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COMMUNICATING VACCINATION COVERAGE: TESTING THE SELFISH VERSUS THE SOCIAL RATIONALITY HYPOTHESIS

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KOMUNIKACIJA OBUHVATA VAKCINOM: PROVERA PRETPOSTAVKI MODELA SEBIČNE NASPRAM MODELA SOCIJALNE RACIONALNOSTI

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Communicating vaccination coverage: Testing the selfish versus the social rationality hypothesis

Abstract

We explored how communicating vaccination coverage affects vaccination intentions. We compared contrasting hypotheses drawing from two theoretical models: selfish rationality and social rationality. The selfish-rational model suggests high coverage reduces motivation by encouraging free-riding on herd immunity, while the social-rational model sees high coverage as a positive descriptive norm that increases motivation. Both suggest the opposite effect at low coverage. A content analysis of 160 Serbian online news articles from the 2017 measles outbreak found that vaccination coverage was often framed negatively (e.g., “only 50% vaccinated”), lacked context and numerical precision, and rarely included explanations of herd immunity. Such reporting reinforces undesirable social norms, while failing to convey the broader societal benefits of immunization. Across all experiments (N = 1076; Hedges’ g = 0.21), communicating high country-level coverage (80–90%) generally increased vaccination intention compared to conditions when low (10–20%) or no coverage was communicated. This insight alone has limited practical use, as coverage values must be reported as they are. We therefore experimentally tested how appeals to individual (protecting oneself), social (protecting others), and collective benefits (stopping the disease) influence vaccination intentions at different levels of vaccination coverage. One effective intervention was emphasizing the social benefits of herd immunity via text and an animated infographic (N = 543; Hedges’ g = 0.23), conceptually replicating a previous finding; incorporating coverage or herd immunity threshold information had no further effect. Another successful intervention, this time in a setting of moderate coverage (60%), was appealing to individual benefits of vaccination (N = 265; Hedges’ g = 0.16). In a separate experiment (N = 217), irrespective of vaccination-coverage level, participants who opted for vaccination commonly endorsed both self-interested and prosocial reasons, while non-vaccination was typically justified by personal risk calculations and the belief that vaccination was unnecessary. Free-riding was rarely endorsed, and descriptive norms were seen as more relevant for vaccination than non-vaccination. Open-ended responses also highlighted (mis)trust in science and vaccines as an important reason. Our findings support the social-rational view more than the selfish-rational one, but also highlight the limitations of applying either model rigidly. We argue that public health messaging should reflect reasonableness, understood as a context-sensitive balancing of individual and social considerations. We discussed directions for future research, such as communicating dynamic norms (changes in coverage) and tailored messaging. By refining theoretical assumptions, using a multi-method approach, and offering practical recommendations, this work helps us better understand and support vaccination decisions in a complex, socially interdependent world.

Keywords: vaccination, vaccination decision-making, rationality, social dilemmas, free riding, social norms, health communication, public health, herd immunity, online media

Scientific field: Psychology
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Komunikacija obuhvata vakcinom: Provera pretpostavki modela sebične naspram modela socijalne racionalnosti

Sažetak

Istraživali smo kako komunikacija obuhvata vakcinom utiče na nameru da se vakcina primi. Poredili smo suprotstavljene pretpostavke proistekle iz dva teorijska modela: sebične racionalnosti i socijalne racionalnosti. Prema modelu sebične racionalnosti, visok obuhvat vakcinom smanjuje motivaciju jer podstiče grebatorstvo (eng. *free-riding*) o kolektivni imunitet, dok model socijalne racionalnosti visok obuhvat vidi kao pozitivnu deskriptivnu normu koja povećava motivaciju. Oba modela predviđaju suprotan efekat u slučaju niskog obuhvata. Analiza sadržaja 160 tekstova sa srpskih portal vesti tokom epidemije malih boginja 2017. godine pokazala je da se obuhvat vakcinom često uokviravao negativno (npr. „samo 50% vakcinisanih"), te da mu je nedostajao kontekst i numerička preciznost, kao i da je kolektivni imunitet retko kada pojašnjen. Takvo izveštavanje u prvi plan stavlja nepoželjne socijalne norme, dok se ne prenosi poruka o široj društvenoj koristi od imunizacije. U svim eksperimentima (N = 1076; Hedžisov g = 0,21), komunikacija visokog obuhvata (80–90%) na nivou države generalno je povećavala nameru da se primi vakcina u poređenju niskim obuhvatom (10–20%) odnosno sa situacijama kada on uopšte nije saopštavan. Ovaj uvid sam po sebi ima ograničenu praktičnu primenu jer vrednosti obuhvata vakcinom moraju biti prikazane onakvima kakve jesu. Stoga smo eksperimentalno testirali kako apeli na individualnu (zaštita sebe), socijalnu (zaštita drugih) i kolektivnu dobit (zaustavljanje bolesti) utiču na nameru da se primi vakcina na različitim nivoima obuhvata. Jedna efikasna intervencija bila je isticanje socijalnih koristi kolektivnog imuniteta putem teksta i animiranog infografika (N = 543; Hedžisov g = 0,23), čime je konceptualno repliciran prethodni nalaz; uključivanje informacija o obuhvatu ili pragu kolektivnog imuniteta nije imalo dodatni efekat. Još jedna uspešna intervencija, ovog puta u uslovima umerenog obuhvata (60%), bila je apelovanje na individualnu dobit (N = 265; Hedžisov g = 0,16). U zasebnom eksperimentu (N = 217), bez obzira na nivo obuhvata, učesnici koji su se odlučivali na vakcinaciju su obično podržavali i razloge zasnovane na ličnom interesu i prosocijalne razloge, dok je nevakcinacija pretežno opravdavana proračunima ličnog rizika i uverenjem da vakcinacija nije potrebna. Grebatorstvo je retko podržavano, a deskriptivne norme su smatrane važnijima za vakcinaciju nego za nevakcinaciju. Otvoreni odgovori su dodatno ukazali na (ne)poverenje u nauku i vakcine kao bitan razlog. Naši rezultati podržavaju pre model socijalne nego model sebične racionalnosti, ali ukazuju i na ograničenja krute primene bilo kog modela. Predlažemo da poruke u javnom zdravlju treba da odražavaju razložnost ili razumnost, shvaćenu kao kontekstualno osetljivo balansiranje individualnih i društvenih aspekata. Razmatrali smo predloge za buduća istraživanja, kao što su komunikacija dinamičkih normi (promena u obuhvatu) i ukrajanje poruka. Produbljivanjem teorijskih pretpostavki, primenom multimetodskog pristupa i davanjem praktičnih preporuka, ovaj rad nam pomaže da bolje razumemo i podržimo odluke o vakcinaciji u složenom, društveno međuzavisnom svetu.

Ključne reči: vakcinacija, odlučivanje o vakcinaciji, racionalnost, socijalne dileme, grebatorstvo, socijalne norme, komunikacija o zdravlju, javno zdravlje, kolektivni imunitet, onlajn mediji

Naučna oblast: Psihologija
Uža naučna oblast: Socijalna psihologija
UDK broj:

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Chapter 1

Introduction

Introduction

"Serious warning: In the first 6 months, only one in four children received the MMR vaccine" (2017)

"More than 60 percent of parents in Stari Grad have not vaccinated their children: The risk of an epidemic grows day by day" (Božić, 2017)

"Every second child in Serbia has not received the vaccine, and it's only a matter of time before we face an EPIDEMIC" (Todorović, 2017)

"A SERIOUS FIGURE: So far, 256,521 citizens vaccinated against the coronavirus in Serbia!" (2021)

"SERBIA CONTINUES TO BREAK RECORDS IN POPULATION IMMUNIZATION: We have surpassed the 'magic' number of 1.6 million vaccinations" (Sikima, 2021)

Vaccination coverage—sometimes used interchangeably with the term *vaccination rate*—is an indicator typically used to report the proportion of a population that received a specific number of doses of a particular vaccine or vaccines (e.g., "60% of children are vaccinated"), while the term *vaccine uptake* is usually defined as the absolute number of people who received a specified vaccine dose or doses (e.g., "256,521 citizens are vaccinated") (MacDonald et al., 2019).

These vaccination indicators seem to be an inevitable part of public health communication, especially during crises such as outbreaks of infectious diseases or pandemics. The quotes at the beginning of this chapter are headlines published by Serbian online news media during the 2017 resurgence of measles and, later, the COVID-19 pandemic, following the start of immunization in 2021. It seems the number of vaccinated individuals is being reported not only for its apparent informational purpose but also because it is supposed to encourage more people to get vaccinated.

From society's perspective, it is indeed desirable that as many people as possible get vaccinated as that slows down the spread of disease; this benefits everyone, especially those who are more vulnerable and cannot get vaccinated (Fine et al., 2011). That said, it is crucial to understand which types of messages communicating vaccination coverage, and under what conditions, are most likely to be conducive to a desired public response.

How does communicating a low or a high country-level vaccination coverage affect an individual's willingness to get vaccinated? Can drawing attention to those who have or to those who have not decided to get vaccinated lead to unintended consequences and even backfire? Two theoretical models—the selfish rationality versus the social rationality hypothesis—offer diverging answers to these questions. The main aim of this research is to compare the two models using a multimethod approach and provide practical recommendations for public communication of vaccination coverage in the media.

Vaccination Coverage Through the Lens of Selfish Rationality

Social Dilemmas

Imagine a person who, driven by their immediate self-interest, chooses not to volunteer (e.g., for a post-disaster cleanup), not to reduce their carbon footprint (e.g., by flying less), not to vote or not to join protests (e.g., against the government). Although, in the long run, this person would ultimately benefit from a cleaner environment or a new government, they conserve their own resources—such as time, money, and comfort—by not contributing to these causes. If more people in a community choose non-cooperation (e.g., not reducing carbon footprint or not joining protests) over cooperation (e.g., reducing carbon footprint or joining protests) today, the whole community will suffer the consequences (e.g., environmental pollution or corrupt politicians staying in power) tomorrow.

Such situations—where individual interests conflict with collective interests or where individually "rational" behaviors lead to collective irrationality (Kollock, 1998)—are known as *social dilemmas*. They can also sometimes be viewed as a choice between a selfish action that prioritizes personal gain and a prosocial action that benefits others (Van Lange et al., 2014).

Strictly speaking, a situation constitutes a social dilemma if (a) each individual gains more by choosing non-cooperation than by choosing cooperation, regardless of how others in the community act; and (b) all individuals would be better off if everyone chooses cooperation rather than if everyone chooses non-cooperation (Dawes, 1980). A temporal dimension should also be kept in mind – while the consequences for individuals are often immediate and short-term, the consequences for the collective unfold over a longer period (Van Lange et al., 2013, 2014).

Historically, research on social dilemmas has been built around the *Prisoner's Dilemma*, the *Public Goods Dilemma*, and the *Commons Dilemma* (Van Lange et al., 2014). The Prisoner's Dilemma involves two persons who are separately given the choice to either cooperate for mutual benefit or betray their partner (defect) for individual gain. For example, a prisoner can either betray their partner in crime or remain silent. While each prisoner stands to benefit individually if they betray the other, if both choose to betray, they will end up worse off than if they had both remained silent. The Public Goods Dilemma shares the same basic structure as the Prisoner's Dilemma but applies to public goods, that is, resources everyone can benefit from even without contributing to them (e.g., public parks, clean air, free software). Finally, the Commons Dilemma describes a situation where individuals sharing a public resource, known as a common, act in their own interest and, in doing so, ultimately deplete or even destroy the resource, to the detriment of all. This can lead to consequences such as overfishing, traffic congestion, and fast fashion.

These three main types of social dilemmas, along with their combinations, are widespread and underlie a range of societal challenges (Van Lange et al., 2014) such as environmental sustainability, education, political participation, organizational behavior, tax compliance, cybersecurity, and disaster preparedness. Moreover, social dilemmas hold the potential for tragedy (see Hardin, 1968), as individuals can be tempted to become *free riders*, benefiting not only from their own non-cooperation (by conserving their own resources) but also from the cooperation of others (by taking advantage of the resources generated by contributors).

Vaccination as a Social Dilemma

Social dilemmas are not just recognized in areas like ecology and politics but also in public health (Henrich & Henrich, 2007). The health decisions of individuals can, both positively and negatively, affect those around them—their family members, friends, neighbors, colleagues. Although this is not always immediately obvious, behaviors such as smoking, overusing antibiotics or avoiding vaccination can affect others as well, through secondhand smoke, antimicrobial resistance and spread of contagious diseases (Krockow et al., 2022; Van Lange et al., 2014). This makes them, at their core, problems of cooperation.

That said, not all vaccinations are social dilemmas. Vaccination is more likely to be considered a social dilemma if it targets diseases that spread from person to person and can prevent or reduce transmission of the pathogen to others. For example, vaccinations against diseases such as measles, polio, COVID-19, and the influenza (flu), may qualify as social dilemmas, while vaccinations against diseases such as tetanus, caused by bacteria, may not.

Herd Immunity

The concept underlying the vaccinations that qualify as social dilemmas is *herd immunity*, sometimes also referred to as *community immunity*, *population immunity* or *collective immunity.* Herd immunity refers to indirect protection occuring when a population is immune, either through vaccination or previous infection (Fine et al., 2011). In other words, vaccinated (immune) individuals serve as a protective barrier against the disease for those who remain unvaccinated. Herd immunity benefits everyone, but especially the vulnerable, who are at a higher risk of severe complications or less likely to be vaccinated due to medical contraindications (such as pregnant women, preterm infants, individuals with immune-compromising conditions, and older adults) (Doherty et al., 2016), including people in socially vulnerable situations (such as those experiencing homelessness, forced displacement, mental health problems or disabilities).

The term herd immunity is also often used in reference to a critical threshold percentage of immune individuals (Fine, et al., 2011). For example, the threshold for measles vaccination coverage is typically set at a minimum of 95% (e.g., Nokes & Anderson, 1988; Institute of Public Health of Serbia, 2018). The *herd immunity threshold* is often thought of as a target that, once attained, will always result in disease elimination (Fine, et al., 2011); this view was, for example, promoted early in the COVID-19 pandemic (Robertson et al., 2024). However, from the public health perspective, this understanding is overly simplistic. It overlooks factors such as non-random interaction between people, varying transmission rates across communities, imperfect vaccine protection, differences in individual infection risk, waning immunity, reinfection, and evolving pathogens (McDermott, 2021; Robertson et al., 2024). Therefore, the herd immunity threshold is better thought of as a proportion of the people in a community (e.g., in Serbia) who need to be immune for the rate of new infections to slow down (McDermott, 2021), ideally maintaining a very low level of transmission.

How Does Vaccination Put Individual and Collective Interests at Odds?

Building on the concept of herd immunity, it is clear that most vaccines provide not only *direct benefits*—reducing the likelihood of infection in vaccinated individuals—but also *indirect benefits*—reducing disease transmission across the entire population (Fine et al., 2011). Thus, from society's perspective, widespread vaccination is desirable because it reduces the probability of disease transmission.

From an individual’s perspective, however, vaccination involves a small risk. In rare cases (ranging from less than 1 in 10,000 to less than 1 in 100), serious vaccine-related reactions requiring medical intervention, such as severe allergic reactions, can occur. In other cases, mild reactions like fever and fatigue, which typically go away on their own, may happen (World Health Organization, 2013). Additionally, vaccination may involve perceived costs, such as time, money, discomfort, needle pain, or the effort required to schedule an appointment (Fine et al., 2011).

Because of this, the ideal, selfish strategy for the individual is for everyone else to be directly protected (vaccinated), allowing them to reap the benefits of indirect protection (Fine et al., 2011). These free riders, in other words, avoid the personal costs of vaccination while relying on others to be vaccinated, thereby reducing their risk of infection through herd immunity alone. However, if too many people refuse vaccination, herd immunity collapses, leaving a larger portion of the population vulnerable to infection. As in other social dilemmas, free riders may gain short-term individual benefits, but if everyone adopts this strategy, the entire population ultimately suffers long-term consequences.

Vaccination can be framed as a *binary-choice game* (Schelling, 1960, 1978) or, more specifically, as a *multi-person prisoner's dilemma* (Betsch et al., 2013; Ibuka et al., 2014), in which the issue is not how much someone contributes but rather how many people make one choice over another. Individuals must choose between contributing (getting vaccinated) or not contributing (refusing vaccination) to the *public good* (herd immunity). Herd immunity exhibits both properties of public goods that, in economic theory, enable free riding. It is *non-rivalrous* (i.e., one person's use of the good does not reduce its availability for others) and *non-excludable* (i.e., once the good is available to one person, it cannot be withheld from others) (Hudson & Jones, 2005).

Vaccination as a Strategic Interaction

Under the assumption of selfish rationality, individual vaccination choices depend on the perceived costs or risks associated with infection vs. vaccination. To fully understand the interplay of these factors, *disease transmissibility* has to be taken into account.

Transmissibility is defined by the *basic reproductive number* ($\boldsymbol{R_0}$), which represents the number of secondary infections generated by a single (typical) case in a fully susceptible population (Horsburgh & Mahon, 2008). In other words, $\boldsymbol{R_0}$ is the number of people an infected individual will transmit the disease to, assuming no prior immunity in the population.

The risk of infection ($\boldsymbol{r_i}$) depends on both the basic reproductive number ($\boldsymbol{R_0}$) and the proportion of vaccinated individuals in the population ($\boldsymbol{p}$) (Bauch & Earn, 2004):

$$r_i = 1 - \frac{1}{R_0(1-p)}$$

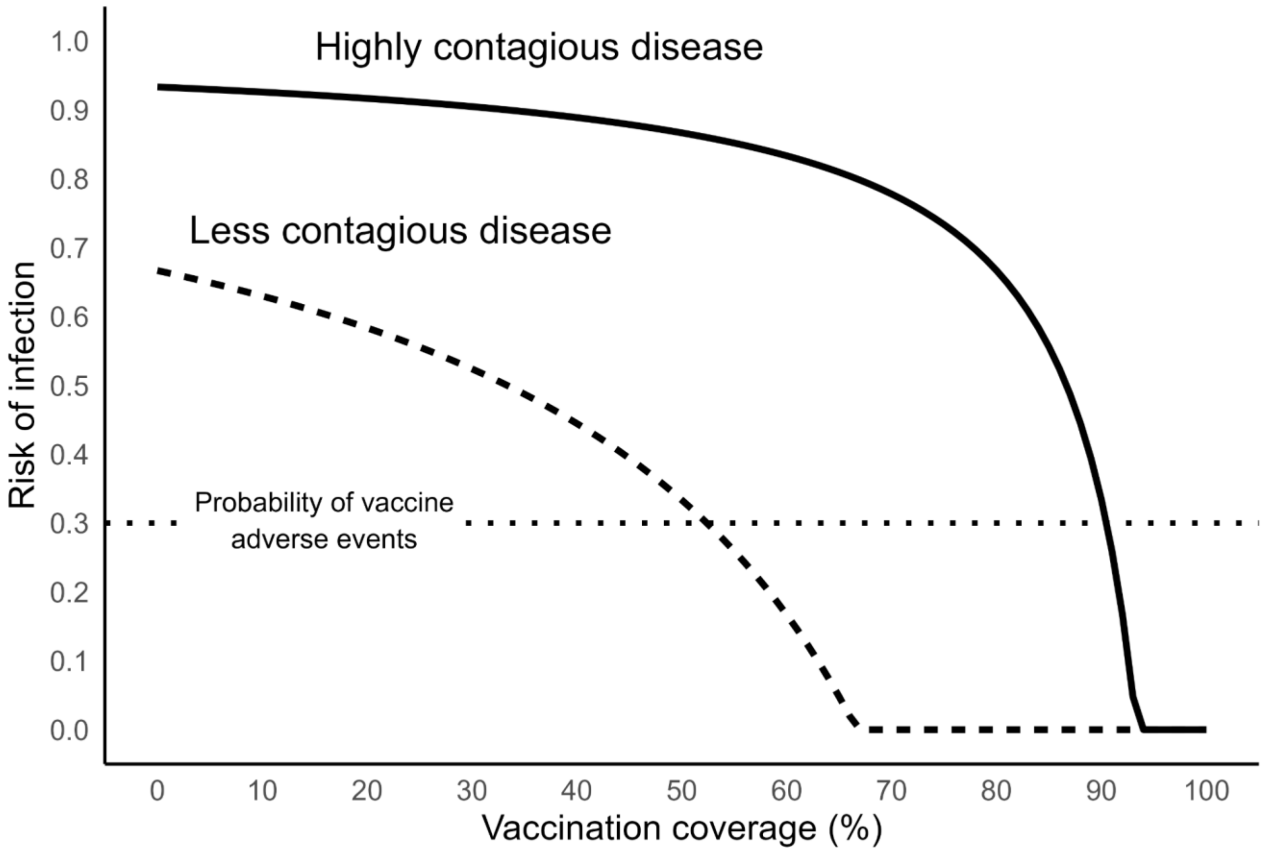
The risk of vaccination ($\boldsymbol{r_v}$), or the risk of vaccine adverse events, naturally varies. For the sake of clarity, we assume $\boldsymbol{r_v = 0.3}$.

An assumption, which has been supported using a theoretical modeling approach (Bauch & Earn, 2004), is that individuals will refuse vaccination if they perceive the risk of vaccination to be greater than the risk of infection, that is, when the relative risk $\boldsymbol{r = r_v / r_i}$ exceeds 1. If the relative risk exceeds the probability of eventual infection when no one is vaccinated ($\boldsymbol{\pi_0}$, which is $\boldsymbol{r_i}$ when $\boldsymbol{p = 0}$) or if the relative risk exceeds the herd immunity threshold, individuals are expected to adopt a pure non-vaccination strategy. We will illustrate this using two hypothetical diseases with differing levels of transmissibility: a less contagious disease with $\boldsymbol{R_0 = 3}$ (typical for influenza) and a more contagious disease with $\boldsymbol{R_0 = 16}$ (typical for measles).

Less Contagious Disease. For a disease with $\boldsymbol{R_0}$ **= 3**, the probability of infection in an unvaccinated population is $\boldsymbol{\pi_0}$ **= 0.667**, with the herd immunity threshold, similarly, being at approximately 67%. Following one calculation method (Betsch et al., 2017), no one will choose to get vaccinated if the perceived risk of infection falls below the perceived risk of vaccination ($\boldsymbol{r_i}$ **< 0.3**); this occurs when vaccine coverage reaches at least 53%. Following another calculation method (Bauch & Earn, 2004), no one will choose to get vaccinated if the relative risk exceeds the probability of infection in an unvaccinated population ($\boldsymbol{r}$ **> 0.667**); this occurs when vaccine coverage reaches at least 40%. Therefore, while achieving at least 67% vaccination coverage is optimal, a rational player will find vaccination less and free riding more appealing once coverage reaches 40–53% (Figure 2).

Figure 1

Risk of Infection as a Function of Vaccination Coverage and Disease Contagiousness



Highly Contagious Disease. For a disease with $\boldsymbol{R_0}$ **= 16**, the probability of infection in an unvaccinated population is $\boldsymbol{\pi_0}$ **= 0.938**, with the herd immunity threshold, similarly, being at approximately 94%. Following one calculation method (Betsch et al., 2017), no one will choose to get vaccinated if the perceived risk of infection falls below the perceived risk of vaccination ($\boldsymbol{r_i}$ **< 0.3**); this occurs when vaccine coverage reaches at least 92%. Following another calculation method (Bauch & Earn, 2004), no one will choose to get vaccinated if the relative risk exceeds the probability of infection in an unvaccinated population ($\boldsymbol{r}$ **> 0.938**); this occurs when vaccine coverage reaches at least 91%. Therefore, while achieving at least 94% vaccination coverage is optimal, a rational player will find vaccination less and free riding more appealing once coverage reaches 91–92% (Figure 2).

Empirical Evidence of Free Riding in Vaccination Decision-Making

Interactive Games

Interactive games are able to effectively model a vaccination decision as a weighing of the expected benefits of vaccination (determined by the cost, such as time and money, and potential vaccine adverse events) and expected benefits of non-vaccination (determined by the risk of infection), allowing the players to assess both the direct and indirect effects of vaccination. These games are typically played in a laboratory setting, via computers. The game can be played only once (one-shot) or repeatedly. Players receive a predetermined number of "fitness points" and information about the infectious disease. After deciding whether to get vaccinated, players receive feedback. In the I-Vax game (Böhm et al., 2016), for example, the feedback included their own vaccination choice, the percentage of players who chose to vaccinate, the resulting probability of infection, any points they lost due to vaccine adverse events or infection, and the points they earned in the previous round. The game is incentivized, meaning players receive monetary rewards based on the number of fitness points they retain by the end of the game.

Studies using interactive games have found that as more players choose to vaccinate in a given round, individuals become less likely to opt for vaccination in the next round, in support of the free-riding motivation. One study (Ibuka et al., 2014) observed this trend regardless of flu severity, the player's assigned role (young or elderly), or the cost of vaccination (low or high).

Other studies have identified the *Nash equilibrium*—the point at which no one (vaccinated or unvaccinated) has an incentive to change their decision—as an important factor in individual vaccination decision-making. When the percentage of vaccinated players in a given round exceeded the Nash equilibrium threshold (e.g., over 58% in Böhm et al., 2016), making vaccination more costly than non-vaccination, fewer players decided to get vaccinated in the subsequent round (Böhm et al., 2016; Böhm et al., 2017). Conversely, when the vaccination coverage fell below this threshold, more players decided to get vaccinated in the subsequent round (Böhm et al., 2016; Böhm et al., 2017).

In another experiment, players were also presented with the vaccination coverage in a fictitious refugee population (Korn et al., 2017). Vaccination uptake in the host population decreased both as more players in their own group had been vaccinated in previous rounds and as vaccine coverage increased within the refugee population. Furthermore, players were less likely to choose vaccination when they received information about low, moderate, or high vaccination rates among refugees, compared to when they received no such information.

Vignettes

Studies framing vaccination as a social dilemma have also relied on vignettes. In vignettes, participants are typically presented with a detailed description of a real or hypothetical infectious disease, along with associated costs and risks, and then privately indicate the extent to which they would be willing to get vaccinated.

When participants read about human papillomavirus (HPV) and flu vaccines, self-reported willingness to vaccinate decreased as a larger percentage of the population was immune to the virus (Vietri et al., 2011). The authors provided percentages of naturally immune individuals rather than those who acquired immunity through vaccination, ensuring that the effect was not driven by conformity to others' decisions. In scenarios where individual probability of infection was held constant, the proportion of non-immune individuals—those who would benefit from the participant getting vaccinated—had no influence on the decision to vaccinate. Based on this, the authors concluded that the observed effect could not be explained by concern for others but rather by free-riding tendencies.

In one cross-cultural study (Betsch et al., 2017), participants' intention to vaccinate against a highly contagious fictitious disease (R_0 = **15**) did not depend on vaccine coverage in society. However, in the case of a less contagious disease (R_0 = **3**), participants were less inclined to vaccinate when they were informed that vaccine coverage was high (62%), compared to when they were informed that it was low (48%). While the empirical evidence reviewed here points to the existence of free riding on herd immunity, some studies have also shown that it can be mitigated through appeals to altruism and social benefit.

Altruistic Motivation and Herd Immunity Awareness as Counterpoints to Free Riding

Altruistic Vaccination

Evidence suggests that some individuals choose to get vaccinated, at least in part, to protect others from infection, indicating that vaccination decisions are influenced not only by selfish interests but also by prosocial or altruistic considerations. For example, Vietri et al. (2011) found that participants were willing to get vaccinated even when it conferred no personal benefit (i.e., when their risk of infection was consistently zero). Under these conditions, their vaccination willingness increased as the number of unvaccinated individuals who could be protected grew. On the other hand, when their personal risk of infection was set at a consistently high level (100%), vaccination willingness was predictably high, irrespective of the proportion of unvaccinated individuals. In another study, individuals with a prosocial value orientation, who strive to maximize equality between outcomes for themselves and others, and/or social welfare, were somewhat more willing to get vaccinated than those with a proself value orientation, who prioritize maximizing their own benefit (Böhm et al., 2016).

Chapman et al. (2012) designed a game in which "young" players contributed more to herd immunity compared to "elderly" players. Additionally, the vaccine was less effective and flu symptoms were more severe for elderly players. When payout incentives were based on individual point totals, player behavior aligned with the Nash equilibrium—more older than younger players opted for vaccination. However, incentives were based on the group point totals, player behavior aligned with the *utilitarian equilibrium*—more younger than older players opted for vaccination, maximizing the overall net payoff for the group. The authors concluded that, under certain conditions, some individuals may be willing to incur personal costs to protect others in their group.

The Awareness of Herd Immunity Benefits

Some studies suggest that explaining the benefits of herd immunity can be useful for promoting vaccination; however, the effectiveness of such messaging may depend on whether it emphasizes individual or social benefits. Betsch et al. (2013) manipulated the salience of either individual benefits by emphasizing the opportunity to free ride ("The more people are vaccinated in your environment, the more likely you are protected without vaccination") or social benefits by emphasizing the opportunity to protect others ("If you get vaccinated, then you can protect others who are not vaccinated"). Highlighting individual benefits reduced vaccination intentions, whereas highlighting social benefits had a weak positive effect, but only when the vaccine was easily accessible (i.e., available immediately without requiring an appointment at a local hospital).

Betsch et al. (2017) found that herd immunity communication should be tailored to vaccination coverage levels. When coverage was low, emphasizing individual benefits increased vaccination intentions, whereas when coverage was high, emphasizing social benefits increased vaccination intentions. However, these effects were observed only with text-based explanations; when an interactive simulation format was used, the effectiveness of herd immunity communication was independent of both coverage levels and message content.

