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Social Psychology

Expert Consensus Messaging as a Lever Against Vaccination Misinformation

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The spread of misinformation about vaccines can slow down collective efforts to respond to life-threatening diseases, and thus severely damage public health. Strategies for counteracting misinformation about vaccines include to pre-emptively inform individuals about misinformation before it occurs, to increase their resilience against misinformation. In a pre-registered online experiment, we tested whether pre-emptive expert consensus messaging (H1) or rebuttal by a science advocate only (H2) decreased convincingness of misinformation and increased behavioral intentions to get vaccinated, compared to a control group and whether a combination of both had additive effects (H3). We also tested whether the intervention effects were a function of individual characteristics that link to perceptions of misinformation, namely subject-matter knowledge, conspiracy mentality and need for authenticity. This study was informed by two pilot studies where individuals who perceived expert consensus in favor of vaccination as strong evaluated misinformation as less and rebuttal arguments as more convincing. In the full sample, hypotheses 1-3 were not confirmed. Patterns observed in an additional, non-pre-registered post-hoc analysis of a subsample that correctly answered a preceding manipulation check question reflected our initial hypotheses. Findings will help understanding how pre-emptive communications of scientific consensus can serve as a cost-effective strategy for targeting misinformation before it even occurs. They thus contribute to strengthening societal support for implementing effective and large-scale policies against diseases.

Medical scientists agree that vaccines are safe and effective for fighting infectious diseases. Individuals who need to make informed decisions about disease prevention are, however, often exposed to misinformation about vaccines, especially online (Gabarron et al., 2021). At the same time, the greatest share of COVID-19 vaccine misinformation in the U.S. on Facebook and Twitter during the pandemic was attributable to only a handful of individuals (Center for Countering Digital Hate, 2020). These small minorities usually argue that science is flawed (Hornsey & Lewandowsky, 2022) and apply a dysfunctional form of skepticism known as science denialism (Schmid & Betsch, 2019) – the "dismissal of well-established scientific evidence or the scientific method as a means to gather reliable evidence." (Jylhä et al., 2022, p. 151).

Common techniques of science denial are to cherry pick data, quotes or personal stories that contradict a scientific consensus , to raise impossible expectations or to spread conspiracy theories with the aim to bias how individuals perceive vaccine information (Hansson, 2017; Schmid & Betsch, 2019). Another aim is to influence individual behaviors (Ecker, Lewandowsky, et al., 2022). In addition, misinformation can damage public health. For example, misinformation slows down collective efforts to respond quickly and effectively and can thus foster the recurrence of life-threatening diseases (van der Linden et al., 2015). The cognitive behavioral and social impacts of misinformation thus pose a major barrier to implementing effective, rapid and large-scale policies for addressing vaccine hesi-

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tancy– the delay or refusal of vaccination despite availability of vaccination services (MacDonald, 2015).

Strategies for Counteracting Misinformation

Advocates of scientific evidence can draw on 'debunking' strategies for retrospectively targeting concrete instances of misinformation. Debunking strategies decrease the belief in vaccination misinformation and support informed decision making (Porter et al., 2023; Schmid & Betsch, 2022). The application of debunking in public discussion with science deniers, e.g. on social media, is often referred to as real-time 'rebuttal' (Kozyreva et al., 2024; Schmid & Betsch, 2019). Sophisticated rebuttals either overwhelm a deniers' argument by providing facts in favor of the scientific standpoint (i.e., topic rebuttal) or uncover techniques used by science deniers and provide detailed information about why claims are false (i.e., technique rebuttal; Schmid & Betsch, 2019). For example, a denier could state that "vaccines should be 100% safe". An advocate can overwhelm this statement with scientific evidence about the large safety record of recommended vaccines (i.e., topic rebuttal) or uncover that the statement is an impossible expectation because no scientific measure can ever guarantee 100% safety (i.e., technique rebuttal; Schmid et al., 2018). Ideally, such debunking information comes from a trusted source, such as governmental institutions (Ecker, Lewandowsky, et al., 2022; Ecker, Sanderson, et al., 2022). But even if trust is low, debunking vaccine misinformation can be effective (Bruns et al., 2024). At the same time, debunking is re- rather than proactive and requires resources and time to counteract many instances of misinformation.

So-called 'pre-bunking'- strategies equip individuals with the necessary tools to recognize and counteract misinformation themselves and thus protect them from its' influence before it even occurs (Ecker, Lewandowsky, et al., 2022). Pre-bunking strategies include to simply warn individuals that they may encounter misinformation, to communicate correct information (Ecker, Lewandowsky, et al., 2022) or to warn individuals that their views may be biased through falsely balanced expert views in media outlets (Schmid et al., 2020). More sophisticated pre-bunking strategies include to first issue a warning that misinformation may occur, and to then explain techniques for spreading misinformation (Ecker, Lewandowsky, et al., 2022; Williams & Bond, 2020).

Consensus Messaging As a Lever Against Misinformation

A potentially effective strategy for increasing resilience against misinformation is information about the quality of scientific evidence, such as the degree of expert consensus (Ecker, Lewandowsky, et al., 2022; Ecker, Sanderson, et al., 2022) which represents what others do or think (Cookson et al., 2021). Simple messages such as "90% of medical scientists agree that vaccines are safe" combine a simple social heuristic such as "trust the doctor" (Blendon et al., 2014; Wegwarth & Gigerenzer, 2013) with a descriptive social norm (Borsari & Carey, 2003; van der Linden, 2021; Vlasceanu & Coman, 2022). This may be effective when people may over- or underestimate expert consensus (Sparkman et al., 2022; van Stekelenburg et al., 2022) because they rely on small and biased samples (Galesic et al., 2012), or on falsely balanced expert views in media outlets (Bartoš et al., 2022; Schmid et al., 2020). Communicating expert consensus shifts individuals' consensus perceptions (van der Linden, 2021; van der Linden et al., 2015), and updates their personal beliefs, while decreasing perceived uncertainty about scientific evidence (Chinn et al., 2018). This helps them to evaluate subsequent arguments for or against scientific evidence. In turn, communicating expert consensus motivates individuals to change behaviors, such as vaccination uptake (Bartoš et al., 2022). Communicating expert consensus also counteracts misinformation about other issues, such as climate change (Cook et al., 2017; Maertens et al., 2020; van der Linden et al., 2017; Williams & Bond, 2020).

