


# BMJ Open Communication-based interventions to increase COVID-19 vaccine willingness and uptake: a systematic review with meta-analysis

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## ABSTRACT

**Objective** This systematic review investigates the effectiveness of different communication strategies to increase COVID-19 vaccine uptake and willingness.

**Design** Systematic review and meta-analysis of randomised controlled trials (RCTs), following recommendations from the *Cochrane Handbook* and reporting according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guideline.

**Data sources** We searched the following databases until 27 July 2022: Cochrane COVID-19 Study Register, PsycINFO, CINAHL, Web of Science Core Collection and WHO COVID-19 Global literature.

**Eligibility criteria for study selection** We included RCTs investigating, any population, communication-based interventions to increase COVID-19 vaccine uptake and comparing these with no intervention (with or without placebo), another communication strategy or another type of intervention.

**Methods** Screening, data extraction and bias assessment, using the Cochrane ROB 1.0 tool, were conducted by two authors independently. We performed meta-analyses if studies were homogeneous using the Review Manager (RevMan 5) software, synthesised the remaining results narratively and assessed the certainty in the evidence using the Grading of Recommendations Assessment, Development, and Evaluation approach.

**Results** We identified 49 studies reporting on the predefined four categories of communication interventions. Evidence from our meta-analyses shows that COVID-19 vaccine uptake may increase when education and information strategies are applied (risk ratio (RR) 1.23, 95% CI 1.17 to 1.28; high-certainty evidence) or social norms are communicated (RR 1.28, 95% CI 1.23 to 1.33; high-certainty evidence) compared with no intervention. The different communication strategies mostly have little to no impact on vaccine intention; however, there may be a slight increase in vaccine confidence when gain framing is applied compared with no intervention.

**Conclusion** Overall, we found that education and information-based interventions or social norm-framing strategies are most effective compared with no intervention given. Our findings show that some of the

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The strengths of this review include our independent dual screening and study selection process, data extraction, risk-of-bias assessment and Grading of Recommendations Assessment, Development, and Evaluation appraisal.
- ⇒ The review Population, Intervention, Comparison, Outcome, defined at protocol stage, is based on results from a scoping review and discussions of an online workshop with German policymakers.
- ⇒ Limitations of the evidence mainly arise from the heterogeneity of the interventions, which made it difficult to classify, compare and synthesise all the results.
- ⇒ Regarding the outcome measures, it is challenging to define and report the construct of intention and confidence from the included study results, and thus, we limited the latter to perceived safety and effectiveness of the vaccine.

investigated communication strategies might influence policy decision-making, and our results could be useful for future pandemics as well.

**PROSPERO registration number** PROSPERO (CRD42021296618).

## INTRODUCTION

The COVID-19 outbreak has been declared to be a pandemic by WHO in March 2020,<sup>1</sup> resulting in more than 775 million confirmed cases as of June 2024.<sup>2</sup> Since the outbreak, effective treatments are still being investigated. Thus, the approval of the first COVID-19 vaccine in December 2020 was a major step towards controlling the pandemic. Accordingly, a major challenge to getting the population vaccinated was hesitancy and doubts towards the new vaccine that were widely present among populations.<sup>3</sup> Therefore, we need to improve our



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understanding of overcoming vaccine hesitancy and improving willingness to vaccinate through effective interventions.

Some measures taken to increase COVID-19 vaccine uptake are, for instance, policy interventions (eg, mandatory vaccine policy), incentives (eg, financial) or combining those as part of multidimensional interventions.<sup>4</sup> Communication-based strategies, aiming to inform and educate their targeted population,<sup>5</sup> are another commonly used way to combat COVID-19 vaccine hesitancy. They encompass all different forms of communication with an addressed population, such as framing, messaging or the use of different media.<sup>6,7</sup> Policy interventions, which include regulations and mandates to ensure compliance, differ from communication strategies as they rely on formal rules and requirements rather than persuasive information. Based on a discussion with policymakers following our scoping review on interventions increasing COVID-19 vaccine uptake, we decided to focus on communication strategies.<sup>4</sup> Communication strategies were chosen because they were viewed as less resource-intensive and time-intensive than other strategies and could be integrated into already existing strategies to reach the population.

A plethora of evidence exists on the effectiveness of interventions to increase vaccine uptake for diseases other than COVID-19.<sup>8,9</sup> However, vaccine hesitancy for COVID-19 vaccines might differ from other vaccines as vaccine production and rollout happened rapidly and were accompanied by uncertainty in the population but also a surge of conspiracy theories.<sup>10</sup> Evidence from a narrative review suggests that communication strategies, specifically sending reminders or personalised messaging, can increase COVID-19 vaccine uptake.<sup>11</sup> Regarding communication content, some evidence points to the effectiveness of framing strategies both for COVID-19 vaccination and other vaccines.<sup>12,13</sup> However, no review has yet systematically investigated which communication strategies can increase the willingness to vaccinate against COVID-19 using meta-analysis.

In this systematic review, we aimed to investigate the efficacy of communication strategies for increasing COVID-19 vaccine uptake and willingness compared with no intervention (with or without placebo interventions), or other intervention categories to increase COVID-19 vaccine uptake, or comparing different communication strategies with each other.

## METHODS

The protocol for this review was registered with PROSPERO (CRD42021296618).<sup>14</sup> We followed the recommendations from the *Cochrane Handbook for Systematic Reviews of Interventions*<sup>15</sup> and the updated Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist.<sup>16</sup> We used the Review Manager 5 (RevMan 5)<sup>17</sup> software for all data analyses.