Vaccination Coverage Through the Lens of Social Rationality

A contrasting perspective on the importance of vaccination coverage information is based on the concept of social norms. It assumes that human decision-making is driven not by selfish rationality but by social rationality. In this view, high vaccination coverage does not promote free riding; rather, it acts as a normative influence encouraging individuals to get vaccinated. We have chosen Cialdini and colleagues' (1990) Focus Theory of Normative Conduct as the theoretical framework of this point of view.

The Focus Theory of Normative Conduct

Social norms can be defined as "rules or standards that are understood by members of a group, and that guide and/or constrain social behavior without the force of laws" (Cialdini & Trost, 1998, p. 152). According to Cialdini and colleagues, researchers can assess the extent to which social norms influence behavior only when they first distinguish between two types of social norms—*descriptive* and *injunctive*—and then direct participants' attention to one of them (Cialdini et al., 1990, 1991).

Descriptive norms specify *what people actually do*, whereas injunctive norms specify *what people ought to do*; descriptive norms describe the state of affairs as it is, while injunctive norms prescribe the state of affairs as it should be. The two types of norms differ not only conceptually but also in how they motivate behavior (Cialdini et al., 1990, 1991; see also Jacobson et al., 2011). A descriptive norm characterizes the perception of what behaviors are common (or uncommon) or what behavior most people exhibit (or do not exhibit). It serves as a kind of decision-making shortcut, providing information about what would likely be an effective and adaptive course of action in a given context: "If everyone is doing it, how bad can it be? / It must be a smart choice." An injunctive norm, on the other hand, characterizes the perception of what behaviors are commonly approved (or disapproved of) or what behaviors are morally acceptable (or unacceptable). While the influence of descriptive norms is based on *social information*, the influence of injunctive norms is based on *social sanctioning*: "If I do what everyone approves of, I will gain their favor / avoid their disapproval."

The distinction between descriptive and injunctive norms parallels Deutsch and Gerard's (1955) classic differentiation between *informational social influence* to accept information from others as factual and *normative social influence* to conform to the positive expectations of others. A similar distinction can be found in Bicchieri and colleagues' work (e.g., Bicchieri & Xiao, 2009), which differentiates between *empirical expectations* (i.e., the belief that most people will follow the norm) and *normative expectations* (i.e., the belief that others think one ought to conform to the norm).

According to Cialdini and colleagues (1990, 1991), it is essential to distinguish between descriptive and injunctive norms, as both can coexist in the same situation and can have either congruent or contradictory influence on behavior. Furthermore, it is important to recognize that norms do not always exert influence, nor do they do so in all situations. "Norms should motivate behavior primarily when they are activated (i.e, made salient or otherwise focused on)" (Cialdini et al., 1990, p. 1015). The more salient a norm is at a given moment, the stronger its influence on behavior. This salience can be shaped by both situational factors (e.g., message framing) and dispositional factors (e.g., strong personal commitment to a particular norm)

(Cialdini et al., 1990, 1991). The authors further conclude that when descriptive and injunctive norms are in clear conflict, directing individuals' attention either to what most people do or to what most people approve of will lead to behavioral change in line with the norm that has been made more salient through the intervention.

As it presents summary information about the behavior of a reference group, vaccination coverage may be the most straightforward way of shaping the perceived descriptive norm around vaccination (Tankard & Paluck, 2016), provided that vaccination is perceived as predominantly voluntary and not driven by mandates or coercion. Accordingly, the remainder of this section will primarily focus on theory and research related to descriptive social norms.

Early Empirical Evidence for the Focus Theory of Normative Conduct

Early research by Cialdini and colleagues (e.g., Cialdini et al., 1990, 1991; Kallgren et al., 2000; Reno et al., 1993) reinforced the core propositions of the Focus Theory of Normative Conduct by applying it to the study of littering behavior in public spaces. We will illustrate this line of research by focusing on the studies in Cialdini et al. (1990) that examined how directing attention to descriptive norms influenced littering.

In these studies, the state of the environment was manipulated (either clean or increasingly littered) to influence the perceived descriptive norm regarding littering. Additionally, participants either observed a confederate littering or simply walking past them without littering. This was designed to affect the extent to which the descriptive norm was salient in participants' attention. The key finding was that emphasizing different descriptive norms can reinforce compliance with widely accepted injunctive norms against littering, but that it can just as easily undermine that compliance. As the authors emphasize, this finding should not be interpreted as evidence that descriptive norms are more influential than injunctive norms. Rather, it underscores the importance of normative focus. As expected, littering was rare in a clean environment, whereas the likelihood of participants littering increased as the amount of existing litter grew. However, when a single piece of litter was present in an otherwise clean environment, participants littered even less frequently than when the environment was completely clean. In this case, their attention was drawn to the surrounding environment, where the descriptive norm was clearly against littering. In other words, the presence of one conspicuous piece of litter made it evident that most people had refrained from littering, apart from a single "environmentally unaware" outlier.

The Boomerang Effect of Descriptive Social Norms

Descriptive norms have been shown to produce a boomerang or backfire effect, demonstrating that a well-intended normative message can actually serve to weaken or even reverse desirable behavior. One example of this are calls to action that emphasize the high prevalence of undesirable behaviors (Cialdini et al., 1990; Cialdini, 2003; Cialdini et al., 2006). For example, a message such as "Only 3 out of 100 people in Serbia donate blood" conveys a powerful but counterproductive normative message: "Many people are not donating blood". So, even when the message is factually correct and well-intended, it could implicitly communicate a message such as "Look at all these people engaging in this undesirable behavior". In situations where undesirable behavior is widespread, Cialdini and colleagues suggest that it is preferable to rely on injunctive norms (as tested, for example, in a national park where fossilized wood theft was a serious issue; Cialdini et al., 2006).

The effect of a descriptive normative message may also depend on the distribution of the targeted behavior in the population. In the study by Schultz et al. (2007), households received descriptive feedback on their energy use compared to their neighbors. While this feedback reduced energy consumption among the households that consumed more energy than the norm, it caused a boomerang effect among low-consuming households, leading them to increase their energy use. The researchers were able to mitigate this unintended effect by pairing the descriptive norm with an injunctive message of social approval for using less energy.

Communicating descriptive norms may also trigger reactance. Howe and colleagues (2021) have proposed that normative appeals such as "The group does X, and you should too" can imply two contrasting stances of the group toward the person. One suggests pressure to conform, potentially triggering reactance and backfiring; the other frames the norm as an invitation to work together for the common good, fostering a sense of shared purpose and intrinsic motivation. The authors demonstrated that descriptive normative appeals for charitable giving and pro-environmental behavior were more effective when they invited people to "join in" and "do it together", reducing reactance (Howe et al., 2021).

Five Misconceptions About Social Norms

Research on social norms has a long history, and over time, several widely accepted "truths" have emerged—many of which have since been debunked using field experiments. Here, I outline five such misconceptions (for a detailed discussion and sources, see Schultz et al., 2008). If there is one key point to take away, it is that social norms are about more than just conformity or the presence of others.

1. *Normative beliefs only result from social interaction.* Normative feedback can also be delivered through various passive media: banners, billboards, and other signs indicating how frequently people engage in certain behaviors; piles of litter or well-trodden paths in nature; view counts on YouTube videos.

2. *Normative beliefs influence behavior only when they come from a close reference group.* Some studies have shown that a generic reference group (e.g., the general public) can exert significant social pressure.

3. *Normative beliefs influence behavior only in novel or ambiguous situations*. Research has clearly demonstrated the effect of normative influence in situations that are familiar to the person and where the behavioral guidance is clear (e.g., in people's homes, in frequently visited parking lots, on their university campuses).

4. *Normative beliefs only influence publicly displayed behavior*. Some studies have shown descriptive norms create lasting effects on private behavior.

5. *People are aware when they are influenced by normative information*. People typically underestimate normative social influence and do not believe that their behavior is shaped by the actual or perceived behavior of others.

Empirical Evidence on the Influence of Descriptive Social Norms on Vaccination

Research on descriptive and injunctive social norms has expanded across various domains, with growing interest in this field over the past two decades (Rhodes et al., 2020). A meta-analysis found that over half of the studies on social norm appeals published between 1990 and 2018 focused on health-related behaviors, particularly alcohol consumption. The remaining studies largely addressed environmental issues (e.g., energy conservation), socio-cultural topics (e.g., bullying, racism), and economic behaviors (e.g., tax compliance) (Rhodes et al., 2020). In the health domain specifically, injunctive norms were found to have a significantly stronger effect on behavior than descriptive norms (Rhodes et al., 2020).

Studies have pointed to the influence of descriptive norms on vaccination decisions, though not always directly. Many *correlational studies* have linked norms to vaccination (for a review, see Brewer et al., 2018). For example, college students who perceived that their peers were getting vaccinated were themselves more likely to opt for the human papillomavirus (HPV), COVID-19, measles-mumps-rubella (MMR) or flu vaccine (Allen et al., 2009, Graupensperger et al., 2021; Hamilton-West, 2006; Rao et al., 2007).

Other studies have explored how *social networks* shape vaccination decisions. For example, the vaccination choices of close others, such as friends, neighbors, and family members, have been found to impact individual decisions (Itaya et al., 2018; Sato & Takasaki, 2019), including those related to COVID-19 (Hao & Shao, 2022). Additionally, in US regions with below-average vaccination rates, parents who did not conform to the recommended vaccination schedule were more likely to have social networks with a higher proportion of other nonconformers (Brunson, 2013). While these associations may result from social influence, they could also arise from homophilic selection (e.g., people choosing friends who share similar preexisting attitudes toward vaccination). Additionally, contextual factors may play a role, with individuals adapting their behavior to common environmental influences (Christakis & Fowler, 2007; Cohen-Cole & Fletcher, 2008). For example, local policies, regional health infrastructure, and the availability of vaccination services may shape both attitudes and opportunities in similar ways within a given social network, making it difficult to disentangle social influence from these shared contextual factors.

Computational modeling, particularly evolutionary models that integrate game theory and epidemic dynamics, can help address these limitations of social network analysis. Studies using such models support the idea that descriptive norms influence vaccination decisions (Bodine-Baron et al., 2013; Fu et al., 2010; Ichinose & Kurisaku, 2017). However, some warn that social influence encourages vaccination only when its cost remains low; once it exceeds a critical threshold, it may instead discourage uptake (Ichinose & Kurisaku, 2017; Wu & Zhang, 2013).

Experimentally Manipulating Community Vaccination Coverage

Experimental studies can also be used to distinguish social influence from selection and environmental effects by examining how hypothetical changes in community vaccination coverage impact individuals' vaccination preferences. In an early study of this kind, Hershey et al. (1994) presented college students with hypothetical scenarios that varied in three factors: the percentage of other students who were vaccinated (36%, 62%, or 88%); message framing (emphasizing the opportunity for altruism—"If you receive the vaccine you cannot give the disease to others"—or for free riding—"You cannot catch the disease from people who have received the vaccine"); and vaccine type (whether or not it prevented disease transmission to others). In all 12 experimental conditions, students' self-reported vaccination willingness increased as the percentage of vaccinated peers rose. This effect was strongest when the vaccine did not prevent disease transmission, removing both the opportunity to protect others and to free ride. While the free-riding frame decreased willingness to vaccinate, the altruistic frame had no significant effect. The authors concluded that some students made vaccination decisions by "jumping on the bandwagon".

To our knowledge, the next study to apply a similar experimental design was conducted by Romley et al. (2016). At the time of data collection, the largest recorded Ebola outbreak in history was unfolding in West Africa. Participants were presented with a hypothetical scenario in which community vaccination coverage was either low (10%) or high (90%) (e.g., "Nine out of ten (90% of) people in your community are using the vaccine"). They then indicated their willingness to receive a hypothetical Ebola vaccine, which was available at different price points ($25, $100, or $250) (e.g., "Would you pay the $100 of your own money to take the vaccine?" with response options "Yes", "No", "Don't know / refuse"). A high community vaccination rate increased willingness to vaccinate, with 48.0% of participants accepting the vaccine compared to 42.1% in the low-coverage condition. The impact of increasing vaccination coverage from 10% to 90% was comparable to reducing the vaccine price by nearly 50%. However, the effect varied based on participants' levels of concern. Among those worried about the outbreak, 60% accepted the vaccine regardless of community vaccination coverage. Among those less concerned, vaccine acceptance rose from 35.3% to 43.3% when community vaccination coverage was high.

This effect of descriptive social norms was observed in subsequent studies (e.g., Belle & Cantarelli, 2021; Palm et al., 2021; Ryoo & Kim, 2021), though not consistently (e.g., Clayton et al., 2021; Sinclair & Agerström, 2021; Xiao & Borah, 2020). However, simply presenting factual vaccination coverage information may be sufficient. In a study by Moehring et al. (2023), providing accurate information about descriptive norms increased individuals' intentions to accept COVID-19 vaccines by partially correcting their underestimation of how many others would do the same.

Rather than focusing solely on current vaccination coverage, descriptive norms can also highlight changes in coverage over time, shaping perceptions of so-called *dynamic norms* (Sparkman & Walton, 2017) or *trending norms* (Mortensen et al., 2019). A large US study on flu vaccine uptake found a small positive effect of a dynamic norm message ("More Americans are getting the flu shot than ever") (Milkman et al., 2022).

Rationale

Both the selfish-rational and the social-rational model assume that the vaccination coverage within a person's group or community influence their vaccination decisions. However, the two models predict opposing directions of this effect (Table 1), with both receiving support from prior research (e.g., Betsch et al., 2017; Böhm et al., 2016; Hershey et al., 1994; Romley et al., 2016).

According to the selfish-rational model, individuals are less likely to get vaccinated when vaccination coverage is high and more likely to get vaccinated when coverage is low. The rationale is that a high number of vaccinated individuals decreases the risk of infection through herd immunity, which provides an incentive for individuals to be free-riders who benefit from the vaccination of others while avoiding certain personal costs, such as money, time, inconvenience or vaccine adverse events (e.g., Bauch & Earn, 2004). Individuals are, therefore, motivated by reasons related to the maximization of personal benefit and the minimization of cost.

Conversely, according to the social-rational model, individuals are more likely to get vaccinated when vaccination coverage is high and less likely to get vaccinated when coverage is low. This is because the vaccination coverage information exerts a descriptive normative influence. By drawing attention to what most others are doing, it provides individuals with cues about the right course of action in the given circumstances, offering a sort of decisional shortcut (e.g., Cialdini et al., 1990). Individuals are, therefore, motivated by reasons related to the desire for accuracy and efficiency.

Table 1

Competing Hypotheses of the Models Under Low and High Vaccination Coverage

	Low vaccination coverage	High vaccination coverage
Selfish-rational decision-making	Vaccination willingness increases	Vaccination willingness decreases
Social-rational decision-making	Vaccination willingness decreases	Vaccination willingness increases

The selfish-rational model assumes that individuals are *purely self-interested*—and therefore prioritize the vaccination outcome that is most advantageous for themselves—as well as *purely rational*—and therefore calculate the relative risks of infection and vaccination based on disease contagiousness and vaccination coverage. On the other hand, viewing vaccination coverage as a source of normative influence assumes that individuals are *socially rational*. Since vaccination decisions are inherently interactive and adapt to the social environment, a choice that may seem irrational in isolation can become rational in interaction with others. As a result, individual vaccination willingness is influenced not only by perceived risks of infection and vaccination but also by the behaviors of others. The distinction between the selfish-rational and the social-rational model used in this research reflects not only the contrast between *economic rationality* and *social rationality*, where the latter is understood as a part of the broader concept of *ecological rationality* (e.g., Gigerenzer & Gaissmaier, 2011; Hertwig & Herzog, 2009), but also the longer-standing distinction between *homo economicus* and *homo sociologicus* (e.g., Elster, 1989).

The two models are not only theoretically relevant for understanding how people make complex decisions, such as those about vaccination, but they also have practical implications for designing public health communication. For example, should vaccination promotion campaigns, such as those delivered online or on social media, emphasize low or high vaccination coverage? According to the selfish-rational model, communicating a high vaccination coverage can be detrimental as it tempts people to free ride on herd immunity and refuse vaccination. However, focusing on low vaccination rates might activate a powerful descriptive norm—"many people are not getting vaccinated"—unintendedly promoting non-vaccination as the right thing to do. The social-rational model would, therefore, recommend that public messaging should highlight a high vaccination coverage.

Overall Aim

This research aims to deepen the understanding of how vaccination coverage communication impacts individual vaccination willingness by testing the competing hypotheses stemming from the selfish-rational and the social-rational model. Since real-world public communication rarely presents vaccination coverage in isolation, some studies will be designed for greater external validity by, for example, incorporating explanations of herd immunity and its social or individual benefits. Combined with an analysis of how vaccination coverage is portrayed in online news media and which of the two models better aligns with the reasons people use to justify their vaccination decisions under varying vaccination coverages, this approach will help identify interventions to mitigate potential backfire effects and offer practical recommendations for effectively communicating vaccination coverage in the media. This will be achieved through a multimethod approach, combining a content analysis of online news stories with online survey experiments, using self-reported measures such as vaccination intention for a hypothetical disease and the extent to which a reason justifies one's vaccination choice. The main research questions, studies, and corresponding publications that have stemmed from this research are outlined below as well as in Table 2 at the end of this chapter.

Research Questions and Dissertation Outline

The research questions addressed in each study within this dissertation—along with references to additional open research materials, open science practices, and conference presentations—are outlined below. The journals in which these studies are published have been categorized by the Serbian Ministry of Education, Science, and Technological Development as M21a, M21, and M22.

Paper 1 | M21

Lazić, A., & Žeželj, I. (2024). Negativity in online news coverage of vaccination rates in Serbia: A content analysis. *Psychology & Health*, *39*(7), 895–913. https://doi.org/10.1080/08870446.2022.2121962 (Published online 2022)

A copy of the first page and the page containing the Acknowledgments, confirming that this work forms part of Aleksandra Lazić's doctoral dissertation, is provided in Appendix A.

Research Questions

The aim of this study was to examine how online news media communicate and frame vaccination coverage and herd immunity. The research questions that were explored were:

1. How frequently and how prominently is vaccination coverage mentioned?
2. Who or what is cited as the source of vaccination coverage information?
3. What (re)vaccinations do the coverages refer to?
4. What reference groups do vaccination coverages pertain to?
5. Are vaccination coverages presented numerically or only verbally?
6. Are they communicated as static or dynamic descriptive norms?
7. Are they framed as the proportion of vaccinated or unvaccinated individuals?
8. Are numerical vaccination coverages framed positively, negatively, or neutrally?
9. How frequently is the term herd immunity mentioned and explained?
10. How frequently is the herd-immunity threshold mentioned?

Open Science Practices

The data that support the findings of this study—including the coding scheme, sampled news stories, datasets, and the inter-coder reliability report—are openly available at: https://doi.org/10.17605/OSF.IO/5BKZ8.

The postprint of this paper is available at: https://reff.f.bg.ac.rs/handle/123456789/4330.

Conference Presentations That Have Stemmed From This Paper

Lazić, A., & Žeželj, I. (2021, August). *News media framing of vaccination uptake and herd immunity: A content analysis*. Talk presented at the 35th Annual Conference of the European Health Psychology Society (Virtual). https://hdl.handle.net/21.15107/rcub_reff_4331 (Slides: https://doi.org/10.17605/OSF.IO/N27FK)

Paper 2 | M21a

Lazić, A., Kalinova, K. N., Packer, J., Pae, R., Petrović, M. B., Popović, D., Sievert, D. E. C., & Stafford-Johnson, N. (2021). Social nudges for vaccination: How communicating herd behaviour influences vaccination intentions. *British Journal of Health Psychology*, *26*(4), 1219–1237. https://doi.org/10.1111/bjhp.12556 (Published Open-Access)

A copy of the first page and the page containing the Acknowledgments, confirming that this work forms part of Aleksandra Lazić's doctoral dissertation, is provided in Appendix A.

Research Questions

The main aim of this study was to attempt to conceptually replicate the finding that explaining herd immunity increases vaccination intentions (Betsch et al., 2017). Additionally, it explored the influence of communicating vaccination coverage and the critical herd-immunity threshold. The research questions that were explored were:

1. How does communicating the social benefit of herd immunity (i.e., protecting others' health) via an animated infographic affect vaccination intentions?
2. How does presenting the country-level vaccination coverage (absent vs. low [20%] vs. high [80%]) along with herd immunity affect vaccination intentions?
3. How does disclosing the vaccination coverage required to reach the herd-immunity threshold (90%) along with herd immunity affect vaccination intentions?

Open Science Practices

The data that support the findings of this study—including survey and experimental materials, the dataset, and R code to reproduce the analyses—are openly available at: https://doi.org/10.17605/OSF.IO/ZB7S3.

The Registered Report Protocol is available at: https://doi.org/10.17605/OSF.IO/JPKU3.

Paper 3 | M22

Lazić, A., & Žeželj, I. (2025). Should public communication of vaccination rates assume rationality, normativity or reasonableness? Insights from three preregistered experiments. *Psychological Reports*. Online first. https://doi.org/10.1177/00332941251340326 (Published Open-Access)

A copy of the first page and the page containing the Acknowledgments, confirming that this work forms part of Aleksandra Lazić's doctoral dissertation, is provided in Appendix A.

Experiment 1 Research Questions

Experiment 1 was preceded by a pretest of the perceived severity of a list of symptoms and a pilot experiment. The research question that was explored was:

1. How does presenting the country-level vaccination coverage (absent vs. low [10%] vs. high [90%]) affect vaccination intentions?

Experiment 2 Research Questions

Experiment 2 aimed to explore the reasons people endorse for getting or not getting vaccinated under a low and high vaccination coverage. The research questions that were explored were:

1. How frequently do people justify their decisions to (not) get vaccinated based on reasons involving (a) relying on others (i.e., free riding); (b) calculation (i.e., weighing personal benefits against risks of vaccination); (c) descriptive norms; (d) wisdom of others (as another proxy for descriptive norms); (e) individual benefit (i.e., protecting one's health); (f) social benefit (i.e., protecting others' health); and (g) collective benefit (i.e., believing vaccination is a collective effort to stop the disease)?
2. Does the endorsement of these reasons for (not) getting vaccinated vary depending on the country-level vaccination coverage (low [20%] vs. high [80%])?

Experiment 3 Research Questions

Experiment 3 aimed to test the effectiveness of different messages when the majority in the country have been vaccinated but the coverage is still not enough to reach the herd-immunity threshold (i.e., when the descriptive norm is positive but weak). The research questions that were explored were:

1. How does presenting the country-level vaccination coverage of 60% affect vaccination intentions?
2. How does communicating the individual benefit appeal (i.e., protecting one's health) alongside the 60% vaccination coverage affect vaccination intentions?
3. How does communicating the social benefit appeal (i.e., protecting others' health) alongside the 60% vaccination coverage affect vaccination intentions?
4. How does communicating the join-in appeal (i.e., joining others in helping stop the spread of the disease) alongside the 60% vaccination coverage affect vaccination intentions?
5. Is communicating the join-in appeal alongside the 60% vaccination coverage more beneficial than presenting the vaccination coverage alone?

Open Science Practices

Experiment 1 was preregistered at https://aspredicted.org/cfv2-kg7w.pdf.
Experiment 2 was preregistered at https://aspredicted.org/46p2-crq5.pdf.
Experiment 3 was preregistered at https://aspredicted.org/hw45-f8yg.pdf.

The data that support the findings of experiments 1–3—including survey and experimental materials, the dataset, R code to reproduce the analyses, symptom severity pretest procedures and results, and pilot experiment methods and results—are openly available at: https://doi.org/10.17605/OSF.IO/2WY9Q.

Conference Presentations That Have Stemmed From This Paper

Lazić, A. (2018, April). *New avenues for vaccine advocacy: A social dilemma perspective*. Talk presented at the 6th International Conference of the Group for Social Engagement Studies, Institute for Philosophy and Social Theory, University in Belgrade, Belgrade, Serbia.

Lazić, A., & Žeželj, I. (2023, September). *Why did you do it? Reasons for vaccination and non-vaccination among young adults in Serbia*. Poster presented at the 37th Annual Conference of the European Health Psychology Society, Bremen, Germany. https://reff.f.bg.ac.rs/handle/123456789/4879
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(Poster: https://doi.org/10.17605/OSF.IO/TKPW9)

Table 2

Studies Outline

Content analysis	**Paper 1**			
Sample	160 stories from 9 Serbian news websites, published July–December 2017, with 339 mentions of vaccination coverage			
Online experiments	**Paper 3 Pilot + Experiment 1**	**Paper 2**	**Paper 3 Experiment 2**	**Paper 3 Experiment 3**
Factor 1 (levels): Manipulation	Vaccination coverage (10%, 90%, absent): Within-subject	Vaccination coverage (20%, 80%, absent): Between-subjects	Vaccination coverage (20%, 80%): Between-subjects	Vaccination coverage (60%, absent): Within-subject
Factor 2 (levels): Manipulation		Herd-immunity explanation (present, absent): Between-subjects		Appeal (individual benefit, social benefit, join-in, absent): Between-subjects
Factor 3 (levels): Manipulation		Herd-immunity threshold (present, absent): Between-subjects		
Main outcome	Vaccination intention	Vaccination intention	Endorsing reasons for (not) getting vaccinated	Vaccination intention
Sample	N = 75 + N = 174 General population of adults residing in Serbia	N = 543 Adults aged 18–64 residing in the United Kingdom	N = 217 Adults aged 18–35 residing in Serbia	N = 1,060 General population of adults residing in Serbia

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Chapter 2

Paper 1 | Negativity in Online News Coverage of Vaccination Rates in Serbia: A Content Analysis

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Negativity in Online News Coverage of Vaccination Rates in Serbia: A Content Analysis

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Abstract

Objective. This content analysis study explored how online news media communicates and frames vaccination rates and herd immunity (the effect where enough people are immune, the virus is contained).

Methods. We analyzed 160 vaccination-related news stories by nine highest-trafficked news websites in Serbia, published July–December 2017, around the start of the measles outbreak. We coded both the news story as a whole and every vaccination-rate mention (N = 339).

Results. News stories framed current vaccination rates and changes in them in a predominantly negative way (175/241 and 67/98 mentions, respectively) (e.g., "only 50% vaccinated", "fewer parents vaccinating their children"), especially when referring to the measles vaccine (202/262 mentions). A total of 23/86 of news stories mentioning vaccination rates did not provide any numerical values. Reference groups for vaccination rates were rarely specified. Out of the 32 news stories mentioning herd immunity, 11 explained the effect.

Conclusions. Even routine communication of vaccination rates can be biased through negative frames and imprecise descriptions. Lamenting low immunization rates could activate a negative descriptive social norm ("many people are not getting vaccinated"), which may be especially ill-advised in the absence of an explanation of the social benefit of achieving herd immunity through vaccination.

Keywords: descriptive norms, framing, health communication, immunization, mass media, vaccine

Negativity in Online News Coverage of Vaccination Rates in Serbia: A Content Analysis

Introduction

There is ample evidence that mass communication brings about societal and individual changes regarding vaccination. Communities with anti-vaccine campaigns in the local media had lower vaccine uptake (Gangarosa et al., 1998; Mason & Donnelly, 2000). Changes in the extent of media coverage coincided with changes in vaccination behavior (Ma et al., 2006) and the public's level of vaccine knowledge (Kelly et al., 2009). Furthermore, mass media are often the main source of health- and vaccine-related information. Vaccine hesitant parents often reported relying on the media as their main source of information or being affected by the media reports (Dannetun et al., 2005; Evans et al., 2001; Guillaume & Bath, 2004). In a 2017 nationally representative survey of Serbian parents, 44% reported relying on websites, forums, or blogs for vaccine information (UNICEF Serbia, 2018).

The present study focused on understanding the types of messages conveyed through online news media – specifically those related to vaccination rates and herd immunity. Vaccination rate refers to the share of those vaccinated in a population; if a large enough share of the population is immune, the virus is contained. This effect is called herd immunity (Fine et al., 2011). We hypothesized that even the seemingly straightforward reporting of vaccination rates is often biased by the introduction of negativity and frames in communication. We further assumed that one such negative framing strategy – signaling low vaccination rates (e.g., "drop in vaccine rates as measles outbreak looms", "many rates are below the 95% target") – would be commonly employed by the news media. We tested these assumptions by conducting a content analysis of online news media in Serbia, around the start of the measles outbreak in 2017.

Framing in News Stories About Vaccination

Informative messages disseminated through news media are expected to contain minimal personal opinion and value judgment. However, the mere fact that it needs to be decided how content is presented implies that the media engages in *framing* practices and in doing so introduces some bias. Framing refers to the words, images, phrases, and presentation styles used when relaying information to the audience (Druckman, 2001). Through framing, the media can affect how members of the public and policymakers think about certain issues and it can realize behavioral changes (e.g., Chong & Druckman, 2007; Yanovitzky, 2002).

Most of the work on the framing effects in the news media has dealt with *emphasis frames*. They provide "an interpretation of an issue or policy by emphasizing which aspect of the issue is relevant for evaluating it, without . . . providing any new substantive information about the issue" (Leeper & Slothuus, 2020, p. 154). For example, human papillomavirus (HPV) vaccination may be presented as either cancer prevention or sexually-transmitted infection prevention (Leader et al., 2009).

The present study focused on another type of frames called *equivalency frames*. While emphasis frames imply that different aspects of an issue or policy may be chosen to build a context around it, equivalency frames imply that even identical pieces of information may be communicated using different, but logically equivalent, descriptions (Tversky & Kahneman, 1987). The effect of equivalency frames on people's preferences has been demonstrated in different health contexts (Akl et al., 2011; Levin et al., 1998).

One basic form of equivalency framing is *attribute framing*, where the frame is applied to a single characteristic of an object or event and is expected to influence the evaluation of that object or event (Levin et al., 1998). For example, framing the HPV vaccine as 70% effective yielded higher ratings of vaccine effectiveness and more support for policies mandating the vaccine, compared to framing it as 30% ineffective (Bigman et al., 2010). Even merely describing the same critical information in either a positive or negative light constitutes an attribute frame (Schneider et al., 2005). Thus, the same vaccination uptake may be positively (as high as 50% vaccinated) or negatively valenced (only 50% vaccinated).

