How skeptics could be convinced (not persuaded) to get vaccinated against COVID-19

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Data availability

Data and analysis code for these studies are available upon request.

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Abstract

Central to the SARS-CoV-2 pandemic strategy, COVID-19 vaccination depends on the population's uptake decisions. Because at least 60% of the population needs to be vaccinated, but fewer, for example, in Germany are expected to do so, it is important to know how to convince those who are undecided or skeptical. According to the health care standard of enabling citizens to make informed decisions based on balanced information (boosting) – instead of persuasion or seduction (nudging) – a comparison of benefits and harms of having or not having the vaccination would be required to inform these groups. With the help of a representative survey, we investigated the contribution of fact boxes, an established intervention format for informed intentions. Study 1 shows the development of knowledge and evaluation of COVID-19 vaccinations by German citizens between Nov 2020 and Feb 2021. Study 2 reveals objective information needs and subjective information requirements of those laypeople at the end of Nov. Study 3 shows that the fact box format is effective for risk communication about COVID-19. Based on these insights, a fact box on the efficacy and safety of mRNA-vaccines was implemented with the help of a national health authority. Study 4 shows that fact boxes increase vaccination knowledge and positive evaluations of the benefit-harm ratio of vaccination in skeptics and undecideds. Our results demonstrate that simple fact boxes can be an effective boost of informed decision making among undecided and skeptical people, and that informed decisions can lead to more positive vaccination evaluations of the public.

Significance Statement

A critical proportion of citizens' intentions to have the COVID-19 vaccination depend on their knowledge about the vaccination. According to Western health care standards, citizens should be enabled to make informed decisions based on balanced information (boosting) rather than persuasion or seduction (nudging). To address both information needs and requirements, a fact box, an established evidence-based health information format, was developed for COVID-19 vaccinations. A population-wide study (for Germany) shows that due to correct inferences from a simple fact box over a control group undecided and skeptical people evaluate vaccinations more positively.

Introduction

The spread of SARS-CoV-2 can only be effectively controlled by vaccination of large parts of the population (1). There is cumulating evidence that vaccinated people will less likely infect non-vaccinated people given contact with the virus (2), meaning that vaccinated people can protect others who cannot be vaccinated (community immunity), such as those with health conditions or therapies that suppress the immune system. Overall, there is public interest in ensuring that enough people get vaccinated, i.e. a proportion of between 60 and 80% of a country's population (3-5).

In Germany, at least 37 to 45% of the adult population intend to get vaccinated for sure, according to population-wide surveys (online [COSMO, ARD] and CATI [WiD, COVIMO, (6, 7)]). Survey-based estimates further suggest that about 4 to 24% are unlikely to be convinced with arguments (clear refusal of vaccination; internationally, 20% refused hypothetical vaccines (8)). However, the decisive factor for COVID-19 vaccination is the large share of at least 24% undecideds and skeptics, who desire and need information in order to weigh potential benefits and harms (9). To convince many of them, evidence about vaccine efficacy and safety needs to be communicated (10) in a way that informs without simply persuading, as persuasion would violate the health care standard of informed decision-making and can damage trustworthiness and credibility of the communicator and vaccination (11).

In Germany, information needs in the pandemic led many people to turn to the Robert Koch Institute (RKI) for trustworthy information (12). Public health authorities need tools that help citizens understand COVID-19 vaccinations. Our studies investigate how a public health intervention ("COVID-19 vaccination fact boxes") that were recently developed jointly by the Harding Center for Risk Literacy and the RKI could increase the number of proponents of COVID-19 vaccination by means of balanced information (boosting) for informed decision-making instead of persuasion (marketing) or seduction (nudging). The fact box was disseminated via established communication channels of the RKI (RKI webpage with about 130 million visits in 2020, Twitter account, Mobile-App of the Permanent Vaccination Commission in Germany).

