reactance to a COVID-19 vaccination mandate was found to elicit activism (e.g., increased intention to sign a petition or join a demonstration against the mandate); to promote avoidance of the new vaccination; to reduce protective behaviors (e.g., intention to wear a mask and avoid close contacts); and to skip voluntary flu shots. The findings highlight how vaccination mandates can trigger varying detrimental effects, even when not being self-relevant.

A3 **Reactance revisited: Consequences of mandatory and scarce vaccination in the case of COVID-19**

Philipp Sprengholz, Cornelia Betsch, and Robert Böhm
Applied Psychology: Health and Wellbeing, 2021

Study	N	Design
1	973	Experiment: one-factorial (unrestricted vs. mandatory vs. scarce vaccination) between-subjects design
2	1,394	Experiment: one-factorial (unrestricted vs. mandatory vs. scarce vaccination) between-subjects design

This article presents results from two studies. Study 1 employed a German sample to compare reactance in mandatory and scarce vaccination scenarios to unrestricted vaccination decisions. The results indicate that reactance was stronger when a priori vaccination intention was low and a mandate was introduced (in line with findings of article A2) or when vaccination intention was high and vaccines were scarce. The preregistered Study 2 replicated the effect using an American sample. Study 2 also compared the behavioral consequences of reactance in mandatory and scarce vaccination scenarios. In both cases, reactance increased the intention to take action against the restriction (e.g., by signing a petition or joining a demonstration). Reactance due to a mandate was positively associated with intentions to avoid the COVID-19 vaccination and an unrelated chickenpox vaccination while it was negatively associated with the intention to take protective actions limiting the spread of the coronavirus (again aligning with the findings in article A2). Importantly, reverse intentions were observed when vaccines were scarce. These findings show how opposing situations that limit the freedom of vaccination or non-vaccination can elicit similar psychological reactions, extending and generalizing previous findings on psychological reactance to the domain of vaccination.

A4 **Zero-sum or worse? Considering detrimental effects of selective mandates on voluntary childhood vaccinations**

Philipp Sprengholz and Cornelia Betsch
The Journal of Pediatrics, 2021

Study	N	Design
1	244	Experiment: one-factorial (mandatory vs. voluntary childhood vaccination) between-subjects design

This article describes a survey experiment that sought to reproduce the original reactance effect reported by Betsch and Böhm (2016) for the vaccination of children. For that reason, only German parents with children younger than 18 years were sampled. After assessing participants' attitudes toward mandatory vaccination of children against COVID-19, half were asked to imagine recommended but voluntary vaccination of their children against COVID-19 while the remainder were asked to imagine mandatory vaccination. To assess psychological reactance, all of the participating parents were asked how angry they felt about the imagined scenario. Afterwards, they were asked to read a short text about meningococcus type B and to imagine that vaccination of their children against this disease was recommended but voluntary. Finally, they should indicate how likely they would get their children vaccinated against meningococcus type B. A mandatory vaccination policy elicited anger, especially when parents' support for a mandate was low. For these parents, meningococcus vaccination intention was also lower than among those who imagined voluntary vaccination. The findings confirm the reactance-driven detrimental effect of selective mandates on parents' decisions about voluntary childhood immunization.

A5 **Attitude toward a mandatory COVID-19 vaccination policy and its determinants: Evidence from serial cross-sectional surveys conducted throughout the pandemic in Germany**

Philipp Sprengholz, Lars Korn, Sarah Eitze, Lisa Felgendreff, Regina Siegers, Laura Goldhahn, Freia De Bock, Lena Huebl, Robert Böhm, and Cornelia Betsch
Vaccine, under review

Study	N	Design
1	27,509	Correlational design

Drawing on data from a series of cross-sectional surveys conducted in Germany between April 2020 and April 2021, this article investigates the changing public support for a

COVID-19 vaccination mandate and examines individual correlates such as individual vaccination intention and the 5C antecedents of vaccination. Support for a vaccination mandate declined before approval of the first COVID-19 vaccine in December 2020 and increased afterwards. At the end of April 2021, however, only half of the survey respondents favored a mandatory regulation. In general, mandates were endorsed by those who perceived the vaccines as safe, anticipated practical barriers, and felt responsible for the collective. Conversely, there was lower support among those who perceived vaccination as unnecessary and weighed the benefits and risks of vaccination. Interestingly, a gap was observed between vaccination intention and the support for a mandate; a considerable proportion of respondents were willing to get vaccinated against COVID-19 but did not support mandatory regulation. This finding indicates that attitude to mandatory vaccination is not simply determined by vaccination-related factors such as vaccine safety or prosocial considerations.

Table 1. Articles and research questions.

	Vaccination mandates						Incentives	
	R1	R2	R3	R4	R5	R6	R7	R8
A1			×					
A2		×	×	×	×			
A3					×	×		
A4				×				
A5	×	×						
A6							×	×
A7							×	×

Note: Crosses indicate which articles (A1-A7) address the research questions (R1-R8) on vaccination mandates and incentives.

Vaccination incentives

The evidence presented here confirms that while mandating vaccination is likely to increase uptake, it can also elicit psychological reactance, with a number of detrimental consequences. Vaccination incentives such as monetary rewards (e.g., payments, gift cards, tax deductions) and legal benefits (e.g., event access, travel authorization) offer a possible alternative. Previous research has shown that incentives can help to maintain a healthier diet and quit smoking (Gardiner & Bryan, 2017; Notley et al., 2019). Thus, offering rewards for vaccination might also bolster vaccination intention. However, systematic reviews differ in their

recommendations. While the Community Preventive Services Task Force (2015) recommended incentives based on findings from seven studies about influenza, tetanus, diphtheria and pertussis as well as childhood vaccination, Adams et al. (2015) could not find sufficient evidence to recommend parental financial incentives for vaccination of preschool children. This inconclusive evidence may reflect the heterogeneity of studies (Brewer et al., 2017); previous research addressed different groups, differed by size and type of reward, and sometimes investigated a combination of incentives and other interventions. For instance, Nowalk et al. (2010) compared the effects of just advertising the influenza vaccination vs. offering free choice between different vaccine types vs. offering free choice plus a 5 USD gift card on vaccination rates in a workplace setting. While the choice plus incentive intervention increased vaccination rates considerably more than advertising alone (without choice or reward), it remained unclear whether incentives alone would have achieved the same increase in vaccination uptake. Vaccine novelty may also play a role. While previous research has investigated rewards for established vaccines, little is known about the effects of incentives on the uptake of the new COVID-19 vaccines. Indeed, scholars have already discussed the matter from an ethical perspective. For instance, Savulescu (2020) advocated paying people to get vaccinated against the new disease, arguing from a utilitarian perspective that payments are just, as they are risk-neutral (because being paid for an approved, marketed, and otherwise unpaid vaccination does not increase risk) and economically reasonable (because the financial benefits of higher vaccination rates should outweigh payment costs). Others disagreed on the grounds that incentives might rob vaccination of its moral significance, possibly generating an expectation of reward for all vaccinations (Largent & Miller, 2021). Large payments might also increase vaccine hesitancy if perceived as compensation for severe adverse effects. In particular, rewards might seem coercive for economically disadvantaged groups (Jecker, 2021). If vaccination incentives were to override potential concerns by exploiting disadvantage, this would not only be morally questionable but might jeopardize social cohesion and trust in the government.