Negativity in News Stories About Vaccination

Negativity has always been a part of news reports, including those about vaccination. A review of content analyses of traditional media found that, of the 13 studies coming from a variety of countries, 62% identified more negative than positive messages about vaccination (Catalan-Matamoros et al., 2019). The negative news messages often framed vaccination around the issues of efficacy, side-effects, and tragic personal stories (Catalan-Matamoros et al., 2019).

The principle that negative events are "more salient, potent, dominant in combinations, and generally efficacious than positive events" (Rozin & Royzman, 2001, p. 297; see also Baumeister et al., 2001) may affect the selection and production of news stories. People tend to learn more from negative than from positive political information (Bradley et al., 2007) and to be more aroused by and attentive to negative video news content (Soroka et al., 2019). A recent preliminary analysis revealed that negative words in news headlines increase consumption rates (Feuerriegel et al., 2022). There is evidence, however, that, when presented to pro-vaccination individuals, negatively framed statements relating to vaccine side-effects and the scientific consensus were not better memorized, were deemed less plausible, and were less appealing to transmit, compared to positively framed statements (Altay & Mercier, 2020).

Public Communication of Vaccination Rates

Even though the majority of people worldwide support vaccination (e.g., World Health Organization, 2018; YouGov, 2021), it appears that the news media often focuses on vaccine refusers. Lamenting low vaccination rates may be even considered part of the pro-vaccine rhetoric, as suggested by an analysis of Australian newsprint media (1993–1998) (Leask & Chapman, 2002). Such a strategy could be seen as problematic as it can distort the perception of group norms surrounding vaccination.

Vaccination Rates as a Source of Normative Influence

The Focus Theory of Normative Conduct (Cialdini et al., 1990) distinguishes between two types of social norms: *descriptive* (what most others are doing) and *injunctive* (what most others approve or disapprove of). It is further assumed that norms influence behavior directly only when they are made salient or focused upon. As a type of summary information about the behavior of a reference group, vaccination rates are probably the most straightforward way of altering the perceptions of descriptive norms surrounding vaccination (Tankard & Paluck, 2016). As such, they are theorized to motivate behavior by providing evidence of what is likely to be an effective and adaptive course of action (Cialdini et al., 1990).

Describing positive behaviors as typical has the potential to introduce social change in a variety of domains (e.g., Behavioural Insights Team, 2012; Gerber & Rogers, 2009; Goldstein et al., 2008). Some studies have shown the same effect in the domain of vaccination. Correlational studies have linked perceptions of peer's behavior to stated vaccination intentions (e.g., Allen et al., 2009; Graupensperger et al., 2021). In experimental studies, the effects were more mixed: while in some participants reported greater vaccination intentions when knowing that the majority of their peers got vaccinated, compared to when most peers did not (Belle & Cantarelli, 2021; Hershey et al., 1994; Palm et al., 2021; Romley et al., 2016; see also Ryoo & Kim, 2021), in other experiments this was not replicated (Clayton et al., 2021; Sinclair & Agerström, 2021; Xiao & Borah, 2020). A recent study during the pandemic showed that presenting accurate information about descriptive norms increased people's intentions to accept COVID-19 vaccines (Moehring et al., 2021).

By the same token, depicting an undesirable behavior (vaccine refusal) as regrettably frequent can activate a powerful descriptive norm message – many people are not getting vaccinated (Cialdini, 2003; Cialdini et al., 2006). Therefore, media warnings of low vaccination rates can unintendedly promote non-vaccination as normal and approved by others and might lead people to underestimate the actual vaccination coverage.

Instead of focusing on the current vaccination rate, descriptive norms can draw attention to the change in the vaccination rate over time (e.g., "vaccination rate has increased to 65%" or "fewer parents vaccinating their children"). Such information can change the perception of the so-called *trending* or *dynamic norms* (Mortensen et al., 2019; Sparkman & Walton, 2017). In previous studies on sustainable consumption and health, dynamic normative messages encouraged positive behavior, even when a change was happening among a minority of people (e.g., Mortensen et al., 2019; Sparkman & Walton, 2017, 2019). A large US study on flu vaccine uptake found a small positive effect of a dynamic norm message ("More Americans are getting the flu shot than ever") (Milkman et al., 2022).

Communicating Vaccination Norms With Respect to the Herd-Immunity Effect

Communicating high vaccination rates can be a double-edged sword due to the possibility of people deciding to *free-ride on herd immunity*. Herd immunity is the effect where a high enough number of people are immune, the spread of the disease is slowed down or the disease is wiped out altogether. Herd immunity protects everyone, especially the vulnerable (Fine et al., 2011). Through herd immunity, a higher vaccination rate decreases the risk of infection. This provides an incentive for individuals to be free-riders who benefit from the vaccination of others while avoiding the costs of vaccination such as money, time, adverse events, inconvenience (e.g., Böhm et al., 2016; Ibuka et al., 2014).

Communicating herd immunity has the potential to increase vaccination intentions (e.g., Betsch et al., 2017; Lazić et al., 2021; Logan et al., 2018), also in the context of the COVID-19 pandemic (Pfattheicher et al., 2022; Schwarzinger et al., 2021; cf. Freeman et al., 2021). A content analysis of Australian newsprint media (1993–1998) found that the notion of vaccination benefiting the society as well as the individual was rarely promoted (Leask & Chapman, 2002). At least before the COVID-19 pandemic, it seems that herd immunity was underutilized in vaccine advocacy.

Overview of the Present Study

Vaccination rates can be a powerful source of normative influence. In addition, the choice of what information to emphasize and whether the information is framed positively or negatively can contribute to the public and policy discussion of vaccination. In contrast to most previous studies on vaccination communication, we did not define negativity as the presence of anti-vaccine themes. Instead, we focused on the negativity that can arise from attribute frames of vaccination rates.

This content analysis study focused on two broad research questions: whether and how online news media communicates and frames vaccination rates and whether and how it reports on herd immunity. We examined:

- how often vaccination rates were mentioned and how much prominence was given to them;
- who or what was cited as the source of vaccination rate information;
- what vaccines the rates referred to and whether revaccinations were mentioned;
- what reference groups (populations and territories) vaccination rates referred to;
- whether vaccination rates were presented numerically versus only verbally;
- whether vaccination rates were communicated as static versus dynamic norms;
- whether vaccination rates were framed as the proportion of those vaccinated versus those not vaccinated, as the first attribute frame;
- whether numerically presented vaccination rates were framed in a positive, negative or neutral way, as the second attribute frame;
- how often the term herd immunity was mentioned and explained; and
- how often the herd-immunity threshold (i.e., the critical proportion of the population that must be immunized to stop the disease from spreading) was communicated.

We analyzed Serbian online news stories published from July to December 2017. This sampling period covered the beginning of the measles outbreak in Serbia. Epidemiological monitoring of measles was strengthened on October 9, 2017 (Institute of Public Health of Serbia, n.d.), making it the official start of the epidemic. Online sources were chosen over traditional media because of their rising importance in health and vaccine information seeking behavior (e.g., UNICEF Serbia, 2018). Countries other than the United States are usually underrepresented in health communication research (Catalan-Matamoros et al., 2019; Kim et al., 2010). This study, thus, further contributes to the field by focusing on a country that is neither an English-speaking country nor a high-income economy.

Immunization in Serbia

The childhood immunization program in Serbia is delivered free of charge for mandatory vaccines, as enforced by law (Official Gazette of RS No. 15/2016, 88/2017). Similarly to a number of post-communist countries (Costa-Font et al., 2021), after introduction of mandatory immunizations in the second half of the twentieth century and a period of low incidence of immuno-preventive diseases, in the last decade Serbia has seen a drop in pediatric vaccine coverage. Despite it being mandatory, a trend of untimely and delayed measles-mumps-rubella (MMR) vaccinations has been observed (Institute of Public Health of Serbia, 2016, 2018). There was an increase from 11 measles cases in 2016 to 721 and 5,076 in 2017 and 2018, respectively (WHO Immunization Data portal, 2021). MCV1 coverage was 81% in 2016 and 85% in 2017, while MCV2 coverage was around 91% in those years (Institute of Public Health of Serbia, 2016, 2018). Regional coverages of the target population were as low as 65% (Belgrade) in 2016 and 60% (Nišava) in 2017. Following the measles outbreak, this trend has been reversed. In 2018, MCV1 coverage was 93.4% (Institute of Public Health of Serbia, 2019).

Method

Identification of Online News Stories

We first set out to identify the highest-trafficked news websites in Serbia. We did not consider investigative journalism websites, news aggregators or magazines. Combining traffic rank data provided by Gemius Audience (rating.gemius.com) – for August 2017 through June 2018 – and Alexa (www.alexa.com) – viewed December 20, 2018 – we chose nine highest trafficked news websites. All websites are in Serbian and focus on national rather than regional or local news; further details can be found in Table 1.

Web search was conducted via Google.rs (the Serbian version of the search engine) between December 2018 and February 2019. We used the terms “vaccine” and “vaccination” in Serbian (*vakcina* OR *vakcinacija*), including “site:” in the query, which restricted the search to one website. The date range was additionally customized. The search was conducted using default modes “Sort by relevance” and “All results”. Ten results per page were shown. We identified relevant news stories among the first two pages of results for each of the nine websites. We carried out the search for the period between July 1 and December 31, 2017. The decision to limit the search to the first two pages was made in advance to ensure that a maximum of 360 news stories could be sampled in total.

The news story referred to content grouped around one headline. Apart from news reports, we also included opinion pieces, blog posts, editorials, and interviews. We discarded all news stories with predominantly video or audio content as well as any duplicate news stories. A news story became part of the sample if it mentioned human vaccines or vaccination.

Following these format and topic requirements, we extracted 180 news stories. Twenty news stories were then removed. The search and identification was done manually by the first author. The final sample consisted of 160 news stories (Table 1). The list of discarded stories, with reasons, and PDFs of included news stories are available at https://osf.io/zwcey.

Table 1

Summary of News Websites With the Number of News Stories and Vaccination-Rate Mentions

Website name; Link	Coverage; Type; Readership; Owner	Number of news stories (%)	Number of vaccination-rate mentions (%)
Blic; www.blic.rs	National coverage; Traditional media's (print) website; General readership; Privately owned	32 (20.00%)	112 (33.04%)
Kurir.rs; www.kurir.rs	National coverage; Traditional media's (print) website; General readership; Privately owned	21 (13.13%)	19 (5.60%)
B92 Net; www.b92.net	National coverage; Traditional media's (television) website; General readership; Privately owned	11 (6.88%)	33 (9.73%)
Espreso; www.espreso.rs	National coverage; News and politics/current affairs website; General readership; Privately owned	12 (7.50%)	17 (5.01%)
Novosti.rs; www.novosti.rs	National coverage; News and politics/current affairs website; General readership; Privately owned	25 (15.63%)	60 (17.70%)
Srbija Danas; www.srbijadanas.com	National coverage; News and politics/current affairs website; General readership; Privately owned	8 (5.00%)	22 (6.49%)
Alo.rs; www.alo.rs	National coverage; Traditional media's (print) website; General readership; Privately owned	12 (7.50%)	7 (2.06%)
N1 info; rs.n1info.com	National coverage; Traditional media's (television) website; General readership; Privately owned	18 (11.25%)	34 (10.03%)
Telegraf.rs; www.telegraf.rs	National coverage; News and politics/current affairs website; General readership; Privately owned	21 (13.13%)	35 (10.32%)

Table 1 Continued

Website name; Link	Coverage; Type; Readership; Owner	Number of news stories (%)	Number of vaccination-rate mentions (%)
Telegraf.rs; www.telegraf.rs	National coverage; News and politics/current affairs website; General readership; Privately owned	21 (13.13%)	35 (10.32%)
Total		160 (100%)	339 (100%)

Note. Coverage, type, and ownership information for all websites except for N1 info was taken from the https://onlajnmediji.rs/ database (Last accessed June 7, 2022).

Content Analysis

The authors developed the initial codes and categories, which the first author expanded and revised by reading the first 68 extracted news stories. The first author then used the final coding scheme to perform content analysis of all included news stories. The present manuscript reports a part of that content analysis. The final coding scheme in English is available at https://osf.io/fsjcn.

We coded the headline, the lead, and the main text, including subheadlines and image titles. We did not code links, trails and previews of other news stories, embedded content, comments, and tags. There were two content analysis units – the news story as a whole and every mention of a vaccination rate within the news story.

News Story-Level Content Analysis

We coded whether the text of the news story mentioned vaccination rates at least once. Vaccination rate was defined as the number or percentage of people who are either vaccinated or not vaccinated. Rates could also be expressed verbally (e.g., "the majority of people have been vaccinated"). Mentions of the general interest in vaccination, vaccine hesitancy and resistance were not coded as vaccination rate.

We coded how many times the text of the news story mentioned vaccination rates. As long as the vaccination-rate information appeared in separate dependent or independent clauses, it was counted as a separate mention. Vaccination-rate information presented via infographics did not count towards this. However, we did code whether the news story used infographics (e.g., charts, number graphics, population diagrams, maps, data tables) to present any vaccination rates. This variable was used as a proxy for the amount of prominence given to vaccination rates.

Next, we coded whether the news story mentioned the term "herd immunity" or "collective immunity" (*imunitet krda*, *kolektivni imunitet*). To be considered complete, the definition had to (a) refer to the need to reach the herd-immunity threshold; and (b) mention at least one of the following two main consequences of reaching the herd-immunity threshold: that the pathogen can no longer be transmitted and/or that everyone in the population is protected (Fine et al., 2011). Examples of complete definitions include "if enough people are vaccinated, the disease cannot spread and no new people can be infected" or "when vaccination coverage reaches a certain threshold, the epidemic is stopped". A definition could not include imprecise statements, such as "corrupting herd immunity risks a higher chance of an outbreak" or "the vaccinated build and sustain herd immunity", without further explanation. Finally, we coded whether the news story mentioned the exact numerical value of the herd-immunity threshold (e.g., 95% for measles).

Vaccination Rate-Level Content Analysis

There was a total of 339 vaccination-rate mentions in the selected news stories (Table 1). Each vaccination-rate mention was coded separately for a number of features. We coded:

- whether the vaccination rate appeared in the first headline on the page (to assess its prominence);
- whether the vaccination-rate information was sourced and who the source was;
- the vaccine the rate referred to and whether it was explicitly mentioned that the rate referred to any dose following the first one (e.g., second dose, revaccination, booster);
- the population and territory the vaccination rate referred to;
- in which (non-)numerical format the vaccination rate was presented and whether the exact numerical value of the vaccination rate was provided;
- whether the vaccination rate was provided as a static or dynamic descriptive norm;
- whether the vaccination rate was framed as the proportion of those vaccinated or those not vaccinated; and
- whether the vaccination rate was framed in a positive (e.g., as high as, increasing, above a satisfactory level, good), negative (e.g., only, decreasing, below a satisfactory level, poor) or neutral way. The valence could have also been deduced from the immediate context surrounding the vaccination-rate mention (e.g., the vaccination rate was presented as an approval or encouragement or as a warning or intimidation).

Inter-Coder Reliability Test

An independent coder was trained on the coding scheme and coded a subsample consisting of randomly chosen 20% of the included news stories (n = 32), containing 64 (18.9%) out of a total of 339 vaccination-rate mentions. We computed Krippendorff's alpha (α) – as well as percent agreement because some variables were skewed or without variation in the data – using the {irrCAC} package (Gwet, 2019) in R 4.1.2 (R Core Team, 2020) (Table 2). Average inter-coder reliability for the variables reported in this paper was α = .89. Out of 16 variables, eight obtained reliability .91-1.00, four .81-.87, and four obtained reliability .70-.79.

Table 2

Inter-Coder Reliability Coefficients for All of the Reported Variables

Variable	Percent Agreement	Krippendorff's Alpha
1. News Story-Level Variables		
Rate mentioned (yes, no)	91%	.81
Number of mentioned rates	82%	.75
Infographics used (yes, no)	100%	1.00
Herd immunity mentioned (yes, no)	100%	1.00
Herd immunity explained (yes, no)	97%	.79
Critical herd immunity mentioned (yes, no)	100%	1.00
2. Vaccination Rate-Level Variables		
Appears in the headline (yes, no)	100%	NA
Source specified (yes, no)	85%	.70
Source type [a]	100%	1.00
Vaccine	94%	.87
Revaccination/second dose (yes, no)	100%	1.00
Reference group - population	93%	.74
Reference group - territory [a]	89%	.85
Format (absolute/relative number, frequency, descriptive)	96%	.94
Trend (static, dynamic)	96%	.91
Frame (proportion of vaccinated/unvaccinated)	100%	1.00
Frame (positive, negative, neutral)	94%	.86

Note. NA indicates that Krippendorff's alpha could not be calculated because the variable had no variability in responses.
[a] Estimates were calculated after the initial categories were collapsed into fewer, broader categories, later used in the analysis.

Results

We carried out a descriptive analysis of the collected data. Datasets are openly available at https://osf.io/zxhtr.

Prevalence and Prominence of Vaccination Rates

Over half of the selected news stories (53.75%, 86/160) mentioned vaccination rates at least once. There were, on average, 2.1 vaccination-rate mentions per news story, with this number ranging from 1 to 26. A total of 1.77% (6/339) of vaccination-rate mentions appeared in the headline; that is, 3.75% (6/160) of news stories had headlines featuring this information. A total of 5.00% (8/160) of news stories used infographics to communicate vaccination rates.

Source of Vaccination Rates

The main sources of vaccination-rate information were domestic medical and public health institutions and experts (Table 3). Institutes for public health, community health centers (*dom zdravlja*), and named epidemiologists were a common source type (30.68%, 104/339, 12.98%, 44/339, and 9.14%, 31/339, respectively). News stories sometimes (8.85%, 30/339) cited generic experts and expert institutions (e.g., scientists, pediatricians). Other sources are listed in Table 3. About a quarter of vaccination rates (28.91%, 98/339) were reported without specifying the source.

Types of Vaccines and Revaccinations

The majority of the vaccination rates (77.29%, 262/339) referred to the MMR vaccine, whereas 13.27% (45/339) referred to vaccinations in general. The other vaccines that the rates referred to were against: diphtheria, tetanus, whooping cough, polio, and Haemophilus influenzae type b (3.24%, 11/339), hepatitis b (2.36%, 8/339), flu (1.18%, 4/339), polio (1.18%, 4/339), tuberculosis (BCG vaccine, 0.59%, 2/339), pneumococcal infections (0.29%, 1/339); in 2 (0.59%) cases vaccine type could not be determined. A total of 5.90% (20/339) of vaccination-rate mentions explicitly referred to a dose that is not the first dose of the vaccine.

Table 3

Frequency of Vaccination-Rate Mentions (N = 339) Coming From Different Sources

	Number of vaccination-rate mentions	%
Institute of Public Health of Serbia Dr. Milan Jovanović Batut	49	14.45%
Community health centers	44	12.98%
Epidemiologists, mentioned by name	31	9.14%
Local institutes for public health (other)	31	9.14%
Generic experts and expert institutions	30	8.85%
City Institute for Public Health Belgrade	24	7.08%
Healthcare professionals, mentioned by name (other)	8	2.36%
Associations of healthcare workers	7	2.06%
Associations of citizens and parents	6	1.77%
Nursery, preschool, elementary, high school	3	0.88%
Medical faculties	2	0.59%
Clinic for Infectious and Tropical Diseases	1	0.29%
Electronic Immunization Registry	1	0.29%
Ministry of Health	1	0.29%
UNICEF	1	0.29%
World Health Organization	1	0.29%
“Unnamed” source	1	0.29%
No source cited	98	28.91%

Note. Individuals/organizations mentioned as sources of vaccination-rate information by the news stories and the number/proportion of vaccination-rate mentions associated with them.

Reference Groups

The majority of the vaccination rates (78.47%, 266/339) referred to children aged 0–14 years. This should not be surprising given that most of the immunization rates referred to the MMR and other pediatric vaccines in Serbia. Different subpopulations of children are specified in Table 4. Vaccination rates among the vulnerable were almost never mentioned (in 1.18% or 4/339 of cases). A total of 2.65% (9/339) of vaccination-rate mentions referred to the general population (e.g., people, persons, citizens).

Most of the vaccination rates were reported for the country of Serbia as a whole (35.10%, 119/339) as well as at the city- or town-level (31.56%, 107/339). Some cities in Serbia are divided into municipalities (*opštine*) – vaccination rates were reported at this level in 11.80% (40/339) of cases. Table 4 lists all of the territories that the vaccination rates referred to.

Table 4

Frequency of Vaccination-Rate Mentions (N = 339) Across Different Populations and Territories

	Number of vaccination-rate mentions	%
1. Population		
Children		
Children 0–14 y.o. (age / school status not specified)	215	63.42%
Children 1–7 y.o. (school status not specified)	22	6.49%
Elementary school (or to be enrolled) (7–14 y.o.)	13	3.83%
Children 0–6 months (newborns, babies)	8	2.36%
Nursery / preschool (or to be enrolled)	8	2.36%
Vulnerable		
People aged 60 and over	2	0.59%
Pregnant women	1	0.29%
Vulnerable (in general or combination of subpopulations)	1	0.29%
Other		
General population	9	2.65%
Undetermined / not mentioned	60	17.70%

Table 4 Continued

	Number of vaccination-rate mentions	%
2. Territory		
Serbia		
Country as a whole	119	35.10%
City / town	107	31.56%
City municipality (*opština*)	40	11.80%
Central Serbia, Serbian enclaves in Kosovo, Vojvodina	21	6.19%
Country district (*okrug*)	3	0.88%
Nursery, preschool, elementary, high school	3	0.88%
Other		
Balkans (country, country region, city / town)	18	5.31%
Europe (continent, country in Europe / European Union)	18	5.31%
Whole world	5	1.47%
Other countries	4	1.18%
Undetermined / not mentioned	1	0.29%

Note. Reference groups in terms of the population and territory and the number/proportion of vaccination-rate mentions referring to different groups. The population and the territory groups were coded separately.

Numerical Versus Verbal Presentation

A total of 57.82% (196/339) of vaccination rates were communicated numerically. Most of the vaccination rates (50.44%, 171/339) were presented in relative terms, such as percentages and fractions (e.g., “80%”, “every second”, “third of”). Other numerical formats included absolute counts (e.g., “9,000”) (6.78%, 23/339) and frequency statements (e.g., “5,496 out of 20,768”) (0.59%, 2/339). The rest of the vaccination rates (143/339, 42.18%) were communicated verbally, without the numerical value. Descriptive terms used were, for example, “most of the population”, “a drop in”, “low”, “weak”, “below an acceptable level”.

Since the same vaccination rate could have been mentioned both in a numerical and verbal format within the same news story, we additionally counted the number of news stories that provided no numerical values, either via text or infographics. A total of 26.74% (23/86) of news stories reporting vaccination rates used only descriptive terms to do so.

Static Versus Dynamic Norms

The majority of vaccination rates (71.09%, 241/339) were communicated as static norms. The remaining vaccination rates (28.91%, 98/339) were communicated as dynamic norms. News stories reported that “more parents are vaccinating their children”, “immunization levels have risen by 10%”, “the rates are declining”, “this year’s coverage will be smaller if the trend stays”.

Framing as the Proportion of Vaccinated Versus Unvaccinated

Almost all vaccination rates were presented as the proportion of vaccinated individuals (90.27%, 306/339), as opposed to the proportion of non-vaccinated individuals (9.73%, 33/339). A news story could report that “60% of children are vaccinated” versus that “40% of children are not vaccinated”.

Positive, Negative or Neutral Frame

While we observed both positive (18.29%, 62/339) and neutral (10.32%, 35/339) vaccination-rate mentions, the majority of mentions were coded as being negative (71.39%, 242/339). News stories, for example, reported that “fewer parents are vaccinating their children”, “the coverage is very low, almost 40% of children haven’t received the vaccine”, “only 50% vaccinated”, “every second child not vaccinated, epidemic just a matter of time”.

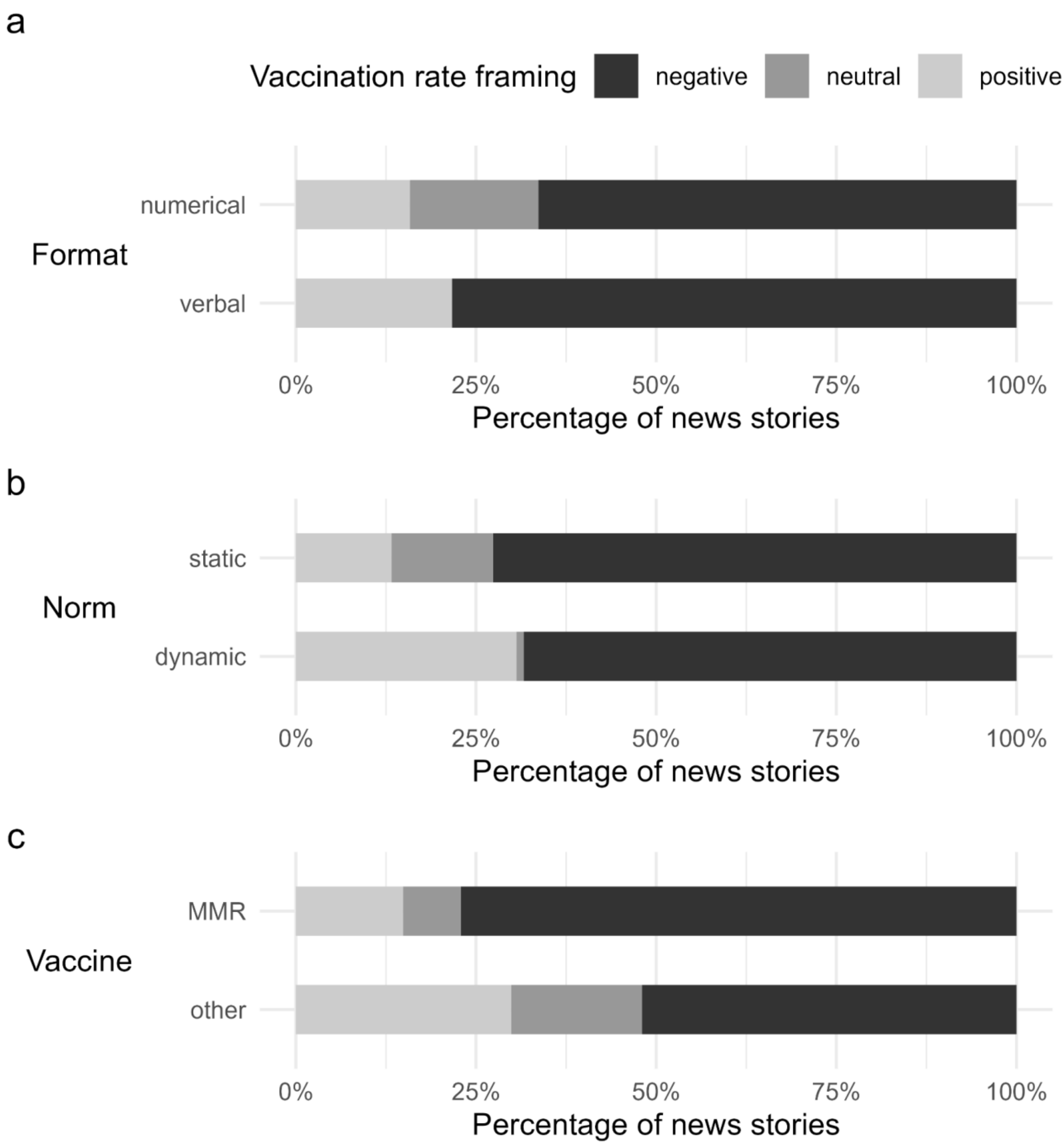
The proportion of negative frames remained similar regardless of the way in which the rates were communicated and of the vaccine they referred to (Figure 1), suggesting that the finding is robust. Negatively valenced attribute frames were identified by calculating the proportion of negative mentions only among the vaccination rates that were communicated numerically; the prevalence of such negative frames remained high (66.33%, 130/196). Vaccination rates that were communicated only verbally were also often presented in a negative way (78.32%, 112/143). Furthermore, both static and dynamic vaccination rates were presented mostly in a negative way (72.61%, 175/241 and 68.37%, 67/98, respectively). Finally, 77.10% (202/262) of MMR vaccination rates and 51.95% (40/77) of the rates for all other vaccines were negatively framed.

Herd-Immunity Communication

Terms referring to herd immunity were mentioned in 20.00% (32/160) of news stories. A total of 9.38% (15/160) of news stories gave a complete and precise definition of the herd-immunity effect, some naming it and some not. Out of the stories mentioning the term, 34.38% (11/32) defined the effect of herd immunity. Almost a quarter (23.13%, 37/160) of news stories provided the exact numerical value of the herd-immunity threshold.

Figure 1

The Proportion of Positive, Neutral, and Negative Frames of Vaccination Rates



Note. This figure shows how many vaccination rates (in percentages) were framed positively, neutrally or negatively depending on (a) their format (numerical, verbal); (b) norms they communicated (static, dynamic); and (c) the vaccine they referred to (MMR, other). Figure created using {ggplot2} (Wickham, 2016) in R 4.1.2 (R Core Team, 2020).