According to international standards of evidence-based health care (13) and the patient protection law in Germany (14) – and, more generally and ideally, in an enlightened and democratic society – every citizen should be enabled to weigh the possible benefits and harms of medical options on the basis of the best available evidence and to decide freely on this basis. Under this premise of informed decision-making (ethos), a comparison of benefits and harms of having or not having the vaccination would be required to inform undecideds and skeptics (target audience) from the beginning of vaccinations (timing). Given the best available evidence, informed decisions are expected to lead more often to COVID-19 vaccinations than not (aim). Therefore, transparent, comprehensible, and balanced communication tools are required that enable this comparison (15-17).

One approach to communicating the best available evidence is the “fact box” (18, 19), a tabular or graphical form of a balance sheet (20) that summarizes benefits and harms of medical options and how likely these will occur. Fact boxes inform various health decisions, including those about medical treatments, cancer screenings, and vaccinations (18, 21, 22). In contrast to regulation, incentives, and (invisible) nudges (23), fact boxes are not designed to enforce directed behavioral change (24). They are boosts that have been shown to enable comprehension of medical options and short-term knowledge acquisition (25, 26). Many undecided or vaccine-skeptical recipients of fact boxes who are uninformed or misinformed could be convinced by the facts to get vaccinated.

Furthermore, those who perceive communication about a vaccine as clear and consistent show both greater trust in institutions and higher intentions to vaccinate (27). Even though perceiving increased risks of COVID-19, influenza (28), or H1N1 (29) can be associated with an increased number of vaccination intentions (30), overstating the risk of COVID-19 in vaccination communication is detrimental to trustworthiness of medical and scientific experts (31), which in turn predicts uptake (30). Enhancing risk perceptions of having or not having a vaccination is thus a prerequisite of informed choices (16). By communicating transparently and comprehensibly, fact boxes can inform without undermining the public’s trust in the communicating institution.

We hypothesize that a COVID-19 vaccination fact box intervention on the population level can achieve a net surplus of proponents over opponents, without persuasion, thereby avoiding the risks of resiliency and distrust. Assuming that this increased intention to get vaccinated leads to greater vaccination uptake, fact boxes could thus serve public health authorities in protecting citizens via transparent and ethical risk communication.

Method and Results

We assessed the relationship of vaccination knowledge and vaccination acceptance in Germany over a period of three months (Study 1). To develop an intervention, we assessed respective information gaps and needs of the population in Germany (Study 2) and verified efficacy of "fact boxes" for risk communication with a convenience sample (Study 3). Based on those insights, Study 4 examined whether different fact box formats are effective for enabling informed vaccination intentions.

Studies 1, 2 and 4 were based on a daily survey of the German population (32, 33). Multi-stratified online samples (N=2,037 (T_0), N=2,090 (T_1), N=4,021 (T_2), N=6,056 (T_3), and N=1,942 (T_4)) of about 14,000 invited panelists within a consumer scheme provided data (Table S1), which are – after weighting – representative of German citizens who are active online (for details see (34).

All four studies were conducted consistent with the Declaration of Helsinki. Study 3 was approved by the ethics committee of the University of Potsdam (Germany). The panel company provided de-identified data for Studies 1, 2 and 4.