Individual Differences

Subjective knowledge (Schmid & Betsch, 2019) may moderate the effectiveness of debunking (Ecker, Sanderson, et al., 2022): Overconfident individuals are less supportive of vaccination policies and more supportive of non-experts (Motta et al., 2018). Therefore, interventions that convey an expert consensus in favor of vaccination are at odds with overconfident peoples' preexisting beliefs and will possibly be less effective in this target group.

Moreover, communications of expert consensus may be less effective if recipients perceive experts as irrelevant (Terry & Hogg, 1996). Individuals who believe in conspiracy theories are less likely to believe scientifically acknowledged claims (Lewandowsky et al., 2013) and often dismiss the general population using terms like 'sleep sheep' (Martin & Vanderslott, 2022). Scientific consensus may therefore be less effective for counteracting misinformation, the more individuals believe in conspiracies.

Finally, the effectiveness of expert consensus for counteracting misinformation may vary as a function of individuals' need for authenticity (Ecker, Sanderson, et al., 2022). That is, individuals who report that they are not strongly influenced by others will probably be less convinced by expert consensus compared to individuals that perceive themselves as more influenced by others.

Current Research

We explored whether pre-emptively communicating expert consensus counteracts the influence of misinformation about vaccines. To this end, we replicated and extended Schmid & Betsch (2019). Schmid & Betsch comprehensively studied interventions for counteracting misinformation against vaccines: Their interventions were tested in six studies with heterogeneous samples, and in different political contexts. More specifically, they employed a 2 (topic rebuttal: absent versus present; between) x 2 (technique rebuttal: absent versus present; between) design. Participants indicated their attitude towards and intention to getting vaccinated before and after receiving rebuttal messages. For testing whether backfire effects occurred in specific subgroups, Schmid & Betsch also measured political ideology and prior confidence into vaccination. Moreover, promising rebuttal effects using the materials from Schmid & Betsch were also found when changing the setting from online to offline lab studies (Schmid et al., 2020), when changing the tone of the messages or when rebutting misinformation about genetically modified foods (Schmid & Werner, 2023). Data availability of Schmid & Betsch (2019) facilitates a comparison of our effect sizes to theirs as well as of Schmid, Schwarzer & Betsch (2020) and Schmid & Werner (2023) in future meta-analyses (Goh et al., 2016).

We analyzed how participants' views and subsequent behavioral intentions in response to a debate addressing risks associated with the fictitious vaccine against dysomeria can be recalibrated. The debate included anti-vaccination misinformation from a science denier and rebuttal arguments from a science advocate (Schmid & Betsch, 2019). We, however, did not compare topic and technique rebuttal, but additionally communicated expert consensus about vaccine effectiveness. We hypothesized that receiving expert consensus will decrease perceived convincingness of anti-vaccination misinformation and increase intention to vaccinate, compared to a control group (H1), that receiving rebuttal arguments will decrease perceived convincingness of anti-vaccination misinformation and increase intention to vaccinate, compared to a control group (H2; Schmid & Betsch, 2019), and that receiving expert consensus combined with rebuttal, will decrease perceived convincingness of anti-vaccination misinformation and increase intention to vaccinate, compared to receiving only one of these messages (H3). We focused on convincingness as the primary outcome measure in our confirmatory analyses because this measure is similar to other belief ratings of misinformation used in previous studies (Cookson et al., 2021; Ecker, Sanderson, et al., 2022) and because pilot data (described below) suggests that effects for this measure are to be expected. Rather than exploring political ideology like Schmid & Betsch (2019), we explored how the effect of expert consensus and rebuttal onto convincingness of misinformation varied with characteristics of the receiver, namely individuals' subjective vaccine knowledge, conspiracy mentality and need for authenticity. Those variables link to participants' social identity which may play a more important role when receiving expert consensus, compared to only rebuttal as in Schmid & Betsch (2019). We also explored how the different messages impacted the convincingness of rebuttal arguments and support of public action.

Pilot Surveys

Aims

Pilot surveys assessed whether people who perceived expert consensus in favor of vaccination as strong evaluated misinformation as less convincing and rebuttal arguments as more convincing. These correlative patterns would be a first signal for the potential effectiveness of expert consensus for weakening the influence of misinformation. Pilot surveys also assessed how people's perceived general population norms linked to convincingness of misinformation and rebuttal arguments.

Method

We implemented the pilot surveys in two larger cross-sectional studies with n = 955 and n = 993 participants in Germany. Participants were recruited via the panel provider Respondi and were screened out if they were younger than 18 or older than 74 years of age. Moreover, participants were asked to answer a captcha question and were screened out if they failed to enter the correct code twice. We excluded participants from all following analyses if they reported percentages above 100% or below 0% (i.e., implausible values) for the measures of perceived expert consensus and general population norms. Thus, the final sample sizes were n = 954 (Mean age = 47.60, Standard Deviation = 14.99; gender: female = 54.7%, male = 45.1%, diverse = 0.2%) for pilot survey 1 and n = 987 (M age = 45.25, SD = 15.19; gender: female = 48.6%, male = 51.1%, diverse = 0.3%) for pilot survey 2.

In both pilot surveys participants read a text about a fictitious disease called dysomeria (Table S1). The text contained information about the route of transmission, the symptoms and possible consequences of the disease, and the availability of a recommended vaccine (Schmid & Betsch, 2019).

In pilot survey 1, we then asked participants about perceived norms in the general population and among their social contacts using the following two questions (Galesic et al., 2012, 2018; Table S2): "*In your opinion, what percentage of all adults living in Germany would get vaccinated against dysomeria?*" and "*In your opinion, what percentage of your social contacts would get vaccinated against dysomeria*?" Social contacts were defined using the following instruction: *Please think of your friends, family, colleagues, and other acquaintances who are older than 18 and with whom you have had contact in the last six months, either in person, by phone, email, or the Internet. We call these your social contacts.* We used the same questions in pilot survey 2 and added a measure of perceived expert consensus, namely physicians: *In your opinion, what percentage of all physicians practicing in Germany would recommend vaccination against dysomeria*? The answers to all three questions were provided in an open text format (Table S2).