Discussion

This content analysis explored online news coverage of vaccination rates and herd immunity in Serbia, around the start of the 2017 measles epidemic. Perhaps under the impression that such messages can be fear-inducing and thus mobilizing, the online news media often signaled low vaccination rates. This finding is in line with a content analysis of Australian newsprint media from twenty years ago (Leask & Chapman, 2002). The majority of vaccination rates, including seemingly objective vaccination rate numbers and changes in vaccination rates over time, were presented in a negative light by applying simple attribute frames (e.g., "only 50% vaccinated", "fewer parents vaccinating their children"). Rather than being mobilizing, framing vaccination rates negatively could discourage vaccination by activating a powerful negative descriptive norm – "many people are not getting vaccinated" (e.g., Belle & Cantarelli, 2021; Milkman et al., 2022; Palm et al., 2021; Romley et al., 2016). Whenever possible, news stories should, therefore, consider framing vaccination rates positively (e.g., "already 60% vaccinated") rather than negatively (e.g., "only 60% vaccinated"), or not framing them at all. Framing would make the positive norms more salient and thus more likely to shape health behavior (Cialdini et al., 1990).

While the majority of vaccination rates came from medical and public health expert sources, no source was provided for over a quarter of vaccination rates. Most of the vaccination rates were reported on the country- or city/town-level. Vaccination rates were less frequently reported for city municipalities, even though these statistics were freely available on the website of the Institute of Public Health of Serbia, which was the most frequent source of information in the news stories. While MMR vaccination coverage was above 70-80% in most of the Serbian city municipalities during the measles outbreak, some city municipalities had coverage below 70% (Institute of Public Health of Serbia, 2018). Reporting this could have been beneficial in order to highlight the limits of the free-riding strategy (Meszaros et al., 1996). Furthermore, when individuals feel identified with the reference group, normative information is generally more likely to be effective (for a review, see Tankard & Paluck, 2016). The news media should, therefore, consider reporting more specific reference groups for the vaccination rates, not only in terms of geographical residence but also in terms of age, school status or vulnerability level.

We found that herd-immunity communication remains underutilized in the media (Leask & Chapman, 2002) – around 9% of online news stories explained the benefits of herd immunity through vaccination, while around a quarter provided the value of the vaccination rate that stops the disease from spreading. Communicating social benefits of herd immunity has been shown to improve vaccination intentions (e.g., Betsch et al., 2017). There have been, however, fewer studies that tested how communicating the herd-immunity threshold would fare at different descriptive norm levels (Lazić et al., 2021). For example, if people learn that the vaccination rate is close to the threshold, this could lead them to expect that their vaccination choice could make a difference; in contrast, if they learn that the vaccination rate is far below the threshold, they may conclude that their individual contribution to herd immunity will not be sufficient (see Moussaoui & Desrichard, 2017).

Strengths, Limitations, and Recommendations for Future Studies

This study represents one of few analyses of news media framing of vaccination rates. In contrast to most previous studies, we attempted to conceptualize negativity mostly irrespective of issue-specific, anti-vaccine rhetoric. This allowed us to provide guidelines for a routine, everyday aspect of public vaccine communication, while identifying some commonly-used communication strategies that have the potential to backfire. We developed a detailed coding scheme, which can be used in future studies of public health communication and applied to other influential events, such as the COVID-19 pandemic.

That said, it should be noted that the generalizability of this study's findings could be limited by some characteristics of the analyzed news stories. First, all news stories appeared online and only news story text was analyzed. Shortcomings we identified may not be reflective of shortcomings in vaccination-rate communication in other formats (e.g., traditional print media or online video news stories). Secondly, the findings might be context specific as they were sampled from a 6-month period around the time of the 2017 measles outbreak in Serbia.

Understanding the full influence of news media will require studying not only descriptive but also injunctive normative messages (about vaccination attitudes, opinions, recommendations, etc.). Future studies could explore specific dimensions of negativity in vaccination-rate communication, such as pessimism or negative tone towards certain actors (e.g., putting blame on parents). To be able to study the construction of the vaccination discourse in local media and connect it with the broader socio-cultural context, future studies could apply more qualitative techniques (such as discourse analysis).

Conclusion

Through a content analysis of online news stories relating to vaccination, we identified ways in which vaccination rates were presented and framed around the start of the 2017 measles outbreak in Serbia. Even routine communication of vaccination rates was biased through negative frames (e.g., "only 50% vaccinated") and imprecise descriptions (e.g., "the coverage is low"). Furthermore, the news stories rarely explained the benefits of achieving herd immunity through vaccination. We explain how some of the common strategies, such as lamenting low vaccination rates, may backfire. While this study provides some initial recommendations for mitigating these issues, more studies are needed to evaluate how and under what conditions normative messages and frames influence vaccine uptake.

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Chapter 3

Paper 2 | Social Nudges for Vaccination: How Communicating Herd Behaviour Influences Vaccination Intentions

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Social Nudges for Vaccination: How Communicating Herd Behaviour Influences Vaccination Intentions

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Abstract

Objectives. This Registered Report attempted to conceptually replicate the finding that communicating herd immunity increases vaccination intentions (Betsch, et al., 2017, *Nat. Hum. Behav.*, 0056). An additional objective was to explore the roles of descriptive social norms (vaccination behaviour of others) and the herd-immunity threshold (coverage needed to stop disease transmission).

Design. An online experiment with a 2 (herd-immunity explanation: present vs. absent) x 3 (descriptive norm: high vs. low vs. absent) x 2 (herd-immunity threshold: present vs. absent) between-subjects fractional design.

Methods. Sample consisted of 543 people (aged 18–64) residing in the United Kingdom. Participants first received an explanation of herd immunity emphasising social benefits (protecting others) in both textual and animated-infographic form. Next, they were faced with fictitious information about the disease, the vaccine, their country's vaccination coverage (80% or 20%), and the herd-immunity threshold (90%). Vaccination intention was self-rated.

Results. Compared to the control, communicating social benefits of herd immunity was effective in increasing vaccination intentions ($F(1,541) = 6.97$, $p = .009$, Partial Eta-Squared = 0.013). Communicating the descriptive norm or the herd-immunity threshold alongside the herd-immunity explanation demonstrated no observable effect.

Conclusion. Communicating social benefits of herd immunity increased self-reported vaccination intentions against a fictitious disease, replicating previous findings. Although this result is positive, the practical relevance may be limited. Further research into the effect of social nudges to motivate vaccination is required, particularly with respect to the recent pandemic context and varying levels of vaccine hesitancy.

Keywords: immunisation, herd immunity, social norms, health communication, vaccination intention, experiment, Registered Report

Statement of contribution

What is already known on this subject?

- Communicating social benefits of herd immunity sometimes increased vaccination intentions.
- Many correlational studies have linked descriptive norms to individual vaccination decisions.
- It is not yet clear whether setting collective goals influences individual vaccination decisions.

What does this study add?

- Tested the effect of communicating herd immunity in combined textual and animated-infographic form.
- Replicated the finding that social-benefit appeals increase vaccination intentions.
- Presenting descriptive norms and the herd-immunity threshold alongside herd immunity had no effect.

Social Nudges for Vaccination: How Communicating Herd Behaviour Influences Vaccination Intentions

Background

Vaccination is the most effective way to protect both individuals and communities from infectious diseases. The World Health Organization (WHO, n.d.-a) estimates that vaccination currently prevents between two and three million deaths every year. However, a growing number of people are delaying or refusing to get vaccinated, even in the absence of structural barriers (e.g., problematic access to healthcare, vaccination costs) (WHO, n.d.-b). This has led to recent outbreaks of previously eliminated diseases, making vaccine hesitancy a major threat to global health (WHO, n.d.-b). In 2019, for example, the United Kingdom lost its 'measles-free' status, with 991 confirmed cases in England and Wales in 2018, compared with 284 cases the year before (Public Health England, 2019).

To tackle vaccine hesitancy, this study explored intervention strategies that harness social processes to motivate vaccination. More specifically, we focused on the following three social nudges: the communication of herd immunity, the herd-immunity threshold, and descriptive social norms.

Herd-Immunity Communication

The more people in a community that are vaccinated against a disease, the less probable it is for the disease to spread. This effect of herd immunity protects everyone but is especially important for vulnerable populations who cannot get vaccinated (such as people with serious allergies or those with weakened immune systems) (Fine et al., 2011). Recent studies have shown that communicating herd immunity has the potential to increase vaccination intentions (e.g., Betsch et al., 2017; Betsch & Böhm, 2018; Logan et al., 2018). Specifically, communicating the social benefit (protecting others) and visually demonstrating this effect seems to have the largest impact (see also Hakim et al., 2019).

The main goal of this study was to attempt to conceptually replicate the finding that communicating the concept of herd immunity increases the willingness to get vaccinated (Betsch et al., 2017). The original study by Betsch et al. (2017) was conducted as an online experiment, with a non-representative sample of 2,107 adult participants from seven countries (the United States, the Netherlands, Germany, India, Hong Kong, Vietnam, and South Korea). The present replication study was also conducted as an online experiment, but with a sample of participants who live in the UK.

Given that herd immunity is under-explained and under-utilised in vaccine advocacy (Brockmann, 2017), it is important to test if the effect of communicating herd immunity replicates. It is especially relevant to see whether this effect is stable across countries with varying vaccination laws and levels of anti-vaccination sentiment. Furthermore, our replication study may have practical implications for the design of herd-immunity communication. The original study used an interactive simulation. As an alternative to this, we used an animated infographic. This medium may be easier to disseminate on television and social networks and may be more familiar to participants.

Like the original study, we explored decision-making about a hypothetical disease transmitted directly through contact with an infected person or indirectly by touching contaminated objects. The effect of herd-immunity communication may be dependent on the mode of disease transmission. For example, in the case of sexually transmitted infections (STIs), this could be due to the extreme heterogeneity in the risk of acquiring and transmitting STIs or the fact that STIs affect sexually active people (Garnett, 2005).

> **Hypothesis 1**: Participants who learn about the social benefit of herd immunity visualised by an animated infographic will show higher vaccination intentions compared to participants who do not learn about it.

Descriptive Norm Communication

Descriptive norms (i.e., what most others are doing) can be a powerful source of informational social influence. By signalling what will likely be an effective and reasonable course of action under the given circumstances (Cialdini et al., 1990, 2006), descriptive norms might also motivate individual vaccination decision-making.

According to a review by Brewer et al. (2017), although many correlational studies have linked norms to vaccination, no field studies have evaluated the use of descriptive norms to modify vaccination behaviour (cf. Leight & Safran, 2019). There have also only been a few survey studies and laboratory experiments exploring descriptive norms as drivers of vaccination (e.g., Hershey et al., 1994; Romley et al., 2016).

In this study, we aim to expand the literature by experimentally manipulating three descriptive-norm levels (high vaccination coverage versus low vaccination coverage versus no coverage information communicated) and by assessing their influence on vaccination intentions.

> **Hypothesis 2**: Exposure to descriptive social norms about vaccination (the level of vaccination coverage in one's country) will influence vaccination intentions. Compared to participants who receive no information about the coverage, participants who are informed about high coverage will show higher vaccination intentions (**Hypothesis 2a**), whereas participants who are informed about low coverage will show lower intentions (**Hypothesis 2b**). Participants who are informed about high coverage will show higher intentions compared to participants who are informed about low coverage (**Hypothesis 2c**).

Although high descriptive-norm messages have the potential to increase vaccination uptake, they can also promote a 'backfire effect'. Employing both interactive games (e.g., Böhm et al., 2016; Ibuka et al., 2014; Korn et al., 2017) and hypothetical scenarios (Betsch et al., 2017; Vietri et al., 2011), previous studies have shown that learning about a high vaccine uptake prompts the individual to strategically 'free-ride' on others' protection and to refuse vaccination. This way, the 'free-rider' also avoids some individual costs (e.g., money, time, inconvenience, vaccine side effects) (Fine et al., 2011).

We did not expect the high descriptive norm in our study to decrease vaccination intentions in such a way. As will be detailed below, prior to learning about the descriptive norm, all of the participants learned about the social benefit of their own vaccination decision. It has been hypothesised that this framing of herd immunity activates an individual's prosocial or other-regarding preferences, thus preventing free-riding (Betsch et al., 2013).

Herd-Immunity Threshold Communication

This study also explored how communicating the vaccination coverage required to reach the herd-immunity threshold influences vaccination intentions. Goal-setting has been shown to be an effective strategy for behaviour change across a variety of domains, especially if the goal is set as a group goal, rather than an individual one (for a meta-analysis, see Epton et al., 2017). In the context of vaccination behaviour, the collectively optimal group goal is the herd-immunity threshold – that is, the proportion of the population that must be immunised to stop the infection from spreading and protect everyone (Fine et al., 2011).

In an interactive game, symbolically rewarding the attainment of a collectively optimal vaccination coverage positively affected uptake (Korn et al., 2018). More closely related to this topic, Logan et al. (2018) presented a convenience sample of participants with the herd-immunity threshold together with the definition of herd immunity and the actual community coverage from the previous year. This multifaceted intervention increased plans to get vaccinated against the flu the following year, but only among those who were not already knowledgeable about herd immunity.

> **Hypothesis 3**: Participants who are informed about the numeric value of the herd-immunity threshold will show higher vaccination intentions compared to the participants who are not informed about this value.

Method

The approved Stage 1 protocol is available at: https://osf.io/jpku3.

Study Design

We ran an online experiment with a 2 (herd-immunity explanation: present versus absent) x 3 (descriptive norm: high versus low versus absent) x 2 (herd-immunity threshold: present versus absent) between-subjects fractional design with seven groups (Table 1). Group 7 was the control which did not receive any experimental intervention to serve as a benchmark for the effect of herd-immunity communication.

The study used simple randomisation. The first randomisation (1:1) served to allocate half of the participants to the control group and the other half to the rest of the groups. In the second randomisation (1:1:1:1:1:1), the participants who had not been recruited to the control group were allocated to one of the six experimental groups. Participants did not know the group to which they had been allocated and researchers were blind to the group allocation process.

Table 1

Study Design With Factors, Groups, and Obtained Sample Sizes

	Factor 1	Factor 2	Factor 3	*n*
	Herd-immunity explanation	Descriptive norm	Herd-immunity threshold	
Levels	present, absent	low, high, absent	present, absent	
Manipulation	between-subjects	between-subjects	between-subjects	
Group 1	present	high	present	45
Group 2	present	low	present	45
Group 3	present	high	absent	45
Group 4	present	low	absent	45
Group 5	present	absent	present	46
Group 6	present	absent	absent	45
Group 7	absent	absent	absent	272
Total				543

Sampling Plan

All participants had to meet the following inclusion criteria: (a) currently residing in the UK, (b) aged between 18 and 64 years, and (c) being confident in their English skills. Typically, individuals aged 65 or above are more susceptible to vaccine-preventable diseases, which can be more severe than for younger people. Additionally, vaccines are less protective in older adults (Goldstein, 2012). It is possible that the community-wide benefit emphasised in the herd-immunity explanation would act as an incentive for younger adults to voluntarily get vaccinated to prevent illness among older adults (Chapman et al., 2012). Social-benefit messaging, however, may not be effective among the elderly and otherwise vulnerable groups (Isler et al., 2020). Due to potential differential effects of herd-immunity communication interventions associated with age, recruiting adults below 65 makes the findings of our study more directly comparable with the findings of the original study, which recruited participants from the same age group of the general population (Betsch et al., 2017).

Participants were recruited through advertisements on social media (e.g., Facebook groups, Twitter, Reddit), websites, and forums. To minimise self-selection, the advertisements and informed consent page did not suggest that the study was related to vaccination. Participation was not compensated.

Data for this study were collected at the time of the COVID-19 pandemic, between October 5 and November 24, 2020. The second half of the data collection period encompassed the second national lockdown (GOV.UK, 2020) but ended before COVID-19 vaccinations were first rolled out in the UK (BBC News, 2020).

Power Analyses

We decided that the sample should be powered to detect the smallest effect of herd-immunity communication that was plausible given previous research. Analysing the raw data from the original study (Betsch et al., OSF, 2017), we estimated the size of the effect at Partial Eta-Squared (η^2) = 0.024, across all locations. Three subsamples were large enough to allow for country-level analysis; the effect remained small to medium in the US and Germany (η^2 = 0.049 and η^2 = 0.073, respectively), but was small (η^2 = 0.002) and did not reach statistical significance in South Korea (Cohen, 1988). The effect of communicating the social benefit of herd immunity was replicated by Betsch and Böhm (2018) among a sample of US parents; the effect sizes in the two experiments were η^2 = 0.042 and η^2 = 0.044. The target sample size is based on an *a priori* one-way ANOVA power analysis using the R package {easypower} (McGarvey, 2015). Assuming α = .05, N = 531 suffices to detect the original effect size of 0.024 with .95 power. Target subsamples for experimental groups 1 through 6 was, therefore, n = 45; target subsample for the control group was n = 270. The total target sample was, thus, N = 540 participants.

We additionally conducted a sensitivity two-way ANOVA power analysis for Hypotheses 2 and 3 using G*Power 3.1.9.4 software (Faul et al., 2007). With the total sample size set at n = 270, α at .05, power at .95, the numerator degrees of freedom (*df*) at 2, and the number of groups at 6, our study would be able to detect a minimum effect size of η^2 = 0.055 of the descriptive-norm manipulation. With the numerator *df* set at 1 and the rest of the parameters remaining the same, it would be able to detect a minimum effect size of η^2 = 0.046 of the herd-immunity threshold manipulation. These effect sizes are small, but approaching the lower limit of what can be considered a moderate effect size, that is, η^2 = 0.06 (Cohen, 1988).

The protocols of power analyses are available at https://osf.io/my2gf.

Procedure and Variables

The study was reviewed and approved by the Institutional Review Board at the [Blinded for peer-review] (protocol #2019-046). After informed consent, the questionnaire first assessed age, gender, country of residence, education, and socioeconomic status. After an attention check, participants received a textual explanation of herd immunity, accompanied by an animated infographic. Next, they were asked to imagine themselves in a scenario in which they had to decide whether to get vaccinated against a fictitious disease. The scenario informed participants about the disease and the vaccine, the herd-immunity threshold, and the level of the vaccination coverage in their country. Following scenario-recall questions, participants rated their intention to get vaccinated. Then, perceived riskiness of the infection and the disease were assessed. This was followed by a measure of vaccine hesitancy and a second attention check. Immediately after the experiment, all participants were fully debriefed and received a link to the WHO website on vaccinations for further information. It was emphasised again that all information regarding the disease and the vaccine was fictitious. The questionnaire is available at https://osf.io/hq9sv.

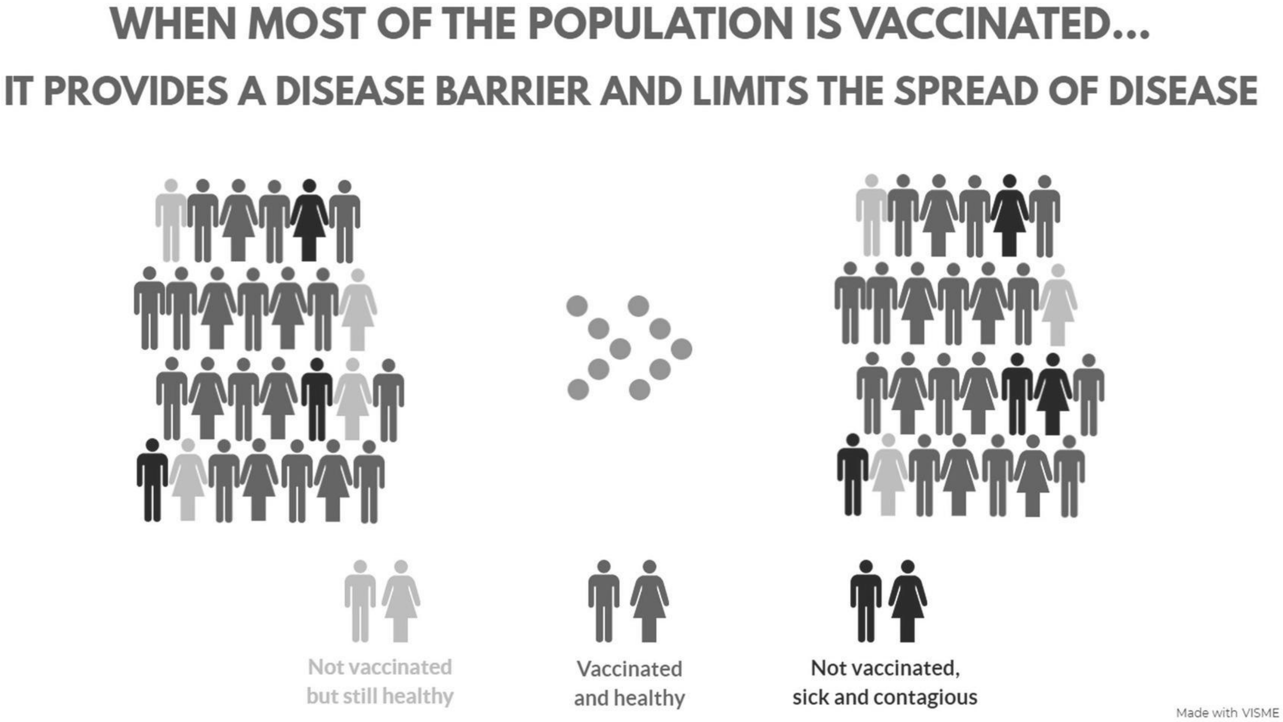
The online experiment was implemented in SoSci Survey. It was pretested on a convenience sample of 14 people (two in each group) from the target population to ensure clarity and comprehension of the materials and fine-tune the survey process. The data from the survey pretest were not included in the analyses.

Manipulated Variables

Herd-Immunity Explanation. Participants read a general explanation of herd immunity that emphasised the social benefit of getting vaccinated (i.e., protecting others in the community, especially the vulnerable). It did not feature the term 'herd immunity', but rather the term 'community immunity', and was 200 words long (see Appendix S1 for the full text). Participants also learned about herd immunity via a 40-second animated infographic. It showed three environments with no versus some versus many people vaccinated and how the pathogen spreads in each one, infecting susceptible individuals (Figure 1). To prevent the participant from skipping the explanation and the infographic, the continue button was disabled for a specified minimum amount of time. If the participant reported any technical difficulties with starting the animation, they were shown a non-animated infographic (depicting only the final outcome in the three environments). The control group received neither a text-based nor an animated explanation of herd immunity. All of the materials have been developed by the authors.

Figure 1

An Example Slide From the Animated Infographic



Note. This slide depicts the final outcome in the environment in which many people were vaccinated. The slide reads: 'When most of the population is vaccinated … it provides a disease barrier and limits the spread of disease'. The legend shows three colours representing 'not vaccinated but still healthy', 'vaccinated and healthy', and 'not vaccinated, sick and contagious' individuals. All of the slides are available at https://osf.io/4hyjt. The animated infographic in full can be viewed at https://youtu.be/Y12LeUoUh-U.

Herd-Immunity Threshold. Participants learned about the coverage needed to reach the herd-immunity threshold for vaccination against a fictitious disease. To allow us to successfully manipulate the social norm, the threshold was set at 90%. To ease comprehension, the threshold was presented both as a percentage and as a number out of 10 ('at least nine out of ten (90% of) people in a population need to get vaccinated to completely stop the [name of the disease] disease from spreading and to protect everyone').

Descriptive Social Norm. Participants were given fictitious information about vaccination coverage in their country. To ease comprehension, this was presented both as a percentage and as a number out of 10 (e.g., 'eight out of ten (80% of) people in the UK have taken the vaccine'). The low coverage was set at 20% and the high coverage at 80%. It was important for these values to be extreme so that they were salient in an individual's attention (Cialdini et al., 1990) and so that the range was wide enough for any reaction to herd behaviour to manifest itself.

Outcome Variable

All participants were faced with a vaccination decision task, which informed them about a severe fictitious disease and a fictitious vaccine. The use of fictitious materials excludes potential confounding variables, such as real infections and vaccine side effects experienced or observed by an individual (e.g., Chapman & Coups, 2006; Lane, et al., 2018). Additionally, it allows unconstrained manipulation of descriptive-norm and herd-immunity threshold levels. Participants first learned about the name of the virus and the path of infection (smear infection). Following Connolly and Reb (2003), the symptoms of the infection and vaccine side effects were described as equally likely (appearing in a small number of cases) and as very similar in content to ensure equal perceived riskiness. The vaccine was described as being easily available at no out-of-pocket cost and as 100% effective against infection with the disease. The source of information was not disclosed, as mistrust in healthcare authorities, government, and pharmaceutical companies has been shown to affect vaccine acceptance (Yaqub et al., 2014). *Vaccination intention* was assessed by asking participants 'If you had the opportunity to get vaccinated against [name of the disease] immediately, what would you do?', on a 7-point scale ranging from 1 = *I would definitely not get vaccinated* to 7 = *I would definitely get vaccinated*.

Other Measured Variables

Sociodemographic Variables

Age. Participants noted their age in years in an open-response box.

Gender. Participants selected 'female', 'male', 'non-binary/third gender', 'prefer to self-describe:' or 'prefer not to say' to indicate their gender (Human Rights Campaign Guidelines).

Education. Participants reported their educational attainment in response to a single item ('What is the highest educational level that you have attained?'). The response scale was adapted for the UK based on the International Standard Classification of Education.

Subjective Socioeconomic Status (SES). Participants used a ladder with 10 steps to indicate their standing in the country relative to other people (Adler et al., 1994).

Vaccine Hesitancy. Participants completed the five-item version of the 5C scale of vaccine hesitancy (Betsch et al., 2018). Additionally, they answered a question about the compatibility of vaccines with their religious beliefs (Larson et al., 2016). All items appeared in a randomised order for each participant and were answered on a 7-point scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*. All items were recoded to reflect higher vaccine hesitancy (higher complacency, constraints, and calculation, and lower confidence, collective responsibility, and compatibility with religious beliefs). Since the internal consistency of the scale was lower than .70 (Cronbach's alpha = .66), we conducted a sensitivity analysis. This indicated that the item assessing calculation ('When I think about getting vaccinated, I weigh benefits and risks to make the best decision possible') had extremely low corrected item-total correlation (r = 0.071) and that removing it would improve reliability. We took the mean of the remaining five items to create a single measure of 'vaccine hesitancy' (Cronbach's alpha = .72).

Perceived Riskiness. Participants rated the perceived riskiness both of the infection ('How risky do you judge a [name of the disease] infection to be if you do not get vaccinated?') and the vaccine ('How risky do you judge the vaccination against [name of the disease] to be?'), on a 0–100 slider (later transformed into a 1–101 scale). The questions were presented in a randomised order for each participant. To assess whether the disease and the vaccine were perceived as equally risky or not, we ran a paired t-test on the perceived riskiness ratings.

Analysis Plan

We used R 4.0.5 (R Core Team, 2021) with {car} (Fox & Weisberg, 2019), {DescTools} (Signorell, 2021), {multcomp} (Hothorn et al., 2008), {psych} (Revelle, 2020), and raincloud plots (Allen et al., 2021). Data and code are available at https://osf.io/zb7s3.

Hypotheses Testing

In all of the following analyses, the dependent variable (DV) is 'vaccination intention'. To test Hypothesis 1, we used a one-way between-subjects ANOVA. The independent variable (IV) is 'herd-immunity explanation' (groups 1–6 versus control). Using a one-way between-subjects ANOVA, we conducted an additional analysis only with those experimental groups which more closely resemble the setting in the original study (Betsch et al., 2017), that is, only with the groups where herd-immunity threshold is not communicated (groups 3, 4, and 6 versus control). A successful replication of the herd-immunity communication effect is defined as finding a statistically significant effect in the same *direction* as the original study.

To test Hypothesis 2 and Hypothesis 3, we used a two-way between-subjects ANOVA without the interaction term. The IVs are 'descriptive norm' and 'herd-immunity threshold'. To test Hypotheses 2a, 2b, and 2c, we additionally performed pairwise comparisons between the three 'descriptive norm' levels.

We repeated all of the above analyses while controlling for age, gender, education, and socioeconomic status (ANCOVA with sociodemographic variables as covariates).

We applied the standard $p < .05$ level for determining if the ANOVA and pairwise comparisons tests suggest that the results are significantly different from those expected if the null hypothesis were correct. The post-hoc Tukey's tests adjust for multiple comparisons.

Exploratory Analyses

To explore the interaction between the 'descriptive norm' (IV1) and the 'herd-immunity threshold' (IV2), we performed a two-way between-subjects ANOVA with the interaction term, with 'vaccination intention' as the DV. We additionally tested the interaction between 'vaccine hesitancy' and the three factors ('herd-immunity explanation', 'descriptive norm', 'herd-immunity threshold') in the linear model, with the same DV.

Data Exclusion

To ensure data quality, we included a recall test and attention checks. After participants received information regarding the descriptive norm and/or the herd-immunity threshold, the recall test ensured they paid attention and remembered the values in their scenario. Depending on the group, the test offered one or two questions, with three choices (correct value, bogus value, 'not sure'). In case of a failed recall, the scenario was presented up to two more times. Only those participants who passed the recall test were able to proceed with the experiment. Additionally, there were two attention-check questions, asking participants to choose a specific response option (Berinsky et al., 2014). Participants who failed both attention checks were excluded from the analyses.

Missing Data

Responses to all questions were mandatory to reduce data errors and omissions. However, education and socioeconomic status questions offered a 'prefer not to say' option (0 out of 549) and responses other than 'female' or 'male' were recoded as a missing value (19 out of 549). In analyses with the gender variable, pairwise deletion on missing data was done.

Results

Sample Characteristics

The survey took participants approximately 7 minutes. Out of 549 participants who completed the study, six were excluded due to failed attention checks. The distribution of the remaining N = 543 participants by experimental group is shown in Table 1. Only 9 out of 271 participants reported technical difficulties and saw the non-animated infographic.

As presented in Table 2, the majority of participants were female (67.77%) and had some higher education experience (75.51%). The mean vaccine hesitancy was low (2.1), with the distribution of responses being positively skewed (Shapiro-Wilk test, $W(543) = 0.88$, $p <$ .001).