Research questions

Given the scarcity of evidence about the effects of incentives on the uptake of new vaccines and the ethical concerns surrounding unequal effects and rewards potentially increasing vaccine hesitancy, the thesis addresses the following research questions.

R7 Can incentives increase vaccination intention in respect of new vaccines?

Given the conflicting evidence about the effects of incentives on the uptake of established vaccines, it remains unclear how rewards might affect uptake of the new COVID-19 vaccines. From an economic perspective, incentives affect individual cost-benefit calculations; when the rewards are high enough, vaccination intention increases. However, in the absence of a long-term safety record, news reports and policymakers emphasizing the rapid pace of vaccine development (e.g., Operation Warp Speed in the US) may have a negative impact on vaccine confidence, which may be further undermined if people feel they are being paid off for potential adverse effects (Cornwall, 2020; Largent & Miller, 2021). To that extent, incentives might actually hamper vaccination uptake. Any effects may also depend on the type of incentive. Multiple companies have offered employees a one-time payment for vaccination against COVID-19 (Maruf, 2021), and in July 2021, the White House called on state governments to pay 100 USD to those who are willing to get vaccinated (Oza, 2021). Beyond monetary rewards, legal incentives have been discussed and implemented. As vaccinated individuals are less likely to transmit the coronavirus (Levine-Tiefenbrun et al., 2021), they may be afforded more rights and freedoms than the unvaccinated. For example, to drive vaccination intention and uptake, vaccinated individuals may be allowed to enter shops and restaurants or attend certain events without having to get tested (Wilf-Miron, Myers, & Saban, 2021).

R8 What are the key determinants of incentivized vaccination?

Demographic, socio-economic, and psychological variables may moderate the effect of incentives on vaccination uptake. For instance, incentives may be more important for younger adults, as it is widely known that the likelihood of severe disease and death as a result of COVID-19 infection increases with age (Davies et al., 2020). As outlined above, incentives may also prove especially compelling for economically disadvantaged groups (Jecker, 2021). From a psychological perspective, the relationship between the 5C antecedents of vaccination and the intention to get vaccinated (with or without incentives) should be investigated. For example, confidence in vaccine safety is usually the strongest predictor of vaccination decisions (Dorman et al., 2021). As confidence is easy to undermine but difficult to build, it is especially interesting to examine whether incentives can compensate for a (minor)

lack of confidence, i.e., if they can motivate vaccination against COVID-19 despite uncertainty about the short- and long-term safety of vaccines.

Overview of the studies

Two articles addressed the research questions above, based on data from online experiments. At the time of thesis submission, one article had been published, and one was under review. Again, the research questions addressed by these articles are shown in Table 1.

A6 **Money is not everything: Experimental evidence that payments do not increase willingness to be vaccinated against COVID-19**

Philipp Sprengholz, Sarah Eitze, Lisa Felgendreff, Lars Korn, and Cornelia Betsch
Journal of Medical Ethics, 2021

Study	N	Design
1	1,349	Experiment: 2 (payment vs. no payment) × 2 (communication vs. no communication) between-subjects design

This article describes a preregistered experiment exploring the effects of monetary incentives on the intention to get vaccinated against COVID-19. The study was conducted in Germany in November 2020, shortly before approval and rollout of the first vaccines. Participants were randomly assigned to a 2 (payment vs. no payment) × 2 (communication vs. no communication) design. Those in the communication condition were told that rapid uptake of the vaccine played an important role in reducing infections, preventing new pandemic waves, and protecting those who could not be vaccinated by achieving herd immunity. All participants were asked to imagine being offered free vaccination against COVID-19. Participants in the payment condition were also asked to imagine being offered a monetary reward for vaccination (a randomly selected amount ranging from 25 to 200 EUR). None of these conditions significantly increased or reduced vaccination intention. This did not change when controlling for participants' financial situation, therefore challenging concerns that economically disadvantaged groups might feel compelled to accede to vaccination.

A7 **Payments and freedoms: Effects of monetary and legal incentives on COVID-19 vaccination intentions in Germany**

Philipp Sprengholz, Luca Henkel, and Cornelia Betsch
Health Economics, under review

Study	N	Design
1	782	Experiment: 2 (between subjects: legal vs. no legal incentive) × 21 (within subjects: monetary incentives from 0 to 10,000 EUR) design

As the promise of a payment of up to 200 EUR did not increase the COVID-19 vaccination intention in the initial experiment in article A6, another experiment was conducted with a German sample to investigate the potential effects of higher monetary rewards and legal incentives. Participants were told that vaccination would (or would not) lead to more freedoms (e.g., removing face masks, attending cultural events without negative test results). Afterwards, they were asked to decide between two options in a series of repeated decisions: not getting vaccinated vs. getting vaccinated and being paid a specific amount (ranging from 0 EUR to 10,000 EUR). While no effect was observed for legal incentives, the proportion of participants willing to be vaccinated increased with payment amount. However, a significant increase required rewards of 3,250 EUR or more. Compared to participants who were willing to get vaccinated without payment, those who favored a monetary incentive were younger and exhibited less confidence, more complacency, and less collective responsibility, indicating that higher incentives can motivate vaccination when there are reasons for not getting vaccinated. In line with the findings reported in article A6, financial worries did not differ between the groups and were comparable for participants unwilling to get vaccinated.