Participants in both pilot surveys were then asked to indicate the perceived convincingness of four fictitious posts from an online discussion forum (Schmid & Betsch, 2019; Table S2). Participants rated how convincing these statements were on a 5-point scale from 1 = *not convincing at all* to 5 = *very convincing*. Two of those statements were anti-vaccination misinformation that contained typical techniques of science denialism such as *impossible expectations* and *conspiracy theories* and addressed the topics of *vaccine safety* and *trust* in health authorities. For example, one statement read: "*The side effects and risks of the vaccine against dysomeria are incalculable. In my opinion, you cannot expect any fellow citizen to vaccinate as long as the vaccine is not 100% safe. Surely it is not too much to ask that a product* *that is injected into a healthy human body is 100% safe."* The other two statements were rebuttal statements of anti-vaccination misinformation (Schmid & Betsch, 2019). For example, one statement read: "*A large proportion of the research that demonstrates the benefits of the vaccine against dysomeria for society and each individual is conducted by independent scientists all over the world. The results of this research consistently show that the vaccine improves the health standard of all individuals.*" We averaged the two responses to misinformation and the two responses to rebuttal (survey 1: misinformation: Spearman-Brown Coefficient r_{SB} = .67; rebuttal: r_{SB} = .84; survey 2: misinformation: r_{SB} = .71; rebuttal: r_{SB} = .85). All items from pilot surveys are also provided at osf.io/23hqj.

Results

Using OLS regression models, we regressed perceived convincingness of misinformation onto perceived norm of the general public, perceived norm of social contacts and, in pilot survey 2, onto perceived norm of experts, namely physicians. We repeated this procedure with perceived convincingness of rebuttal as the outcome measure.

Participants who perceived vaccination norms in the general public to be strong rated misinformation as less convincing, pilot survey 1: unstandardized regression coefficient b = -0.009, SE = 0.002, p < .001; pilot survey 2: b = -0.006, SE = 0.001, p < .001 (Figure 1A–B). The same negative association was observed for the norm among social contacts, pilot survey 1: b = -0.010, SE = 0.001, p < .001; pilot survey 2: b = -0.010, SE = 0.001, p < .001. A similar pattern occurred for perceived expert consensus, pilot survey 2: b = -0.005, SE = 0.001, p < .001 (Figure 1C).

In addition, participants who perceived vaccination norms in the general public to be strong rated rebuttal statements about vaccination as more convincing, pilot survey 1: b = 0.013, SE = 0.001, p < .001; pilot survey 2: b = 0.012, SE = 0.001, p < .001 (Figure 1D–E). Again, the same positive association was observed for the norm among social contacts, pilot survey 1: b = 0.014, SE = 0.001, p < .001; pilot survey 2: b = 0.015, SE = 0.001, p < .001, and for perceived expert consensus, pilot survey 2: b = 0.011, SE = 0.001, p < .001 (Figure 1F).

As this data was correlational, it did not reveal whether expert consensus can cause a reduction in the perceived convincingness of misinformation, that is, whether it caused a protective effect. Moreover, it was also unclear whether there are effects of consensus messaging beyond perceived convincingness. Thus, in the following study we tested the impact of communicating expert consensus on perceived convincingness of misinformation as well as intention to get vaccinated. We also explored the impact on support for public action.

Methods

Sample and Power Analysis

The questionnaire was planned to be shared with N = 1000 participants via Bilendi (formerly known as Respondi). Assuming a dropout rate of 15%, participants were included if they answered all questions. The final sample of N = 848 participants was planned to be representative of the population living in Germany in terms of age, gender and federal state. Ultimately, N = 1811 individuals clicked on the link, N = 1769 agreed to participate and N = 1020 finished the study. Due to an error, exclusions of participants based on full quotas for age, gender and federal state were based on a limit of N = 1000 and not N = 848. The twenty additional participants that exceed N = 1000 resulted from simultaneous participation. This deviation from the preregistration was deemed unproblematic because the larger sample increases the test's severity. Demographics of the final sample (N = 1020) closely resembled demographics of the population living in Germany in terms of age (M = 45.98; SD = 15.03), gender (female = 50.5%; male = 49.4%; non-binary = 0.1%) and federal state (Table S3).

The initial sample size was based on an a-priori simulation-based power analysis using Superpower's Power Shiny App (Lakens & Caldwell, 2021). The power analysis for a 2 x 2 between subjects ANOVA (α = .05) revealed a required sample size of n = 212 per group (N = 848) to achieve an estimated power of at least 1 – β = .95 for all hypothesized effects (expert consensus vs. no expert consensus; rebuttal vs. no rebuttal; combined messaging vs. one message only). The expected effect size in the power analysis was set to eta squared = .03 (Cohen's d = .35) and was informed by lower bounds from previous research. For example, Ecker et al. (2022) analyzed the impact of combining rebuttal and social norms from the general population, compared to rebuttal in a climate setting, using a within-subject design. Their partial eta squared effect sizes for this comparison ranged from .03 to .14 (Experiment 3B), depending on outcome measure. Another study that tested the effectiveness of social norm interventions as a between factor in a vaccination context also reported a partial eta squared effect size of .03 (Cookson et al., 2021). Moreover, Schmid & Betsch (2019) reported that the lower bound from a 95% confidence interval for the standardized mean differences between rebuttal and control conditions was d = .37.

Power analysis using the TOSTER spreadsheet (Lakens & Caldwell, 2021) revealed that N = 848 participants were sufficient to achieve a power of 1 – β = .98 for all equivalence tests using SESOI (bounds: d = .35 – -.35; α = .10). We are not aware of any other study that has set SESOI for research on consensus messaging and misinformation and theories in this research domain do not predict effects of a specific size. Thus, we defined the SESOI (Cohen's d = .35) in a way that at least effects similar to those reported by previous studies can be rejected.