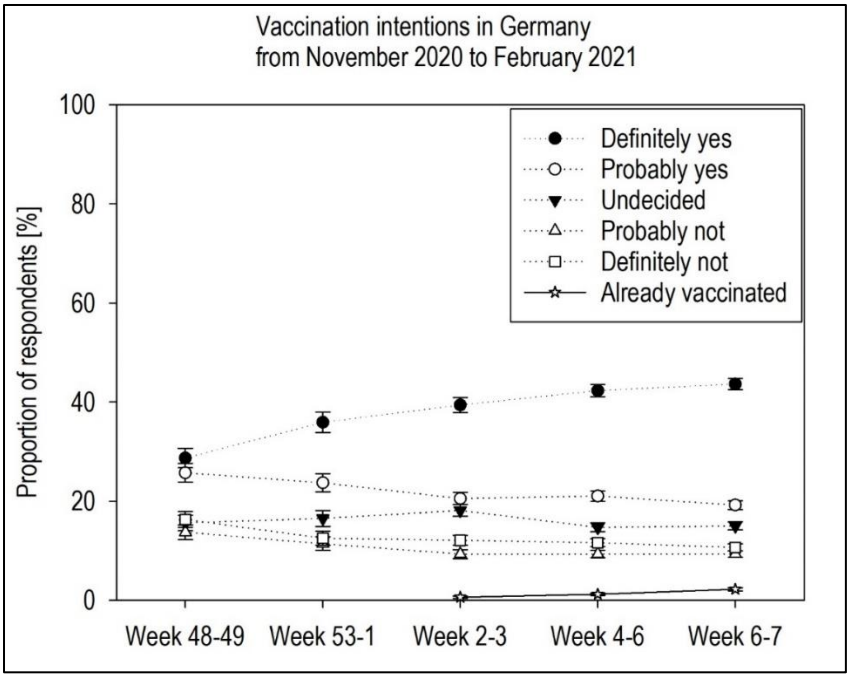


Figure 1. Proportion of respondents according to their intention to have vaccination against COVID-19 or their reports that they already did. Error bars show 95% confidence intervals. Independent samples were weighted at the time of their assessment.

Study 1. Five independent cross-sectional samples showed increased vaccination intention between Nov 2020 and Feb 2021 in Germany. The cumulative proportions of proponents (probably or definitely having the vaccination; not weighted) grew from 54.4% (T_0, end of Nov) to 65.1% (T_4, mid-Feb, including 2.2% already vaccinated) (Figure 1), though the proportion of those who probably want to have the vaccination decreased. Also, the proportions of undecideds shrank. The proportion of opponents (definitely not) and skeptics (probably not) decreased until actual vaccinations began but remained stable in January and February at about 12% and 9%, respectively.

Furthermore, between the end of Dec 2020 and the beginning of Feb 2021 (only mRNA vaccines available) the samples surveyed showed increasing vaccination knowledge (Figure 2). Over this time course, those without or with low educational attainment showed a similar increase in vaccination knowledge (from M=4.40, SE=0.08 to M=4.67, SE=0.07) compared with those with higher educational attainment (from M=4.68, SE=0.04 to 4.96, SE=0.03).

Vaccine intentions were associated with increasingly correct knowledge (r_{T0} = .36 and r_{T4} = .36) with respect to the items. Among those who were undecided in Feb, little improvement in knowledge could be

observed when compared with undecideds at the turn of the year, e.g. the proportion of undecideds who could rule out many false assertions about vaccine-related uncertainty remained relatively stable (+0,1 of out 4 test items, compared with +0,3 among proponents).

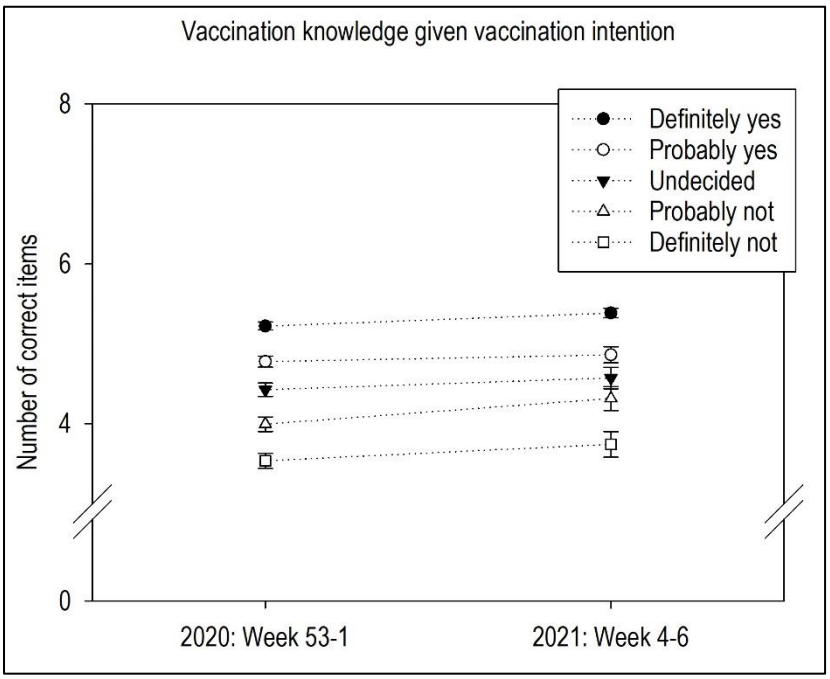


Figure 2. Number of correct items increased over two months according to respondents' intention to get vaccinated against COVID-19. Error bars show the standard error of the mean. The independent samples were weighted at the time of their assessment.

