Transparent communication about negative features of COVID-19 vaccines decreases acceptance but increases trust

Michael Bang Petersen[a,1] , **Alexander Bor[a]** , **Frederik Jørgensen[a]** , **and Marie Fly Lindholt[a]**

[a]Department of Political Science, Aarhus University, Aarhus DK-8000, Denmark

During the rapid development and rolling out of vaccines against COVID-19, researchers have called for an approach of "radical transparency," in which vaccine information is transparently disclosed to the public, even if negative information can decrease vaccine uptake. Consistent with theories about the psychology of conspiracy beliefs, these calls predict that a lack of transparency may reduce trust in health authorities and may facilitate the spread of conspiracy theories, which may limit the long-term capabilities of health authorities during and after the pandemic. On the basis of preregistered experiments conducted on large, representative samples of Americans and Danes (N > 13,000), the current study contrasts the effects of vague vaccine communication with transparent communication, which discloses either positive or negative vaccine features. The evidence demonstrates that transparent negative communication may indeed harm vaccine acceptance here and now but that it increases trust in health authorities. Furthermore, the alternative of vague, reassuring communication does not increase vaccine acceptance either and leads to both lower trust and higher endorsement of conspiracy theories.

COVID-19 | vaccine acceptance | health communication | transparency | trust

The World Health Organization (WHO) has emphasized that a vaccine against COVID-19 is a "vital tool" to counter the current pandemic (1) and, accordingly, unprecedented amounts of resources have been invested in the race toward the development and distribution of vaccines. Yet, the challenges of a vaccine-based solution to the COVID-19 pandemic does not end with the development of an effective and safe vaccine. A rapidly developed vaccine will have no effect if citizens across the world are not willing to get vaccinated. Given the emergence of more contagious and potentially vaccine-resistant coronavirus variants, a significant proportion of the public will need to get vaccinated to reach herd immunity (2) and may need to be revaccinated. As a number of international studies have demonstrated significant public vaccine hesitancy (3–6), a key challenge is to ensure sufficient vaccine acceptance both now and in the future.

Over the course of the pandemic, the importance of ensuring sufficient compliance with health recommendations has placed health communication at the center of pandemic management and, accordingly, there has been a pressing need for research on the factors underlying effective health communication. In the initial phases of the pandemic, as uncertainties about the COVID-19 disease and its cures abounded, a necessary focus was on how health authorities and researchers could transparently disclose what is not yet known (7) and the evidence documented that such uncertainties can be disclosed without harming public trust (8, 9). Yet, as knowledge is accumulating, discussions are increasingly shifting toward whether and how to transparently disclose what is known by authorities but which may constitute a barrier to public compliance with health recommendations.

Not disclosing health-relevant information transparently is a frequent problem in relationships between patients and health practitioners and a source of distrust (10). While practitioners sometimes worry that full transparency will cause emotional distress in patients (11, 12), the incentives toward lack of transparency during the COVID-19 pandemic relates more to the massive pressure of ending the pandemic as quickly as possible and, hence, to incentives to not disclose information that may jeopardize vaccine acceptance. These incentives may be larger because health communication during the pandemic is strongly influenced and often conducted by politicians. As evidenced by a rich history of political science research, politicians are motivated by myopic goals (13) and may prioritize short-term successes compared with building trust for the next health crisis.

In the domain of COVID-19 vaccines, negative information may relate to the fact that distribution and production difficulties require the use of vaccines with lower effectiveness and more side effects than other vaccines; unwelcome news may emerge about long-term side effects; the duration of immunity following vaccination may be lower than expected; and effectiveness may drop against new and emerging variants. Studies suggest that such negative information (e.g., information about lower effectiveness and side effects) may lower acceptance of vaccines in general (14) and COVID-19 vaccines specifically (15). This has been a real concern for health authorities in both Europe and United States where discussions about the presumed lower effectiveness and potential side effects of some COVID-19 vaccines have been argued to spur

hesitancy and implies that millions of doses of those vaccines remain unused (16, 17). Also, several countries worldwide—including Western democracies—have started vaccination campaigns without or prior to the publication of phase III trial results (18).

Against such developments, research communities have called for the transparent disclosing of information about the development, approval processes, and features of COVID-19 vaccines. The Royal Society DELVE Initiative (19) calls for "clear, transparent communication," a Nature editorial (20) for "radical transparency," and Mahase (21) for "real transparency" (see also ref. 22). As discussed by the Royal Society DELVE Initiative (19) this entails a commitment to "not hide the potential limitations of vaccines, including possible limited availability, incomplete protection requiring boosting and reactogenicity," even if "such negative or complicating factors might lower uptake" as "their discovery post-rollout is likely to have a far greater negative impact on uptake." Importantly, these current calls resonate with a number of critiques of the lack of transparency in prior but smaller-scale immunization campaigns (23–25).

While transparency is normatively important in itself, calls for transparent communication also resonate with psychological research on vaccine skepticism both during and prior to the COVID-19 pandemic. Disregarding outright disinformation, the often used alternative to transparently disclosing distressing information in communication between doctors and patients is the use of vague communication (11). Such communication has been demonstrated to have the potential to elicit feelings of uncertainty (26), a psychological state linked to triggers of vaccine skepticism (27, 28). In particular, feelings of uncertainty have been found to be fertile ground for distrust and conspiracy beliefs, which are major predictors of skepticism toward vaccines both in general and in relation to the COVID-19 pandemic (6, 29–31). Hence, while transparently disclosing negative vaccine information may elicit rationally grounded vaccine hesitancy (19), the alternative of vague communication may elicit hesitancy grounded in conspiratorial beliefs. Indeed, prior work on the communication of uncertainty suggests that uncertainty communicated in vague rather than specific terms may decrease trust in the communication (8). As noted in several of the calls for transparency, this emergence of conspiratorial beliefs may not just create a short-term obstacle in the coming months but may also create long-term obstacles by inducing general conspiracy-based distrust toward authorities. This may impede not just reimmunization campaigns during the pandemic but also the handling of future health crises.

Despite these hopes for the benefits of transparent health communication, even when disclosing negative information, other researchers remain skeptical. In particular, the effectiveness of any communication strategy may hinge on the prior existence of trust in the communicator (32). In the words of O'Neill (33), "unless the individuals and institutions who sort, process, and assess information are themselves already trusted, there is little reason to think that transparency and openness are going to increase trust." This challenge is exacerbated by the fact that the transparent disclosing of negative information may trigger the very psychological state that transparency was intended to guard against, namely uncertainty. In particular, there is substantial evidence that concerns about side effects, even if well grounded, can elicit anxiety and uncertainty (34).