Table 2

Sample Characteristics (N = 543)

	n (%)	Range
Age in years (mean; *SD*)	38.0 (12.3)	18–64
Gender		
Female	368 (67.77)	
Male	157 (28.91)	
Non-binary/third gender	10 (1.84)	
Prefer to self-describe	2 (0.37)	
Prefer not to say	6 (1.10)	
Education		
No formal education	6 (1.10)	
Completed secondary school	48 (8.84)	
Completed post-16 education	79 (14.55)	
Some higher education	82 (15.10)	
Completed higher education	177 (32.60)	
Completed advanced degree	151 (27.81)	
Subjective socioeconomic status (mean; *SD*)	5.5 (1.7)	1–10
Vaccine hesitancy (mean; *SD*)	2.1 (1.1)	1–7
Perceived riskiness (mean; *SD*) [a]		
Riskiness of the infection	56.1 (30.4)	1–101
Riskiness of the vaccine	30.4 (28.3)	1–101

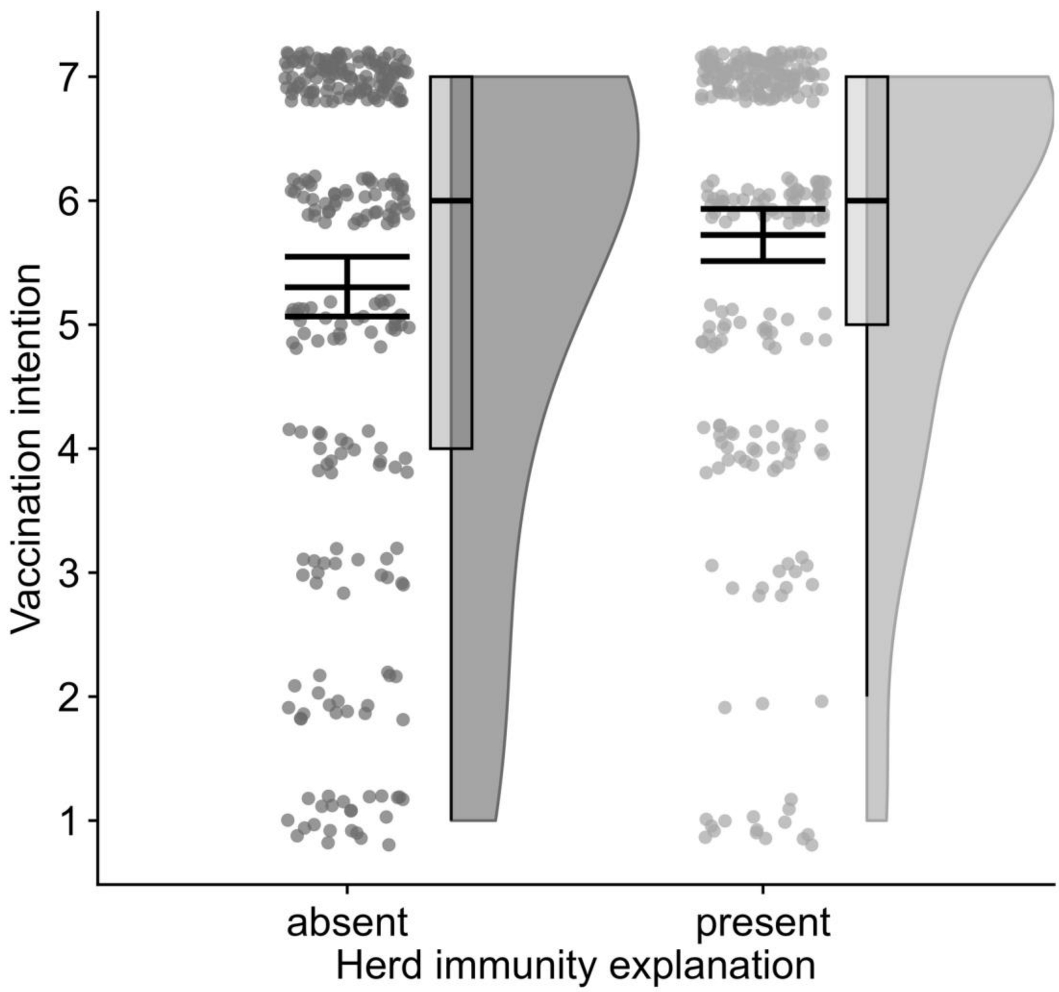
Note. SD = standard deviation.
[a] The riskiness of the infection with the disease was perceived as statically significantly higher than the riskiness of taking the vaccine, $t(542) = 14.46$, $p < .001$.

Hypotheses Testing

Communicating herd immunity significantly increased vaccination intentions compared to the control (*M* = 5.7, *SD* = 1.7 versus *M* = 5.3, *SD* = 2.0), $F(1,541) = 6.97$, $p = .009$, $\eta^2 = 0.013$ (Figure 2), supporting Hypothesis 1. The effect remained significant after controlling for sociodemographic variables, $F(1,519) = 5.92$, $p = .018$, $\eta^2 = 0.011$. After excluding the groups where the herd-immunity threshold was communicated (and without any covariates included in the model), the effect was no longer significant, although it remained in the same direction, $F(1,405) = 3.48$, $p = .063$, $\eta^2 = 0.009$.

Figure 2

Vaccination Intentions Depending on Whether Herd-Immunity Explanation Was Provided

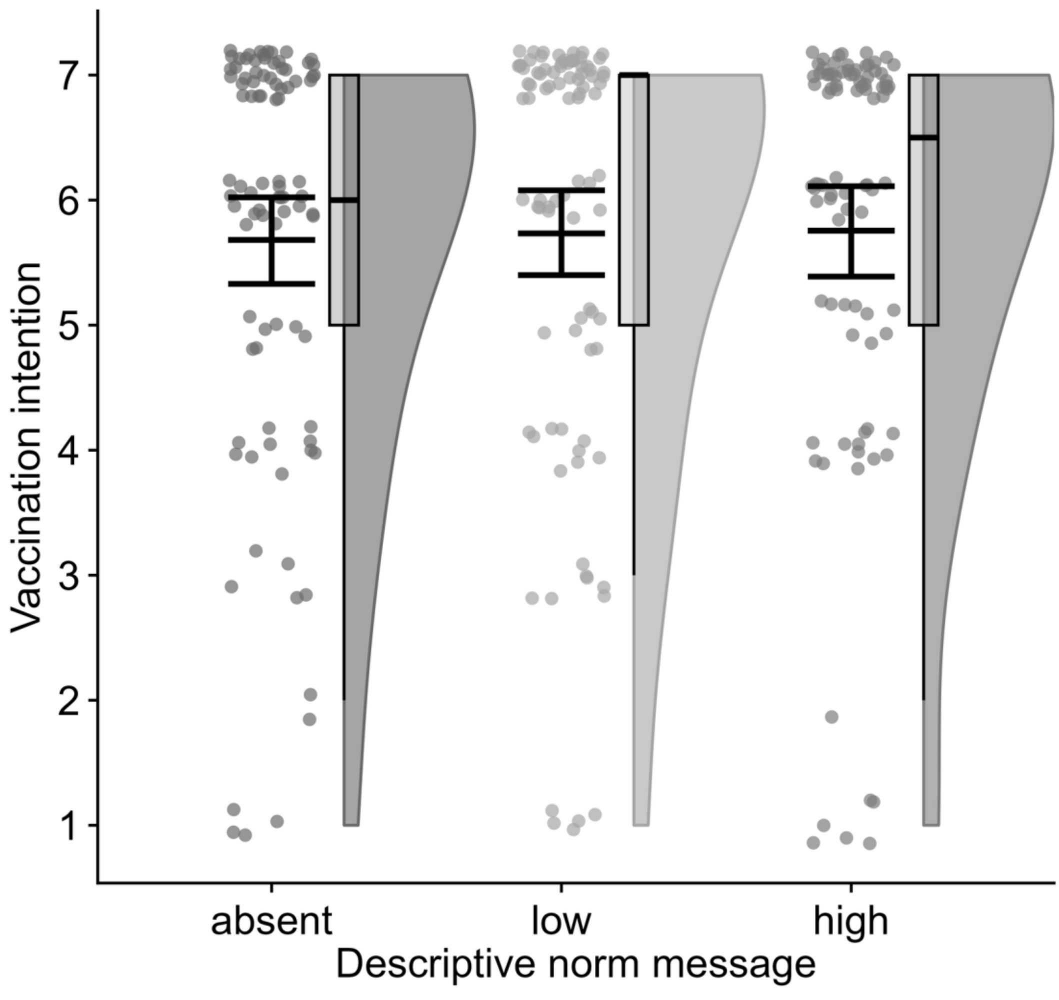


Note. Communicating herd immunity via text and animated infographic was effective in increasing vaccination intentions. The figure shows a raincloud plot with the distribution of the data and jittered raw data; the box plot indicates the interquartile range from the 25th to the 75th percentile, including the median; the mean (with 95% confidence interval) is plotted on top of the jittered points.

Exposure to descriptive norms did not influence vaccination intentions, $F(2,267) = 0.05$, $p = .956$, $\eta^2 < 0.001$, not supporting Hypothesis 2 (Figure 3). Neither low ($M = 5.7$, $SD = 1.8$) nor high norms ($M = 5.8$, $SD = 1.7$) were significantly different from the no-coverage message ($M = 5.7$, $SD = 1.7$) (estimate = 0.05, $SE = 0.26$, $p = .977$, 95% CI [-0.55, 0.66] and estimate = 0.07, $SE = 0.26$, $p = .954$, 95% CI [-0.53, 0.68], respectively). There was also no difference between low and high norms, estimate = -0.02, $SE = 0.26$, $p = .996$, 95% CI [-0.63, 0.58]. Hypotheses 2a, 2b, and 2c were, therefore, not supported. The main effect of norms did not change after controlling for sociodemographic variables ($F(2,255) = 0.05$, $p = .951$, $\eta^2 < 0.001$), and neither did the differences between the levels.

Figure 3

Vaccination Intentions Depending on the Levels of the Descriptive Norm Message

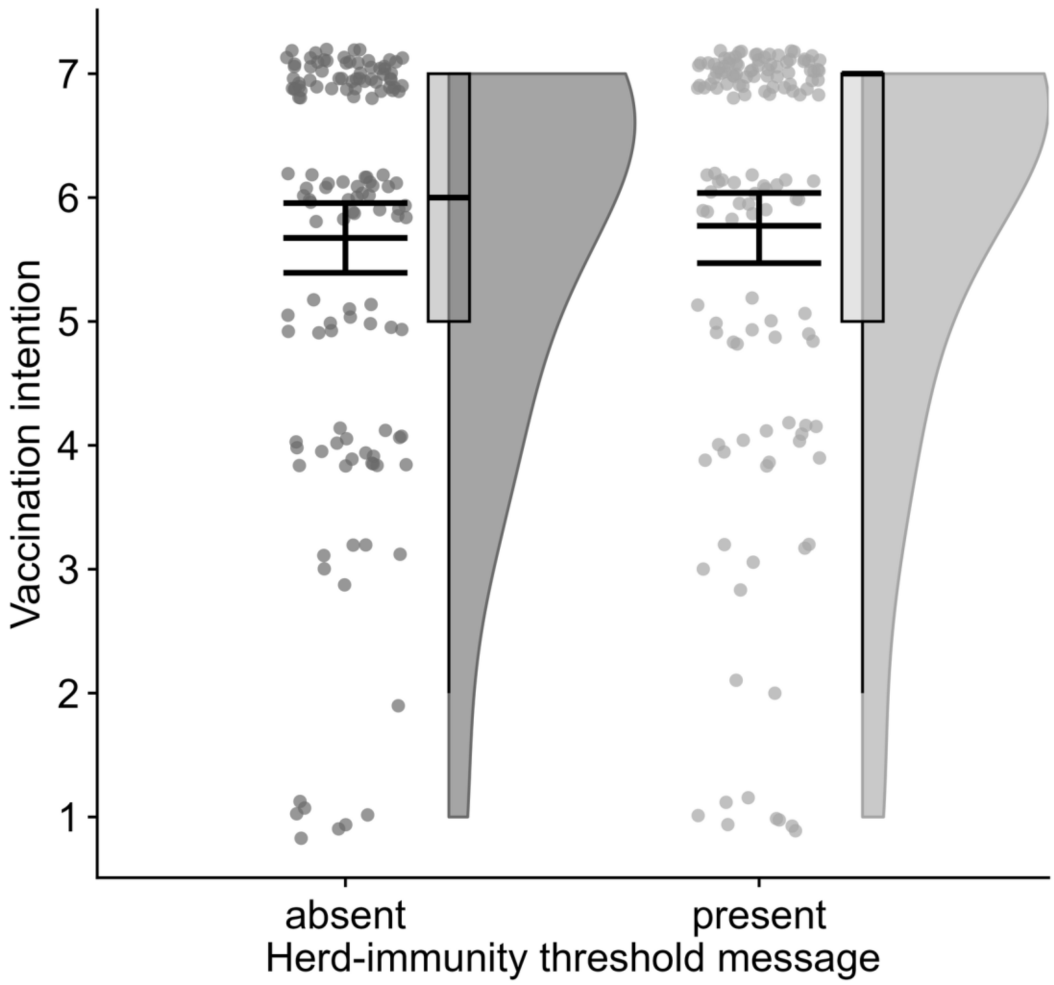


Note. Communicating different descriptive norm messages (no-coverage versus low-coverage [20%] versus high-coverage [80%] message) alongside herd immunity was not effective in increasing vaccination intentions. The figure shows a raincloud plot with the distribution of the data and jittered raw data; the box plot indicates the interquartile range from the 25th to the 75th percentile, including the median; the mean (with 95% confidence interval) is plotted on top of the jittered points.

The presence of the herd-immunity threshold did not influence vaccination intentions, $F(1,267) = 0.22$, $p = .639$, $\eta^2 = 0.001$, not supporting Hypothesis 3 (Figure 4). Intentions of the participants who were informed about the threshold ($M = 5.8$, $SD = 1.8$) were not significantly different from the intentions of the participants who were not informed about it ($M = 5.7$, $SD = 1.7$). This effect did not change after controlling for sociodemographic variables, $F(1,255) = 0.45$, $p = .501$, $\eta^2 = 0.002$.

Figure 4

Vaccination Intentions Depending on Whether the Herd-Immunity Threshold Was Provided



Note. Communicating the herd-immunity threshold alongside herd immunity was not effective in increasing vaccination intentions. The figure shows a raincloud plot with the distribution of the data and jittered raw data; the box plot indicates the interquartile range from the 25th to the 75th percentile, including the median; the mean (with 95% confidence interval) is plotted on top of the jittered points.

Exploratory Analyses

We detected no significant interaction between the descriptive-norm and herd-immunity threshold factors, $F(2,265) = 1.32$, $p = .269$, $\eta^2 = 0.010$. When the threshold information was absent, mean vaccination intentions were 5.7 (*SD* = 1.6), 5.4 (*SD* = 1.8), and 5.8 (*SD* = 1.7) for the no-norm, low-norm, and high-norm level, respectively. When the threshold information was present, mean vaccination intentions were 5.6 (*SD* = 1.8), 6.0 (*SD* = 1.7), and 5.7 (*SD* = 1.8), for the no-norm, low-norm, and high-norm level, respectively.

We detected no significant interaction between vaccine hesitancy and either of the three factors (herd-immunity explanation, $F(1,539) = 0.51$, $p = .476$, $\eta^2 = 0.001$; descriptive norm, $F(2,265) = 1.72$, $p = .181$, $\eta^2 = 0.013$; herd-immunity threshold, $F(1,267) = 0.55$, $p = .460$, $\eta^2 = 0.002$). We thus did not proceed with testing the moderating effect of vaccine hesitancy on the relation between the three factors and vaccination intentions.

Discussion

This Registered Report successfully replicated Betsch et al.'s (2017) finding that communicating the social benefits of herd immunity increases stated vaccination intentions against a fictitious disease, with novel materials – a differently-worded explanation and an animated infographic – and with participants from another country – the UK. Communicating the descriptive norm (low or high vaccination coverage in the country) or the threshold (coverage needed to stop disease transmission) alongside herd immunity demonstrated no observable effect. It is possible that norms and the threshold showed no effect precisely because all participants were familiarized with the concept of herd immunity. Future studies should further disentangle the relation between these three factors.

When it comes to herd immunity, the observed effect size (Partial Eta-Squared = 0.013 or Cohen's $d = 0.23$) was smaller than in previous studies (e.g., Betsch et al., 2017; Betsch & Böhm, 2018). This might be due to the pandemic context in which participants had been living. Firstly, some preventative measures (such as physical distancing or mask wearing) required people to bear a personal cost to benefit others or society as a whole (for a review, see Capraro et al., forthcoming). This might have caused participants to have a generally stronger focus on social benefits, which might have consequently reduced the observed herd-immunity effect. Secondly, in March 2020, herd immunity briefly came to be seen as the UK government's strategy to respond to COVID-19, attracting heavy criticism and public backlash. The confusion stemmed from interviews in which government advisers appeared to suggest that one way to manage the epidemic would be to naturally reach herd immunity by aiming for 60 percent of the population to fall ill (e.g., Freedman, 2020; Sasse et al., 2020; Yong, 2020). Although our study materials mentioned the term 'community immunity' only, explaining that it was generated through vaccination (not infection), some participants might have misinterpreted the materials or felt repelled by them due to confusing public messaging earlier that year.

In the context of the COVID-19 pandemic, some recent self-reported online surveys pointed to the usefulness of social-benefit messaging in promoting vaccine acceptance (in France, Schwarzinger et al., 2021; in the UK, Pfattheicher et al., in press). However, data from a representative UK sample did not corroborate these findings (Freeman et al., 2021). In this study, message type had no effect for people willing to be vaccinated and people who were doubtful. However, highlighting *individual* benefits increased vaccination intentions in people who were strongly hesitant, more than highlighting collective benefits of not getting ill and not transmitting the virus. This study also provided preliminary findings suggesting that ethnicity might moderate the impact of different messages on COVID-19 vaccine hesitancy (Freeman et al., 2021). The effectiveness of herd-immunity appeals is also likely contingent on the scientific consensus on whether COVID-19 vaccines provide herd immunity in the first place and on people's knowledge on this issue (Korn et al., 2021).

More research is also needed to uncover how best to apply existing theories on descriptive-norm communication and collective-goal setting. Future studies could focus on testing more realistic interventions of using normative messages with factual information about others' vaccine intentions or behaviours that correct people's underestimation of how many other people accept a vaccine (see, for example, Moehring et al., 2021).

The effect of communicating the herd-immunity threshold at different levels of vaccination coverage should be further explored in studies adequately powered to detect a potential interaction effect. One question of practical relevance would be whether public communication should highlight the threshold value when the coverage is very close or very far from reaching it. In the context of collective goals, some studies suggest that people would be more likely to contribute as a goal nears completion, in part because this provides them with a heightened sense that their action will have an impact (e.g., Cryder et al., 2013; Moussaoui & Desrichard, 2017; see also Anik & Norton, 2020).

The main limitation of the present study was that the sample was not representative of the UK population. The results, therefore, cannot be presumed to generalise to the whole population. In particular, most of the participants were highly educated and reported, on average, low vaccine hesitancy. Another limitation is that ethnicity was not recorded. It is possible that people who are strongly hesitant or come from subgroups with low vaccination acceptance would react less favourably to social-benefit messaging (e.g., Freeman et al., 2021). To develop more tailored, culturally sensitive communication strategies, future studies should explore intersections of social categories and issues that make people more likely to refuse vaccination (Independent Scientific Advisory Group for Emergencies, 2021).

This study explored three intervention strategies that leverage social processes to motivate vaccination – herd immunity, the herd-immunity threshold, and descriptive norms – with a sample of non-senior adults residing in the UK. We conceptually replicated a previous finding that communicating the social benefit of herd immunity increases stated vaccination intentions. To provide further empirical guidance for effective and scalable communication strategies that rely on social nudges, it might be useful to replicate this study design with real-world vaccine-preventable diseases; to conduct the studies in other countries and with samples that are representative of the population (also with respect to vaccine hesitancy); and to assess the long-term effects of providing people with information about herd behaviour.

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Appendix S1

Herd Immunity Explanation

What Is Community Immunity?

Getting vaccinated protects us in two ways. It protects the individual against an infectious disease. Not only does the vaccine stop the individual from catching the disease, it also means that they can't pass it on to other people in their community. So, vaccines don't only protect you but also those around you.

Germs can spread quickly through communities and make a lot of people sick. However, as more people get vaccinated, it is harder for the disease to spread. When a high enough number of people in the community are vaccinated, the disease can be wiped out altogether.

Who Does Community Immunity Protect?

Community immunity protects everyone but it's especially important for individuals who are more vulnerable to infectious diseases.

When you get vaccinated, you protect people who can't get vaccinated - such as newborn babies, older people, and people with weak immune systems (like people who have cancer, HIV/AIDS, type 1 diabetes, or other health conditions).

These people rely on community immunity to protect them. So, even if you don't feel personally at risk from a disease, getting yourself vaccinated benefits others in your family and your community.

Getting vaccinated protects you and those around you.

Chapter 4

Paper 3 | Should Public Communication of Vaccination Rates Assume Rationality, Normativity or Reasonableness? Insights From Three Preregistered Experiments

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Should Public Communication of Vaccination Rates Assume Rationality, Normativity or Reasonableness? Insights From Three Preregistered Experiments

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Data Availability Statement: The data that support the findings of this study are openly available in Open Science Framework at https://osf.io/2wy9q/.

Abstract

The proportion of the population who are vaccinated against an infectious disease is significant – not only because vaccination keeps the virus from spreading, but also because learning about how many members of one's community have decided to get vaccinated has been shown to affect individual vaccination intention. In three preregistered online experiments featuring country-level vaccination rates against a hypothetical disease, we tested two theoretical approaches which offer contrasting predictions on how public health messaging should leverage vaccination rates. If selfish rationality is assumed, a high uptake would tempt people to free-ride on herd immunity (so low uptake should be emphasized); conversely, if vaccination rates exert a descriptive normative influence, a high uptake would signal that vaccination is the best choice, and vice versa (so high uptake should be emphasized). In the pilot (N = 75) and Experiment 1 (N = 174), communicating a high (90%) vaccination rate (vs. 10% vs. no rate) increased vaccination intentions, with no detectable effect of a low vaccination rate. In Experiment 2 (N = 217), decisions to get vaccinated were frequently justified based on reasons involving self-protection, but also the protection of others and the collective, irrespective of the vaccination rate level (20% vs. 80%); participants, on the other hand, rarely endorsed any of the tested reasons for non-vaccination, including free-riding; furthermore, descriptive norms were perceived as more relevant for vaccination than non-vaccination decisions. Experiment 3 (N = 1,060) tested the effectiveness of different messages when the majority have been vaccinated (60%) but the coverage is still not optimal. Alongside a weak descriptive norm, the self-benefit message worked better than other- and collective-benefit messages. We argue that public health messaging should incorporate both theoretical approaches, closer to the notion of reasonableness (rather than pure rationality or normativity), which is context-sensitive and pragmatic.

Keywords: descriptive social norms, free riding, immunization, vaccine advocacy

Should Public Communication of Vaccination Rates Assume Rationality, Normativity or Reasonableness? Insights From Three Preregistered Experiments

Introduction

Vaccination rates, representing the proportion of a population that received a particular vaccine, are an inevitable part of public health communication, especially during crises such as outbreaks of infectious diseases or pandemics. In addition to having an apparent informational purpose, they seem to be often used with the intention to help encourage more people to get vaccinated, especially by the news media (Lazić & Žeželj, 2022; Leask & Chapman, 2002). Lamenting low vaccination rates has been identified as a part of pro-vaccine rhetoric in Australia's newspapers (Leask & Chapman, 2002). Similarly, during the measles outbreak in Serbia, online news media predominantly framed vaccination rates in a negative light (e.g., "the coverage is very low, almost 40% of children haven't received the vaccine", "only 50% vaccinated") (Lazić & Žeželj, 2022).

From society's perspective, it is desirable that as many people as possible get vaccinated as that slows down the spread of disease, which benefits everyone, especially those who are more vulnerable and cannot get vaccinated. This effect is called herd immunity (Fine et al., 2011). The term is also often used in reference to a critical threshold percentage of immune individuals (Fine, et al., 2011). For example, the threshold for measles is typically set at a minimum of 95% (e.g., Nokes & Anderson, 1988). The herd immunity threshold is often thought of as a target that, once attained, will always result in disease elimination (Fine, et al., 2011; Robertson et al., 2024); this view was, for example, promoted early in the COVID-19 pandemic (Robertson et al., 2024). However, from the public health perspective, this understanding is overly simplistic. It overlooks factors such as non-random interaction between people, varying transmission rates across communities, imperfect vaccine protection, differences in individual infection risk, waning immunity, reinfection, and evolving pathogens (McDermott, 2021; Robertson et al., 2024). Therefore, the herd immunity threshold is better thought of as a proportion of the people in a community who need to be immune for the rate of new infections to slow down significantly (McDermott, 2021).

That said, it is crucial to understand which types of messages communicating vaccination rates, and under what conditions, are most likely to elicit the desired public response. Is the strategy of drawing people's attention to those who have decided not to get vaccinated by highlighting low vaccination rates, often employed by the news media, truly effective? Two theoretical approaches offer diverging answers to this question.

Two Approaches to Public Communication of Vaccination Rates

Selfish-Rational Approach

One approach frames vaccination as a social dilemma (Van Lange et al., 2014): while vaccination benefits both the individual and the community, it can prove costly for someone to get vaccinated. Out of rational selfishness, individuals would be less likely to get vaccinated, the more people in their community are vaccinated. This is because, due to the effect of herd immunity (Fine et al., 2011), a higher vaccination rate lowers their risk of catching the disease. Individuals are incentivized to become a free-rider who indirectly benefits from the vaccination of others while avoiding certain personal costs, such as money, time, inconvenience or vaccine adverse events [VAEs] (Bauch & Earn, 2004). The selfish-rational approach has found support in studies using interactive games (Böhm et al., 2016; Ibuka et al., 2014; Korn et al., 2017) and hypothetical scenarios (Betsch et al., 2017; Vietri et al, 2011).

Descriptive Social Norms Approach

Social norms are "rules or standards that are understood by members of a group, and that guide and/or constrain social behavior without the force of laws" (Cialdini & Trost, 1998, p. 152). The Focus Theory of Normative Conduct (e.g., Cialdini et al., 1990; Cialdini et al., 2006) distinguishes between two types of social norms – descriptive (what behaviors are common or uncommon) and injunctive (what behaviors are commonly approved or disapproved of) – and assumes that norms influence behavior directly only when they are made salient or focused upon. A similar distinction can be found in Bicchieri and colleagues' work (e.g., Bicchieri & Xiao, 2009), which differentiates between empirical expectations (i.e., the belief that most people will follow the norm) and normative expectations (i.e., the belief that others think one ought to conform to the norm).

As they present summary information about the behavior of a reference group, vaccination rates may be the most straightforward way of shaping the perceived descriptive norm around vaccination (Tankard & Paluck, 2016), provided that vaccination is seen as predominantly voluntary and not driven by mandates or coercion. As such, they are theorized to motivated behavior by providing evidence about what would likely be an effective and adaptive course of action in a given situation, serving as a kind of a decision-making shortcut (Cialdini et al., 1990). It follows that a high vaccination rate would trigger a descriptive norm motivating individuals to get vaccinated, and vice versa (a low vaccination would discourage vaccination). This prediction contrasts with the selfish rational approach.

While correlational studies tend to link perceptions of peer's behavior to stated vaccination intentions (e.g., Allen et al., 2009; Graupensperger et al., 2021), results from experimental studies are mixed. When knowing that the majority of their peers are vaccinated, compared to when most peers are not, participants are more willing to get vaccinated too (Belle & Cantarelli, 2021; Hershey et al., 1994; Lyu et al., 2024; Romley et al., 2016; Ryoo & Kim, 2021); however, this was not replicated in some experiments (Clayton et al., 2021; Sinclair & Agerström, 2021; Xiao & Borah, 2020). There is some indication that descriptive norms work better when they invite people to work together toward a common goal (e.g., "Do it together", "Join in!") by helping mitigate reactance that can be provoked by social influence; this was, however, so far only studied on charitable giving and pro-environmental behavior (Howe et al., 2021).

Thus, according to the selfish-rational approach, public communication of high vaccination rates can be detrimental as it tempts people to free-ride on herd immunity and refuse vaccination (e.g., Betsch et al., 2017). However, if public communication is more focused on low vaccination rates, this can activate a powerful descriptive norm – "many people are not getting vaccinated" – unintendedly promoting non-vaccination as the right thing to do (Cialdini et al., 2006). Therefore, the descriptive norms approach would recommend that public messaging should focus on high vaccination rates.

Mitigation of the Effect of Vaccination Rates

While public communication can refrain from biased portrayal of vaccination rates (e.g., framing them negatively even though they are above 50%, Lazić & Žeželj, 2022), their concrete values, be they low or high, cannot be hidden from the public. Previous studies have, therefore, tested if the supposed negative effect of vaccination rates can be mitigated. The most consistent finding seems to be that explaining the concept of herd immunity increases vaccination intentions (e.g., Betsch et al., 2017; Lazić et al., 2021; Logan et al., 2018; Pfattheicher et al., 2022), especially when social benefits (protecting others) are emphasized. This could be because such messaging activates people's prosocial or altruistic tendencies (e.g., Betsch et al., 2013; Böhm et al., 2016; Chapman et al., 2012; Vietri et al, 2011). Some studies pointed to the usefulness of communicating only social (e.g., Schwarzinger et al., 2021; Zhu et al., 2022) or both social and individual benefits at the same time (Mussio & de Oliveira, 2022). However, this effect might be dependent on the vaccination rate and vaccine hesitancy levels. For example, highlighting social benefits alongside herd immunity was beneficial when uptake was high, while highlighting individual benefits was beneficial when uptake was low (Betsch et al., 2017). In one study, message type had no effect for pro-vaccination individuals and only emphasizing individual benefits managed to increase vaccination intentions in people who were strongly hesitant (Freeman et al., 2021).