Procedure

The procedure followed a 2 (expert consensus: present versus absent) x 2 (rebuttal: present versus absent) between-design. Participants first indicated their perceived vaccination knowledge, conspiracy mentality and need for authenticity. They then read a short information text about the vaccine against dysomeria, similar to pilot studies (Table S1; Schmid & Betsch, 2019). Participants in the ex-

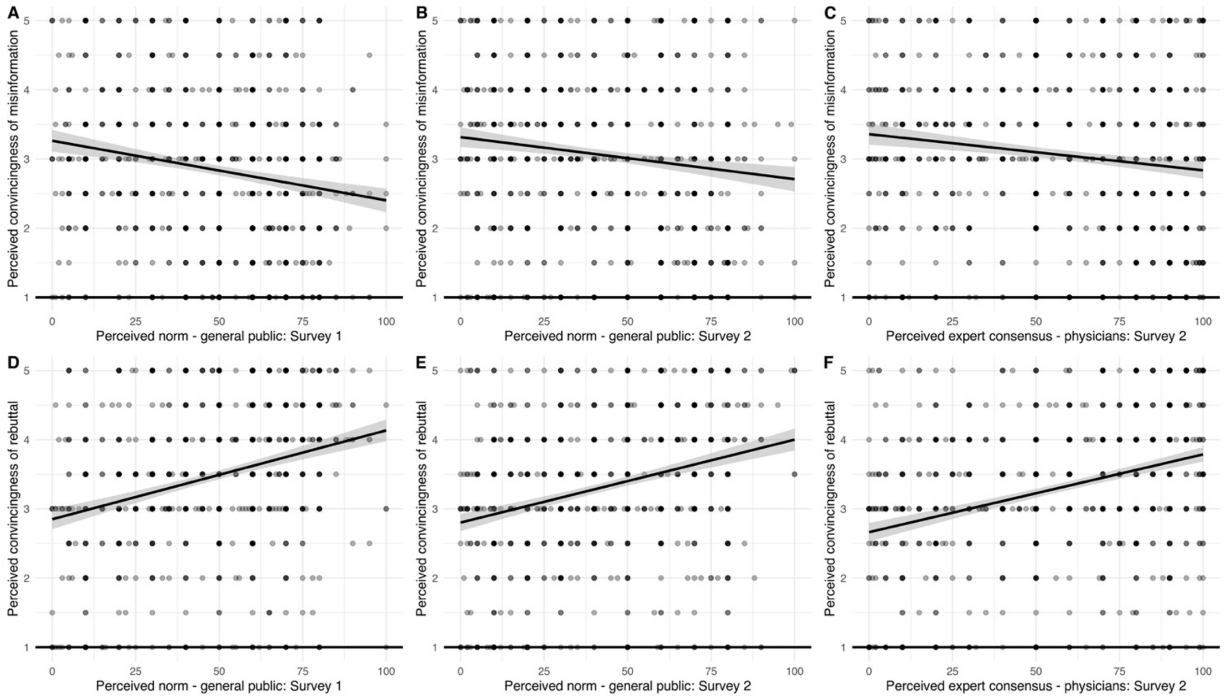

Figure 1. Correlational Data from Pilot Surveys

Note. Perceived convincingness of anti-vaccination misinformation regressed onto perceived norm of the general public (pilot survey 1: A; pilot survey 2: B) or onto perceived physicians' consensus (Survey 2: C). Likewise, perceived convincingness of rebuttal, regressed onto perceived norm of the general public (pilot survey 1: D; pilot survey 2: E) or onto perceived expert consensus among physicians (pilot survey 2: F).

pert consensus message-condition received a graph (Ecker, Sanderson, et al., 2022; McDowell et al., 2016; van der Linden et al., 2014) showing that "90% of physicians practicing in Germany would recommend the vaccine against dysomeria" (Figure 2). The "90%" were adopted from Bartoš et al. (2022). Similar to Bartoš et al. (2022) participants did not receive any statement in the control condition. All participants were then asked about perceived expert consensus. This was followed by a series of arguments for or against the vaccine (adopted from Schmid & Betsch, 2019; Table S1): Two statements from a science denier reflected anti-vaccination misinformation about vaccine safety and trust in health authorities. In the rebuttal present-condition, participants also read two statements by a science advocate. Those reflected topic rebuttal (vaccine safety and trust into science). Subsequently, participants were asked about perceived convincingness of each argument, their intention to get vaccinated, their support of public action and convincingness of rebuttal (Table S2).

Figure 2. Expert Consensus Message Presented to Participants

Note. The original German text translates to "90% of practicing physicians in Germany recommend vaccination against the dysomeria virus"

Measures

All measures, materials and analyses are provided at [osf.io/23hqj](osf.io/23hqj) and Tables S1 and S2.

Manipulation Check

Perceived Expert Consensus. Participants were asked: "*In your opinion, what percentage of all physicians practicing in Germany would recommend vaccination against dysomeria? ___%*" Answers were provided in an open text format.

Individual Difference Variables

Perceived Vaccination Knowledge. We adopted items by Motta et al. (2018). Participants were asked whether they think they know more than *medical doctors* (Item 1) and *scientists* (Item 2) about the safety of vaccines. The scale ranged from 1 = *I know a lot less* to 6 = *I know a lot more*. We changed the wording so that it matched the topic of the fictitious discussion about vaccine safety (see above). Two items were averaged in advance to the analysis (r_{SB} = .90).

Conspiracy Mentality. Participants answered the 5-item conspiracy mentality scale (Bruder et al., 2013; Schmid & Betsch, 2019). The 11-point scale for the items (e.g., *"I think that events which superficially seem to lack a connection are often the result of secret activities"*) ranged from 0 = *0% certainly not* to 10 = *100% certain.* The items were averaged in advance to the analysis (Cronbach's alpha = .90).

Need for Authenticity. We adopted the need for authenticity (NFA) scale developed by Wood et al. (2008), similar to Ecker et al. (2022). The scale includes 12 items (e.g., "*I always feel I need to do what others expect me to do*") that are measured on a 7-point scale ranging from 1 = *does not describe me at all* to 7 = *describes me very well*. The scale consists of three subscales. We used factor analysis (varimax rotation) and confirmed the three-factor structure. Each subscale was treated as a unique moderator (authentic living: α = .76; self-alienation: α = .85; accepting external influence: α = .76).

Outcome Measures

Convincingness of Misinformation and Rebuttal. Similar to pilot studies, participants were asked: "*Please evaluate how convincing this argument is*" on a 7-point scale from 1 = *not convincing at all* to 7 = *very convincing*. Depending on condition, participants also rated the perceived convincingness of rebuttal on the same 7-point scale. For the pilot study, we had to slightly adjust the original item from Schmid & Betsch (2019) which was *"How convincing do you judge the preceding argument to be?".* Again, we averaged the two responses to misinformation and the two responses to rebuttal (misinformation: r_{SB} = .79; rebuttal: r_{SB} = .87).