On this basis, there is a pressing need to understand the role of transparency in health communication in the context of the COVID-19 pandemic and beyond. The core purpose of the present set of studies is to add to this understanding by examining how vague health communication and transparent health communication—both when disclosing negative and positive information—influence short- and long-term factors associated with acceptance of a COVID-19 vaccine.

Study 1

Study 1 focused on the potential short-term benefits of transparent (versus vague) health communication. Specifically, it examines whether transparent communication, even if disclosing negative information, increases public vaccine support and buffers against conspiracy theorists' attempts to decrease such support. Because of the potential negative effects of transparent negative communication, a final purpose of study 1 was to assess whether countervailing communication, which seeks to remedy any felt uncertainties, can buffer this potential adverse effect. Specifically, prior studies in public legitimacy find that policies with negative repercussions are viewed as more legitimate to the extent that people feel that their uncertainties are explicitly acknowledged (35). In the context of a vaccine against COVID-19, the management of concern and uncertainty involves both acknowledgment and action: Acknowledging the uncertainties that citizens may legitimately feel (7) and stating what specific actions have been taken to address these concerns.

Overall, study 1 was thus designed to test four predictions:

- Prediction 1: Compared with vague communication, transparent communication about a COVID-19 vaccine will increase support for the vaccine (support of its approval and use, etc.).
- Prediction 2: Compared with vague communication, even transparent negative communication about a COVID-19 vaccine will increase support for the vaccine.
- Prediction 3: Transparent communication about a COVID-19 vaccine will decrease the negative effects of conspiratorial communication about a COVID-19 vaccine (i.e., a conspiracy induction) on vaccine support.
- Prediction 4: Compared with vague communication, potential negative effects from transparent communication about a COVID-19 vaccine on vaccine support can be decreased by exposure to health communication that acknowledges public vaccine uncertainty and describes concrete steps taken to decrease this uncertainty (i.e., a certainty induction).

In addition, in a series of exploratory analyses we examine associations between vaccine support and a range of individual difference variables.

Study 1 Methods

The study was preregistered at Open Science Framework (OSF) and the study received ethical approval from the ethics review board at Aarhus University. Written informed consent was obtained from all participants. The preregistration, materials, data, and command files are available at OSF (https://osf.io/s7p5r/) and the preregistration is reproduced in SI Appendix, S1.

Data Collection. Between October 14 and October 21, 2020, prior to the release of any information about the features of vaccines against COVID-19, a sample of 3,436 Americans and 3,427 Danes completed a survey on attitudes toward a fictitious vaccine against COVID-19. The surveys were collected by the survey agency YouGov. The sample size was determined on the basis of a power analysis that showed that a combined sample of 6,800 would provide us with 90% power to detect a true effect size of Cohen's $d \geq 0.1$ for predictions 1 and 2 and 90% power to detect a true effect size of Cohen's $d \geq 0.12$ for predictions 3 and 4. The samples were quota sampled on gender, age, geographical location, education, and, in the United States, race, to match the respective populations on these sociodemographic variables. Our case selection was guided by an ambition to include countries where the pandemic has been more (United States) and less (Denmark) politicized (36).

Experimental Design. Using a factorial experiment, participants were randomly assigned to receive different information about a new fictional vaccine against COVID-19, referred to as COVACID. To create a judgmental anchor for both the features of COVACID and the transparency of the provided information, COVACID was compared with transparent and factual information about the seasonal vaccine against the common flu. The experiment had a 3 (communication: transparent neutral/transparent negative/vague) × 3 (induction: control/conspiratorial/certainty) full factorial design. The first experimental factor described the effectiveness, the side effects, and the duration of tests of COVACID. The transparent neutral condition described

the COVACID as equal in all aspects to one of the world's most used vaccines, the vaccine against the common flu. Negative communication implied that COVACID was described as less effective, having more side effects, and a shorter test period than the vaccine against the common flu. The vague communication condition suggested that publicly available information does not allow for precise comparisons with common flu shots, but the authorities stated that COVACID is "sufficiently effective," has "acceptable" side effects, and that the test period was "adequate."

The second experimental factor manipulated whether participants saw any additional information about the context of COVACID. Participants in the conspiracy induction condition learned that the approval of the vaccine had elicited debate and were exposed to the specific statement (presented as appearing on social media) that "the authorities attempt to force a vaccine on us and hide all relevant facts about it. They lie about all its side effects to stimulate the economy. Once again, the power-greedy elite demonstrates its complete disregard for ordinary Americans' [/Danes'] health and safety." Participants in the certainty induction condition read that the authorities explicitly acknowledge concerns about a rapidly developed and approved vaccine, which—consistent with reality for a number of vaccines—therefore was tested on a much larger sample than seasonal flu vaccines. Participants in the control condition received no additional information.

No deception was involved in the study and participants were debriefed subsequently and provided links to the most recent official information about vaccines against both the flu and COVID-19. Full wordings of the experimental materials, manipulation checks, and full wordings of all measures are available in *SI Appendix*, S3 and S10, respectively.

Dependent Measure. After exposure to the communication about the vaccine, participants were asked about their agreement with 12 statements about the COVACID vaccine (e.g., "I support the health authorities' approval of COVACID," "I would get vaccinated with COVACID if my general practitioner [GP] recommended it," "I would not feel safe getting a COVACID vaccine," and "I feel that the authorities are withholding important information about COVACID"). The preregistration divided these statements into multiple different scales (*SI Appendix*, S7) but an exploratory factor analysis shows that a single latent variable explains 87% of the total variance in all of the items and, for the sake of simplicity, a summary scale of all 12 indicators is created with a high level of reliability (US: $a = 0.90$; DK: $a = 0.92$). The measure, vaccine support, is recoded to vary between 0 and 1 with higher values indicating greater support and positivity for the COVACID vaccine. *SI Appendix*, S8 provides separate analyses for each of the separate scales. The results from those analyses do not differ from the results presented in the main text (for further information, see *SI Appendix*, S8 and S9).