Study 2. By asking open-ended questions, we identified objective informational needs (e.g. false beliefs) and subjective requirements (e.g. desired facts) of the target population: people from 60 years of age on with a higher risk for severe courses of COVID-19 and those younger than 60 years (more social, more mobile) as mitigators and facilitators of the pandemic. Beyond reasons to choose from (36%: no threat of a severe COVID-19 course, 20%: pandemic passing without larger harm; Table S2) responses to open-ended questions were successively coded, reduced, and summarized according to the 5C scale for monitoring psychological antecedents of vaccination (35).

Predominantly, undecided respondents' motivations to have the vaccination were related to confidence in the vaccines and the delivering system, such as more investigations (36%), exclusion of harms (14%; more often from 40 years of age on), and long-lasting high efficacy (7%). Besides those requirements, about 11% of undecideds below 40 years of age explicitly claimed their motivation to depend on more or better

information. Motivations of those below 40 were more likely extrinsic (e.g., no contact restrictions, freedom to travel) but also reflected collective responsibility (18% stated that they would agree to vaccination if that would protect others, but only 7% of those aged 40-59 and 4% over 60 mentioned the same).

Nearly all reasons against vaccination of undecideds, skeptics, and opponents showed information needs related to confidence and trust (Table S3): belief in insufficient research on the vaccine and uncertainty about its efficacy and safety (28-52%, increasing with age), fear of harms (34-49%, decreasing with age), and distrust of policies or the vaccine (11-21%). Personal requirements (8%) and low disease risk perception (7%) played minor roles.

Confidence-related information needs about vaccine efficacy, safety, short- and long-term reactions and harms, and uncertainty were revealed as the dominant target of vaccination information with the aim of building trust. This is in line with information requirements of health information guidelines (36).

Study 3. Accurate risk perception of having or not having a vaccination enables informed decision-making (16). Our online study with a convenience sample controlled whether fact boxes, as evidence-based health information that helps understand the risks of medical options (25, 26), do improve COVID-19 risk perception and promote vaccination intentions accordingly, even though fact boxes are not designed to enforce directed behavioral change (24).

Fact boxes decreased (Table 1) numeric disease risk perception ($F(1,357) = 10.05$, $P = .002$, $n_p^2 = 0.03$) compared with control presentation, leading to more accurate estimates (Figure S3, $P < .001$). Only control presentation increased both fear ($F(1,357) = 4.17$, $P = .042$, $n_p^2 = 0.01$) and perceived severity of developing the disease ($F(1,357) = 19.90$, $P < .001$, $n_p^2 = 0.05$).

More positive evaluations ($F(1,357) = 12.55$, $p < .001$, $n_p^2 = 0.03$) and increasing intentions to get vaccinated ($F(1,357) = 7.63$, $P = .006$, $n_p^2 = 0.02$) were not format-specific (Table S4). Here, control information may have been as effective as fact boxes, albeit by promoting fear and perceived severity.

Table 1. Personal and social fear, subjective and numeric risk perception across conditions, diseases, baseline, and post