Intention to Get Vaccinated. Participants were asked "*If you had the opportunity to get vaccinated against dysomeria next week, what would you do?*". This item was rated on a 7-point scale from 1 = *I will definitely not get vaccinated* to 7 = *I will definitely get vaccinated* (Schmid & Betsch, 2019).

Support of Public Action. Participants indicated their support of public action in favor of the dysomeria vaccine on an 8-item scale on vaccines adopted from van der Linden et al. (2015) and adjusted to the dysomeria vaccine. For example, the original item "*I believe that vaccines are a safe and reliable way to avoid the spread of otherwise preventable diseases*" was rephrased to "*I believe that dysomeria vaccines are a safe and reliable way to avoid the spread of dysomeria*". Each item was rated on a 7-point scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*. Items were averaged in advance to the analysis (α = .95).

Analysis

Differences between experimental groups in perceived convincingness of anti-vaccination misinformation from science deniers and intention to vaccinate were analyzed in two between-Analyses of Variance (ANOVA; alpha = .05) with two experimental factors (expert consensus message: present versus absent; rebuttal: present versus absent), followed by planned contrasts (Supplementary Material S11). Results of planned contrasts were used to test H1 (expert consensus only better than none: $-1_{\text{No rebuttal/no expert consensus}}$, $1_{\text{No rebuttal/expert consensus}}$), H2 (rebuttal only better than none: $-1_{\text{No rebuttal/no expert consensus}}$, $1_{\text{Rebuttal/no expert consensus}}$) and H3 (combination better than rebuttal only: $-1_{\text{Rebuttal/no expert consensus}}$, $1_{\text{Rebuttal/expert consensus}}$; combination better than expert consensus only: $-1_{\text{No rebuttal/expert consensus}}$, $1_{\text{Rebuttal/expert consensus}}$). We report the results of contrasts using Welch's t-test (Delacre et al., 2017). The same model was used for exploring convincingness of rebuttal and support of public action.

We explored the robustness of findings and potential moderator effects by repeating all analyses including three moderator variables (perceived vaccination knowledge, conspiracy mentality, need for authenticity) and demographic variables (age, gender, education) as covariates into ANCOVAs.

Equivalence tests were conducted for all confirmatory analyses using the TOSTER spreadsheet (Lakens & Caldwell, 2021). That is, we explored whether the effect sizes were significantly within the equivalence bounds of *d* = 0.35 and *d* = -0.35. In addition to p-values, these analyses allowed us to determine whether results confirmed or disconfirmed our hypotheses or whether results were inconclusive.

Results

On average, participants judged the misinformation (*M* = 4.07; *SD* = 1.79) and the rebuttal as rather convincing (*M* = 4.71; *SD* = 1.55), were rather willing to get vaccinated (*M* = 4.21; *SD* = 2.05) and were also rather supportive of public actions (*M* = 4.07; *SD* = 1.65). With regard to the moderator variables, participants judged their own knowledge compared to experts as rather low (*M* = 2.09; *SD* = 1.24), judged conspiracies as rather likely (*M* = 6.41; *SD* = 2.28), and were rather authentic personalities (authentic living: *M* = 5.42; *SD* = 1.02; self-alienation: *M* = 2.75; *SD* = 1.47; accepting external influence: *M* = 3.00; *SD* = 1.44).

Replication of Pilot Analyses and Manipulation Check

Participants who perceived the expert consensus to be higher rated misinformation as less convincing (*b* = -0.014, *SE* = 0.002, *p* < .001), were more willing to get vaccinated (*b* = 0.024, *SE* = 0.002, *p* < .001), rated rebuttal as more convincing (*b* = 0.017, *SE* = 0.003, *p* < .001), and reported higher support for public action (*b* = 0.015, *SE* = 0.002, *p* < .001). This aligned with pilot results.

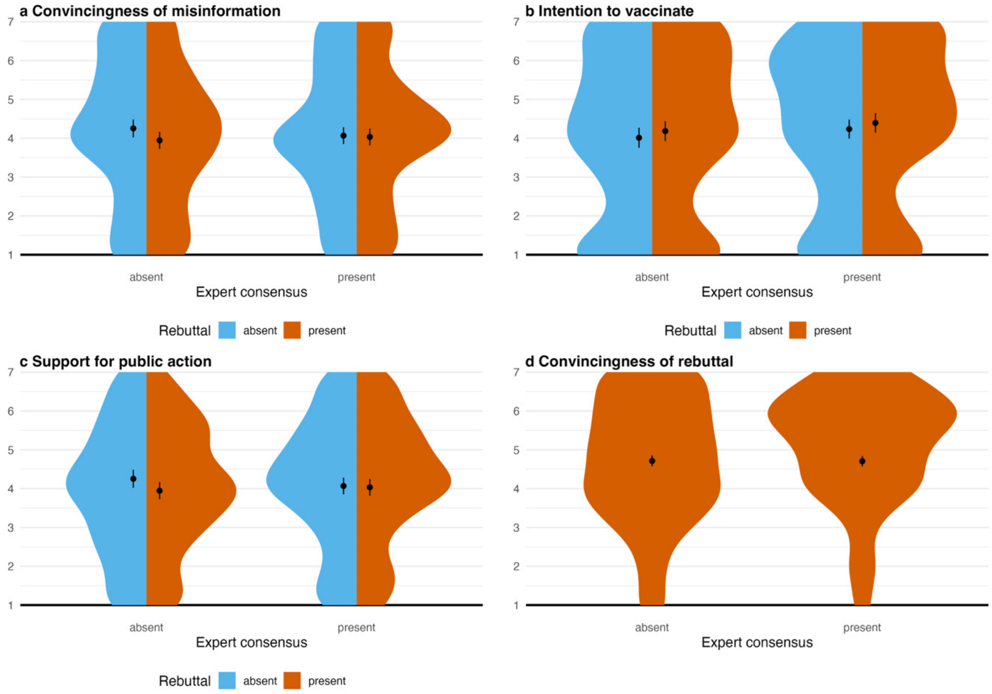

Figure 3. Violin Plots for Four Dependent Variables Convincingness of Misinformation and Intention to Vaccinate (a,b: Confirmatory) and Support for Public Action and Convincingness of Rebuttal (c,d: Exploratory), in Response to Presence of Expert Consensus, Rebuttal or a Combination of Both

Note. Black dots represent means. Black intervals show 95% confidence intervals.