Reasons for (non-)vaccination

Interventions to increase vaccination depend on understanding people's motives for vaccination and non-vaccination, though, to our knowledge, there have thus far been no studies investigating this under varying levels of vaccination rates. A review by Yaqub et al. (2014) found that healthcare professionals' advice, advice from friends and family, and self-protection were among the most cited reasons for vaccination in previous literature, while safety concerns and perceived low risk of catching the disease were among the most cited reasons for non-vaccination. In the study by Attari et al. (2014), main self-reported reasons for vaccination against flu were self-protection, protection of one's family, and avoiding spreading the disease to others, while main reasons for non-vaccination were perceived invulnerability to illness and mistrust in vaccine effectiveness. In addition to confidence (trust in the effectiveness and safety of vaccines), complacency (low perceived risks of diseases), and collective responsibility (protecting others), studies relying on the 5C model also related constraints (structural or psychological barriers in daily life) and calculation (weighing personal costs and benefits) to vaccine uptake (e.g., Betsch et al., 2018).

Overview of Studies

Three preregistered experiments investigated communication of vaccination rates. Experiment 1 examined how communicating a low vs. high country vaccination rate affects intention to get vaccinated by testing diverging hypotheses derived from two theoretical approaches, contrasting rationality versus normativity. Experiment 2 was designed to better understand the reasons people give for getting or not getting vaccinated as well as whether those reasons differ under low vs. high country vaccination rate and whether they correspond to the reasons stemming from the two theoretical approaches. Informed by previous experiments, Experiment 3 tested the effectiveness of interventions when the majority (60%) of the country have been vaccinated, which is, nonetheless, usually not enough to reach the herd immunity threshold.

The experiments are comparable in that they were conducted with samples of Serbian participants, who were presented with the same disease and vaccination fact sheet and asked to rate their vaccination intention (main outcome) in the same way. In addition to comprehensively testing two influential theoretical approaches in the context of vaccination-rate communication and identifying important directions for future research and practice, this work contributes to the field by studying a country that has been underrepresented in health communication research (Kim et al., 2010).

Open Data

Datasets and questionnaires for all studies are openly available at https://osf.io/2wy9q/. Analyses were performed using R version 4.4.0 (R Core Team, 2023); code and the citations of used R packages are openly available at https://osf.io/2wy9q/.

Experiment 1

Using a one-factor repeated measures design, Experiment 1 compared three types of messages to improve vaccination intention: a baseline with no information on the vaccination rate and two experimental messages featuring low (10%) vs. high (90%) country-level vaccination rate. We opted for a within-subjects design because, in addition to being able to control for a variety of individual-level differences, this setting is arguably more externally valid compared to a between-subjects design: in real life, vaccination rate information is dynamic and an individual would likely be exposed to varying levels of vaccination rates against the same disease.

Hypotheses

Relying on the selfish-rational approach described above, we hypothesized that learning about a high vaccination rate will *decrease* vaccination intention, compared to when a low vaccination rate is communicated (**H1a**) as well as compared to the baseline, when no vaccination-rate information is provided (**H2a**). Based on this approach, on the other hand, learning about a low vaccination rate should, compared to the baseline, *increase* vaccination intention (**H3a**).

Relying on the descriptive norms approach described above, we hypothesized that learning about a high vaccination rate will *increase* vaccination intention, compared to when a low vaccination rate is communicated (**H1b**) as well as compared to the baseline, when no vaccination-rate information is provided (**H2b**). Based on this approach, on the other hand, learning about a low vaccination rate should, compared to the baseline, *decrease* vaccination intention (**H3b**).

Method

Preregistration

This study was preregistered at https://aspredicted.org/cfv2-kg7w.pdf. To develop the materials and ensure the appropriateness of the measures, we conducted a pilot experiment (N = 75); a detailed report on its methods and results is available at https://osf.io/2wy9q/.

Power Analysis

An *a priori* repeated measures ANOVA power analysis with a minimum overall effect size of f = 0.3 (estimated based on the overall effect obtained in the pilot of partial Omega-squared = 0.11), 95% power, and the .05 alpha error probability, revealed a target sample size of N = 174.

Data Quality and Exclusion

There were two attention-check questions, asking participants to choose a specific response option. Participants who failed both attention checks were excluded from the analyses.

Participants

Out of 191 participants who completed the survey, 17 (8.9%) were excluded due to failed attention checks. The remaining *N* = 174 participants (131 female), all Serbian residents, were aged 18–73 (*M* = 36.3, *SD* = 11). Recruitment was done through advertisements on social media in April 2021. At the time of data collection, mass vaccinations against COVID-19 in Serbia had been going on for three months ("Vaccination against COVID-19", n.d.).

Materials and Procedure

After informed consent, an online survey first assessed age, sex, and country of residence. Next, participants read a disease and vaccination fact sheet and were asked to imagine themselves in a scenario in which they have to decide whether or not to get vaccinated against the fictitious disease. Participants then rated their intention to get vaccinated three times, following the presentation of different vaccination-rate messages. Lastly, perceived relative severity of the disease and VAEs, disease concern, and general attitude towards vaccination were assessed.

Disease and vaccination fact sheet. The fact sheet presented a fictitious contagious disease called Hebdo fever and the vaccine against it. Fictitious materials were chosen because they exclude potential confounding variables, such as real infections and VAEs experienced or observed by the participant, and allow unconstrained manipulation of the vaccination-rate levels.

The sheet informed about the path of infection (via droplets or particles in the air) and described the vaccine as being recently developed, tested, with an efficacy of 100%, and easily available at no out-of-pocket cost. Following Connolly and Reb (2003), the symptoms of the disease and VAEs were described as equally likely (appearing "in a small number of cases") and very similar in content, to assure equal perceived riskiness. We expressed probabilities qualitatively rather than quantitatively as such a setting is arguably more externally valid. Most decisions in everyday life are based on values that are imprecise or qualitative (Shiffrin, 2021), and the same is true for real-life public communication surrounding vaccination.

The combinations of symptoms had been pretested in a battery of 62 symptoms, with a convenience sample of *N* = 39, and assembled in a way that assured equal perceived severity. A detailed description of the pretest procedures and results is available at https://osf.io/2wy9q/. The fact sheet was shown as a screenshot of a simulated web page on the Institute of Public Health of Serbia website. To prevent participants from skipping it, the continue button was disabled for a specified minimum amount of time.

Message Manipulation and Outcome Measure. All participants first received no information on vaccination rate in their country; all of them then went through both of the remaining two conditions in a counterbalanced order, in which they learned about a low (10%) and high (90%) vaccination rate. They were warned that they might be presented with a different value of the vaccination rate than before. The rates were presented both as a number out of 10 and a percentage, to ease comprehension (e.g., "Currently, one out of ten (10% of) citizens of Serbia have gotten vaccinated"). The Institute of Public Health of Serbia was named as the source of this information. We decided to present country-level rates to avoid introducing variability in how participants define some less specific terms used in previous studies (such as "community", "population" or "society"); furthermore, country-level vaccination rates are often featured in media and public health messages (e.g., Lazić & Žeželj, 2022).

In all three conditions, participants reported their intention to get vaccinated. Participants were informed that, roughly six months before, first cases of the disease were reported in the country and that the vaccination is ongoing. They then assessed their vaccination intention ("You have the opportunity to get vaccinated against Hebdo fever. What will you do?") on a slider ranging from 0 = *I will definitely not get vaccinated* to 100 = *I will definitely get vaccinated* (later transformed into a 1–101 scale), in increments of 1%.

Other Measures

Perceived relative severity. To check whether the symptoms of the disease and VAEs were perceived as equally severe, participants were asked the following questions: "From what you have read, how do the disease symptoms and vaccine side-effects compare in terms of overall seriousness?" (1 = *The symptoms of Hebdo fever are more serious than the vaccine side-effects*, 2 = *The symptoms of Hebdo fever and the vaccine side-effects are equally serious*, 3= *The vaccine side-effects are more serious than the symptoms of Hebdo fever*) (adapted from Connolly & Reb, 2003); the options appeared in randomized order.

Disease concern. Participants were asked about their degree of concern that they or their families would get sick from the disease ("How worried would you be, if at all, that you or someone in your family will get sick from Hebdo fever?", 1 = *not at all worried*, 2 = *not too worried*, 3 = *somewhat worried*, 4 = *very worried*).

General attitude towards vaccination. This was assessed on a slider ranging from 0 = *absolutely against vaccinations* to 100 = *absolutely in favor of vaccinations* (later transformed into a 1–101 scale), in increments of 1%.

Results and Discussion

Primary analyses were done using a repeated-measures, within-subjects ANOVA, with post-hoc contrast TukeyHSD tests. In addition to the partial Eta-squared (η_p^2), partial Omega-squared (ω_p^2) was computed based on the F-statistic (Albers & Lakens, 2018, p. 194) to provide a less biased effect size estimator.

Hypotheses Testing

Means and standard deviations of the outcome measure across experimental conditions, as well as correlations between the measures, are reported in Table 1. There was an overall significant effect of the vaccination-rate message, $F(2, 346) = 25.59$, $p < .001$ ($\eta_p^2 = 0.13$; $\omega_p^2 = 0.12$) (Figure 1).

Table 1

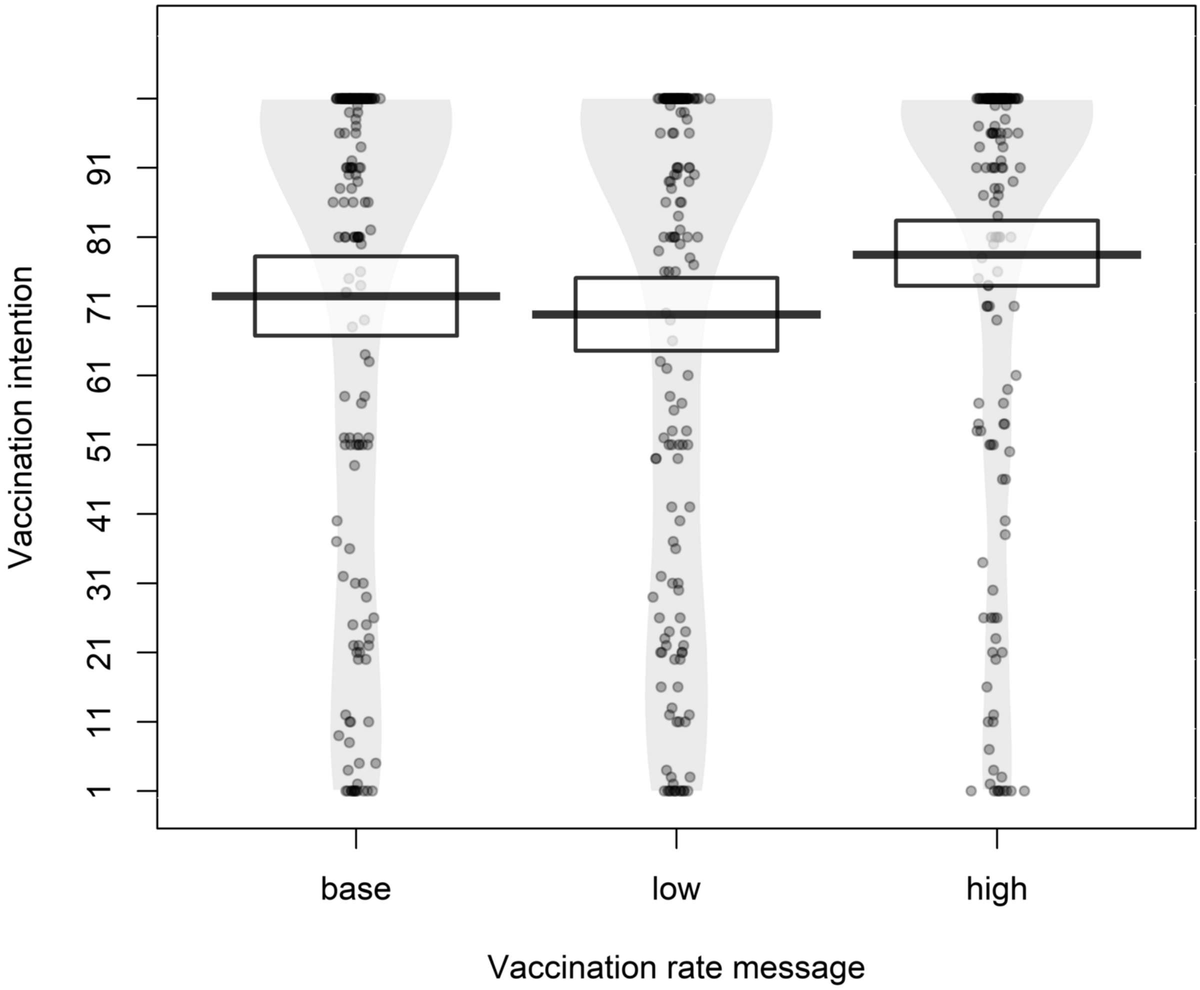
Condition Means and Standard Deviations, With Correlations Among Outcome Measures

Experimental condition	Mean	Standard Deviation	Range	Correlation between measures (Pearson's r)		
				Baseline (no rate)	Low rate (10%)	High rate (90%)
Baseline (no rate)	72.4	35.4	1–101	—		
Low rate (10%)	69.8	36.2	1–101	0.94	—	
High rate (90%)	78.5	32.6	1–101	0.90	0.84	—

Learning about a high vaccination rate significantly increased vaccination intentions, both compared to learning about a low rate (estimate = 8.63, SE = 1.24, $p < .001$, 95% CI [5.73, 11.53]) and to receiving no vaccination-rate information (estimate = 6.01, SE = 1.24, $p < .001$, 95% CI [3.11, 8.91]), supporting H1b and H2b derived from the descriptive norms approach, respectively. On the other hand, communicating a low vaccination rate did not significantly affect baseline vaccination intentions (estimate = −2.62, SE = 1.24, p = 0.086, 95% CI [−5.52, 0.28]), not supporting H3b. Contrastingly, the results indicated no support for any of the hypotheses derived from the selfish-rational model (H1a, H2a, H3a). This pattern of results fully replicated the findings previously observed in the pilot.

Figure 1

Vaccination Intentions Depending on the Vaccination-Rate Message



Note. Mean vaccination intention in each experimental condition (no-rate vs. low-coverage [10%] vs. high-coverage [90%] message). The plot shows the full distribution of the data and jittered raw data. Horizontal bars represent means; boxes represent 95% confidence intervals.

Additional Descriptive Analyses

While 33.9% of the participants thought that the disease symptoms and VAEs were equally severe, 56.3% rated disease symptoms and 9.8% rated VAEs as more severe; our attempt to make the disease and the VAEs seem equally severe was, thus, only partially successful. Most participants were somewhat (49.4%) or very (23%) worried about the fictional disease; the rest were not too (22.4%) or not at all (5.2%) worried about it. On average, participants reported a highly positive vaccination attitude (M = 91, SD = 19.2, range 3–101).

Experiment 2

Experiment 1 found partial support for the descriptive norms approach and no support for the selfish-rational approach. However, this does not imply that participants would justify their vaccination choices by relying (solely) on descriptive norms or that they would not justify them by using notions stemming from the selfish-rational approach, such as free-riding. Therefore, in Experiment 2, we explored the reasons people endorse for getting or not getting vaccinated under a low and high vaccination rate. Apart from further testing of the two approaches, this experiment would inform the succeeding design of message interventions.

We chose to restrict the sample to younger people (below the age of 35), since that group seemed to be most polarized regarding vaccination. According to a 2021 representative survey in Serbia, the lowest proportion of vaccinated individuals and the highest proportion of those decidedly refusing to get vaccinated against COVID-19 was in the 18–39 age cohort (Žeželj et al., 2021, p. 9). This was done to reach the sufficient number of participants deciding against vaccination under both the low and high vaccination rate more efficiently and because a sample that is more diverse in vaccination attitudes allows us to better gauge people's reasons for (non-)vaccination.

Unlike Experiment 1, this experiment used a between-subjects design. We decided against repeated measures because requiring participants to describe their personal reasons and exposing them to different types of motivations for (non-)vaccination in one condition might influence their responses in the next one. Furthermore, while Experiment 1 one featured vaccination rates of 10% and 90%, here we chose to change them to 20% and 80% because reflecting on an extremely high vaccination rate might affect participants' endorsement of different reasons as it could be perceived as neither selfish rational or collectively optimal ("if the uptake is that high, the disease could have been already eliminated").

Method

Preregistration

This study was preregistered at https://aspredicted.org/46p2-crq5.pdf. Open-ended reasons for (non-)vaccination will be reported in a separate publication.

Data Quality and Exclusion

Participants who provided poor-quality responses to an open-ended question asking them to describe their main reason for (non-)vaccination against the fictitious disease were excluded from the analyses. Signs that suggested poor quality included gibberish, nonsensical, and inconsistent responses (e.g., justifying non-vaccination when asked about vaccination).

Participants

Out of 229 participants who completed the survey, 12 (5.2%) were excluded due to poor-quality responses to the open-ended question. A total of N = 217 participants (157 female), all Serbian residents, aged 18–35 (M = 26.7, SD = 4.8), remained. The majority of them (71%) had some higher education experience, 23.5% finished only high school, and the rest had less education. Recruitment was done through advertisements on social media in April–May 2022.

Materials and Procedure

After informed consent, an online survey first assessed age, sex, education, and country of residence. Participants then read the same fictitious disease and vaccination fact sheet that was administered in Experiment 1. Next, participants were randomly assigned to learn either about a low (20%) or a high (80%) vaccination rate in their country (the presentation followed the same wording as in Experiment 1), after which they assessed their vaccination intention on the same 0–100% slider used in Experiment 1. Immediately afterwards, participants were also asked to select an option which best describes their choice (1 = *Yes, I will definitely get vaccinated*, 2 = *Yes, I will probably get vaccinated*, 3 = *No, I will probably not get vaccinated*, 4 = *No, I will definitely not get vaccinated*). Depending on whether they reported they would definitely/probably get vaccinated or that they would definitely/probably not get vaccinated, participants were divided into two groups – vaccinators and non-vaccinators. An open-ended question asked (non-)vaccinators to describe their main reason for (non-)vaccination.

Vaccinators were then shown a closed-ended list of nine possible reasons for vaccination, while non-vaccinators were shown a closed-ended list of nine possible reasons for non-vaccination. They were asked to indicate how closely each reason matches their personal reasons on a 4-point scale (1 = *Completely describes my reasons*, 2 = *Mostly describes my reasons*, 3 = *Mostly does not describe my reasons*, 4 = *Does not describe my reasons at all*).

Formulation of reasons for (non-)vaccination. We formulated the reasons to reflect seven different motivations for (non-)vaccination (see Table 2 and Table 3 for the complete wording of the questions). "Relying on others" refers to how free-riding is incentivized/disincentivized when the vaccination rate is high/low and assumes that people take personal risk of infection into account (Bauch & Earn, 2004); this motivation is directly rooted in the selfish-rational approach. "Calculation" can also be seen as stemming from this approach as it similarly assumes that people engage in complex calculations; we operationalized it as weighing personal benefits against risks of vaccination (Betsch et al., 2018). "Descriptive norm" is directly based on how these norms are defined in the Focus Theory of Normative Conduct (Cialdini et al., 1990). We included another proxy for descriptive norms – "wisdom of others" – inspired by the concept of the trust in the wisdom of the common man (Žeželj et al., 2023). "Individual benefit" and "social benefit" reasons were included to reflect the belief that vaccination is (un)necessary to protect one's health and the health of others. Like "social benefit", "collective benefit" also reflects altruistic motivations but is focused on believing that vaccination is (or is not) a collective effort to stop the disease from spreading via herd immunity (Betsch et al., 2018). The reasons eliciting "relying on others" and "descriptive norm" motives were provided in a weak (e.g., "some people") and strong versions (e.g., "few/most people") to better correspond to varying vaccination rate levels.

Results

Out of 106 participants in the low vaccination rate condition, 38 were categorized as vaccinators and 68 as non-vaccinators; mean vaccination intention was 41.7 (*SD* = 36.1, range 1–101). Out of 111 participants in the high vaccination rate condition, 49 were categorized as vaccinators and 62 as non-vaccinators; mean vaccination intention was 43.0 (*SD* = 39.6, range 1–101). Therefore, the intended polarization of the sample regarding vaccinations was achieved.

Endorsement of Reasons for (Non-)Vaccination

Tables 2 and 3 show the percentage of participants endorsing each of the listed reasons for vaccination and non-vaccination, respectively, across low and high vaccination rate conditions. "Endorsement" indicates that the participant reported the reason "completely" or "mostly" corresponded to their own personal ones. These options were collapsed to ease interpretation; the descriptive statistics for all four original options are available at https://osf.io/2wy9q/.

Three reasons stood out as most frequently endorsed among the vaccinators: viewing vaccination as necessary to protect oneself and others and as a collective task to stop the disease. Personal benefits outweighing risks was also a highly common reason for vaccination.

Around a half of vaccinators tended to agree they cannot rely on others for personal protection and that the behavior of the majority (descriptive norm) was relevant for them. Around a half of vaccinators also reported they trusted the wisdom of the common man, and this was the only reason where there appeared to be a noticeable difference between low and high vaccination rate conditions (23.7% vs. 59.2%).

In general, non-vaccinators tended to endorse fewer reasons than vaccinators did. However, three reasons were endorsed by the majority of non-vaccinators: personal risks outweighing benefits, believing vaccination is not necessary to protect oneself, followed by believing that vaccination is not a collective effort. All other reasons were rarely endorsed, including free-riding (reliance on others) and descriptive norms.

Table 2

Percentage of Participants Endorsing Each of the Reasons for Vaccination

Reason for vaccination	Low vaccination rate (20%)	High vaccination rate (80%)
	Vaccinators	
	n = 38	*n* = 49
Relying on others (weak) Others got vaccinated but that is not enough to protect me from infection, so I should get vaccinated	57.9%	69.4%
Relying on others (strong) Few people got vaccinated and that is not enough to protect me from infection, so I should get vaccinated	44.7%	49%
Calculation Personally, I gain more than I risk if I get vaccinated	86.8%	83.7%
Descriptive norm (weak) Some people got vaccinated so I conclude that vaccination is the right decision for me as well	42.1%	55.1%
Descriptive norm (strong) Most people got vaccinated so I conclude that vaccination is the right decision for me as well	39.5%	53.1%
Wisdom of others People know what they are doing if that number of them have decided to get vaccinated	23.7%	59.2%
Individual benefit I need to get vaccinated to protect my health	97.4%	100%
Social benefit I need to get vaccinated to protect the health of the people around me	86.8%	93.9%
Collective benefit I see vaccination as a collective task against the spread of the disease	89.5%	91.8%

Table 3

Percentage of Participants Endorsing Each of the Reasons for Non-Vaccination

Reason for non-vaccination	Low vaccination rate (20%)	High vaccination rate (80%)
	Non-Vaccinators	
	n = 68	*n* = 62
Relying on others (weak) Others got vaccinated and that is enough to protect me from infection, so I do not have to get vaccinated	22.1%	19.4%
Relying on others (strong) A lot of people got vaccinated and that is enough to protect me from infection, so I do not have to get vaccinated	19.1%	16.1%
Calculation Personally, I risk more than I gain if I get vaccinated	72.1%	72.6%
Descriptive norm (weak) Some people did not get vaccinated so I conclude that vaccination is not the right decision for me as well	20.6%	12.9%
Descriptive norm (strong) Most people did not get vaccinated so I conclude that vaccination is not the right decision for me as well	27.9%	12.9%
Wisdom of others People know what they are doing if that number of them have decided to not get vaccinated	33.8%	27.4%
Individual benefit I do not need to get vaccinated to protect my health	63.2%	58.1%
Social benefit I do not need to get vaccinated to protect the health of the people around me	39.7%	32.3%
Collective benefit I do not see vaccination as some collective task against the spread of the disease	47.1%	53.2%

Discussion

The results suggest that at least some vaccinators take personal risk of infection into account and that most of them engage in cost-benefit calculations. Even though they were similarly calculating and saw vaccination as costly, non-vaccinators did not endorse free-riding, at either low or high vaccination rate. Though it was initially assumed that calculation encourages non-vaccination (Betsch et al., 2018), this was not always replicated (e.g., Schindler et al., 2020), in line with the present findings. Low endorsement of free-riding among non-vaccinators was also found by Attari and colleagues (2014). As pointed out by these authors, this could reflect social desirability motives and motivated cognition (desire to retain a prosocial self-image), but it could also happen out of ignorance (i.e., not understanding how one benefits from others' vaccination) (Attari et al., 2014). Not endorsing free-riding might also reflect general vaccination mistrust as well as belief that vaccination is unnecessary to protect one's health. In fact, in the present study, more than half of participants agreed they do not need vaccination to protect their health. Descriptive norms (including the "wisdom of the common man" formulation) were more frequently endorsed as a reason for vaccination than non-vaccination, which might explain why low vaccination rates in Experiment 1 did not lower vaccination intention, even though this was hypothesized by the descriptive norms approach.

Experiment 3

Experiment 1 found that communicating a high vaccination rate of 90% increases people's vaccination intention. In Experiment 3, we investigated if and how it was possible to leverage this positive descriptive social norm when the country-level vaccination rate is 60%. This is when, from the public policy perspective, motivating more people to get vaccinated is crucial: while the majority of the population have been vaccinated, this is usually not enough to reach the herd immunity threshold. At that point, vaccination uptake is also likely to stall. For example, many European countries appear to have reached their ceiling on COVID-19 vaccinations at around 60% of vaccinated adults. Roughly a year following the start of COVID-19 vaccination, the percentage of people who were fully vaccinated was 61% across Europe, and 47% in Serbia (December 31, 2021); six months later, vaccination rate remained at similar levels, 65% and 48%, respectively (July 23, 2022) (Mathieu et al., 2021).

Experiment 3 used a 2 (intervention: absent vs. present) x 4 (intervention message: only the 60% norm vs. "protect your health" appeal alongside the norm vs. "protect others' health" appeal alongside the norm vs. "join-in" appeal alongside the norm) mixed design, with repeated measures on the first factor. The three intervention appeals were chosen to reflect the top three reasons for vaccination observed in Experiment 2: individual, social, and collective benefit, respectively. Furthermore, individual benefit and prosocial messaging was found to be effective in some previous studies (e.g. Betsch et al., 2017, Pfattheicher et al., 2022), while one multi-country investigation identified prosociality as a determinant of COVID-19 vaccination (Enea et al., 2022). The "join-in" appeal, reflecting collective benefit, contained the invitation to join the others in stopping the disease; following the work of Howe et al., 2021, this was supposed to make the norm more motivating.

Hypotheses

We hypothesized that, compared to baseline, communicating only the descriptive norm (i.e., the vaccination rate) will increase vaccination intention (**H1**). We also hypothesized that when "protect your health" (**H2**), "protect others' health" (**H3**), and "join-in" (**H4**) appeals are communicated alongside the descriptive norm, this will, compared to baseline, increase vaccination intention. Compared to communicating only the descriptive norm, we hypothesized that additionally communicating the "join-in" appeal will increase vaccination intention (**H5**).

Method

Preregistration

This study was preregistered at https://aspredicted.org/hw45-f8yg.pdf.

Power Analysis

An *a priori* repeated measures t-test power analysis with a minimum overall effect size of Cohen's d = 0.2, 90% power, and the .05 alpha error probability, revealed a target sample size of 265, per each of the four experimental groups. We expected the effect size to be small based on some previous published research (Betsch et al., 2017; Lazić et al., 2021).

Data Quality and Exclusion

There were two attention-check questions, asking participants to choose a specific response option. Participants who failed both attention checks were excluded from the analyses.

Participants

Out of 1,303 participants who completed the survey, 243 (18.6%) were excluded due to failed attention checks. The remaining N = 1,060 participants (814 female), all Serbian residents, were aged 18–77 (M = 47.8, SD = 12.9). There was a total of n = 265 in each experimental group, comparable in terms of age and sex (a full report is available at https://osf.io/2wy9q/). The majority of participants (59.1%) had some higher education experience, 37.1% finished only high school, and the rest had less education. Recruitment was done through advertisements on social media in December 2023.

Materials and Procedure

After informed consent, an online survey first assessed age, sex, education, and country of residence. Following the presentation of the fictitious disease and vaccination fact sheet, all participants assessed their vaccination intention on a 0–100% slider (these materials were the same as in Experiment 1 and 2), which constituted the baseline. Participants were then randomly assigned to one of the four experimental message conditions, when they were asked to assess their vaccination intention one more time. Each experimental message showed the same value of the vaccination rate – "According to the Institute of Public Health, currently six out of ten (60%) of Serbian citizens have gotten vaccinated against Hebdo fever" – with a different call to action. In the only-norm condition, the message was "Get vaccinated too!"; in the protect-self, it was "Get vaccinated too to protect your health!"; in the protect-others, "Get vaccinated too to protect the health of the people around you!"; and in the join-in condition, the message was "Get vaccinated too to join the others in helping stop the spread of the disease!". On the survey page featuring the experimental message, the continue button was disabled for a specified minimum amount of time. Finally, participants rated their general attitude towards vaccination (on the same slider measure used in Experiment 1).

Results

To test hypotheses H1–H4, we ran four separate repeated measures t-tests. To test hypothesis H5, we ran a t-test for independent means. Means and standard deviations of the outcome measure across experimental conditions, correlations between the measures, as well as the results of t-tests are reported in Table 4.