Presentation format	Disease	Personal fear		Social fear		Subjective Risk perception		Numeric risk perception (out of 1,000)	
		Pre M (SD)	Post M (SD)	Pre M (SD)	Post M (SD)	Pre M (SD)	Post M (SD)	Pre M (SD)	Post M (SD)
Vaccine fact box	COVID-19	5.8 (2.6)	6.0 (2.7)	6.1 (2.8)	6.2 (2.8)	6.3 (2.5)	6.4 (2.6)	327 (294)	248 (222)
	Influenza	3.4 (2.4)	3.5 (2.5)	3.6 (2.5)	3.7 (2.7)	3.6 (2.4)	3.7 (2.6)	257 (246)	190 (192)
Social framing box	COVID-19	5.5 (2.5)	5.7 (2.6)	6.3 (2.4)	6.4 (2.4)	5.9 (2.4)	6.0 (2.3)	345 (323)	259 (245)
	Influenza	2.8 (2.1)	2.9 (2.1)	3.1 (2.0)	3.3 (2.2)	3.6 (2.0)	3.4 (2.2)	288 (294)	220 (242)
Standard information	COVID-19	5.5 (2.5)	6.0 (2.5)	6.3 (2.4)	6.9 (2.4)	5.5 (2.5)	6.2 (2.4)	317 (323)	314 (281)
	Influenza	2.9 (2.0)	3.4 (2.4)	3.2 (2.1)	4.0 (2.4)	3.3 (2.2)	3.8 (2.5)	207 (220)	171 (190)

Study 4. Undecideds and skeptics desire and need information (Study 2) to weigh potential benefits and harms (9); otherwise they are hesitant to get vaccinated (37). To address that, Study 4 compared complex and simple fact boxes – based on the implemented version and facilitating access for people of diverse educational backgrounds – with regards to improving vaccination knowledge and evaluation.

First, vaccination knowledge was higher after fact box presentations ($F(1, 3101) = 36.58$, $p < .001$, $n_p^2 = 0.01$) than with none. Respondents below and from 60 years of age onward recalled vaccine efficacy, safety, and related uncertainties differentially (Table S5): In the case of fact box presentation, people considered the side effect of fatigue to be more likely (OR = 1.85 [1.69, 2.01]), people aged 60 and above more likely

considered a potential risk of facial paresis (OR = 1.16 [1.04, 1.28]), and younger people more likely remembered vaccine efficacy (OR = 1.13 [1.02, 1.24]). Finally, vaccine efficacy was (OR = 1.85 [1.53, 2.17], $p < .001$) more likely correctly inferred when a fact box was present (controlled for education).

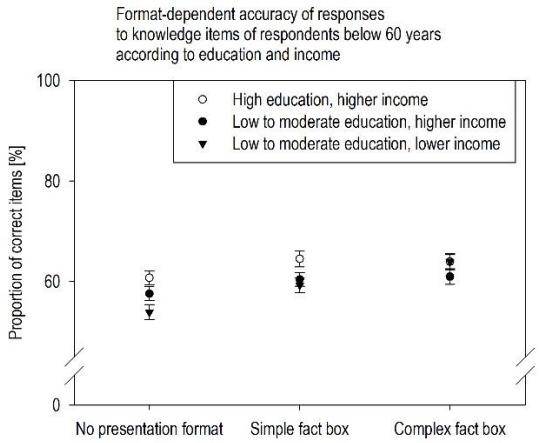
Second, fact boxes more likely prompted any change (OR = 1.36 [1.20, 1.52]; $\chi^2(1) = 14.53$, $p < .001$, adjusted $R^2 = 0.01$) and a positive change (OR=1.25 [1.06, 1.44]; ($\chi^2(1) = 5.29$, $P = .021$, adjusted $R^2 < 0.01$) of the evaluation of the vaccination compared with no intervention. Whereas 18.6% of respondents without any intervention changed their evaluation of a COVID-19 vaccination positively, 20.3% did so if studying a complex fact box, and 24.2% if studying a simple fact box. At the same time, however, 14.5%, 19.8%, and 16.3%, respectively, evaluated the evaluation more negatively when asked a second time (at post assessment).

The shift in vaccination evaluation after being presented simple fact boxes (+7.9%) could, to a substantial extent, be related to the skeptical and undecided respondents' comprehension of the information presented. Those who drew correct inferences about vaccine efficacy after having seen simple fact boxes showed a positive change in evaluation, but not those who drew incorrect inferences ($F(1,467) = 3.88$, $P < .050$, $n_p^2 = 0.01$). Separate sub-analyses highlighted that this effect is due to the younger skeptics and undecideds ($F(1,387) = 5.65$, $P = .018$, $n_p^2 = 0.01$), not to those aged 60 and above ($F(1,76) = 0.04$, $P = .836$). Knowledge recall after information presentation was not related to positive evaluation change (for skeptical and undecided respondents' showing at least 80% correct responses; ($F(1,387) = 0.59$, $P = .445$).