The manipulation check showed that participants who received the expert consensus also perceived expert consensus to be higher (M = 74.4; SD = 25.14), compared to the control group (M = 66.35; SD = 24.44; $t(993)$ = 5.13, p < .001, Cohen's d = 0.33, 95% Confidence Interval [0.20, 0.45]). However, only 55% (N = 281) of the intervention group reported the correct consensus that was communicated to them during the experiment (90%; Figure 2). Thus, in an additional non-pre-registered post-hoc analysis, we repeated the ANOVA and ANCOVA, but excluding participants from the intervention group that did not report the correct expert consensus.

Main Results

We found no consistent evidence of a significant benefit of using either expert consensus or rebuttal on outcome measures when conducting pre-registered ANOVA and ANCOVA models (Table 1; Figure 3).

We report results of the registered planned contrasts to test H1 (expert consensus only better than none), H2 (rebuttal only better than none), and H3 (combination better than rebuttal only or expert consensus only) on main dependent variables (convincingness of misinformation, intention to vaccinate) and variables included into exploratory analyses (support for public action, convincingness of rebuttal).

Convincingness of Misinformation (Confirmatory; Figure 3a). Participants who received the expert consensus only found misinformation to be slightly less convincing (M = 4.07; SD = 1.78), compared to those who received nothing (M = 4.25; SD = 1.86). Planned contrasts remained statistically non-significant: *Mean-Difference (MD)* = -0.19, 95% CI [-0.50, 0.13], $t(507.59)$ = 1.16, p = .247. Moreover, the CI of the effect size was within equivalence bounds, d = -0.10, 90% CI [-0.25, 0.04]. Results disconfirmed H1.

Participants who received the rebuttal statement only (M = 3.95; SD = 1.77) found misinformation to be slightly less convincing, compared to those who received nothing: MD = -0.31, 95% CI [-0.63, 0.01], $t(496.53)$ = 1.89, p = .059. Again, the CI of the effect size was within equivalence bounds, d = -0.17, 90% CI [0.02, 0.32]. Results disconfirmed H2.

Participants who received a combination of expert consensus and rebuttal did not find misinformation less convincing (M = 4.03; SD = 1.75) compared to receiving expert consensus only: MD = 0.03, 95% CI [-0.27, 0.34], $t(517.29)$ = 0.22, p = .827, or rebuttal only, MD = 0.09, 95% C*I* [0.22, -0.40], $t(501.78)$ = 0.56, p = .577. Again, the CI of the effect sizes were within equivalence bounds, expert consensus: d = 0.02, 90% CI [-0.13, 0.19], Rebuttal: d = 0.05, 90% CI [-0.10, 0.20]. Results disconfirmed H3.

Intention to Vaccinate (Confirmatory; Figure 3b). Participants were slightly more willing to get vaccinated when they received the expert consensus (M = 4.26; SD = 2.03), compared to no intervention (M = 4.01; SD = 2.08). Again, planned contrasts remained statistically non-significant and CIs of effect sizes were within equivalence bounds. Results disconfirmed H1, MD = 0.22, 95% CI [-0.58, 0.13], $t(509.29)$ = 1.23, p = .217, d = 0.11, 90% CI [-0.04, 0.25].

Participants who received the rebuttal statement (M = 4.18; SD = 2.06) were not more willing to get vaccinated compared to no intervention; MD = 0.17, 95% CI [-0.19,

Table 1. ANOVA, Examining Whether the Presence of Expert Consensus (H1), of Rebuttal (H2) or a Combination of Both (H3) Impacted Dependent Variables (Main Analysis)

	Convincingness misinformation (confirmatory)			Intention to vaccinate (confirmatory)			Public action support (exploratory)			Convincingness rebuttal (exploratory)		
	F	*p*	η^2	*F*	*p*	η^2	*F*	*p*	η^2	*F*	*p*	η^2
Expert consensus: absent vs. present	0.20	.651	<.001	2.89	.090*	.003	2.31	.129	.002	0.00	.956	<.001
Rebuttal: absent vs. present	2.24	.135	.002	1.65	.200	.002	0.62	.431	<.001	--	--	--
Rebuttal × Expert consensus	1.48	.223	.001	0.00	.963	<.001	0.01	.922	<.001	--	--	--
Degrees of Freedom		1016			1016			1016			492	

Note. The asterisk (*) indicates if this result was statistically significant when entering three demographic variables (age, gender, education) into the model (Table S4).

0.56], $t(497.85) = 0.92$, $p = .357$. Again, the effect size was within equivalence bounds, $d = 0.08$, 90% CI [-0.06, 0.23]. Results disconfirmed H2.

Participants who received a combination of expert consensus and rebuttal were not more willing to get vaccinated ($M = 4.40$; $SD = 2.03$) compared to those who received the expert consensus only: $MD = 0.16$, 95% CI [-0.19, 0.51], $t(516.55) = 0.89$, $p = .371$, or rebuttal only, $MD = 0.21$, 95% CI [-0.15, 0.57], $t(501.67) = 1.16$, $p = .245$. Again, the effect sizes were statistically within equivalence bounds, expert consensus: $d = 0.08$, 90% CI [-0.07, 0.22], Rebuttal: $d = 0.10$, 90% CI [-0.04, 0.25]. Results disconfirmed H3.

Support for Public Action, Convincingness of Rebuttal (Exploratory; Figures 3c, d). The two exploratory outcome measures also did not differ between conditions (Table 1).

Furthermore, the effect of expert consensus or rebuttal were not a function of conspiracy mentality, perceived knowledge or authenticity (Tables S5–S9).

Post hoc Analysis

We excluded participants from the intervention group (expert consensus: present) that did not report the correct expert consensus in the manipulation check question. In the resulting subsample ($N = 781$), we found consistent significant benefits of using rebuttal on judgements of convincingness of misinformation and consistent significant benefits of using expert consensus on intention, support for public policy and convincingness of rebuttal in ANOVA and ANCOVA models (Table 2; Table S10). Figure 4 shows results for all dependent variables in this subsample.

Planned contrasts in the subsample showed that the combination of expert consensus and rebuttal resulted in the most stable benefits across conditions and outcome measures (Figure 4, Table 3). Comparing the combination to no intervention consistently produced meaningful expected effect sizes around the smallest effect size of interest (range $d = 0.33$–0.40, Table 3). The combination was also more effective than only rebuttal (intention: $d = 0.33$; support: $d = 0.37$) and more effective than only expert consensus (intention: $d = 0.27$) –at least for some outcome measures (Table 3). The potential benefit of combing the approaches is also highlighted by the fact that individuals perceived the rebuttal messages as more convincing when seeing the expert consensus (Figure 4d, Table 3).