Article A1

Herd immunity communication counters detrimental effects of selective vaccination mandates: Experimental evidence

Authors: Philipp Sprengholz and Cornelia Betsch (University of Erfurt)
Published in: EClinicalMedicine (2020)
DOI: 10.1016/j.eclinm.2020.10035

Abstract: *Background.* Low vaccine uptake results in regular outbreaks of severe diseases, such as measles. Selective mandates, e.g. making measles vaccination mandatory (as currently implemented in Germany), could offer a viable solution to the problem. However, prior research has shown that making only some vaccinations mandatory, while leaving the rest to voluntary decisions, can result in psychological reactance (anger) and decreased uptake of voluntary vaccines. Since communicating the concept of herd immunity has been shown to increase willingness to vaccinate, this study assessed whether it can buffer such reactance effects. *Methods.* A total of *N* = 576 participants completed a preregistered 2 (policy: selective mandate vs. voluntary decision) × 2 (communication: herd immunity explained yes vs. no) factorial online experiment (AsPredicted #26007). In a first scenario, the concept of herd immunity was either introduced or not and vaccination either mandatory or voluntary, depending on condition. The dependent variable was the intention to vaccinate in the second scenario, where vaccination was always voluntary. Additionally, we explored the mediating role of anger between policies and intentions. *Findings.* Herd immunity communication generally increased vaccination intentions; selective mandates had no overall effect on intentions, and there was no interaction of the factors. However, selective mandates led to increased anger when herd immunity was not explained, leading in turn to lower subsequent vaccination intentions. *Interpretation.* Explaining herd immunity can counter potential detrimental effects of selective mandates by preventing anger (reactance).

Online supplement: https://osf.io/pnjs9/

Contributions: PS: Conceptualization, Methodology, Investigation, Formal analysis, Writing—Original draft preparation, Visualization. CB: Conceptualization, Methodology, Resources, Supervision, Writing—Review & Editing.

Funding: This study was funded by the University of Erfurt and the German Research Foundation (BE-3979/11-1).

Ethical declaration: The study was conducted in accordance with German Psychological Association guidelines. All participants provided written informed consent to use and share their data for scientific purposes without disclosure of their identities.

Article A2

Vaccination policy reactance: Predictors, Consequences, and Countermeasures

Authors: Philipp Sprengholz, Lisa Felgendreff (University of Erfurt), Robert Böhm (University of Copenhagen), and Cornelia Betsch (University of Erfurt)
Published in: Journal of Health Psychology (2021)
DOI: 10.1177/13591053211044535

Abstract: Ending the COVID-19 pandemic will require rapid large-scale uptake of vaccines against the disease. Mandating vaccination is discussed as a suitable strategy to increase uptake. In a series of cross-sectional quota-representative surveys and two preregistered experiments conducted in Germany and the US (total *N* = 4,629), we investigated (i) correlates of individual preferences for mandatory (vs. voluntary) COVID-19 vaccination policies; (ii) potential detrimental effects of mandatory policies; and (iii) interventions potentially counteracting them. Results indicate that reactance elicited by mandates can cause detrimental effects, such as decreasing the intention to vaccinate against influenza and adhere to COVID-19 related protective measures.

Online supplement: https://osf.io/nzkqd/

Contributions: PS, LF, RB, and CB designed the research; PS and LF performed research; PS planned and performed data analysis; PS wrote the initial draft, which was revised and approved by all authors.

Funding: This work was supported by the German Research Foundation, (BE3970/11-1 and BE3970/12-1), the Federal Centre for Health Education, the Robert Koch-Institute, the Leibniz Centre for Psychological Information and Documentation, the University of Erfurt, and the University of Copenhagen.

Ethical declaration: The research obtained ethical clearance from the University of Erfurt's IRB (#20200302/20200501), and all participants provided informed consent prior to data collection.

Acknowledgements: Studies 1 and 2 were conducted as part of Germany's COVID-19 Snapshot Monitoring (COSMO), a joint project of the University of Erfurt (Cornelia Betsch [PI], Lars Korn, Philipp Sprengholz, Philipp Schmid, Lisa Felgendreff, Sarah Eitze), the Robert Koch Institute (RKI; Lothar H. Wieler, Patrick Schmich), the Federal Centre for Health Education (BZgA; Heidrun Thaiss, Freia De Bock), the Leibniz Centre for Psychological Information and Documentation (ZPID; Michael Bosnjak), the Science Media Center (SMC; Volker Stollorz), the Bernhard Nocht Institute for Tropical Medicine (BNITM; Michael Ramharter), and the Yale Institute for Global Health (Saad Omer).

Article A3

Reactance revisited: Consequences of mandatory and scarce vaccination in the case of COVID-19

Authors: Philipp Sprengholz, Cornelia Betsch (University of Erfurt), and Robert Böhm (University of Copenhagen)
Published in: Applied Psychology: Health and Wellbeing (2021)
DOI: 10.1111/aphw.12285

Abstract: Psychological reactance theory assumes that the restriction of valued behaviors elicits anger and negative cognitions, motivating actions to regain the limited freedom. Two studies investigated the effects of two possible restrictions affecting COVID-19 vaccination: the limitation of non-vaccination by mandates and the limitation of vaccination by scarce vaccine supply. In the first study, we compared reactance about mandatory and scarce vaccination scenarios and the moderating effect of vaccination intentions, employing a German quota-representative sample (N = 973). In the preregistered second study, we replicated effects with an American sample (N = 1,394) and investigated the consequences of reactance on various behavioral intentions. Results revealed that reactance was stronger when a priori vaccination intentions were low and a mandate was introduced or when vaccination intentions were high and vaccines were scarce. In both cases, reactance increased intentions to take actions against the restriction. Further, reactance due to a mandate was positively associated with intentions to avoid the COVID-19 vaccination and an unrelated chickenpox vaccination; it was negatively associated with intentions to show protective behaviors limiting the spread of the coronavirus. Opposite intentions were observed when vaccination was scarce. The findings can help policymakers to curb the spread of infectious diseases such as COVID-19.

Online supplement: https://osf.io/ktp98/

Contributions: PS, CB, and RB designed the research; PS performed the research, planned and performed data analyses, and wrote the initial draft, which was revised and approved by all authors.

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Ethical declaration: The research obtained ethical clearance from the University of Erfurt's IRB (#20200302/20200501), and all participants provided informed consent prior to data collection.

Acknowledgements: Study 1 was conducted as part of Germany's COVID-19 Snapshot Monitoring (COSMO), a joint project of the University of Erfurt (Cornelia Betsch [PI], Lars Korn, Philipp Sprengholz, Philipp Schmid, Lisa Felgendreff, Sarah Eitze), the Robert Koch Institute (RKI; Lothar H. Wieler, Patrick Schmich), the Federal Centre for Health Education (BZgA; Heidrun Thaiss, Freia De Bock), the Leibniz Institute of Psychology (ZPID; Michael Bosnjak), the Science Media Center (SMC; Volker Stollorz), the Bernhard Nocht Institute for Tropical Medicine (BNITM; Michael Ramharter), and the Yale Institute for Global Health (Saad Omer). We are grateful to Regina Böhm for the fruitful discussions that inspired this research.