Taking into account vulnerable individuals with expected limited reading skills, we compared simple and complex fact boxes for those with lowest educational attainment (16.5% of respondents). They recalled less ($F(1,3086) = 11.44$, $P = .001$, $n_p^2 < 0.01$), but there was no box type effect ($F(2,3086) = 0.20$, $P = .820$). Recall of information from simple fact boxes was lower than from complex fact boxes for respondents with low to moderate levels of education ($F(1,2048) = 4.10$, $P = .043$, $n_p^2 < 0.01$) in both age groups (Figures 3A-B).

For complex fact boxes, the proportion of quick responders (below median response time of the control condition) among those with the lowest educational attainment was lower (7%; higher: 15%), which indicates that they needed more time for reading and/or for deciding to skip reading. However, for simple fact boxes, the proportion of quick responders was similar (about 11-12%), although longer reading times of those with the lowest educational attainment indicate that the simple formats more likely invited them to skip reading.

3A



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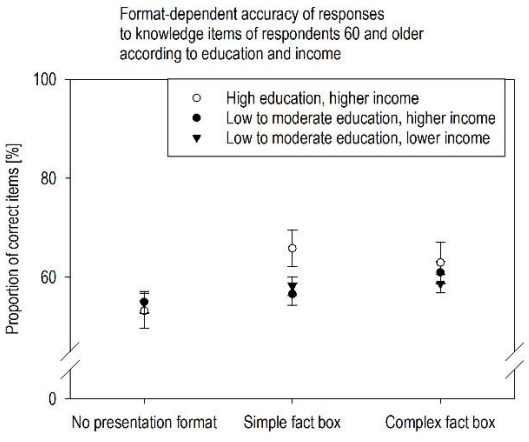

Figures 3A-B. Proportion of correct responses to five knowledge items according to different levels of education and household net income for respondents below 60 years of age (A) and 60 years of age and older (B). Error bars show the standard error of the mean. The sample is weighted.

Discussion

The association of vaccination knowledge and uptake implies one crucial mechanism with regards to the goal of an immunized society. Besides showing a differential increase in vaccination knowledge in proponents, the undecided, and opponents from the start of COVID-19 vaccination in Germany, Study 1 showed increasing intentions to have the (mRNA) vaccinations (6). Study 2 found that both undecideds and skeptics lack various pieces of information for making a decision, paired with false beliefs and a lack of trust in vaccine safety and efficacy. To address those gaps, a fact box format was developed in Study 3, which improved disease risk perception without increasing COVID-19 fears (unlike in the control condition). Applied on the population level in Study 4, fact boxes boosted knowledge of undecideds and skeptics together with a more positive evaluation of the vaccination's benefit-harm ratio. Studying simple or complex fact boxes instead of nothing was 1.3 times more likely to lead to any positive change in evaluation.

Although a common factor (e.g. peers' behaviors) admittedly may underlie information acquisition and evidence-based intentions, and stable vaccination preferences may prompt differential information acquisition, knowledge about benefits and harms of COVID-19 vaccinations may lead to informed intentions for fact box readers, if they base their intentions on these facts. This mechanism, in line with the standards of the Western health care system, also contributes to the trustworthiness of authorities engaged in vaccination risk communication. For example, since denying information gaps can undermine perceived credibility (38, 39), fact boxes contain epistemic uncertainty disclaimers (19). Transparently informing about vaccinations' limitations does not reduce vaccination intentions (40). Persuasive communications, e.g. messages framed in relative risks, however, can increase vaccination intentions (41) but are both misinformative and incomprehensible (42), which collides with the rights and needs of undecided and skeptical citizens. Also, incomprehensible information has the potential for a backlash effect. Future research may investigate the causal link between the grade of comprehensibility of information about benefits and harms and people's vaccination intentions.