Discussion

Misinformation about ineffectiveness of vaccines increasingly permeates public online media. Consequently, people may perceive vaccinations to be less effective than they are and in turn, become less willing to get vaccinated. This vaccine hesitancy (MacDonald, 2015) represents one of the top ten global threats to public health (Dubé et al., 2021). Here, we experimentally tested whether an expert consensus helps to pre-bunk against online misinformation about vaccines. To this end, in a preregistered experiment, we presented a representative German sample with an expert consensus that echoed the effectiveness of the fictitious vaccine against dysomeria (versus not; Ecker, Sanderson, et al., 2022; McDowell et al., 2016; van der Linden et al., 2014), arguments rebutting misinformation about dysomeria (versus not; Schmid & Betsch, 2019), or a combination of both, combined with typical misinformation statements (Schmid & Betsch, 2019). We measured participants perceived convincingness of misinformation, and their intention to get vaccinated, replicating and extending Schmid & Betsch (2019). Moreover, we explored impacts of interventions on support for public action and convincingness of rebuttal. Participants perceived misinformation statements as similarly convincing and were similarly willing to get vaccinated, independent of a preceding expert consensus (H1), a rebuttal statement (H2), or a combination of both (H3; Figure 3). In the full sample, all preregistered hypotheses were thus not confirmed.

In a non-pre-registered post hoc analysis, we re-examined our hypotheses with a subsample of participants who had correctly answered a manipulation check on the number presented in the expert consensus ($N = 781$): Participants who received a rebuttal statement perceived misinformation as less convincing, compared to a control group, but were similarly willing to get vaccinated. Participants who received an expert consensus compared to a control group perceived misinformation as less convincing. This only held when we did not control for demographic variables. They were also less willing to get vaccinated. Participants also reported higher support for public action and perceived rebuttal messages as more convincing when receiving the expert consensus. Also, contrast analyses revealed that the combination of both interventions was most promising. The combination outperformed single interventions at least on some outcome measures and was overall consistently better than the no-intervention control. The effect sizes of comparing the combination with the control were also practically meaningful because they reached the SESOI and confidence intervals were not within equivalence bounds (Table 3; Figure 4).

Thus, the presence of a science advocate who points out procedures for ensuring vaccine safety or why it may be warranted to trust scientific evidence about vaccines may be somewhat beneficial for counteracting misinformation people may encounter in online discussions about vaccinations (H1; Schmid & Betsch, 2019). Simple messages such as the one employed here may thus present a cost-effective means for protecting people from the influence of misinformation, before it even occurs (Ecker, Lewandowsky, et al., 2022), even if observed differences on our 7-point scale were relatively small (Figure 4a). Health authorities may thus consider developing and testing simple statements such as the one employed by the science advocate in our experiment. These effects may, however, not extend to behavioral intentions. This contrasts previous study results from Schmid & Betsch (2019) where participants' vaccinations intentions were less affected by misinformation, when they received a rebuttal message. Despite the overwhelming evidence that rebuttal decreases the impact of a denier (Schmid et al., 2020; Schmid & Betsch, 2019; Schmid & Werner, 2023) there are still instances where it fails to produce protective effects, like in this study. To ensure pro-

Table 2. ANOVA, Examining Whether the Presence of Expert Consensus (H1), of Rebuttal (H2) or a Combination of Both (H3) Impacted Dependent Variables (post hoc Analysis With Subsample of N = 781)

	Convincingness misinformation (post hoc)			Intention to vaccinate (post hoc)			Public action support (post hoc)			Convincingness rebuttal (post hoc)		
	F	*p*	η^2	*F*	*p*	η^2	*F*	*p*	η^2	*F*	*p*	η^2
Expert consensus: absent vs. present	**5.12**	**.023**	**.006**	**13.15**	**<.001***	**.017**	**10.19**	**.001***	**.013**	**6.19**	**.013***	**.016**
Rebuttal: absent vs. present	**5.16**	**.023***	**.006**	2.64	.105*	.003	3.00	.132*	.003	--	--	--
Rebuttal × Expert consensus	0.01	.930	<.001	0.38	.539	<.001	2.28	.132	.002	--	--	--
Degrees of Freedom	777			777			777			375		

Note. Statistically significant values are **bold**. Asterisks indicate that results were statistically significant when entering three demographic variables (age, gender, education) into the model (Table S10)

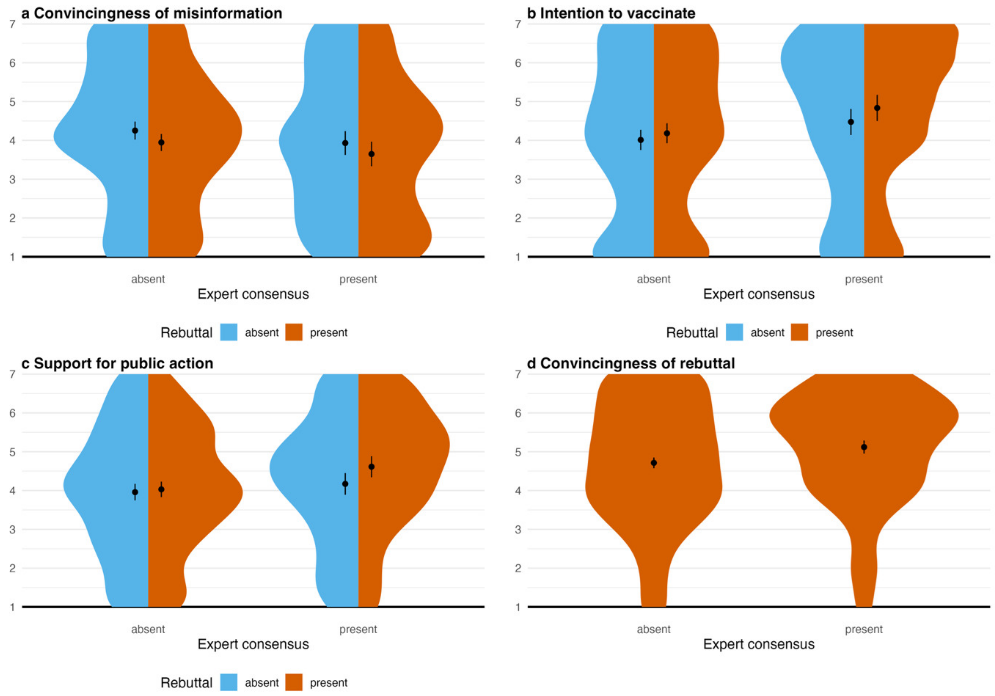

Figure 4. Violin plots for Four Dependent Variables, that is Convincingness of Misinformation and Intention to Vaccinate (a, b: Confirmatory) and Support for Public Action And Convincingness of Rebuttal (c, d: Exploratory), in Response to Presence of Expert Consensus, Rebuttal or a Combination of Both, for Subset of Participants Who Correctly Answered the Manipulation Check (Additional Post Hoc Analysis; N =781)