Article A4

Zero-sum or worse? Considering detrimental effects of selective mandates on voluntary childhood vaccinations

Authors: Philipp Sprengholz and Cornelia Betsch (University of Erfurt)
Published in: The Journal of Pediatrics (2021)
DOI: 10.1016/j.jpeds.2021.08.018

Online supplement: https://osf.io/vtcpe/

Contributions: PS and CB designed the research. PS performed the research, planned and performed the data analyses, and wrote the initial draft, which was revised and approved by all authors.

Funding: This work was supported by German Research Foundation (BE3970/12-1), Federal Centre for Health Education, Robert Koch Institute, Leibniz Institute for Psychology, Klaus Tschira Foundation, and University of Erfurt.

Ethical declaration: The research obtained ethical clearance from the University of Erfurt's IRB (#20200302/20200501), and all participants provided informed consent prior to data collection.

Acknowledgements: The study was conducted as part of Germany's COVID-19 Snapshot Monitoring (COSMO), a joint project of the University of Erfurt (Cornelia Betsch [PI], Lars Korn, Philipp Sprengholz, Philipp Schmid, Lisa Felgendreff, Sarah Eitze), the Robert Koch Institute (RKI; Lothar H. Wieler, Patrick Schmich), the Federal Centre for Health Education (BZgA; Heidrun Thaiss, Freia De Bock), the Leibniz Institute of Psychology (ZPID; Michael Bosnjak), the Science Media Center (SMC; Volker Stollorz), the Bernhard Nocht Institute for Tropical Medicine (BNITM; Michael Ramharter), and the Yale Institute for Global Health (Saad Omer).

Article A5

Attitude toward a mandatory COVID-19 vaccination policy and its determinants: Evidence from serial cross-sectional surveys conducted throughout the pandemic in Germany

Authors: Philipp Sprengholz, Lars Korn, Sarah Eitze, Lisa Felgendreff, Regina Siegers und Laura Goldhahn (University of Erfurt), Freia De Bock (Bundeszentrale für gesundheitliche Aufklärung), Lena Hübl (Bernhard-Nocht-Institut für Tropenmedizin), Robert Böhm (University of Copenhagen), and Cornelia Betsch (University of Erfurt)
Published in: Vaccine (2022)
DOI: https://doi.org/10.1016/j.vaccine.2022.01.065

Abstract: *Background.* Mandating vaccination against COVID-19 is often discussed as a means to counter low vaccine uptake. Beyond the potential legal, ethical, and psychological concerns, a successful implementation also needs to consider citizens' support for such a policy. Public attitudes toward vaccination mandates and their determinants might differ over time and, hence, should be monitored. *Methods.* Between April 2020 and April 2021, we investigated public support for mandatory vaccination policies in Germany and examined individual correlates, such as vaccination intentions, confidence in vaccine safety, and perceived collective responsibility, using a series of cross-sectional, quota-representative surveys (overall N = 27,509). *Results.* Support for a vaccination mandate declined before the approval of the first vaccine against COVID-19 in December 2020 and increased afterwards. However, at the end of April 2021, only half of respondents were in favor of mandatory regulations. In general, mandates were endorsed by those who considered the vaccines to be safe, anticipated practical barriers, and felt responsible for the collective. On the contrary, perceiving vaccination as unnecessary and weighing the benefits and risks of vaccination was related to lower support. Older individuals and males more often endorsed vaccination mandates than did younger participants and females. Interestingly, there was a gap between vaccination intentions and support for mandates, showing that the attitude toward mandatory vaccination was not only determined by vaccination-related factors such as vaccine safety or prosocial considerations. *Conclusions.* Because of low public support, mandatory vaccination against COVID-19 should be considered a measure of last resort in Germany. However, if removing barriers to vaccination and educational campaigns about vaccine safety and the prosocial impact of vaccination are not sufficient for increasing vaccination uptake to the required levels, mandates could be introduced. In this case, the rationale behind the measure should be explained to ensure acceptance and adherence.

Online supplement: https://osf.io/pe3rd/

Contributions: PS: conceptualization, methodology, investigation, formal analysis, visualization, writing – original draft. LK, SE, LF, RS, LG: conceptualization, methodology, writing – review & editing. FDB, LH: conceptualization, writing – review & editing. RB: conceptualization, methodology, writing – review & editing, supervision. CB: conceptualization, methodology, writing – review & editing, supervision, funding acquisition.

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Ethical declaration: Our research obtained ethical clearance from the University of Erfurt's IRB (#20200302/20200501), and all participants provided informed consent prior to data collection.

Acknowledgements: The study was conducted as part of Germany's COVID-19 Snapshot Monitoring (COSMO), a joint project of the University of Erfurt (Cornelia Betsch [PI], Lars Korn, Philipp Sprengholz, Philipp Schmid, Lisa Felgendreff, Sarah Eitze), the Robert Koch Institute (RKI; Lothar H. Wieler, Patrick Schmich), the Federal Centre for Health Education (BZgA; Heidrun Thaiss, Freia De Bock), the Leibniz Institute of Psychology (ZPID; Michael Bosnjak), the Science Media Center (SMC; Volker Stollorz), the Bernhard Nocht Institute for Tropical Medicine (BNITM; Michael Ramharter), and the Yale Institute for Global Health (Saad Omer).

Article A6

Money is not everything: experimental evidence that payments do not increase willingness to be vaccinated against COVID-19

Authors: Philipp Sprengholz, Sarah Eitze, Lisa Felgendreff, Lars Korn, and Cornelia Betsch (University of Erfurt)
Published in: Journal of Medical Ethics
DOI: 10.1136/medethics-2020-107122

Abstract: Rapid, large-scale uptake of new vaccines against COVID-19 will be crucial to decrease infections and end the pandemic. In a recent article in this journal, Julian Savulescu argued in favour of monetary incentives to convince more people to be vaccinated once the vaccine becomes available. To evaluate the potential of his suggestion, we conducted an experiment investigating the impact of payments and the communication of individual and prosocial benefits of high vaccination rates on vaccination intentions. Our results revealed that none of these interventions or their combinations increased willingness to be vaccinated shortly after a vaccine becomes available. Consequently, decision makers should be cautious about introducing monetary incentives and instead focus on interventions that increase confidence in vaccine safety first, as this has shown to be an especially important factor regarding the demand for the new COVID-19 vaccines.

Online supplement: https://osf.io/89eux/

Contributions: PS and CB designed the research. PS, SE, LF and LK performed the research. PS planned and performed data analyses, and wrote the initial draft, which was revised and approved by all authors.

Ethical declaration: Our research obtained ethical clearance from the University of Erfurt's IRB (#20200302/20200501), and all participants provided informed consent prior to data collection.