Individual Difference Measures. Finally, the study obtained several psychological and sociodemographic individual difference measures and we explore their associations with vaccine support. As to the psychological measures, we collected, first, Webster and Kruglanski (37)'s scale of the need for cognitive closure, which taps an individual's ability to cope with uncertainty and is a major psychological predictor of conspiracy beliefs. The scale is reliably measured in both the United States ($a = 0.72$) and in Denmark ($a = 0.73$). Second, we used Dekker and Meijerink (38)'s scale of political cynicism, which is a major political predictor of conspiracy beliefs (39). This scale is also reliably measured in both the United States ($a = 0.70$) and Denmark ($a = 0.86$). Third, we used Kachanoff et al. (40)'s scale of threats from the COVID-19 pandemic. Consistent with Kachanoff et al., we created two separate scales, a scale of perceived symbolic threats (e.g., agreement with the statement that the coronavirus outbreak is a threat to "the rights and freedoms of the US population as a whole") ($a_{US} = .85$; $a_{DK} = .81$) and a scale of realistic threats (e.g., agreement with the statement that the coronavirus outbreak is a threat to "your personal health") associated with the COVID-19 pandemic ($a_{US} = 0.75$; $a_{DK} = 0.66$). Finally, we obtained a 10-point measure of ideological self-placement on a scale from left to right. In terms of sociodemographics, we collected information on gender, age, and education as well as vote choice in the last election for president in the United States and parliament in Denmark, which was recoded into a dichotomous variable reflecting a left-wing or right-wing vote choice. All individual difference measures are recoded with 0 and 1 as their endpoints, and higher values reflect higher need for cognitive closure, higher cynicism, higher perceived threat, a more right-wing orientation, being female, being older, being more educated, and voting for a right-wing party, respectively.

Statistical Analyses. Consistent with the preregistration, all predictions were tested using ordinary least squares (OLS) regression on the pooled sample of Danes and Americans with two-sided *P* values and poststratification on the

variables used for quota sampling (for unweighted means, see *SI Appendix*, S14). To facilitate interpretation, we also graphed the predicted effects in each sample separately. Consistent with the preregistration, we report unstandardized regression coefficients as effect size measures. When all variables are coded to vary between 0 and 1, the effect sizes reflect the change in percentage points of the full scale of the dependent variable as a function of an experimental condition or of a change in a continuous independent variable from its minimum to its maximum observed value (for further discussion and alternative effect size measures, see *SI Appendix*, S22). All statistical models are provided in *SI Appendix*, S12 and S13.

As specified in the preregistration, the planned inclusion criterion was to include only participants who provided correct answers to two of the three attention checks but here we tested the predictions on the full sample (for further information and discussion, see *SI Appendix*, S7 and S11). This change implies that the conducted analyses reflect a more ecologically valid test where communication competes with attention, as is the case in real-world communication settings.

Study 1 Results

Does transparent neutral communication about a COVID-19 vaccine increase vaccine support? Yes. Consistent with prediction 1 and as demonstrated in Fig. 1 (the "pooled" panel), transparent neutral communication relative to vague communication significantly increases vaccine support overall ($b_{Combined} = 0.07$ [0.06; 0.09], $P < 0.001$).

Does transparent negative communication about a COVID-19 vaccine increase vaccine support? No. Against prediction 2, Fig. 1 demonstrates that transparent negative communication relative to vague communication slightly decreases vaccine support overall ($b_{Combined} = -0.02$ [-0.03; -0.01], $P = 0.001$).

Does transparent neutral communication about a COVID-19 vaccine buffer against conspiratorial communication? No. Given the setup of Fig. 1 (i.e., showing the marginal effects of transparent communication across the conditions of the second experimental factor), prediction 3 entails that the positive effect of the transparent
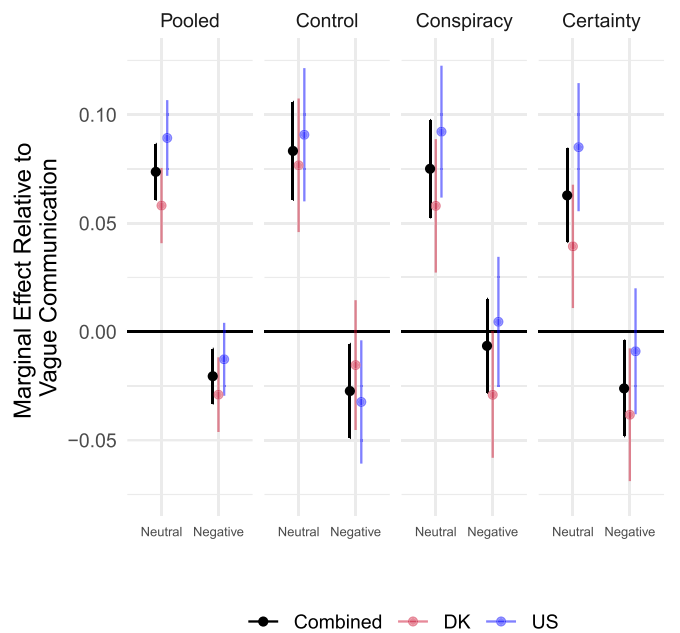
Fig. 1. Marginal effects of transparent negative and transparent neutral communication, respectively, relative to vague communication on vaccine support, pooled across induction conditions, and separated by induction conditions. Marginal effects are calculated using OLS regression, regressing vaccine support on communication conditions (for "pooled" panel) and the two-way interaction between the two experimental factors (for the other panels). The reference category is vague communication. Vaccine support is coded between 0 and 1. Whiskers represent 95% confidence intervals. $N = 3,436$ (United States) and 3,427 (Denmark).

Petersen et al.
Transparent communication about negative features of COVID-19 vaccines decreases acceptance but increases trust

www.manaraa.com

condition (versus the vague condition) should be larger in the conspiracy induction condition relative to the control condition. Against this prediction, there is no evidence that the effect of transparent communication is larger in the conspiracy induction condition overall ($b_{Combined} = -0.01$ [$-0.04; 0.02$], $P = 0.61$).

Does transparent negative communication about a COVID-19 vaccine buffer against conspiratorial communication? No. As shown in Fig. 1, there is no evidence that the marginal effect of transparent negative communication is significantly larger in the conspiracy induction than in the control condition ($b_{Combined} = 0.02$ [$-0.01; 0.05$], $P = 0.18$). With this rejection of prediction 3, it is relevant to note that additional analyses reveal that the conspiracy induction only significantly decreases vaccine support (and only slightly so) relative to the certainty induction ($b = -0.03$ [$-0.04; -0.01$], $P < 0.001$) but not relative to the control condition ($b = -0.01$ [$-0.02; 0.00$], $P = 0.18$). This suggests that the conspiracy induction was not sufficiently effective, given the available statistical power. We return to this in study 2.