Note. Black dots show means. Black lines show 95% confidence intervals.

tection it seems thus wise to additionally make use of expert consensus because this increases convincingness of rebuttal and also leads to higher intentions and more support for public action when combined with rebuttal. However, all results are purely post hoc. From our pre-registered analysis we can not confirm the effectiveness of either rebuttal or expert consensus.

The presence of expert consensus may represent a similarly simple way to counteract the influence of misinformation (H2). This may be because physicians are commonly a trusted source for vaccine information (Dubé et al., 2021), or, because people may use simple heuristics such as 'trust your doctor' (Wegwarth & Gigerenzer, 2013), especially when it is combined with a social cue, such as a majority of physicians. Expert consensus may also serve as an injunctive norm, namely what others (such as trusted experts) approve or disapprove of (van Bavel et al., 2020). At the same time, such a use of expert consensus may not extend to other domains, such as climate change (Spampatti et al., 2024). This calls first for confirming the observed pattern from our post hoc analysis, and then examining when and how expert consensus messages impact both cognition and behavior across domains.

Combining rebuttal with expert consensus (H3) may represent some additional benefits, compared to presenting only one of those messages. This may be the most promising avenue for counteracting misinformation. Similarly, others observed additive effects of e.g., communicating social norm messages together with refutations for counteracting information about e.g. refugee uptake in Australia (Ecker, Sanderson, et al., 2022).

Future Research

First, future research needs to address whether effects of expert consensus observed in our subsample hold. Second, our expert consensus adhered to empirically validated graph communication guidelines for statistical proportions (McDowell et al., 2016). Still, many participants did not correctly recall expert consensus. This requires examining how expert consensus can be conveyed even more simply and effectively, using pre-post measures. Third, participants substantially underestimated expert consensus. This calls for future studies on the role of previous knowledge: Some people may initially think that expert consensus is particularly low, or, in other words, display 'pluralistic ignorance' (Sparkman et al., 2022) about expert consensus. Their responses may change more, compared to others, whose initial knowledge about expert consensus is correct. Fourth, future studies need to examine the longitudinal impacts of both rebuttal and expert consensus. This includes examining when and how their influence can turn into a lasting imprint onto perceptions and behaviors that reflects current evidence about vaccinations. Finally, highly-powered many lab studies may help detecting small effects in different populations, while controlling for relevant individual differences that may shape responsiveness to misinformation (Spampatti et al., 2024). If those find that the effects observed in our subsample hold, communicating ex-

Table 3. Effect Sizes of Planned Contrasts for the Post Hoc Analysis in Subsample

	Convincingness misinformation (post hoc)		Intention to vaccinate (post hoc)		Public action support (post hoc)		Convincingness rebuttal (post hoc)	
	d	*95% CI; 90% CI*	*d*	*95% CI; 90% CI*	*d*	*95% CI; 90% CI*	*d*	*95% CI; 90% CI*
H1: Expert Consensus vs. none	-0.17	[-0.38, 0.03]; [-0.34, 0.00]	**0.22**	**[0.02, 0.43]; [0.05, 0.39]**	0.12	[-0.08, 0.33]; [-0.05, 0.30]	**0.27**	**[0.06, 0.48]; [0.09, 0.44]**
H2: Rebuttal vs. none	-0.17	[-0.34, 0.01]; [-0.32, 0.02]	0.08	[-0.09, 0.26]; [-0.06, 0.23]	0.04	[-0.13, 0.22]; [-0.10, 0.19]	--	--
H3: Combination vs. Rebuttal	-0.17	[-0.37, 0.05]; [-0.34, 0.01]	**0.32**	**[0.11, 0.53]; [0.14, 0.50]**	**0.37**	**[0.16, 0.58]; [0.19, 0.54]**	--	--
H3: Combination vs. Expert Consensus	-0.15	[-0.39, 0.08]; [-0.35, 0.05]	0.18	[-0.06, 0.41]; [-0.02, 0.37]	**0.27**	**[0.03, 0.50]; [0.07, 0.46]**	--	--
Combination vs. none	**-0.33**	**[-0.54, -0.11]; [-0.50, -0.15]**	**0.40**	**[0.19, 0.61]; [0.22, 0.58]**	**0.39**	**[0.18, 0.61]; [0.22, 0.57]**	--	--

Note. Statistically significant values are **bold**.

pert may represent a cost-effective means for counteracting misinformation online.

Conclusion

Communicating expert consensus can represent one among several empirically validated tools for counteracting misinformation about vaccines (see Roozenbeek et al., 2023 for an overview). Two pilot studies and an exploratory analysis of an experimental study with representative German samples provide initial evidence that communicating expert consensus can protect target audiences against misinformation. This only holds, however, if people correctly recall and understand the expert consensus communicated to them.

Overall, messages tested here represent individual-level interventions (Roozenbeek et al., 2023). For effectively counteracting misinformation, it is yet unknown how they can effectively accompany system level change, such as a change in social media algorithms, or legislative measures (Roozenbeek et al., 2023).

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Ethics Statement

IRB approval for this study was obtained (2023-7250) through Radboud University.

Conflict of Interest

All authors declare that there are no conflicts of interests.

Data Accessibility

The associated registered report can be found at https://archive.org/details/osf-registrations-kjd5s-v1. All data and code is available on osf.io/23hqj

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Supplementary Materials

Supplemental Materials

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Figure 1

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Figure 2

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Figure 3

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Figure 4

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