Article A7

Attitude toward a mandatory COVID-19 vaccination policy and its determinants: Evidence from serial cross-sectional surveys conducted throughout the pandemic in Germany

Authors: Philipp Sprengholz, Luca Henkel (University of Bonn), and Cornelia Betsch (University of Erfurt)
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Abstract: Monetary and legal incentives have been proposed to promote COVID-19 vaccination uptake. To evaluate the suitability of incentives, an experiment with German participants examined the effects of payments (varied within subjects: 0 to 10,000 EUR) and freedoms (varied between subjects: vaccination leading vs. not leading to the same benefits as a negative test result) on the vaccination intentions of previously unvaccinated individuals (n = 782). While no effect could be found for freedoms, the share of participants willing to be vaccinated increased with the payment amount. However, a significant change required large rewards of 3,250 EUR or more. While monetary incentives could increase vaccination uptake by a few percentage points, the high costs of implementation challenge the efficiency of the measure and call for alternatives. As experimental data suggest that considering vaccination as safe, necessary, and prosocial increases an individual's likelihood of wanting to get vaccinated without payment, educational campaigns should emphasize these features when promoting vaccination against COVID-19.

Online supplement: https://osf.io/4kw2u/

Contributions: PS: conceptualization, methodology, investigation, formal analysis, visualization, writing – original draft. LH: conceptualization, methodology, investigation, formal analysis, visualization, writing – review and editing. CB: conceptualization, writing – review & editing.

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Ethical declaration: Our research obtained ethical clearance from the University of Erfurt's IRB (#20200302/20200501), and all participants provided informed consent prior to data collection.

Acknowledgements: The study was conducted as part of Germany's COVID-19 Snapshot Monitoring (COSMO), a joint project of the University of Erfurt (Cornelia Betsch [PI], Lars Korn, Philipp Sprengholz, Philipp Schmid, Lisa Felgendreff, Sarah Eitze), the Robert Koch Institute (RKI; Lothar H. Wieler, Patrick Schmich), the Federal Centre for Health Education (BZgA; Heidrun Thaiss, Freia De Bock), the Leibniz Institute of Psychology (ZPID; Michael Bosnjak), the Science Media Center (SMC; Volker Stollorz), the Bernhard Nocht Institute for Tropical Medicine (BNITM; Michael Ramharter), and the Yale Institute for Global Health (Saad Omer).

Discussion

> *Vaccination provides a high-stakes, real-world test bed for evaluating a broad array of theories in psychological science. An understanding of the psychology behind vaccination behavior can inform both theoretical development and facilitation of evidence-based vaccination policy and practice.*
>
> — Brewer et al. (2017)

The seven articles presented here investigated two strategies for directly influencing vaccination intentions: mandates sanctioning non-vaccination and incentives rewarding vaccination. Adopting the above words from Brewer et al. (2017) as a mission statement, we deployed and tested psychological theories to examine the intended and unintended effects of the two strategies, as well as moderating factors. The results extend and strengthen existing theory and contribute to social and behavioral research on vaccination hesitancy, helping decision makers to design and implement effective evidence-based vaccination policies. The following section summarizes and integrates the findings, notes their limitations, and identifies avenues for future research and implications for policymaking.

Vaccination mandates

As the most intrusive policy initiative for increasing vaccination uptake, mandates are ethically acceptable only if the loss of individual liberty is outweighed by the positive effects on public health. While previous research confirms the positive effects of mandatory regulations on vaccination uptake (Hull et al., 2019; Lee & Robinson, 2016; Pitts et al., 2014; Vaz et al., 2020), detrimental effects must be considered as well. The thesis builds on the initial observation that vaccination mandates elicit psychological reactance among individuals with a rather negative attitude toward vaccination (Betsch & Böhm, 2016). The studies in four published articles (A1, A2, A3, and A4) reproduced this effect and confirmed the detrimental consequences for the uptake of voluntary vaccines. The results underpin concerns about the negative impact of selective mandates on the immunization program by reducing vaccination intentions for various diseases such as influenza or chickenpox. Besides replicating the reactance effect, the thesis studies answered a series of research questions about attitudes, interventions, and policy characteristics that moderate this effect and its behavioral consequences.

Support for mandatory policies

The thesis confirms that mandatory regulation produces reactance among individuals who do not support the mandate. It follows that mandatory vaccination should only be considered when endorsed by an overwhelming majority of the population. Regarding individual determinants of the support for mandatory vaccination (R2), articles A2 and A5 report that older people and males were more likely to support a vaccination mandate for COVID-19, possibly reflecting the higher fatality rates in these groups (Davies et al., 2020; Peckham et al., 2020). However, demographic characteristics played only a minor role as compared to psychological variables like moral principles and the 5C antecedents. Support for a mandate was found to be low among those who hold libertarian values, exhibit low confidence in vaccine safety, and do not feel responsible for protecting others by getting vaccinated. As attitudes can change over time, the support for mandatory vaccination fluctuates. In the case of COVID-19, Germans' support for a mandate was strongest at the beginning of the pandemic when disease dynamics and the consequences of infection were less certain. This support subsequently declined, possibly because fake news and the high pace of vaccine development triggered a decrease in vaccine confidence (Cornwall, 2020; van der Linden, Roozenbeek, & Compton, 2020). For that reason, policymakers should consider introducing mandatory vaccination only after the public has been made aware of a vaccine's excellent safety profile (Omer, Betsch, & Leask, 2019).

While confidence and collective responsibility also predicted the willingness to get vaccinated, article A5 reports that vaccination intention and the support for mandatory regulation are not interchangeable (R1). In the case of COVID-19, a significant proportion of German survey participants favored vaccination but opposed mandatory regulation after the first vaccines became available, suggesting the importance of moral values. Of course, when citizens are accustomed to vaccination mandates or when communal motives are considered more important than individualistic values like freedom, the gap between vaccination intention and support for mandatory regulation may be smaller or non-existent (Smith et al., 2021). However, when making decisions about introducing mandatory vaccination, policymakers should not rely exclusively on evidence of vaccination intention but should take account of attitudes to the mandate in question in order to quantify potential reactance effects.

Mitigating reactance by explaining mandate rationale

There is evidence that triggering prosocial motives for vaccination increases vaccination willingness (Betsch et al., 2017; Korn et al., 2020), even among those who value liberty and freedom of choice (Betsch & Böhm, 2018). Based on the idea that perspective-taking can also reduce reactance (Steindl & Jonas, 2012), articles A1 and A2 show that highlighting the collective benefits of high vaccination rates can buffer the reactance associated with a vaccination mandate. Regarding R3, a mandate's rationale should always be explained in order to reduce anger and subsequent detrimental effects. When considering the implementation of a mandate, decision makers should emphasize herd immunity as a means of protecting those who cannot be vaccinated. The results also confirm the positive effects of explaining how a mandate safeguards employment and the economy by eliminating the need for lockdowns and other restrictions.