Does health communication that acknowledges uncertainty buffer against the negative effects of negative transparent communication? No. As a first step, we observed that the certainty induction slightly but significantly increases vaccine support compared with both the control condition ($b = 0.02$ [$0.01; 0.03$], $P = 0.006$) and the conspiracy induction ($b = 0.03$ [$0.01; 0.04$], $P < 0.001$). Given the setup of Fig. 1, prediction 4 entails that any negative effect of the transparent condition (versus the vague condition) should decrease in the certainty induction condition relative to the control condition. However, against prediction 4, there is no evidence for a significant interaction effect overall ($b_{Combined} = 0.001$ [$-0.03; 0.03$], $P = 0.94$). Similar results are obtained when the transparent neutral condition is examined rather than the transparent negative condition ($b_{Combined} = -0.02$ [$-0.05; 0.01$], $P = 0.20$).

What individual differences are associated with vaccine skepticism? Turning to the exploratory analyses, we analyzed the bivariate associations between our individual difference measures and vaccine support. Specifically, we regressed vaccine support on each of the individual difference measures in separate regression models for each measure, controlling for country in the combined sample (see *SI Appendix*, S15 for all pairwise correlations). We pooled the results across all experimental conditions. The results are shown in Fig. 2. The results show that vaccine skepticism is not associated with a need for cognitive closure ($b_{Combined} = -0.01$ [$-0.04; 0.02$], $P = 0.50$) or by concerns related to realistic threats from COVID-19 ($b_{Combined} = -0.02$ [$-0.04; 0.01$], $P = 0.20$). There is only little evidence that people who are on the ideological ($b_{Combined} = -0.03$ [$-0.05; -0.01$], $P < 0.001$) or electoral ($b_{Combined} = -0.02$ [$-0.02; 0.00$], $P = 0.007$) right-wing are less supportive of the COVID-19 vaccine. Nor are demographics consistently important. Overall, the key correlates of vaccine skepticism are concerns about symbolic threats from COVID-19 (e.g., its potential impact on democratic freedoms; $b_{Combined} = -0.16$ [$-0.19; -0.14$], $P < 0.001$) and, in particular, a general distrust of the political system reflected in the measure of political cynicism ($b_{Combined} = -0.30$ [$-0.33; -0.27$], $P < 0.001$). Overall, political cynicism is the strongest predictor of vaccine skepticism across both the United States and Denmark.

Study 2

Study 1 suggests that vaccine skepticism is highest among people who distrust authorities and that transparent communication about a vaccine, if negative, increases rather than reduces this skepticism. Study 2 was designed to replicate the communication effect and directly examine how communication and individual dispositions interact: Even if transparent communication might not decrease skepticism among everyone, could it perhaps reduce skepticism among those who are disposed toward the greatest skepticism? Most importantly, however, study 2 was designed to ask the key follow-up question: Are there important alternative benefits of
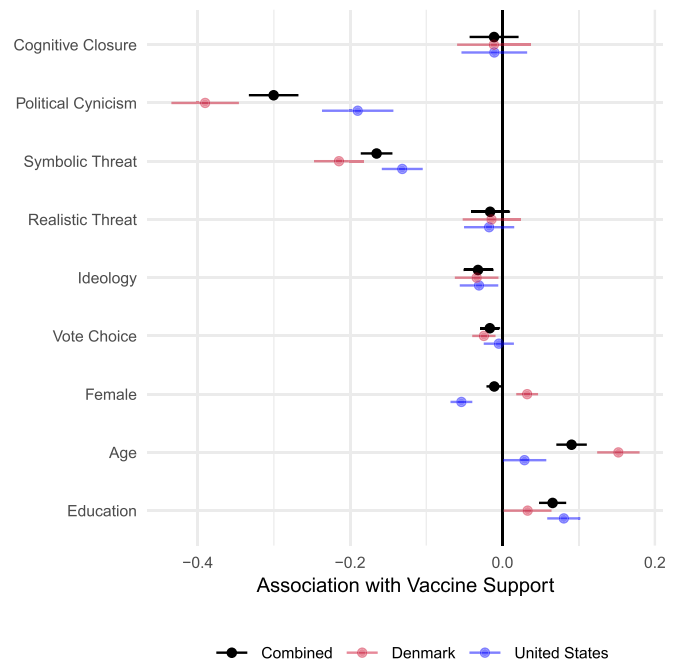

Fig. 2. Associations between a range of individual differences and vaccine support. Associations reflect unstandardized OLS regression coefficients calculated from bivariate regressions, except "combined" models that control for country. All correlates are recoded to vary between 0 and 1. Higher values on ideology and vote choice equal more right-wing ideology and vote choice, respectively. Whiskers represent 95% confidence intervals. $N = 3,436$ for all US analyses, except vote where $n = 2,079$. $N = 3,427$ for all Danish analyses, except vote where $n = 3,004$.

transparent communication on trust in health authorities and the rejection of conspiracy theories? In addition, study 2 disentangles the effects of transparent and vague communication by including a neutral baseline and zooms in on the most important outcome variable for the replication: Individual rates of vaccine acceptance (for comparable analyses for study 1, see *SI Appendix*, S16). Specifically, study 2 was designed to test three preregistered hypotheses:

- Prediction 1: Compared with a baseline of no communication about the features of a vaccine, transparent communication about the features of a COVID-19 vaccine will increase 1) vaccine acceptance; 2) rejection of conspiracy-related statements about the vaccine; and 3) general trust in national health authorities whether or not the content of the transparent communication is positive, neutral, or negative.
- Prediction 2: Compared with a baseline of no communication about the features of a vaccine, vague communication about a COVID-19 vaccine will decrease 1) vaccine acceptance; 2) rejection of conspiracy-related statements about the vaccine; and 3) general trust in national health authorities whether or not the content of the transparent communication is positive, neutral, or negative.
- Prediction 3: The effect of transparent relative to vague communication on vaccine acceptance is larger among those individuals who hold conspiracy-related beliefs compared with those who do not hold such beliefs. Thus, to the extent transparency buffers against conspiratorial thinking, it could potentially be effective among those who hold such beliefs, even if transparency itself does not increase vaccine acceptance on average.

In addition to measures of individual difference in conspiracy-related beliefs, study 2 also included a range of other individual difference measures to further buttress the findings from study 1.

Petersen et al.
Transparent communication about negative features of COVID-19 vaccines decreases
acceptance but increases trust

Study 2 Methods

The study was preregistered at OSF and the preregistration, materials, data, and command files are available at OSF (https://osf.io/s7p5r/). The preregistration is reproduced in *SI Appendix*, S2. The study complies with Aarhus University's Code of Conduct as well as the Committee Act of the Danish National Committee of Health Research Ethics and included only slightly modified materials from study 1. Written informed consent was obtained from all participants.