In our population-wide sample, simple fact boxes appear to be more beneficial than complex ones for those with more education or income. This contradiction to the design intention could be due to overly brief reading time of the simple box by vulnerable groups (equal to that of those with higher levels of education). Further, although information needs and requirements were surveyed, the lower educated target group did not actively take part in the development process. Additional factors associated with formal education can also lead to inequality (e.g. working and living conditions). Future studies should incorporate approaches such as the PROGRESS Plus framework, which describes inequity-generating factors at multiple levels and takes into account concepts such as critical health literacy or digital health literacy, to examine the conditions under which who benefits and who does not benefit from fact boxes and how this affects health inequities (43). An additional limitation of our work concerns the set of vaccination knowledge items that covered certain requirements of health information guidelines but were not a validated scale of vaccination knowledge.

In Germany the current implementation of fact boxes (44) supports evidence-based education and, thus, empowerment on the population level. Our figures imply, theoretically presenting about 11 million undecided and skeptical adults under 60 years in Germany with a simple fact box for about 90 seconds would make more than 600.000 people learn vaccine efficacy. A majority of those would evaluate vaccinations more positively. By avoiding persuasion, reactance and distrust concerning the sender's intentions can be prevented or alleviated. In return, informed decision-making is not a threat to the goal of population vaccination. For achieving this preference, ensuring every individual's right to decide about their own health could be sufficient, while other types of social contract (45) could be minor. The legally binding standard of evidence-based health care (13), benchmark of a democratic society, would assure responsible vaccination decisions and future commitment when refreshments of the vaccination might be necessary or when individuals might have to decide to get vaccinated against other diseases.

Material and Methods

Samples. Independent samples with (T_1, T_3) and without (T_0, T_2, T_4) knowledge assessment (Studies 1, 2, and 4) were conducted between 25 Nov 2020 and 16 Feb 2021 (T_4). The "Corona Online Opinion Panel Survey Special", COMPASS, by the research institute "infratest dimap" (Berlin, Germany) was set up to monitor the pandemic over time. Between 13,664 and 13,816 German-speaking panelists (a multi-stratified sample from a pool of 75,000 panelists who belong to the 25 million members of the German PAYBACK consumer scheme) were invited in each case T_0 to T_4 (300 per day). Between 14 and 46 of them were not eligible. Among those who were eligible, between 25.4% and 28.0% were non-responders in each case, between 1.0% and 1.5% did not complete the survey, and N=2,037 (T_0), N=2,090 (T_1), N=4,021 (T_2), N=6,056 (T_3), and N=1,942 (T_4) were presented with our items (samples described in Table S1), and received remuneration worth about 1 euro. In Study 4, we excluded respondents (n=182, 6.1%) who studied an intervention for more than fivefold the average time (> about 18 minutes), assuming that this group had likely turned to other activities.

719 adults aged 18 to 68 years (M=28.8, SD=8.8), who were recruited as a convenience sample through the online portal Prolific.co, completed Study 3 (Table S6). Participants were eligible if their mother tongue was German and if Germany was their current country of residence. Participants were contacted by email

with information about the study and a link to the online survey. They were remunerated with 2.65 pounds (about 3 euros).

Design. Studies 1, 2 and 4 were plain surveys. The experiment in Study 4 had a mixed design. Between-subjects presentation format (simple (n=984) vs. complex fact box format (n=974) (Figure S1) vs one group without information presentation (n=991)) was varied for separate age groups (18-59 years vs. 60 onward) and with repeated assessments of vaccination evaluation within-subjects (baseline and post). Study 3 also had a mixed design: between-subjects (six presentation formats) and within-subjects (baseline and post). The three conditions were (1) vaccine fact box (n=120, Figure S2A), (2) vaccine fact box with social framing (n=123, Figure S2B), and (3) the control condition (n=116; website from www.helios-gesundheit.de (46)), in which standard information on SARS-CoV-2, COVID-19 (without vaccination) and influenza from the internet was presented (between 20 Nov 20 and 21 Feb among the top three German search findings comparing SARS-CoV-2 and influenza). Three further fact boxes for another experiment on disease risks are not reported here. Participants were not aware of the alternative formats. The same introductory text was provided for each condition.