Non-self-relevant mandates

Vaccination mandates usually do not affect the whole population but apply to specific subgroups such as children, caregivers, and health professionals (Attwell & Navin, 2019; Haviari et al., 2015). According to previous research, reactance is stronger when restrictions affect oneself, but the effect may also occur when the freedom of others is under threat (Sittenthaler, Jonas, & Traut-Mattausch, 2016). In response to R4, article A2 reports this vicarious reactance effect for vaccination mandates as well. Lower support for mandatory vaccination increased reactance, especially when the individual was directly affected by the mandate. However, reactance was also elicited (to a lesser degree) when the policy applied only to health professionals and was not self-relevant. For that reason, subgroups should only be mandated when there is public support, as such measures may otherwise generate anger and detrimental effects for the population as a whole.

Vaccination mandates for children can be regarded as a special case of non-self-relevant mandates because they interfere with parental vaccination decisions. Article A4 confirms that mandating COVID-19 vaccination for children elicits anger among parents with low vaccination intentions and reduces their acceptance of an unrelated voluntary vaccination. As previous research indicates that parents tend to make more risk-averse decisions for their children than for themselves (Dore, Stone, & Buchanan, 2014), the small but undeniable risk of adverse effects is likely to arouse greater anger when a mandate affects children

rather than parents themselves. While this claim was not tested here, the reactance effects of mandatory COVID-19 vaccination policies for adults (article A2) and for children (article A4) clearly differ. Accordingly, childhood vaccination should be mandated with care. As outlined by Omer et al. (2019), overly strict mandates may prompt parents to avoid vaccination requirements—for example, by seeking medical exemption (MacDonald et al., 2018).

Detrimental effects of vaccination mandates

Betsch and Böhm (2016) initially showed that reactance related to selective vaccination mandates can reduce intention for unrelated voluntary vaccinations. This effect has been reproduced repeatedly in the thesis studies. Individuals who were annoyed by mandatory regulation were less willing to get vaccinated against influenza (A2), chickenpox (A3), or a fictitious disease (A1). While this is concerning, other detrimental effects should also be taken into account (R5). As shown in articles A2 and A3, reactance related to mandatory vaccination against COVID-19 can increase intentions to avoid the mandate, to take action against the regulation (e.g., by joining a demonstration), and to cease adherence to pandemic regulations such as mask orders and contact restrictions. As protective behaviors will remain crucial until most of the population have been vaccinated against COVID-19, policymakers should be alarmed by the finding that merely announcing a vaccination mandate could exacerbate disease dynamics.

An integrated model of mandatory vaccination reactance

The present findings regarding mandatory vaccination policies and associated predictors, consequences, and countermeasures can be incorporated into a psychological model (Figure 3). This model provides a foundation for future research and can help policymakers to design vaccination policies that are accepted and therefore efficient. The model serves as a reminder that increasing uptake of mandated vaccination comes at a price. In particular, demographic and psychological factors influence the attitude toward mandatory regulation. This attitude, policy characteristics, and communication interventions explaining the mandate's rationale influence the extent of reactance. The greater the reactance, the more detrimental effects can be expected. It follows that mandating a single vaccination can endanger the vaccination

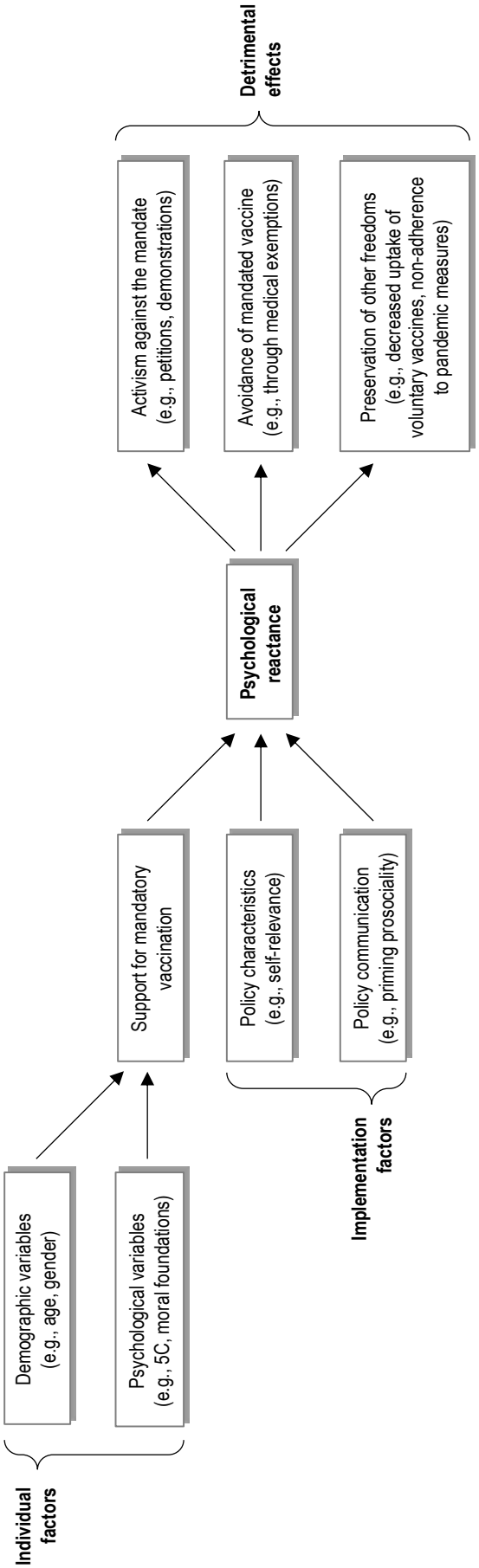

Figure 3. Model of mandatory vaccination reactance.

program by reducing the uptake of voluntary vaccines, triggering activism, and driving intention to work around the mandate. Associated efforts to preserve other freedoms may lead to further risky health behaviors.

Reactance related to vaccine scarcity

While the focus here is on the effects of mandatory vaccination, major findings were also tested in another detrimental scenario: vaccine scarcity (R6). As reported in article A3, both mandated vaccination and scarce vaccine supplies can trigger reactance if they conflict with behavioral intentions. In both cases, reactance driven by the elimination of a valued choice option increased intentions to act against that elimination, to pursue the eliminated behavior, and to compensate for the elimination by acting contrarily in the case of an unrelated non-mandated vaccination decision. While mandate-related reactance increased intentions to work around the mandate, to skip voluntary chickenpox shots, and to resist behaviors that protect against COVID-19 infection, individuals who were annoyed by scarce vaccine supplies exhibited opposite intentions. As vaccine scarcity was associated with more favorable behavioral intentions and seemed to increase the attractiveness of vaccination, policymakers should clearly communicate any such scarcity to the public. In these circumstances, people should not be misled to believe that they will soon be vaccinated, as this might jeopardize adherence to protective measures such as avoiding close contacts during a pandemic.