Data Collection. Between February 24 and March 5, 2021, i.e., after vaccinations against COVID-19 started in the two focal countries, a sample of 3,478 Americans and 3,450 Danes completed a survey on attitudes toward a fictitious vaccine against COVID-19, conducted by YouGov. The sample size was determined on the basis of a power analysis that showed that a combined sample of 6,800 would provide us with more than 80% power to detect a difference of five percentage points for predictions 1 and 2. The samples were quota sampled on gender, age, geographical location, education, and, in the United States, race, to match the respective populations on these sociodemographic variables.

Experimental Design. The experimental design replicated the three conditions of the first experimental factor of study 1 but added two additional conditions. First, given the high degree of effectiveness of the vaccines currently being used against COVID-19, we added a transparent positive condition that described COVACID as better than the vaccine against the common flu (specifically, being 90% effective, having serious side effects among only 1 in 100,000, and having been tested for an extended period of time). Second, to be able to disentangle the causal effects of vague and transparent communication, we added a control condition that simply read: "Imagine that the US health authorities approve a new vaccine against COVID-19. We will call the vaccine COVACID. COVACID has been approved on the basis of the ability to protect against coronavirus, the level of side effects, and the length of the period in which it has been tested." Full experimental wordings and measurement details are provided in *SI Appendix*, S5 and S6.

Dependent Measures. Study 2 included three dependent measures. First, following Murphy et al. (41), we measured rates of vaccine acceptance by an indicator variable with a value of "1" for everyone answering "yes" when asked whether they would get vaccinated with COVACID if it became available and was recommended for them. Participants answering maybe or no received a value of "0."

Second, we measured trust in health authorities by asking participants two questions that assessed how their trust in health authorities would be affected, if health authorities circulated the prior information about COVACID. The two items ($r_{US} = 0.39$; $r_{DK} = 0.59$) were combined into a single scale, with higher values indicating higher trust in health authorities. The scale was recoded into a continuous measure with 0 and 1 as endpoints.

Third, we measured endorsement of conspiracy beliefs by exposing all participants to the conspiracy induction from study 1 and asking all participants three items that tapped their degree of agreement with the conspiratorial social media statement. The three items were combined into an overall reliable scale ($\alpha_{US} = 0.63$; $\alpha_{DK} = 0.77$) with higher values indicating higher endorsement. The scale was recoded into a continuous measure with 0 and 1 as endpoints. To validate that the content was indeed conspiratorial in nature, we subsequently asked participants how conspiratorial they found the statement on a four-point scale from "not at all conspiratorial" to "very conspiratorial." Only 11% of the participants answered "not at all conspiratorial" and the modal answer was "very conspiratorial" with 34%.

Individual Difference Measures. To test prediction 3, study 2 included two individual difference measures: The scale of political cynicism from study 1 ($\alpha_{US} = 0.76$; $\alpha_{DK} = 0.88$) and the conspiracy mentality scale ($\alpha_{US} = 0.83$; $\alpha_{DK} = 0.84$) from Bruder et al. (42) to directly assess the degree of conspiracy-related beliefs. In addition, we included a range of trust-related variables and an alternative scale of abilities; to manage uncertainty (following van der Bles et al. (8), we included Herman et al. (43)'s tolerance of ambiguity scale). We report and discuss exploratory correlations between the outcome measures and these other individual differences measures below and in *SI Appendix*, S19.

Statistical Analyses. All predictions are tested using OLS regression on the combined sample. Predictions 1 and 2 were tested by regressing each of the three dependent variables on the experimental condition of the participant with the control condition as the reference category. For prediction 3, vaccine acceptance was regressed separately on each of the two measures of conspiracy-related beliefs, an indicator variable of whether the respondent was exposed to a transparent communication (i.e., pooling across negative, neutral, and positive conditions) (1) or the vague communication condition (0) and their interaction. We chose and preregistered to pool across the three transparent conditions for testing prediction 3, due to the need for higher statistical power to detect the predicted interaction effect. Full statistical models and additional analyses using logistic regression (given the binary vaccine acceptance variable) are available in *SI Appendix*, S17 and S21, respectively. The preregistered analyses do not include any attention checks, but we report equivalent findings excluding inattentive respondents in *SI Appendix*, S18.

Study 2 Results

Does vaccine acceptance increase in the face of transparent communication and decrease in the face of vague communication? Partly. Against prediction 1 but replicating the findings of study 1, Fig. 3 demonstrates that vaccine acceptance only increases when exposed to transparent positive communication ($b_{Combined} = 0.07$ [0.03; 0.10], $P < 0.001$) and transparent neutral communication ($b_{Combined} = 0.05$ [0.01; 0.08], $P = 0.011$). Transparent negative communication, in contrast, decreases vaccine acceptance ($b_{Combined} = -0.15$ [−0.18; −0.1], $P < 0.001$). Consistent with prediction 2, vague communication also decreases vaccine acceptance ($b_{Combined} = -0.09$ [−0.13; −0.06], $P < 0.001$).

Is the effect of transparent relative to vague communication larger among those who hold conspiracy-related beliefs? No. For neither political cynicism ($b_{Combined} = 0.02$ [−0.12; 0.17], $P = 0.79$) nor conspiracy mentality ($b_{Combined} = -0.16$ [−0.30; −0.02], $P = 0.02$) do we find any evidence that the effect of transparent communication is larger among individuals with conspiracy-related beliefs. In fact, the significant negative interaction term for conspiracy mentality suggests that transparent communication is less effective among those high in conspiratorial mentality. Hence, against prediction 3, the transparent declaring of vaccine features does not motivate those with a conspiracy-related mindset to get vaccinated. Graphical displays of the interaction effects appear in *SI Appendix*, S20. Exploratory analyses in *SI Appendix*, S19, furthermore, demonstrate (consistent with the associations in Fig. 2) that vaccine acceptance is significantly correlated with both political cynicism ($r = -0.26$) and conspiratorial mentality ($r = -0.25$) as well as a trust in national institutions. Consistent with the findings about need for cognitive closure in study 1, the alternative measure of tolerance for ambiguity is only weakly correlated with vaccine acceptance ($r = 0.05$).