The only statistically significant difference between baseline and intervention vaccination intentions was observed in the protect-self condition, with the effect size of Cohen's d = 0.16, supporting H2 (but not H1, H3, and H4). All of the differences, however, were in the expected direction (Figure 2). Across all conditions, an exploratory analysis revealed a statistically significant effect of intervention messages ($t(1059) = 2.87$, $p = .004$, $d = 0.09$), slightly larger when the only-norm condition was excluded ($t(794) = 3.14$, $p = .002$, $d = 0.11$).

The difference between intervention means in the only-norm and join-in conditions was not statistically significant ($t(528) = -0.03$, $p = .975$), not supporting H5. In an exploratory analysis, the differences in vaccination intention from baseline in these two conditions were also found not to be statistically significantly different ($t(528) = 0.97$, $p = .331$).

Table 4

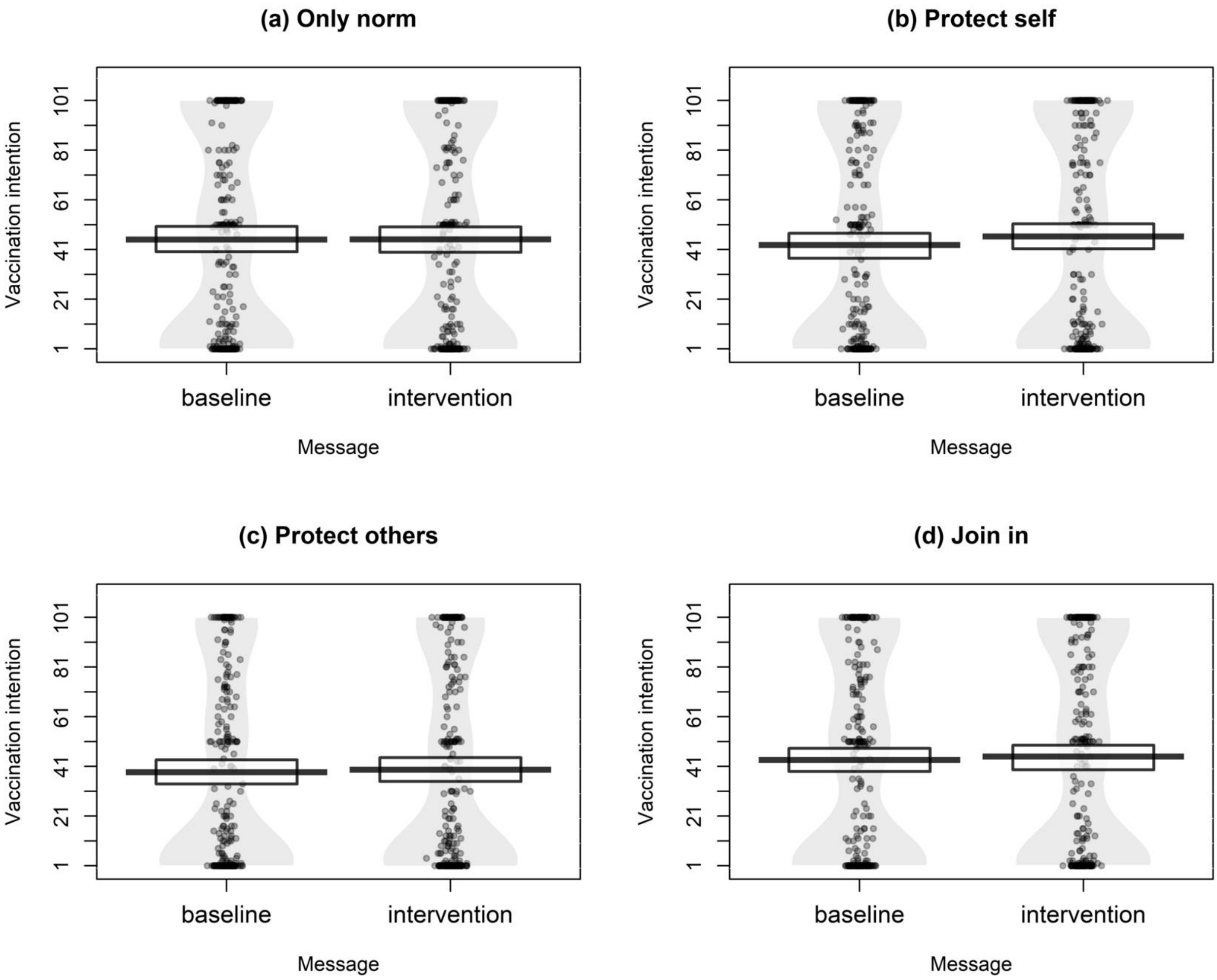
Condition Means, With Correlations Among Outcome Measures, and the Results of Statistical Tests Comparing Baseline and Interventions Means

Experimental condition	Baseline mean	Intervention mean	Correlation	Repeated measures t-test
Only-norm	45 (41.1)	45.1 (41.4)	0.94	$t(264) = 0.08$, $p = .939$, $d < 0.01$, 95% CI [-0.12, 0.13]
Protect-self	42.8 (41.3)	46.3 (42)	0.87	$t(264) = 2.67$, $p = .008$, $d = 0.16$, 95% CI [0.04, 0.29]
Protect-others	38.7 (39.7)	39.7 (40)	0.93	$t(264) = 1.18$, $p = .238$, $d = 0.07$, 95% CI [-0.05, 0.19]
Join-in	43.6 (40.3)	45 (41.5)	0.92	$t(264) = 1.36$, $p = .176$, $d = 0.08$, 95% CI [-0.04, 0.20]

Note. Standard deviations of the means are presented in parentheses. Observed ranges for baseline and intervention outcomes in all conditions was 1–101. Correlation is Pearson's r measure of association between baseline and intervention outcomes. d is Cohen's d.

Figure 2

Vaccination Intentions Depending on the Vaccination-Rate Message (Experiment 3)



Note. Outcome at baseline vs. when an experimental message (a–d) was presented; only the protect-self message was effective in increasing vaccination intentions. The plots show the full distribution of the data and jittered raw data. Horizontal bars represent means; boxes represent 95% confidence intervals.

General Vaccination Attitude

On average, participants reported slightly more positive than negative vaccination attitude (M = 64.1, SD = 38, range 1–101). Mean attitudes across experimental groups were similar and are reported at https://osf.io/2wy9q/.

In an exploratory analysis, we checked if the effectiveness of the messages depended on participants' vaccination attitude using a multiple regression model, with the differences in vaccination intention from baseline as the dependent variable. Since there was no significant interaction between attitude and message type ($F(1,1056) = 1.58$, $p = .209$), even after the only-norm group was excluded ($F(1,791) = 0.07$, $p = 0.784$), we did not proceed with testing the moderating effect further.

Discussion

The vaccination rate of 60%, contrary to our hypothesis, did not exert a detectable descriptive normative influence; it is possible that these values need to be more extreme (e.g., 90% in Experiment 1) so that they are more salient in an individual's attention (Cialdini et al., 1990) and able to influence vaccination intentions. All of the intervention messages tested in Experiment 3, taken together across all participants, positively influenced vaccination intentions, even alongside a weak social norm; while this effect was significant, it was rather small (with the analysis being likely overpowered). The message with the largest effect was the one featuring an individual benefit appeal: as hypothesized, vaccination intentions increased after communicating that getting vaccinated protects one's health. While it is promising that the other two tested appeals (social benefit and join-in) did not backfire, we did not, contrary to our hypotheses, detect a significant positive effect.

The ineffectiveness of these prosocial appeals is surprising given some previous experimental research (e.g., Pfattheicher et al., 2022; Schwarzinger et al., 2021; Zhu et al., 2022). Since Serbia has a collectivistic cultural background ("Country comparison tool", n.d.), one could further expect that prosocial appeals would be more effective than individual ones.

The finding that (only) the individual benefit appeal was effective might be, however, explained by taking the selfish-rational approach into account. When vaccination rates were lower, one study found that explaining individual, but not social, benefits alongside the concept of herd immunity increased vaccination intentions (Betsch et al., 2017); the opposite was true when vaccination rates were higher. This is because lower rates encourage vaccination as a selfish-rational strategy, while, when rates are high, vaccination is no longer selfishly rational but only collectively optimal (Betsch et al., 2017).

In Experiment 2, individual benefit was endorsed as a reason for vaccination by almost all participants. While social and collective benefits were also among the most frequently endorsed reasons, it is possible that, as intervention messages, they need to be further explained to participants. For example, it might be relevant to assure that participants understand collective effects of vaccination or to specify whom individual vaccination benefits (e.g., friends or the society, Stoffel & Herrmann, 2021).

General Discussion

We conducted three preregistered experiments, starting with diverging recommendations for public communication of vaccination rates stemming from two influential theoretical approaches. If people are selfishly rational, a high uptake will tempt them to free-ride, while a low uptake will motivate them to get vaccinated (Bauch & Earn, 2004); it follows that high rates harm, while low rates benefit public vaccination campaigns. Conversely, if vaccination rates exert a descriptive normative influence (Cialdini et al., 1990), a high uptake will encourage, while a low uptake will discourage vaccination; it follows that low rates harm, while high rates benefit public vaccination campaigns.

Partially in line with the descriptive norms approach, Experiment 1 found that communicating a 90% rate improved vaccination intentions, which were, however, not affected by a 10% rate. Lowering one's intention to get vaccinated in response to a low uptake might have been construed as unreasonable, that is, participants' choices might have aligned more with the concept of reasonableness: context sensitive balancing of maximizing individual gains *and* socially conscious norms (Grossmann et al., 2020). Participants in Experiment 1 were, on average, highly provaccine, and the low uptake might not have provided a good enough reason not to get vaccinated. Furthermore, pro-vaccination choices in Experiment 2 were more frequently justified based on reasons involving considerations of individual benefits and risks as well as protecting others than on reasons reflecting descriptive normative influence. As a future line of research, we propose to study the reasonableness of vaccination choices.

The absence of a negative effect of communicating a low uptake in Experiment 1 might also be explained by a limitation of its scenario: it introduced possible VAEs, but the fictitious vaccine was presented as 100% effective and easily available for free. While such a scenario excludes potential confounding variables, it might have caused a ceiling effect. Future studies should include more realistic depictions of personal costs of vaccination (e.g., monetary cost or the requirement to visit a hospital), which might be a more valid test not only of the mechanisms behind descriptive norms (Lyu et al., 2024) but also of the selfish-rational approach, which frames vaccination as a social dilemma. Strictly speaking, vaccination can be considered a social dilemma only by those participants who perceive the costs of vaccination to be higher than the costs of the disease (Betsch et al., 2013). The opposite was true for the majority of participants in Experiment 1. Furthermore, while non-vaccinators in Experiment 2 endorsed fewer reasons in general, the endorsement of free-riding reasons was especially rare (Table 3). Taken together, these findings point to certain caveats when testing the assumptions of the selfish-rational approach, which can be addressed by future studies (e.g., the need to assure that vaccination costs are tangible or that participants understand the herd immunity mechanism).

To further explore the complex relationship between vaccination rates and vaccination intention, future studies would benefit from testing more than two or three levels of vaccination rates (e.g., Moussaoui et al., 2024) and from testing so-called *dynamic* descriptive norm messages (e.g., Milkman et al., 2022), such as “More and more people are getting vaccinated”.

Our analysis points to several potential boundary conditions for testing both the selfish-rational and the descriptive norms approach, representing important directions for future research. At the present state of empirical evidence, it seems that public communication surrounding vaccination rates will profit most by accounting for both approaches, closer to the notion of reasonable judgments. Specifically, our results suggest that when vaccination rates are low or unlikely to exert positive normative influence, public communication may emphasize individual benefit, overcoming the belief that vaccination is unnecessary to protect one’s health; when vaccination rates are high, public communication may leverage the power of descriptive norms and emphasize prosocial reasons for getting vaccinated. Self- vs. other-benefit messages studied in Experiment 3 are, however, likely to be differentially effective for different groups of people (e.g., Ruggeri et al., 2024), for example, in terms of age, vulnerability or vaccine hesitancy, pointing to the need for public communication to assume a targeted approach.

Chapter 4 References

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Chapter 5

Brief Report: Analysis of Open-Ended Reasons from Paper 3 Experiment 2

Brief Report: Analysis of Open-Ended Reasons from Paper 3 Experiment 2

Method

Open-ended reasons for (non-)vaccinating against a fictitious disease were collected as part of the survey administered in Paper 3 Experiment 2, using the same final sample of N = 217 participants (adults aged 18–35 residing in Serbia). For details on the preregistration, data quality and exclusion procedures, and participant characteristics, please refer to the Method section of that study.

After reporting whether they would definitely/likely get vaccinated or definitely/likely not get vaccinated against a fictitious disease, and before rating a closed-ended list of possible reasons for (non-)vaccination, participants were asked to provide their main reason for getting vaccinated or not getting vaccinated in an open-ended format. The raw responses in Serbian are available in the open dataset: https://doi.org/10.17605/OSF.IO/2WY9Q.

Data Coding and Analysis

The open-ended responses were coded by one rater (the first author of the paper), who developed a codebook for each decision (vaccination and non-vaccination) inductively after data collection, based on a close reading of participants' responses. The codebook in English is available at https://doi.org/10.17605/OSF.IO/2WY9Q.

Although participants were instructed to provide a single main reason, many included multiple reasons in their responses. These were divided and coded as separate entries only when the rater determined they represented distinct categories. All of the extracted and coded reasons are available at https://doi.org/10.17605/OSF.IO/2WY9Q.

An independent rater was trained on the codebook and coded a subsample consisting of randomly chosen 20% of the extracted reasons. Krippendorff's alpha was 1 (percent agreement = 100%) for vaccination reasons and 0.91 (percent agreement = 94%) for non-vaccination reasons, which was deemed satisfactory. Inter-rater reliability and agreement analysis was conducted using the {irrCAC} package (Gwet, 2019) in R version 4.3.2 (R Core Team, 2023). The dataset and code to reproduce this analysis are available at https://doi.org/10.17605/OSF.IO/2WY9Q.

Results and Discussion

Based on responses from n = 87 participants who opted for vaccination, we extracted a total of 110 reasons for that decision. From n = 130 participants who opted against vaccination, we extracted 151 reasons. The prevalence of reasons coded into each category, along with direct participant quotations, is presented in Tables 1 and 2.

Table 1

Coding of Open-Ended Reasons for Vaccination

Category label	Quotations of participants	Relative frequency
Self-Protection	Better safe than sorry; To protect my own health; I don’t want to catch the disease	38% (42/110)
Trust in Science and Vaccination	Experts say so; I trust science; The vaccine is safe and tested; Because vaccines are one of the greatest inventions ever	25% (27/110)
Protection of Others	To protect my family; To not infect others	15% (17/110)
Collective Responsibility	Prevention of any disease is the key . . . , if hypothetically I don't get sick, the doctor will be more available to people who need him	6% (7/110)
Social Influence	A large number of fellow citizens also got vaccinated; I should set an example to young people that they should get vaccinated	5% (5/110)
Calculation	I'm not losing anything by doing this	2% (2/110)
Normal Life	I don't want Hebdo fever to affect my work	2% (2/110)
Knowledge	[I understand] the system of protection through vaccines	2% (2/110)
Other		5% (6/110)

Note. The categories “Mandates” and “Perceived High Severity of Illness” each contained only one response and were therefore merged into the “Other” category.

Nearly 80% of all reasons for vaccination reflected participants’ motivation to protect themselves and others from the disease, as well as their trust in science and vaccination. Less frequently mentioned justifications included collective responsibility (e.g., stopping the spread of disease) and adherence to social norms (e.g., descriptive, injunctive, or moral norms).

Table 2

Coding of Open-Ended Reasons for Non-Vaccination

Category label	Quotations of participants	Relative frequency
Mistrust in Science and Vaccination	Insufficiently tested vaccine; Vaccine manufacturers never show all vaccine ingredients and do not objectively inform about the harmfulness of those same ingredients or the technology they apply; I don’t trust vaccines	33% (50/151)
Perceived Low Severity of Illness	The virus doesn’t cause any serious problems and is similar to the seasonal flu	19% (28/151)
Calculation	Unwanted effects . . . are just as bad as the symptoms of the disease themselves; Because it is obviously not a fatal disease and the vaccine can cause some kind of damage; The symptoms are not worth the risk	12% (18/151)
Perceived Invulnerability to Illness	I believe in the body’s immune response to “harmless” viruses; Healthy, young, without health problems; I think there is a very small chance of me getting sick	9% (13/151)
Conspiracy Theories	Because it's another virus from a laboratory and you just want to inject us with vaccines and earn money; We saw what a fraud the corona virus was; . . . Pharmaceutical mafia	5% (7/151)
Natural Immunity	I will get infected and that's how I will get immunity; It's best when the body develops antibodies on its own	3% (5/151)
Misinformation	I don't want to poison myself with a vaccine; There is a cure in food	3% (4/151)
Personal Choice	I don't want anyone to blackmail me with vaccinations; I have the right not to be vaccinated	2% (3/151)
Free Riding	The fact that 80% of Serbia was vaccinated . . . shows that the virus should . . . be less prevalent, which in my opinion reduces the need for vaccination	1% (1/151)
Other		15% (22/151)

Approximately half of all reasons for non-vaccination reflected mistrust—such as in health authorities, vaccine developers, or vaccination in general—and some form of misinformation (e.g., the belief that vaccines are poisonous or that natural immunity is superior), along with conspiracy theories (e.g., "Big Pharma"). Participants also frequently cited low perceived severity of the disease and a sense of personal invulnerability. Apart from potentially being linked to participants' younger age, these reasons align with the broader concept of *risk perception*—that is, how likely individuals believe they are to contract the disease, how susceptible they feel, or how severe they expect the illness to be. This factor has been identified as a consistent predictor of actual vaccination behavior in a meta-analysis by Brewer et al. (2007), and it has long been central to key health behavior theories, such as the Health Belief Model (Rosenstock, 1974). Returning to the remaining reasons, while some responses reflected a calculated weighing of risks and benefits, only one explicitly mentioned free riding.

These findings mostly align with the analysis of the endorsement of a closed-ended list of reasons presented in Paper 3, particularly the importance of self-protection and protecting others among vaccinators, and the perception that vaccination is unnecessary for self-protection among non-vaccinators. However, calculation was mentioned spontaneously less often by both vaccinators and non-vaccinators. The open-ended responses pointed to an important theme not captured by the closed-ended questions: the role of trust in science and vaccination among those in favor and mistrust among those opposed. These (mis)trust-related reasons closely align with the factor known as *confidence*, which has been consistently linked to vaccination behavior and intentions (e.g., Betsch et al., 2018; Geiger et al., 2022).

Chapter 5 References

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Chapter 6

General Discussion

General Discussion

Summary of the Overall Findings of this Research

Findings From the Media Content Analysis

- In the second half of 2017, around the start of the measles outbreak, Serbian online news media referred to vaccination coverage relatively often, though not prominently (almost never in headlines or through infographics).
- Medical and public health experts were cited as the source of vaccination coverage information in most cases; however, over a quarter of the stories provided no source at all.
- Most of the reported coverage concerned the MMR vaccine. Revaccinations (doses that were not the first dose of the vaccine) were almost never mentioned.
- The reference group was usually children, but their age or school status was rarely specified. Vaccination coverage among vulnerable populations was almost never addressed. Coverage was typically reported at the country- or city-level, and much less frequently for other territories such as city municipalities.
- Vaccination coverage figures were commonly presented using relative numerical formats, such as percentages or fractions (e.g., “80%”, “every second child”), or using descriptive language (e.g., “most of the population”, “low”, “weak”). More than a quarter of news stories used only descriptive, non-numerical terms.
- Although current vaccination coverage was most often reported, some stories also mentioned changes over time (e.g., “more parents are vaccinating their children”, “immunization levels have risen by 10%”), which could convey dynamic descriptive norms.
- Coverage was almost always framed in terms of the proportion of vaccinated individuals (e.g., “60% of children are vaccinated”), rather than the unvaccinated (e.g., “40% of children are not vaccinated”).
- Most vaccination coverage was framed negatively (71%)—for example, “fewer parents are vaccinating their children” or “the coverage is very low, almost 40% of children haven’t received the vaccine”—compared to positively (18%) or neutrally. This pattern held regardless of how vaccination coverage was conveyed (numerical vs. verbal; current level vs. change over time) or which vaccine it referred to (MMR vs. others).
- About one in five news stories mentioned herd immunity; among those, only around a third explained what the term means. Around a quarter of news stories reported the numerical value of the herd-immunity threshold.

Findings From Online Experiments Testing Communication Interventions

- Communicating high country-level vaccination coverage (90%) increased intention to get vaccinated, compared to both communicating no coverage information and communicating low-coverage (10%) information.

- Communicating low country-level vaccination coverage (10%) had no observable effect on vaccination intention compared to communicating no coverage information.
- Explaining herd immunity while emphasizing its social benefit (i.e., protecting others' health) via an animated infographic increased intention to get vaccinated, compared to baseline.
  - Communicating different country-level vaccination coverages (absent vs. low [20%] vs. high [80%]) alongside this herd immunity explanation had no observable effect on vaccination intention.
  - Communicating the vaccination coverage required to reach the herd-immunity threshold (absent vs. 90%) alongside the same herd immunity explanation had no observable effect on vaccination intention.
- Communicating that a slight majority in the country had been vaccinated (60%) had no observable effect on vaccination intention, compared to baseline.
  - Emphasizing individual benefits of vaccination (i.e., protecting one's health) alongside the 60% coverage increased intention to get vaccinated, compared to baseline.
  - Emphasizing social benefits of vaccination (i.e., protecting others' health) alongside the 60% coverage had no observable effect on vaccination intention.
  - Emphasizing collective benefits of vaccination (i.e., an invitation to join others in helping stop the spread of the disease) alongside the 60% coverage had no observable effect on vaccination intention and was not more effective than presenting the coverage information alone.
  - When analyzed together, all three benefit appeals (individual, social, and collective) led to greater intention to get vaccinated compared to presenting the 60% coverage information on its own.

Findings From an Experiment Exploring Reasons for (Non-)Vaccination

- Decisions in favor of vaccination were most commonly justified by reasons concerning individual benefit (i.e., protecting one's health), social benefit (i.e., protecting others' health), collective benefit (i.e., stopping the spread of the disease), and calculation (i.e., personal benefits outweighing risks). Less frequently, but still in around half of the cases, reasons related to avoiding free riding (i.e., not relying on others for protection) and descriptive norms (i.e., following the behavior of the majority) were endorsed. Endorsement of descriptive norms was slightly higher when country-level vaccination coverage was described as high (80%) rather than low (20%). The qualitative analysis of open-ended responses supported these findings and further identified trust in science and vaccination as a commonly cited reason for getting vaccinated.
- Compared to decisions in favor of vaccination, decisions against vaccination were less frequently justified by any of the tested reasons, and the pattern of endorsement did not vary between low (20%) and high (80%) country-level vaccination coverage. Still, reasons concerning individual benefit (i.e., vaccination not being necessary to protect one's health) and calculation (i.e., personal risks outweighing benefits) were endorsed in most cases, while the reason related to collective benefit (i.e., vaccination not being a collective task against the spread of disease) was endorsed roughly half of the time.

Other reasons—related to social benefit (i.e., vaccination not being necessary to protect others' health), descriptive norms (i.e., following the behavior of the majority), and free riding (i.e., relying on others for protection)—were endorsed only rarely. The qualitative analysis of open-ended responses was in line with these findings, especially in emphasizing low risk perception, and also indicated that mistrust in science and vaccination was a commonly cited reason for not getting vaccinated.

Contribution of this Research

Across five empirical studies, including four online experiments and a one content analysis, this research program offered a multimethod exploration of how individuals interpret and respond to vaccination-coverage messages as well as how vaccination coverage is framed in online news media. To the best of our knowledge, this research is the first to directly test the contrasting hypotheses of the selfish-rational and the social-rational model. By doing so, it provided new insights into the boundary conditions of these two influential theoretical approaches, potentially informing more nuanced and evidence-based vaccination communication strategies.

The selfish-rational and social-rational models offer contrasting explanations for how individuals respond to information about vaccination coverage, with important implications for designing public health communication. The selfish-rational model (e.g., Bauch & Earn, 2004) suggests that high vaccination coverage reduces people' willingness to get vaccinated, as the perceived risk of infection drops and free riding becomes more attractive. In contrast, the social-rational model (e.g., Cialdini et al., 1990) views a high vaccination coverage as a source of descriptive normative influence—an indication of what most people are doing—which can promote vaccination by framing it as the smart thing to do. Accordingly, the selfish-rational model would favor messaging that emphasizes low coverage to motivate action, while the social-rational model would advocate highlighting high coverage to leverage social influence.

The first experimental study (Paper 3 Pilot + Experiment 1) found partial support for the social-rational model, with high vaccination coverage (positive descriptive norm) improving vaccination intention, which was, however, not affected by low vaccination coverage (negative descriptive norm). On the other hand, these findings provided no support for the selfish-rational model.

The second experimental study (Paper 2) replicated an earlier finding (Betsch et al., 2017) that communicating the social benefits of herd immunity can increase vaccination intention, even when using new materials and in a different national context. Our study was included in a recent meta-analysis examining the role of herd immunity in vaccine advocacy (Reiter et al., 2024). Based on a decade of research and a total of 41 studies, the meta-analysis found a small positive effect (Hedges' g = 0.13), indicating that emphasizing herd immunity and thereby framing vaccination as a collective responsibility can modestly increase individuals' motivation to get vaccinated, compared to control or alternative conditions. Our study also found that presenting low versus high vaccination uptake or the herd immunity threshold, after the herd immunity effect had already been explained, had no impact on vaccination intention. This suggests that the influence of vaccination coverage information may depend on the broader context in which it is presented.

In the third experimental study (Paper 3 Experiment 2), the design was adjusted to more directly examine the motivations behind individuals' vaccination decisions. Although the first experimental study provided partial support for the social-rational model and no support for the selfish-rational model, this does not rule out the possibility that people may choose not to justify their choices based on descriptive norms, or that elements of the selfish-rational perspective such as free riding may still inform their reasoning. This study builds on the understanding that the tension between selfish and social rationality is fundamentally a question of motivation, requiring an experimental design that reflects this. Regardless of whether vaccination coverage was low or high, decisions to get vaccinated were frequently justified by reasons related to self-protection, the protection of others, collective benefit, and risk-benefit calculation. In contrast, the tested reasons for non-vaccination—including free riding—were rarely endorsed. Descriptive norms were also perceived as more relevant for vaccination than for non-vaccination decisions. A closer look at the open-ended reasons (Chapter 5) highlighted (mis)trust in health authorities, vaccine developers, and vaccination more broadly as another meaningful consideration in public vaccination communication.

The fourth experimental study (Paper 3 Experiment 3) examined whether a positive descriptive norm could be leveraged at 60% vaccination coverage. This is a crucial stage from a public policy perspective, as it is the first point at which such a norm can be effectively communicated: the majority has been vaccinated, but herd immunity is typically not yet achieved. For example, COVID-19 vaccination rates in many European countries stalled around this level within a year of rollout (Mathieu et al., 2021). A 60% vaccination coverage alone did not influence vaccination intention. The study further showed that emphasizing social or collective benefits alongside this coverage information did not lower vaccination intention, and that emphasizing individual benefits enhanced it. This finding suggests that not only prosocial appeals (as tested in the second experimental study) but also individual-benefit appeals can motivate vaccination, with the latter potentially being more effective under certain conditions, particularly when descriptive norms are weak. Alongside the third experimental study, these results further indicate that individuals engage in a form of cost-benefit evaluation rather than relying solely on cues from descriptive social norms.

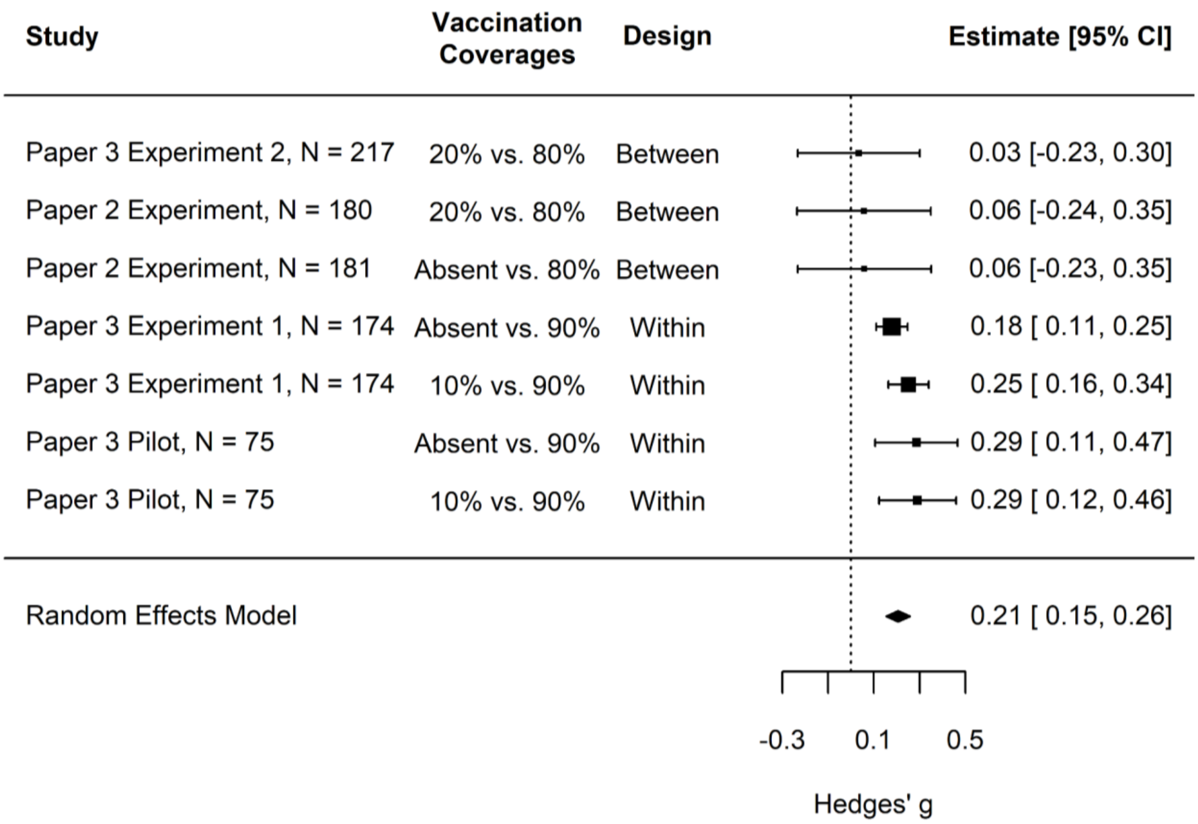
Our content analysis of Serbian online news media (Paper 1) revealed that vaccination coverage reporting often lacked clarity and precision, relied heavily on negative framing, and rarely included explanations of herd immunity. To avoid unintentionally undermining vaccine acceptance, our experimental findings indicated that mass media should instead aim to contextualize vaccination coverage information, specifically by explaining the individual and social benefits of immunization, as well as to frame vaccination coverage in a positive way when possible, conveying strong descriptive social norms.