Limitations

The present research has several limitations. First, all of the findings relate to perceptions and intentions in hypothetical policy scenarios that may differ from real-world affects and behaviors (Sheeran, 2002). However, to the extent that the subjective effects of mandatory vaccination and vaccine scarcity are likely to be even stronger when personal freedom is at stake, the results can be seen as conservative estimates. Habituation may also play an important role; that is, psychological reactance may be strongest when a constraint such as a mandate is first announced or introduced and may subsequently decline as people become accustomed to the measure in question. While the thesis investigated the ad hoc consequences of vaccination policies, no account was taken of such time effects. Additionally, the results are based on samples from Germany and the United States and should be replicated

in other regions. For example, as vaccination mandates are commonly used to regulate school entry and employment in the United States, reactance effects may be stronger in countries where mandates are less common.

Vaccination incentives

In light of their potential detrimental effects, mandatory regulations should be implemented with care, especially when public support for a mandate is low. For instance, article A5 reports that half of the German population opposed mandatory vaccination against COVID-19 in April 2021. In such circumstances, policymakers should refrain from implementing vaccination mandates and instead devise less intrusive measures. Instead of restricting the vaccination decision, it could be guided by incentives. As noted in the introduction, research on the effectiveness of rewards is inconclusive and usually refers to established vaccines (Adams et al., 2015; Brewer et al., 2017). To extend the evidence to new vaccines, two of the thesis studies investigated the impact of monetary and legal incentives on vaccination against COVID-19 (R7), along with potential moderators (R8).

Monetary incentives

In the initial study (article A6), offering small payments (up to 200 EUR) to German survey participants did not alter vaccination intention. While these results were based on fictitious decisions, and the social desirability of getting paid to be vaccinated may be low, it seems that the small rewards offered by some companies (Maruf, 2021) and the US government (Oza, 2021) may not have the desired impact. Article A7 reported that higher payments (greater than 3,000 EUR) caused a significant proportion of participants to change their minds and switch from non-vaccination to vaccination. High payments were found to motivate vaccination by overcoming reasons for not getting vaccinated. Compared to individuals who were willing to get vaccinated without payment, those who favored a monetary incentive exhibited less confidence in vaccine safety, were more complacent, and showed less collective responsibility.

While high monetary incentives might increase vaccination uptake by a few percentage points for COVID-19, the costs of implementation raise questions about the measure's economic efficiency. As reported in article A7, incentives might help to increase Germany's

vaccination rate from 70% to 80% at most, but this would probably cost 500 billion EUR or more. Clearly, the economic cost of sustaining pandemic measures and recurring lockdowns may be higher (Spreter, 2020), but controlling infections and preventing further pandemic waves would require a higher vaccination rate than seems achievable using monetary incentives alone (Wichmann et al., 2021).

Monetary incentives for vaccination also raise some ethical concerns. For example, some scholars have argued that payments may increase vaccine hesitancy by creating unwarranted suspicion (Jecker, 2021; Savulescu, 2020). If payments exceed reimbursement of vaccination-related costs (such as the time required to make and attend a vaccination appointment), recipients may feel they are being paid to ignore any potential adverse effects of an unsafe vaccine and refrain from vaccination. However, no evidence was found of any such effect; at worst, offering a payment had no effect on vaccination intention. Jecker (2021) argued that large payments to economically disadvantaged groups could be viewed as coercive, but again, no evidence was found here to support this claim, as intentions to get vaccinated with or without being paid were comparable for participants who had financial worries and those who did not.

In sum, the evidence suggests that monetary incentives may contribute to a moderate increase in vaccination rates when payments are sufficiently high. While ethical concerns may be unwarranted, policymakers should take account of economic considerations and balance costs and benefits before introducing monetary incentives.

Legal incentives

As an alternative to monetary payments, people could be rewarded in kind for vaccination by granting certain rights and freedoms (Brown, Savulescu, Williams, & Wilkinson, 2020). As the probability of contracting or transmitting COVID-19 diminishes following vaccination (Levine-Tiefenbrun et al., 2021), it has been argued that there is no ethical justification for restricting the liberty of vaccinated individuals (Voo et al., 2021). Consequently, they should be allowed to enter shops and restaurants, travel, and be exempted from contact restrictions and mask mandates. Introducing legal incentives of this kind may motivate unvaccinated people to opt for vaccination.

Unlike monetary rewards, legal incentives are inexpensive and easy to implement. Furthermore, they seem less likely to backfire by increasing vaccine hesitancy; as the benefit

is linked to the outcome (i.e., increased immunity and reduced contagiousness) rather than to the act of vaccination, legal incentives are unlikely to be perceived as payment for any potentially adverse reaction to the vaccine (Savulescu, 2020). Despite these theoretical advantages, the study reported in article A7 found no positive effect of legal incentives on vaccination intention in Germany. The willingness to be vaccinated against COVID-19 was not increased by promising that vaccination would enable participants to abandon face masks and to attend cultural events and services without a negative test result. Clearly, this finding may relate to the specific incentives offered in the study, where vaccination was predominantly framed as a replacement for testing. Stronger incentives, such as being allowed to travel for leisure or to attend a music festival, might boost vaccination intention. However, the present findings suggest that policymakers cannot be sure that lifting restrictions for vaccinated individuals will in itself guarantee a large increase in vaccination uptake.

Limitations

The present research on incentives has the same limitations as the investigation of mandatory vaccination. The findings are based on fictitious scenarios that may differ in reality. Furthermore, the results refer to a specific temporal and regional context. Although parallel research by Serra-Garcia and Szech (2021) showed that a hypothetical payment of 500 USD leveraged vaccination intention in the US by more than 10%, the German samples used here disclosed no such effect. While the social desirability of getting paid to be vaccinated may be lower in Germany, these conflicting results may also reflect methodological differences. For example, while Serra-Garcia and Szech (2021) and the study in article A7 both used price lists to estimate within-subject effects of different payments on vaccination intention, the range of these price lists differed. Existing evidence of people's tendency to be drawn toward the center of price lists (Andersen, Harrison, Lau, & Rutström, 2006; Birnbaum, 1992; Simonson, 1989) may explain the differing findings.

Future research

The above limitations should be addressed in future research, which should also seek to integrate the findings regarding vaccination mandates and incentives.