Does endorsement of conspiracy beliefs decrease in the face of transparent communication and increase in the face of vague communication? Mostly. As shown in Fig. 3, endorsement of conspiracy beliefs decreases when exposed to transparent positive communication ($b_{Combined} = -0.04$ [−0.06; −0.02], $P < 0.001$) and transparent neutral communication ($b_{Combined} = -0.04$ [−0.05; −0.02], $P < 0.001$) but is unmoved by transparent negative communication ($b_{Combined} = 0.01$ [−0.003; 0.03], $P = 0.13$). Hence, while transparent negative communication clearly decreases vaccine acceptance it does not significantly influence the endorsement of conspiracy beliefs relative to the control condition. In contrast, and consistent with prediction 2, vague communication significantly increases endorsement of conspiracy beliefs ($b_{Combined} = 0.04$ [0.02; 0.05], $P < 0.001$).

Does trust in health authorities increase in the face of transparent communication and decrease in the face of vague communication? Yes. Consistent with prediction 1 and as shown in Fig. 3, trust in health authorities increases when exposed to both transparent positive communication ($b_{Combined} = 0.07$ [0.05; 0.08], $P < 0.001$), transparent neutral communication ($b_{Combined} = .07$ [0.06; 0.09], $P < 0.001$) and transparent negative communication ($b_{Combined} = 0.02$ [0.00; 0.03], $P = 0.04$). Consistent with prediction 2, vague communication significantly decreases trust in health authorities ($b_{Combined} = -0.05$ [−0.06; −0.03], $P < 0.001$).

Petersen et al.
Transparent communication about negative features of COVID-19 vaccines decreases acceptance but increases trust

PNAS | 5 of 8
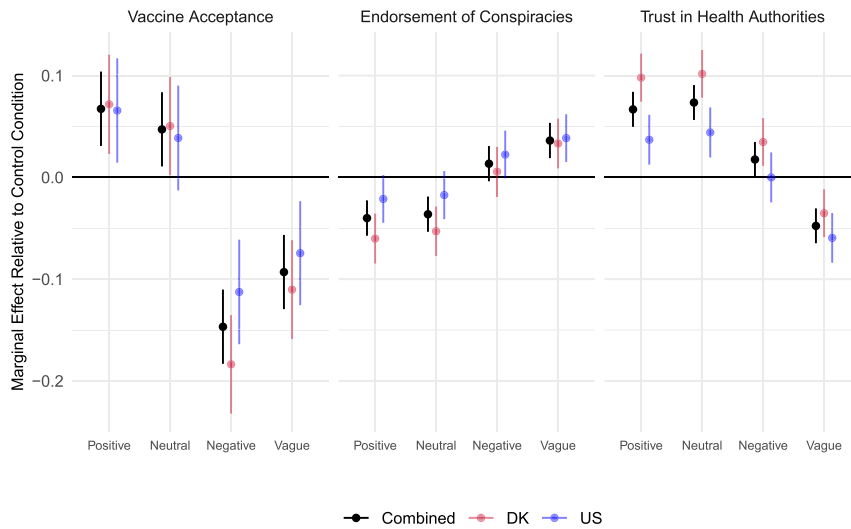https://doi.org/10.1073/pnas.2024597118

www.manaraa.com

Fig. 3. Marginal effects of vague and transparent negative, neutral, and positive communication, respectively, relative to a control condition on vaccine acceptance, endorsement of conspiracy theories, and trust in health authorities, combined and separated by country. Marginal effects are calculated using OLS regression to regress the outcome variable on communication conditions. The reference category is the control condition. All outcome variables vary between 0 and 1. Whiskers represent 95% confidence intervals. $N = 3,478$ (United States) and $3,450$ (Denmark).

Discussion

These results demonstrate that transparent communication about a fictitious COVID-19 vaccine that discloses features that are comparable to or better than well-known influenza vaccines increases vaccine support and acceptance. In contrast, transparent communication that discloses negative features decreases support and acceptance. This negative effect of transparent negative communication on vaccine support is not significantly buffered by countervailing health communication that seeks to induce feelings of certainty (i.e., study 1's certainty induction) but neither is it significantly exacerbated by exposure to conspiracy-related misinformation (i.e., study 1's conspiracy induction). As such, there is a clear cost for immediate vaccine uptake of transparently disclosing negative features of a vaccine as it induces vaccine skepticism. At the same time, however, there is no evidence to suggest that the alternative of vague health communication generates vaccine acceptance. In fact, the consistent negative effect of vague communication on acceptance seems to suggest that it is perceived as a cover for negative vaccine features. Furthermore, vague communication has long-term negative effects by eroding trust in health authorities and increasing the reception of conspiracy theories. Importantly, the transparent disclosing of negative vaccines has no such negative long-term effects. While transparent disclosing of negative vaccine information may hurt in the short term, transparency has key long-term benefits by sustaining trust, which is a critical resource for handling both future health emergencies and the continuing pandemic with the potential need of repeated vaccinations. Despite differences in political systems and levels of polarization, the evidence for this conclusion was remarkably consistent across the Danish and American samples.

The importance of these findings is buttressed by the fact that the present findings, together with prior studies, clearly document that conspiracy-related beliefs have been strongly associated with vaccine skepticism during the course of the COVID-19 pandemic. Thus, the strongest predictors of vaccine skepticism in both the United States and Denmark were individual differences in political cynicism, i.e., beliefs that political elites are corrupt and incompetent, and in conspiratorial thinking. Furthermore, the results of study 2 demonstrate that transparency is unlikely to increase immediate vaccine acceptance among those with an already

conspiratorial mindset. Consistent with concerns raised in prior work on transparency (33), transparent communication cannot induce compliance among those who already distrust the communicator. The key long-term function of transparency is thus to ensure that conspiratorial beliefs do not spread into new population segments, making them difficult-to-reach audiences for health communicators.

In this regard, it is also relevant to consider the type of vaccine hesitancy triggered by negative transparent communication. Psychological variables related to the ability to handle diffuse uncertainty (e.g., need for cognitive closure and tolerance of ambiguity) display little association with vaccine skepticism, suggesting that some vaccine skepticism emerges from more strict calculations about costs and benefits, as emphasized in a number of accounts (44). In this light, it may be prudent to consider the hesitancy triggered by transparently disclosing negative vaccine features a form of rationally grounded hesitancy. This could explain why there is a disconnect between the short-term hesitancy and the long-term trust induced by transparently disclosing negative information. This is also consistent with the finding that the certainty induction in study 1, which targets the uncertainty underlying conspiracy-based hesitancy, does not significantly moderate the vaccine concerns triggered by transparent negative vaccine information.