Interpreting Effect Sizes in the Context of Related Research

We conducted an internal meta-analysis of changes in vaccination intention using data from Paper 2 Experiment and Paper 3 (Pilot, Experiment 1, and Experiment 2), comprising a total of 1,076 participants. Specifically, we compared conditions in which no or low (10% or 20%) vaccination coverage was communicated to those in which high coverage (80% or 90%) was communicated. Effect sizes were recalculated as unbiased standardized mean differences (Hedges' g) using data reported in the original papers.

The meta-analysis was performed in R version 4.3.2 (R Core Team, 2023) using the packages {esc} (Lüdecke, 2019) and {metafor} (Viechtbauer, 2010). The dataset and analysis code, including details on the calculation of effect sizes and sampling variances, are available at https://github.com/ale-lazic/vacc_cvrg_meta.

Figure 1
Forest Plot from Internal Meta-Analysis Comparing High vs. Low/Absent Vaccination Coverage Messages



The pooled effect size—Hedges' g = 0.21, 95% CI [0.15, 0.26], $p < .001$—indicated that communicating high (vs. no or low) vaccination coverage led to increased willingness to get vaccinated (Figure 1). All effects were in the expected direction, suggesting robustness and replicability. The analysis also suggests that within-subject designs—where participants are presented with both no/low and high coverage conditions—produce larger effects, potentially reflecting the greater salience of social norms (Cialdini et al., 1990, 1991). However, this may be confounded with other study characteristics that differed across designs, such as the extremity of coverage values, whether herd immunity explanations were included, and overall study power, some of which could be systematically disentangled in future research.

Other communication interventions tested in this work produced effects of a similar magnitude. In Paper 2 (N = 543, between-subjects design), explaining herd immunity and emphasizing its social benefits using text and an animated infographic increased willingness to get vaccinated (Hedges' g = 0.23). In Paper 3 (Experiment 3, N = 265, between-subjects design), communicating individual benefits of vaccination alongside information that 60% of others were vaccinated yielded a smaller, but still positive effect (Hedges' g = 0.16).

The effect sizes we identified are relatively small but comparable in magnitude to what has been found in previous work testing similar communication strategies. For example, a meta-analysis by Rhodes et al. (2020) found that descriptive norm manipulations had an average effect of d = 0.11 on behavioral intention, while Reiter et al. (2024) reported an average Hedges' g = 0.13 for the effect of herd immunity communication on vaccination motivation. Our observed effects—a mini meta-analytic Hedges' g = 0.21 for communicating high vaccination coverage and Hedges' g = 0.23 for herd immunity communication—are larger than these meta-analytic averages. Moreover, an analysis of published meta-analyses in social psychology by

Lovakov and Agadullina (2021) cautioned against the routine use of Cohen's conventional benchmarks (d = 0.2 small, d = 0.5 medium, d = 0.8 large), as these tend to overestimate typical effect sizes in the field. Their analysis showed that the 25th, 50th, and 75th percentiles correspond to Cohen's d values of 0.15, 0.36, and 0.65 respectively, suggesting that the effects of our interventions fall within the lower to middle range typically found in social psychology. Moreover, even modest effects, like those observed in our studies, may translate into meaningful real-world impact when interventions are implemented at scale across entire populations (Carey et al., 2023; Matthay et al., 2021). Since communication about vaccine coverage is already a routine part of public health efforts, the approach we suggest requires little to no additional cost or effort, and simply offers evidence-based guidance on how to frame these messages more effectively.

Implications for Theory Testing

Introducing the Concept of Reasonableness

Our experimental studies collectively challenge a simplistic application of either the selfish-rational or the social-rational approach to vaccination decision-making. In line with the social-rational approach, high vaccination coverage increased vaccination intention. Moreover, descriptive norms did not exert a strong influence unless vaccination coverage was extreme (i.e., 90%), supporting the notion that for social norms to be impactful, they must be salient and clearly understood (Cialdini et al., 1990, 1991). Low vaccination coverage, however, did not produce the expected demotivating effect. Therefore, while high vaccination coverage may signal social consensus and suggest the appropriate course of action, low coverage does not necessarily discourage vaccination, especially in samples that are already provaccine. In fact, pro-vaccination choices were more often justified by considerations of individual benefits and risks, as well as the protection of others, than by reasons reflecting compliance with descriptive norms. Furthermore, our tests of communication interventions demonstrated that emphasizing either the social or individual benefits of vaccination can effectively increase vaccination intention under certain conditions.

Taken together, these findings align more with the concept of *reasonableness*: context sensitive balancing of maximizing individual gains *and* socially conscious norms (Grossmann et al., 2020). Across 12 studies, Grossmann et al. (2020) investigated how laypeople's intuitions and behavior align with the concepts of rationality and reasonableness. Rationality was seen as an abstract, preference-maximizing standard, reflecting game theory and neoclassical economics, whereas reasonableness was seen as context-sensitive and socially conscious, reflecting legal scholarship and ethical considerations. Rationality was further associated with individual-focused, instrumental thinking and emotional detachment, while reasonableness was associated with interpersonal sensitivity and other-oriented thinking, including qualities like honesty, fairness, and kindness. This distinction is not merely semantic; Grossmann et al. (2020) demonstrated that it shapes expectations and behaviors in economic games. For example, people shared more money in a Dictator Game (a two-player game in which one player unilaterally allocates resources) when prompted to act reasonably rather than rationally. In social dilemmas such as the Commons and Prisoner's Dilemma, reasonable players were expected to cooperate, while rational players were expected to defect.

While rationality and reasonableness seem to be distinct concepts, they are not necessarily mutually exclusive. Grossmann et al. (2020) propose that individuals internalize both standards of judgement and draw on them flexibly depending on the context (e.g., whether the situation calls for justifying a preference-maximizing choice or a socially conscious one).

The authors conclude that the folk understanding of rationality—as centered on individual preferences and instrumentality—and reasonableness—as centered on social norms and context—directly impacts decision-making: "Irrational behavior may not necessarily be a sign of failure to understand game theoretical principles but rather an attempt to follow a competing folk standard of reasonableness" (Grossmann et al., 2020, p. 6). As a future line of research, we therefore propose examining not only the selfish or social rationality of vaccination choices but also their reasonableness. This may open up an unexplored avenue for encouraging vaccination by simultaneously reducing the demand to be (selfishly) rational and increasing the appeal to be reasonable.

The Role of Experimental Design Choices

The outcomes and interpretations of experimental studies are not solely determined by theoretical assumptions but are also shaped by specific design choices and materials. In retrospect, our experimental studies may have favored the social-rational model—or at least reasonableness—because we aimed for greater ecological validity. For example, we sought to mirror how vaccination is typically communicated in real life by using qualitative rather than quantitative expressions of risk (e.g., disease symptoms and vaccine adverse events were described as appearing "in a small number of cases"). Most decisions in everyday life are based on values that are imprecise or qualitative (Shiffrin, 2021), and our content analysis study further showed that the same holds true for how mass media communicate about vaccination. However, this design choice may have affected whether and how participants engaged in cost-benefit calculation, which is central to the selfish-rational model. This limitation was compounded by the fact that the fictitious vaccine was described as 100% effective and freely available, which—while eliminating confounds—likely minimized the perceived costs of vaccination.

Building on the previous discussion, while it is possible that our participants were following a competing standard of social rationality (or reasonableness) rather than simply failing to understand the game theoretical principles behind the vaccination dilemma, the latter possibility should not be ruled out. For example, participants mentioned calculation-based reasons less often on their own than when those reasons were offered as options, while free-riding reasons were rarely mentioned at all, regardless of format. Future research could build on these insights by incorporating more realistic personal costs (e.g., monetary expenses or the need to visit a hospital) and by ensuring that participants clearly understand the mechanism of herd immunity. Such adjustments could allow for a more valid test of the selfish-rational model, though they may also shape participants' responses in ways that align with its assumptions. This underscores a broader trade-off in theory-driven research: design choices intended to fairly test one model may unintentionally favor it over a competing account. It is a challenge that should be acknowledged in any research program comparing theoretical frameworks.

Strengths, Limitations, and Additional Directions for Future Research

A key strength of our work lies in its methodological diversity: by combining experimental studies with content analysis of real-world media, we were able to investigate both the effects and the context of vaccination-coverage messages. All studies adhered to Open Science practices, such as preregistration and open data, enhancing their rigor and reproducibility. We also tested our hypotheses experimentally in two national contexts (Serbia and the UK), increasing the cross-cultural relevance of our findings. Another notable strength is our empirical comparison of two competing theoretical models—the selfish-rational and the social-rational—through a series of comparable experiments, where the core materials and procedures, such as the disease and vaccination fact sheet and vaccination intention assessment, were kept consistent.

However, there are some limitations that merit consideration. The experimental studies primarily relied on online convenience samples, which were not representative of the general population. In particular, the samples were often skewed toward more educated and more provaccine individuals. This may have reduced variability in responses and introduced ceiling effects. It also limits the generalizability of the findings, especially for understanding the responses of vaccine-hesitant individuals. Future studies should aim to incorporate more representative and diverse samples, especially focusing on hesitant and vulnerable communities, as well as individuals who are less trusting of scientists and vaccines, as indicated by our analyses of open-ended reasons for non-vaccination. Recent research has increasingly focused on how tailoring public health messages to people's values, group identity, or stage of decision-making can improve communication effectiveness.

Tailoring health messages has been recognized as an important part of infodemic management, particularly during the COVID-19 pandemic, as well as in countering online misinformation (e.g., Lazić & Žeželj, 2021; Vraga et al., 2023; World Health Organization, 2021). The World Health Organization (2021) recommends designing public health strategies that consider individuals "holistically" within the context of their multiple communities—such as where they live and work, their faith, consumer habits, political affiliations, and social activities—to better tailor prevention efforts. One recommended strategy is to involve highly *trusted community leaders* in the design and dissemination of official information. For example, trusted military personnel were chosen as the face of the COVID-19 vaccine rollout in Portugal (Hatton, 2021). A synthesis of behavioral science evidence during COVID-19 (Ruggeri et al., 2024) confirmed that using credible sources—such as local, religious, or community leaders—to share public health messages can be useful; the effect was medium in size overall and replicated in field studies and other real-world settings. Although no real-world studies with behavioral measures were identified, a small positive effect was also found for tailoring information to *marginalized communities* (Ruggeri et al., 2024), who often experience different exposures to health risks, face structural barriers, and receive less accessible information. One such example comes from Dhanani and Franz (2022), who found that messages acknowledging past unethical treatment of Black Americans in medical research and emphasizing current safeguards was associated with less vaccine hesitancy among Black participants. Survey data and online experiments have also suggested a small positive effect for tailoring messages to align with recipients' *moral values* (Ruggeri et al., 2024). In the context of vaccination, this may mean that communication directed at mothers whose narratives of vaccine choices mention neoliberal goals—as identified, for instance, in interviews by Reich (2014)—should emphasize individual benefits of vaccination rather than on the fact that those who decide to free-ride on herd immunity put the community at a collective disadvantage. This illustrates how qualitative research can inform the design of tailored immunization interventions by providing in-depth understanding of people's motivations, concerns, and lived experiences. Such research can support the development of profiles or *personas* within the target group (WHO Regional Office for Europe, 2019). These personas—such as "Deborah, the community-focused mother" or "Leah, the skeptical mother"—can be given representative characteristics including age, education, number of children, beliefs, and lifestyle. Presenting findings this way can help make insights more actionable and easily understood (WHO Regional Office for Europe, 2019).

Our experimental studies measured behavioral intentions ("I will get vaccinated") instead of actual vaccination behavior. While intentions are a known predictor of behavior, they are not perfectly correlated (e.g., Conner & Norman, 2022). Additionally, all of the experiments employed a hypothetical disease scenario, which—while useful for controlling potential confounding variables—may have limited the ecological validity of participants' decisions. Finally, some effects of communication interventions, though statistically significant, were small in magnitude.

Although these limitations highlight the need for longitudinal studies to assess the durability of message effects over time, and for larger-scale field studies to evaluate the real-world impact of communication interventions and help translate insights into scalable strategies, such approaches are not always feasible. An alternative could be to leverage virtual reality (VR) and artificial intelligence (AI)–based methods. For example, experiential VR interventions that not only teach participants about herd immunity but let them "live" its consequences have been shown to outperform non-experiential approaches such as text-based materials (Reiter et al., 2024).

Furthermore, recent advances in AI, particularly in the development of large language models (LLMs), have enabled increasingly realistic simulations of individuals and communities. These simulations often involve the use of generative agents, which are software entities powered by LLMs and capable of engaging in complex, natural language-based reasoning, memory recall, and dynamic social interactions (e.g., Hou et al., 2025; Park et al., 2023). In contrast, traditional agent-based models simulate entities with simpler predefined rules or behaviors that may change in response to environmental or social stimuli (e.g., Chopra et al., 2023; Naderi et al., 2021). Both approaches offer promising tools for public health research. For example, by simulating decision-making and social influence in virtual environments, researchers can develop and evaluate communication interventions to increase vaccine acceptance without relying on high-cost, real-world field experiments. This modeling approach can reduce logistical burdens and ethical risks while providing valuable insights for public policy (e.g., Hou et al., 2025; Kreimeyer et al., 2024).

Building on our findings, future research should further explore the boundary conditions of descriptive-norm messaging. Experimental studies would benefit from testing a broader range of vaccination rate levels to better capture the (potentially non-linear) dynamics of social influence (Moussaoui et al., 2024), as well as the impact of communicating the herd immunity threshold. Additional studies should also investigate how individuals process dynamic norm information, such as upward or downward trends in vaccine uptake. Future research could examine the effects of using more specific reference groups for vaccination coverage, such as those based on narrower geographic areas, levels of vulnerability, or social identity. Normative messages are generally more likely to be effective when individuals feel identified with the reference group (for a review, see Tankard & Paluck, 2016). For example, positive descriptive norms may be more persuasive when tailored to the target audience, such as: "Most people from your ethnic group," "Most working professionals your age," or "Most students at your university have already received the vaccine."

Our content analysis was limited to online media in Serbia during a six-month window around the 2017 measles epidemic. While it provided valuable insights into media practices at that time and place, the findings may not generalize to other forms of media, cultural contexts, or more recent outbreaks. Expanding future analyses to include television, social media, and international comparisons would offer a broader understanding of how vaccination and vaccination coverage are framed across different platforms and settings. Further research could also examine additional dimensions of media messaging related to vaccination coverage, such as injunctive norms (e.g., opinions and recommendations), sentiment (e.g., specific forms of negativity like blame or fear), and source credibility. These insights will be essential for informing media guidelines that are both ethically sound and effective in supporting vaccination uptake.

Concluding Remarks: Selfish or Social Rationality?

In this dissertation, we explored two competing models of motivation and decision-making—selfish rationality and social rationality—to understand how people respond to vaccination coverage and how this influences public health communication. While both models recognize the role of others' vaccination decisions, they lead to opposing predictions: selfish rationality predicts reduced motivation to vaccinate at high coverage due to free-riding, whereas social rationality suggests high coverage strengthens motivation through descriptive normative influence.

Vaccination coverage is an important topic in media reporting and public discourse, especially during health crises such as measles outbreaks, seasonal flu surges, or global pandemics like COVID-19. Our empirical findings consistently supported the view that high vaccination coverage tends to encourage, rather than discourage, vaccination—lending partial support to the social rationality model. However, this insight alone offers limited practical value: low coverage cannot be concealed, nor can high coverage values be fabricated.

Our findings showed that online news media often framed vaccination coverage in predominantly negative terms, likely reinforcing negative descriptive norms. Together with our experimental tests of how individual- and social-benefit appeals influence vaccination intentions, these insights informed the development of communication strategies that account for both coverage levels and media framing. As vaccine coverage is already routinely communicated, our approach adds little to no extra burden and simply offers guidance on more effective messaging.

Our work builds on a diverse body of research—correlational, experimental, and field studies, economic games, social network analyses, computational modeling—and contributes a multimethod program combining media content analysis, vignette experiments, and a survey of reasons for (non-)vaccination. In the final chapter, we explore how future research using LLMs could enable more scalable interventions and we open fruitful directions for further work, including message tailoring, communicating dynamic norms, and more extensive media analysis.

More broadly, this research shows that assuming people are either selfishly or socially rational does more than shape communication—it also influences how studies are designed and how findings are interpreted. Instead of endorsing one model over the other, we present a more nuanced perspective rooted in the concept of reasonableness: people may weigh both social and individual considerations depending on context.

This dissertation (a) challenges the binary between selfish and social rationality; (b) discusses reasonableness as a more flexible conceptual lens; (c) identifies boundary conditions for theory testing; (d) develops context-aware strategies for public health communication; and (e) outlines promising directions for future research. By moving beyond narrow models, we can better understand and support vaccination decisions in a complex, socially interdependent world.

Chapter 6 References

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Appendix A

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Negativity in online news coverage of vaccination rates in Serbia: a content analysis

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ABSTRACT

Objective: This content analysis study explored how online news media communicates and frames vaccination rates and herd immunity (the effect where enough people are immune, the virus is contained).

Methods: We analyzed 160 vaccination-related news stories by nine highest-trafficked news websites in Serbia, published July–December 2017, around the start of the measles outbreak. We coded both the news story as a whole and every vaccination-rate mention ($N=339$).

Results: News stories framed current vaccination rates and changes in them in a predominantly negative way (175/241 and 67/98 mentions, respectively) (e.g., "only 50% vaccinated", "fewer parents vaccinating their children"), especially when referring to the measles vaccine (202/262 mentions). A total of 23/86 of news stories mentioning vaccination rates did not provide any numerical values. Reference groups for vaccination rates were rarely specified. Out of the 32 news stories mentioning herd immunity, 11 explained the effect.

Conclusions: Even routine communication of vaccination rates can be biased through negative frames and imprecise descriptions. Lamenting low immunization rates could activate a negative descriptive social norm ("many people are not getting vaccinated"), which may be especially ill-advised in the absence of an explanation of the social benefit of achieving herd immunity through vaccination.

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descriptive norms; framing; health communication; immunization; mass media; vaccine

Introduction

There is ample evidence that mass communication brings about societal and individual changes regarding vaccination. Communities with anti-vaccine campaigns in the local media had lower vaccine uptake (Gangarosa et al., 1998; Mason & Donnelly, 2000). Changes in the extent of media coverage coincided with changes in vaccination behavior (Ma et al., 2006) and the public's level of vaccine knowledge (Kelly et al., 2009). Furthermore, mass media are often the main source of health- and vaccine-related

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of the common strategies, such as lamenting low vaccination rates, may backfire. While this study provides some initial recommendations for mitigating these issues, more studies are needed to evaluate how and under what conditions normative messages and frames influence vaccine uptake.

Acknowledgments

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Disclosure statement

No potential conflict of interest was reported by the author(s).

Authors contribution

Aleksandra Lazić (Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization; Writing - original draft; Writing - review & editing).
Iris Žeželj (Conceptualization; Methodology; Supervision; Writing - review & editing).

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Data availability statement

The data that support the findings of this study are openly available in Open Science Framework at https://osf.io/5bkz8/.

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Registered Reports

Social nudges for vaccination: How communicating herd behaviour influences vaccination intentions

Aleksandra Lazić[1], Kalina Nikolova Kalinova[2,†], Jali Packer[3,†], Riinu Pae[4*,†], Marija B. Petrović[1,†], Dora Popović[5,6,†], D. Elisabeth C. Sievert[7,†] and Natalie Stafford-Johnson[8,†]

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[8]Dublin, Ireland

Objectives. This Registered Report attempted to conceptually replicate the finding that communicating herd immunity increases vaccination intentions (Betsch, et al., 2017, *Nat. Hum. Behav*., 0056). An additional objective was to explore the roles of descriptive social norms (vaccination behaviour of others) and the herd-immunity threshold (coverage needed to stop disease transmission).

Design. An online experiment with a 2 (herd-immunity explanation: present vs. absent) × 3 (descriptive norm: high vs. low vs. absent) × 2 (herd-immunity threshold: present vs. absent) between-subjects fractional design.

Methods. Sample consisted of 543 people (aged 18–64) residing in the United Kingdom. Participants first received an explanation of herd immunity emphasising social benefits (protecting others) in both textual and animated-infographic form. Next, they were faced with fictitious information about the disease, the vaccine, their country's vaccination coverage (80% or 20%), and the herd-immunity threshold (90%). Vaccination intention was self-rated.

Results. Compared to the control, communicating social benefits of herd immunity was effective in increasing vaccination intentions ($F(1,541) = 6.97$, $p = .009$, Partial Eta-Squared = 0.013). Communicating the descriptive norm or the herd-immunity threshold alongside the herd-immunity explanation demonstrated no observable effect.

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Conflicts of interest

All authors declare no conflict of interest.

Author Contributions

Aleksandra Lazić (Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing); Kalina Nikolova Kalinova (Conceptualization; Investigation; Methodology; Writing – review & editing); Jali Packer (Conceptualization; Investigation; Methodology; Writing – review & editing); Riinu Pae (Conceptualization; Investigation; Methodology; Writing – review & editing); Marija B. Petrović (Conceptualization; Formal analysis; Investigation; Methodology; Writing – review & editing); Dora Popović (Conceptualization; Investigation; Methodology; Writing – review & editing); D. Elisabeth C. Sievert (Conceptualization; Investigation; Methodology; Project administration; Writing – review & editing); Natalie Stafford-Johnson (Conceptualization; Investigation; Methodology; Writing – review & editing).

Data availability statement

The approved Stage 1 protocol is available at: https://osf.io/jpku3. The materials, data, and code that support the findings of this study are made openly available in the Open Science Framework at: https://osf.io/zb7s3.

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Should Public Communication of Vaccination Rates Assume Rationality, Normativity or Reasonableness? Insights from Three Preregistered Experiments

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Abstract
The proportion of the population who are vaccinated against an infectious disease is significant – not only because vaccination keeps the virus from spreading, but also because learning about how many members of one's community have decided to get vaccinated has been shown to affect individual vaccination intention. In three pre-registered online experiments featuring country-level vaccination rates against a hypothetical disease, we tested two theoretical approaches which offer contrasting predictions on how public health messaging should leverage vaccination rates. If selfish rationality is assumed, a high uptake would tempt people to free-ride on herd immunity (so low uptake should be emphasized); conversely, if vaccination rates exert a descriptive normative influence, a high uptake would signal that vaccination is the best choice, and vice versa (so high uptake should be emphasized). In the pilot (*N* = 75) and Experiment 1 (*N* = 174), communicating a high (90%) vaccination rate (vs. 10% vs. no rate) increased vaccination intentions, with no detectable effect of a low vaccination rate. In Experiment 2 (*N* = 217), decisions to get vaccinated were frequently justified based on reasons involving self-protection, but also the protection of others and the collective, irrespective of the vaccination rate level (20% vs. 80%); participants, on the

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Data Availability Statement included at the end of the article

than on reasons reflecting descriptive normative influence. As a future line of research, we propose to study the reasonableness of vaccination choices.

The absence of a negative effect of communicating a low uptake in Experiment 1 might also be explained by a limitation of its scenario: it introduced possible VAEs, but the fictitious vaccine was presented as 100% effective and easily available for free. While such a scenario excludes potential confounding variables, it might have caused a ceiling effect. Future studies should include more realistic depictions of personal costs of vaccination (e.g., monetary cost or the requirement to visit a hospital), which might be a more valid test not only of the mechanisms behind descriptive norms (Lyu et al., 2024) but also of the selfish-rational approach, which frames vaccination as a social dilemma. Strictly speaking, vaccination can be considered a social dilemma only by those participants who perceive the costs of vaccination to be higher than the costs of the disease (Betsch et al., 2013). The opposite was true for the majority of participants in Experiment 1. Furthermore, while non-vaccinators in Experiment 2 endorsed fewer reasons in general, the endorsement of free-riding reasons was especially rare (Table 3). Taken together, these findings point to certain caveats when testing the assumptions of the selfish-rational approach, which can be addressed by future studies (e.g., the need to assure that vaccination costs are tangible or that participants understand the herd immunity mechanism).

To further explore the complex relationship between vaccination rates and vaccination intention, future studies would benefit from testing more than two or three levels of vaccination rates (e.g., Moussaoui et al., 2024) and from testing so-called *dynamic* descriptive norm messages (e.g., Milkman et al., 2022), such as "More and more people are getting vaccinated".

Our analysis points to several potential boundary conditions for testing both the selfish-rational and the descriptive norms approach, representing important directions for future research. At the present state of empirical evidence, it seems that public communication surrounding vaccination rates will profit most by accounting for both approaches, closer to the notion of reasonable judgments. Specifically, our results suggest that when vaccination rates are low or unlikely to exert positive normative influence, public communication may emphasize individual benefit, overcoming the belief that vaccination is unnecessary to protect one's health; when vaccination rates are high, public communication may leverage the power of descriptive norms and emphasize prosocial reasons for getting vaccinated. Self- versus other-benefit messages studied in Experiment 3 are, however, likely to be differentially effective for different groups of people (e.g., Ruggeri et al., 2024), for example, in terms of age, vulnerability or vaccine hesitancy, pointing to the need for public communication to assume a targeted approach.

Acknowledgments

This work is part of Aleksandra Lazić's PhD thesis titled "Communicating vaccination coverage: Testing the selfish versus the social rationality hypothesis", under the supervision of Iris Žeželj, PhD.

PhD Candidate Biography

Aleksandra Lazić was born on September 12, 1992, in Šabac, Serbia. She completed Stojan Novaković Elementary School in Šabac and graduated from the Philological High School in Belgrade in 2011.

Aleksandra earned a Bachelor's degree in Psychology from the University of Belgrade – Faculty of Philosophy in 2015 with a GPA of 9.5/10, and a Master's degree in 2016 with a GPA of 9.7/10, focusing her thesis on enhancing cooperativeness in social dilemmas using economic games. In 2017, she enrolled in the doctoral program at the same faculty, conducting research under the supervision of Professor Iris Žeželj on the interplay between vaccination communication, social processes, and media, using experimental methods and content analysis.

Aleksandra was employed at the Institute for Philosophy and Social Theory from 2018 to 2019, and from 2019 to 2025, at the University of Belgrade – Faculty of Philosophy, Department of Psychology, where she contributed to the REASON4HEALTH project (2022–2025; Science Fund of the Republic of Serbia) and supported research and outreach activities at the LIRA Lab. As a PhD student, she also assisted in delivering undergraduate courses in social psychology over eight semesters. She was selected and funded to attend several international seasonal schools, including Bounded Rationality Winter School in India and Behavioural Insights Summer School in Germany. In 2019, she was selected to be a Research Supervisor for an international student team in the Junior Researcher Programme.

During her doctoral studies, she gave nine presentations at international conferences and, as of now, has co-authored 16 peer-reviewed journal articles, including seven as first or lead author. She also contributed to two major big-team science collaborations. Aleksandra actively promotes Open Science through talks, workshops, and online resources. She co-founded REPOPSI—the Repository of Psychological Instruments in Serbian—in 2020, managed it for six years, and led a nine-month Horizon 2020–funded project to enhance the platform. Since 2023, she has served on the Executive Committee of ABRIR (Advancing Big-team Reproducible Science through Increased Representation) and as Coordinator of Open Science Community Serbia.

In 2020, she received a Researchers in the Global South Grant from the Society for the Psychological Study of Social Issues. In 2024, Aleksandra received the Đoka Vlajković Endowment Award for the best scientific work by a young researcher at the University of Belgrade, and the Sarah Jones Award from the Research Data Alliance for exceptional contributions to fostering collaboration in Open Science.

Образац 5.

Изјава о ауторству

Име и презиме аутора: Александра Лазић

Број индекса: 4П16-2

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Име и презиме аутора: Александра Лазић

Број индекса: 4П16-2

Студијски програм: Психологија

Наслов рада: Комуникација обухвата вакцином: Провера претпоставки модела себичне наспрам модела социјалне рационалности (Communicating vaccination coverage: Testing the selfish versus the social rationality hypothesis)

Ментор: проф. др Ирис Жежељ

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Образац 7.

Изјава о коришћењу

Овлашћујем Универзитетску библиотеку „Светозар Марковић“ да у Дигитални репозиторијум Универзитета у Београду унесе моју докторску дисертацију под насловом:

Комуникација обухвата вакцином: Провера претпоставки модела себичне наспрам модела социјалне рационалности (Communicating vaccination coverage: Testing the selfish versus the social rationality hypothesis)

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