Measures. Vaccination intention (Studies 1 and 4) was assessed with single-option choice ("Vaccines against the Corona virus are now available. If you get the chance, will you get vaccinated against Corona?": Definitely yes, probably yes, probably not, definitely not, I cannot yet say / am still undecided, I am already vaccinated (not at T_0 and T_1)). In Study 3, participants were asked if they plan to get vaccinated within the next six months. Reasons in favor of or against COVID-19 vaccination (Study 2) were asked, with single-choice and open-response items depending on vaccination intention (e.g. for skeptics and opponents: "Why would you not want to be vaccinated if necessary?"). Participants of all studies evaluated the benefit-harm ratio of COVID-19 vaccination in question on an 11-point rating scale.

Knowledge (Study 1) was assessed with a focus on vaccination decisions: four items on potential harms (e.g. headache with and without vaccine), and uncertainty (e.g. reduction of contagiousness). The responses were scored according to the best available evidence in Dec 2020 (Table S7). Respondents' estimates of how many people get sick with COVID-19 if vaccinated or not after meeting an infected person were elicited in Study 1 and 4 using a normalized frequency format (out of 1,000 people) to show understanding of vaccine efficacy instead of recall of deficient relative risk reduction (omitting base rate and absolute effect size). Resulting inferences reflected an underlying risk ratio between the estimations (to avoid zero, division numerator and denominator were adjusted with +1 out of 1,000); 88% to 98% vaccine efficacy was scored as correct (for mRNA vaccines across different age groups, from a meta-analysis

published on 4 Feb 2021 (47): 90% to 96%; we tolerated a +-2% margin of error). After information presentation (Study 4), five items with true-false statements tested participants' recall of vaccination safety (fatigue, serious adverse events), uncertainty (later harm, facial paresis), and efficacy.

Risk perception and fear (Study 3). Five items measured the fear of getting or spreading COVID-19 ("How much do you fear…"), its perceived severity ("How severe would be for you personally…"), and numerical risk perception. A frequency format elicited to which extent participants could provide estimates of the probability of developing COVID-19 within a correct range spanning the best available evidence (5-28%, Table S8 on the evidence). For control, all items were presented with numbers for influenza as well.

Procedure. After their informed consent to multi-theme study participation, participants received demographic questions, items about pandemic conditions, and an inquiry on COVID-19 experience and evaluation of non-pharmaceutical interventions, followed by questions on vaccination intention, evaluation, and knowledge items (Studies 1, 2, and 4). In Study 4, the vaccine efficacy item was presented with fact boxes (intervention groups). Knowledge recall and once again vaccination evaluation were requested after intervention removal. In Study 3, after giving informed consent and responding to demographic questions, participants answered items on disease risk perception and fear, on previous adherence to COVID-19 measures, and on vaccination intention and evaluation. After reading the presentation formats with evaluation items (e.g. trust in the information presented), the intervention was removed and questions on fear, risk perception, adherence, and vaccination intentions and evaluations were repeated.

Analyses. Repeated measures analyses of variance were used to compare interventions with presentation formats (Studies 3 and 4), logistic regressions were used to study confounders, and McNemar tests were used to compare dichotomous data for individual formats from baseline to post-assessment.

To analyze open responses (Study 2) about reasons in favor of and against COVID-19 vaccination, two category systems starting with the subgroup of 18- to 39-year-olds were inductively developed independently by two researchers (one was the author C.E.). Successively, generated codes were reduced and summarized according to the 5C scale (35), a tool to monitor psychological antecedents of vaccination that describes five key elements: confidence (e.g. in the effectiveness and safety of vaccination, of the health care system), complacency (perception of risk), constraints (barriers to execution), calculation (extent of information seeking), and collective responsibility (sense of responsibility for the community). Afterwards, the raters compared and consensually agreed on a combined category system with consistent codes for each item (Table S9) and coded the responses of the three items again independently from each other. Interrater reliability was high, Cohen's kappa = .92 (motivation), kappa = .90 (against vaccination), and

kappa = .87 (undecided), respectively. Discrepancies in the coding of the individual answers were discussed, a uniform coding was jointly decided upon, and the codes were quantified.

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