As with any empirical study, there are a number of limitations to the present findings. First of all, the effect sizes are small to medium sized. This was expected and, hence, we preregistered and utilized large samples (with over 13,000 participants in total). The effect sizes reflect, in part, the short-term nature of a survey experiment and, hence, effects may be larger when real-world communication is repeatedly circulated in both legacy and social media. The limited effects of communication also likely reflect that vaccine skepticism is highly associated with more stable individual differences (such as conspiratorial beliefs), underscoring the importance for health communication of not activating such differences in the first place. Second, the communication materials used are highly stylized to ensure experimental control but as real-world communication unfolds multiple nuances would likely emerge. At the same time, the vague, reassuring communication used in the experiment is not radically different from the way some political leaders have been communicating about vaccines. When the first batch of Sinopharm, a vaccine without transparent,

peer-reviewed phase III trial documentation, arrived to Serbia (i.e., a European parliamentary democracy) in January 2021, President Vučić asserted that "he is convinced that those vaccines are excellent, and that he will ask the Minister of Health [...] to speed up the vaccination process from next week." (45). Third, because of the practical and ethical challenges involved, we examined attitudes toward a fictitious COVID-19 vaccine. Accordingly, the present results suffer from hypothetical bias, which implies that communication effects on vaccination intentions may not directly translate into effects on actual vaccination behavior (46).

Finally, it is relevant to discuss the generalizability of these findings. In this regard, it is relevant to consider the comparability of the findings in study 2 and the findings in study 1. Thus, studies 1 and 2 were conducted under different contexts. When study 1 was conducted, no public information about the features of COVID-19 vaccines had been released. When study 2 was conducted, vaccinations had started in both countries under investigation, and concerns about the effectiveness of some COVID-19 vaccines had received public attention (16). Despite these contextual differences (and differences in question wordings, etc.), the results are highly comparable. In study 1, the difference in vaccine support for transparent neutral and transparent negative communication relative to vague communication was 0.07 and −0.02, respectively. In study 2, the corresponding differences for vaccine acceptance were 0.14 and −0.06. If anything, the importance of vaccine communication for public attitudes has increased from study 1 to study 2 and, hence, there is reason to believe that this importance will generalize to future phases of the pandemic, including in relation to current concerns about potential side effects of some COVID-19 vaccines (17). This also suggests that it is likely that these findings will generalize to

situations where the effectiveness and side effects of vaccines for other diseases than COVID-19 are discussed.

Overall, these results underscore that transparency itself cannot reduce immediate vaccine skepticism but transparency is nonetheless of key importance for sustaining long-term trust and avoiding the spread of conspiracy beliefs. Furthermore, while there are clear short-term costs to transparent negative communication, there are no benefits to the alternative of reassuring the public about vaccine safety and effectiveness using vague communication, which leads to both short-term vaccine skepticism and long-term distrust of authorities. As such, the present findings provide a clear warning for health authorities and politicians against succumbing to the use of vague communication to satisfy myopic goals of increasing vaccine acceptance here and now. Many countries already face the challenge of beating distrust-based skepticism of the vaccines and, according to the present results, the main available tool of health communication has little persuasive power once people become truly skeptical. If health communicators do not insist on transparent communication, even if this entails disclosing negative information, such challenges are likely to increase and may undermine future vaccination efforts, both if repeated vaccinations are required during the current pandemic and in future health emergencies.