From hypothetical to real decisions

The effects reported here need to be replicated in the field. As some countries have introduced COVID-19 vaccination mandates for specific subgroups (Paterlini, 2021; Wise, 2021), predictors and consequences of reactance can be investigated in the real world, and communication interventions can be meaningfully evaluated. For instance, if the German government was to consider following other countries by introducing mandatory COVID-19 vaccination for health professionals, it would make sense to test any information that might be provided to explain the rationale. The effects of real incentives on vaccination behavior should also be investigated. For instance, by offering citizens of a pilot region a specific amount of money for getting vaccinated against COVID-19, vaccination rates could be compared with earlier figures and the uptake in other areas to quantify the real impact of monetary rewards.

Long-term effects and feedback cascades

Few existing studies have investigated the long-term effects of restricting individual freedoms. While the present findings indicate that vaccination mandates may elicit reactance and a range of detrimental effects, it remains unclear whether and how these effects persist. As mandates change the behaviors of entire populations, social norms may shift, altering thoughts and feelings about mandatory vaccination (Brewer et al., 2017). In this way, support for the mandate may increase over time along with vaccination intention while reactance and its detrimental effects diminish. Future research should explore this potential feedback cascade and the basic cognitive mechanisms that drive reactance effects. Anger about freedom restrictions may prompt ad hoc formation of implementation intentions (Brandstatter, Lengfelder, & Gollwitzer, 2001) to restore freedom in specific contexts. However, as reactance effects have been shown to vary, reactance itself may persist over longer periods and initiate context-dependent actions to regain individual freedom. If so, it remains unclear when and how reactance is eventually activated. Cognitive psychology and neuroscience may help to answer these questions, thus clarifying the long-term consequences of vaccination mandates.

Psychological reactance among mandate advocates

While the present thesis focuses on psychological reactance among those who do not support mandatory vaccination, evidence also emerged of anger about voluntary vaccination policies among those who support mandates. Future research should investigate the effects of this anger because failure to introduce a mandate when large parts of the population demand it may erode social cohesion and trust in the government.

Detrimental effects of vaccination incentives

While vaccination mandates and incentives were investigated separately here, the distinction between these measures is somewhat blurred. Just like mandates, unaccepted incentives can restrict individual freedom. For instance, when only those who are vaccinated can attend social events, non-vaccination may not be perceived as a real option, potentially leading to reactance and the same detrimental effects that were observed in the case of mandatory vaccination. For example, rewarding COVID-19 vaccination may prompt opposing petitions, demonstrations, and reduced compliance with protective behaviors. Future research should investigate the circumstances in which incentives elicit reactance and which detrimental effects should be considered when designing reward programs. This should include the closer examination of the effects of monetary incentives on future compensation expectations. Largent and Miller (2021) argued that paying people to get vaccinated may reduce the moral significance of vaccination, prompting demands to be rewarded for other immunizations. To investigate such crowding-out effects, country-level studies should examine the relationship between reward programs and subsequent adherence to local vaccination schedules.

Conclusion

Vaccination mandates and incentives have been proposed as effective measures for increasing vaccination uptake (Brewer et al., 2017). However, the present findings suggest that both approaches are far from perfect. Mandatory vaccination probably increases vaccination uptake but may elicit psychological reactance even when the regulation is not self-relevant. While explaining the rationale behind the measure can buffer this effect, detrimental consequences are certain. In particular, policymakers should refrain from mandating a specific vaccine when large parts of the population oppose it, as many citizens may develop risky

health behaviors that undermine immunization programs and other public health efforts. Given the detrimental effects of mandates, vaccination incentives might seem a viable alternative, but these appear to have only a limited impact on vaccination uptake. The thesis studies found no effect in the case of legal incentives, and monetary rewards had to be high to make a significant difference. This adds to previous inconclusive literature about the effectiveness of vaccination incentives. Let alone, potential detrimental (reactance-mediated) effects of vaccination incentives have not been investigated.

Taken together, the available evidence suggests that policymakers should employ a mix of measures. Most important, practical barriers toward vaccination need to be removed (Gerend et al., 2013). Getting vaccinated must be as easy as possible. In the case of the present COVID-19 pandemic, vaccination should be locally available without prior appointment. Furthermore, vaccination programs should be accompanied by educational campaigns highlighting the individual and social importance of vaccination. For example, explaining herd immunity and framing vaccination as a social contract can bolster vaccination intentions (Betsch et al., 2017; Korn et al., 2020). Additionally, individuals should be allowed to choose their preferred vaccine (Sprengholz, Eitze, Korn, Siegers, & Betsch, 2021). If vaccination rates remain below target thresholds, more intrusive policies can be introduced, including incentives and, as a measure of last resort, compulsory vaccination for specific subgroups. In every case, policymakers should defer to the empirical evidence when deciding which vaccination policies to implement and how to communicate these policies to the public.

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Additional publications

Besides the seven articles comprising this thesis, I co-authored various articles during the time of my dissertation project.

First authorship

Sprengholz, P., & Betsch, C. (2021). Ok Google: Using virtual assistants for data collection in psychological and behavioral research. *Behavior Research Methods*. https://doi.org/10.3758/s13428-021-01629-y

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Ehrenwörtliche Erklärung

Ich erkläre hiermit ehrenwörtlich, dass ich die vorliegende Arbeit ohne unzulässige Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe; die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sind als solche kenntlich gemacht. Bei der Auswahl und Auswertung des Materials sowie bei der Herstellung des Manuskripts habe ich Unterstützungsleistung von folgenden Personen erhalten:

Prof. Dr. Cornelia Betsch
Prof. Dr. Robert Böhm
Prof. Dr. Freia De Bock
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Lisa Felgendreff
Regina Siegers
Laura Goldhahn
Lena Hübl
Luca Henkel

Weitere Personen waren an der geistigen Herstellung der vorliegenden Arbeit nicht beteiligt. Insbesondere habe ich nicht die Hilfe einer Promotionsberaterin bzw. eines Promotionsberaters in Anspruch genommen. Dritte haben von mir weder unmittelbar noch mittelbar geldwerte Leistungen für Arbeiten erhalten, die im Zusammenhang mit dem Inhalt der vorgelegten Dissertation stehen.

Die Arbeit oder Teile davon wurden bisher weder im Inland noch im Ausland in gleicher oder ähnlicher Form einer anderen Prüfungsbehörde als Dissertation vorgelegt. Ferner erkläre ich, dass ich nicht bereits eine gleichartige Doktorprüfung an einer Hochschule endgültig nicht bestanden habe.

Jena, 16.09.2021
Ort, Datum

Unterschrift

Lebenslauf

Philipp Sprengholz

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