1. WHO, WHO Director-General's opening remarks at the media briefing on COVID-19 – 21 August 2020. https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—21-august-2020.
2. T. Britton, F. Ball, P. Trapman, A mathematical model reveals the influence of population heterogeneity on herd immunity to SARS-CoV-2. *Science* **369**, 846–849 (2020).
3. T. Callaghan *et al.*, Correlates and disparities of COVID-19 vaccine hesitancy. SSRN (2020) https://ssrn.com/abstract=3667971 or https://dx.doi.org/10.2139/ssrn.3667971.
4. J. V. Lazarus *et al.*, A global survey of potential acceptance of a COVID-19 vaccine. *Nat. Med.* **27**, 225–228 (2021).
5. Marie Fly Lindholt, Frederik Jørgensen, Alexander Bor, Michael Bang Petersen, Public acceptance of COVID-19 vaccines: cross-national evidence on levels and individual-level predictors using observational data. *BMJ Open* **11**, e048172 (2021).
6. J. Roozenbeek *et al.*, Susceptibility to misinformation about COVID-19 around the world. *R. Soc. Open Sci.* **7**, 201199 (2020).
7. M. Blastland, A. L. J. Freeman, S. van der Linden, T. M. Marteau, D. Spiegelhalter, Five rules for evidence communication. *Nature* **587**, 362–364 (2020).
8. A. M. van der Bles *et al.*, Communicating uncertainty about facts, numbers and science. *R. Soc. Open Sci.* **6**, 181870 (2019).
9. A. M. van der Bles, S. van der Linden, A. L. J. Freeman, D. J. Spiegelhalter, The effects of communicating uncertainty on public trust in facts and numbers. *Proc. Natl. Acad. Sci. U.S.A.* **117**, 7672–7683 (2020).
10. L. Robins *et al.*, Identifying transparency in physician communication. *Patient Educ. Couns.* **83**, 73–79 (2011).
11. M. C. J. Cuisinier, J. T. M. Van Eijk, R. Jonkers, H. J. Dokter, Psychosocial care and education of the cancer patient: Strengthening the physician's role. *Patient Educ. Couns.* **8**, 5–16 (1986).
12. L. M. Ong, J. C. de Haes, A. M. Hoos, F. B. Lammes, Doctor-patient communication: A review of the literature. *Soc. Sci. Med.* **40**, 903–918 (1995).
13. K. Strøm, A behavioral theory of competitive political parties. *Am. J. Pol. Sci.* **34**, 565–598 (1990).
14. C. L. Byington, Vaccines: Can transparency increase confidence and reduce hesitancy? *Pediatrics* **134**, 377–379 (2014).
15. M. Motta, Can a COVID-19 vaccine live up to Americans' expectations? A conjoint analysis of how vaccine characteristics influence vaccination intentions. *Soc. Sci. Med.* **272**, 113642 (2021).
16. H. Boytchev, Covid-19: Germany struggles with slow uptake of Oxford AstraZeneca vaccine. *BMJ* **372**, n619 (2021).
17. K. Kupferschmidt, G. Vogel, Vaccine link to serious clotting disorder firms up. *Science* **372**, 220–221 (2021).
18. C. Zimmer, J. Corum, S.-L. Wee, Coronavirus vaccine tracker. NY Times. https://www.nytimes.com/interactive/2020/science/coronavirus-vaccine-tracker.html. Accessed 5 March 2021.
19. DELVE Initiative, SARS-CoV-2 vaccine development & implementation; scenarios, options, key decisions (DELVE Rep., No. 6, 2020).
20. COVID vaccine confidence requires radical transparency. *Nature* **586**, 8 (2020).
21. Mahase, E. (2020). Covid-19: Vaccine trials need more transparency to enable scrutiny and earn public trust, say experts. *BMJ*, **371**, m4042.
22. A. F. Cohen *et al.*, COVID-19 vaccines: The importance of transparency and fact-based education. *Br. J. Clin. Pharmacol.* **86**, 2107–2110 (2020).
23. S. Black, R. Rappuoli, A crisis of public confidence in vaccines. *Sci. Transl. Med.* **2**, mr1 (2010).
24. J. C. Bélisle-Pipon, L. Ringuette, V. Doudenkova, B. Williams-Jones, Protecting public health or commercial interests? The importance of transparency during immunization campaigns. *Ethics Med. Public Health* **3**, 241–245 (2017).
25. M. M. Dayrit, R. U. Mendoza, S. A. Valenzuela, The importance of effective risk communication and transparency: Lessons from the dengue vaccine controversy in the Philippines. *J. Public Health Policy* **41**, 252–267 (2020).
26. E. Hanganu, G. Popa, Cancer and truth. *J. Med. Ethics* **3**, 74–75 (1977).
27. M. Marchlewska, A. Cichocka, M. Kossowska, Addicted to answers: Need for cognitive closure and the endorsement of conspiracy beliefs. *Eur. J. Soc. Psychol.* **48**, 109–117 (2018).
28. J. W. Van Prooijen, N. B. Jostmann, Belief in conspiracy theories: The influence of uncertainty and perceived morality. *Eur. J. Soc. Psychol.* **43**, 109–115 (2013).
29. M. Browne, Epistemic divides and ontological confusions: The psychology of vaccine scepticism. *Hum. Vaccin. Immunother.* **14**, 2540–2542 (2018).
30. D. Freeman *et al.*, Coronavirus conspiracy beliefs, mistrust, and compliance with government guidelines in England. *Psychol. Med.*, 1–13, 10.1017/S0033291720001890 (2020).
31. L. Palamenghi, S. Barello, S. Boccia, G. Graffigna, Mistrust in biomedical research and vaccine hesitancy: The forefront challenge in the battle against COVID-19 in Italy. *Eur. J. Epidemiol.* **35**, 785–788 (2020).
32. E. J. Wilson, D. L. Sherrell, Source effects in communication and persuasion research: A meta-analysis of effect size. *J. Acad. Mark. Sci.* **21**, 101–112 (1993).
33. O. O'Neill, *A Question of Trust: The BBC Reith Lectures 2002* (Cambridge University Press, 2002).
34. E. Paul, A. Steptoe, D. Fancourt, Attitudes towards vaccines and intention to vaccinate against COVID-19: Implications for public health communications. *Lancet Reg. Health Eur.* **1**, 100012 (2021).
35. T. R. Tyler, *Why People Obey the Law* (Princeton University Press, 2006).
36. F. Jørgensen, A. Bor, M. B. Petersen, Compliance without fear: Individual-level protective behaviour during the first wave of the COVID-19 pandemic. *Br. J. Health Psychol.* **26**, 679–696 (2021). Epub 2021 Mar 24.
37. D. M. Webster, A. W. Kruglanski, Individual differences in need for cognitive closure. *J. Pers. Soc. Psychol.* **67**, 1049–1062 (1994).

Petersen et al.
Transparent communication about negative features of COVID-19 vaccines decreases acceptance but increases trust

PNAS | 7 of 8
https://doi.org/10.1073/pnas.2024597118

38. H. Dekker, F. Meijerink, Political cynicism: Conceptualization, operationalization, and explanation. *Politics, Culture and Socialization* **3**, 33–48 (2012).

39. Viren Swami, Tomas Chamorro-Premuzic, Adrian Furnham, Unanswered questions: A preliminary investigation of personality and individual difference predictors of 9/11 conspiracist beliefs. *Appl. Cognit. Psychol.* **24**, 749–761 (2009).

40. F. J. Kachanoff, Y. E. Bigman, K. Kapsaskis, K. Gray, Measuring realistic and symbolic threats of COVID-19 and their unique impacts on well-being and adherence to public health behaviors. *Soc. Psychol. Personal. Sci.* **12**, 603–616 (2021).

41. J. Murphy *et al.*, Psychological characteristics associated with COVID-19 vaccine hesitancy and resistance in Ireland and the United Kingdom. *Nat. Commun.* **12**, 29 (2021).

42. M. Bruder, P. Haffke, N. Neave, N. Nouripanah, R. Imhoff, Measuring individual differences in generic beliefs in conspiracy theories across cultures: Conspiracy mentality questionnaire. *Front. Psychol.* **4**, 225 (2013).

43. J. L. Herman, M. J. Stevens, A. Bird, M. Mendenhall, G. Oddou, The tolerance for ambiguity scale: Towards a more refined measure for international management research. *Int. J. Intercult. Relat.* **34**, 58–65 (2010).

44. C. Betsch *et al.*, Beyond confidence: Development of a measure assessing the 5C psychological antecedents of vaccination. *PLoS One* **13**, e0208601 (2018).

45. Danas, One million doses of Chinese vaccine arrived in Serbia. https://mefdlwsbh4wrmmse7eif2mxvlu-adwhj77lcyoafdy-www-danas-rs.translate.goog/drustvo/u-srbiju-stiglo-milion-doza-kineske-vakcine. Accessed 16 January 2021.

46. I. Ajzen, T. C. Brown, F. Carvajal, Explaining the discrepancy between intentions and actions: The case of hypothetical bias in contingent valuation. *Pers. Soc. Psychol. Bull.* **30**, 1108–1121 (2004).

47. M. B. Petersen, A. Bor, F. J. Jørgensen, M. F. Lindholt, Transparent communication about negative features of COVID-19 vaccines decreases acceptance but increases trust. Open Science Framework. https://osf.io/s7p5r/. Deposited 10 March 2021.

8 of 8 | PNAS
https://doi.org/10.1073/pnas.2024597118

Petersen et al.
Transparent communication about negative features of COVID-19 vaccines decreases acceptance but increases trust

www.manaraa.com