## Search strategy and study selection criteria

On 27 July 2022, the following databases were searched: Cochrane COVID-19 Study Register (CCSR); PsycINFO (via Ovid); CINAHL (via EBSCO); Web of Science Core Collection; WHO COVID-19 Global literature on coronavirus disease (<https://search.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/>), without any restrictions to publication type (full-text publications, preprint versions, abstract publications and clinical trial registry records). The search strategies can be found in the supplement (pp 3–5, online supplemental table S1). Searches were based on a prior search for the scoping review that served as a precursor for the current review.

We included randomised controlled trials (RCTs) or cluster randomised trials, investigating any population, communication-based interventions to increase COVID-19 vaccine uptake or vaccination willingness and comparing these with no intervention (with or without placebo), another communication strategy or another type of intervention. We did not exclude studies based on the length of follow-up. Predefined outcomes were actual COVID-19 vaccine uptake (documented uptake of at least one dose of any COVID-19 vaccine by health agencies or governments), self-reported COVID-19 vaccine uptake, COVID-19 vaccination intention (individuals self-reported plans or willingness to get vaccinated) and COVID-19 vaccine confidence (trust in the vaccines safety and/or effectiveness). After duplicates were removed, two review authors independently screened the results of the search for eligibility by reading titles and abstracts using the web-based online platform Rayyan ([www.rayyan.ai](http://www.rayyan.ai)). Disagreements were solved by discussion or consulting a third review author. Two review authors independently assessed the full texts of the selected studies, and in case of disagreements, we consulted a third review author to reach a final decision. We documented the study selection process in a flow chart as recommended in the PRISMA statement.<sup>18</sup>

## Data extraction and outcome assessments

We conducted data extraction according to Cochrane guidance.<sup>19</sup> Two review authors extracted data in duplicate using a pilot-tested data extraction form, developed in Microsoft Excel. Disagreements were solved by discussion or by including a third author. We extracted information on the trial design, study context, characteristics of participants, intervention details (including their theoretical basis), time of follow-up, reported outcomes, outcome measures, study quality, financial support and sponsoring, and declaration of interests.

If relevant data were missing, we requested these from the principal study investigators. We analysed data according to the following four categories of intervention: education and information aiming to empower and inform people on topics related to COVID-19 vaccine (1), social norm framing (SNF) aiming at appealing to identity and moral values (2), gain framing (GF) focusing on advantages of adopting a recommended behaviour (3)

and loss framing (LF) focusing on disadvantages of not performing the advocated behaviour (4) (supplement p 5, online supplemental table S2). These four categories were chosen based on communication and behavioural theories,<sup>20</sup> and expert consensus of different stakeholders relevant to the field.

### Risk of bias and certainty of evidence assessment

Two authors independently assessed the risk of bias of included studies, at a study level, using the Cochrane Risk of Bias 1.0 tool.<sup>21</sup> In case of conflict, a third author was consulted. We followed the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach to assess the certainty of the evidence for each outcome.<sup>22</sup>

### Data analysis

For continuous outcome data, we collected the mean, SD and total number of participants from the intervention and control groups. We used the mean difference (MD) for the same measurement scales and standardised mean difference (SMD) for different scales, with 95% CIs, using changes from baseline rather than post-intervention scores for the calculation. For dichotomous outcome data, we recorded the total number of events and participants in both groups and to report pooled risk ratio (RR) with 95% CI. If trials and outcome definitions were sufficiently homogeneous, we conducted meta-analyses using the random-effects model and assessed heterogeneity of treatment effects using  $\chi^2$  test with a significance level at  $p < 0.1$  and  $I^2$  statistic.<sup>23</sup> Furthermore, we considered studies' methodological and statistical diversity for assessing heterogeneity. These aspects, specifically differences in outcome measurement, study design and intervention effects, were discussed and agreed on in the review team. For  $I^2$  above 80%, suggesting explained heterogeneity, we did not pool data in meta-analyses, but depicted them in forest plots without a combined effect estimate.<sup>24 25</sup> Forest plots were conducted using the Review Manager (RevMan 5) software. If incomplete data were available, we synthesised the results narratively and presented them in tabular format. For 'multi-arm' studies, we planned to compare each arm with the common comparator separately, as recommended in Chapters 6 and 23 of the *Cochrane Handbook*.<sup>15</sup> For pair-wise meta-analysis, we split shared groups, adjusting sample sizes while keeping means and SDs unchanged. We performed subgroup analyses on the applicable COVID-19 vaccine approval date of each country (conduction of study before or after approval).

### Patient and public involvement

Patients and members of the public were not directly involved in this study. However, within this project, we invited different stakeholders to develop a relevant research question, based on the findings of our prior conducted scoping review, which maps the available evidence on interventions to increase COVID-19 vaccine

intention of different populations.<sup>4</sup> Together with relevant stakeholders from policy and research, we prioritised types of interventions and target populations and developed the PICO (Population, Intervention, Comparison, Outcome)<sup>26</sup> for this systematic review. Finally, we discussed the findings of this systematic review and the implementation of identified intervention strategies with experts from the Robert Koch Institute and the Center for Health in North Rhine-Westphalia, Germany. Also, we intend to engage the public in disseminating our results, including social media engagement, newsletters and conferences.

## RESULTS

We searched all databases until 27 July 2022. Our search retrieved 10 280 records. After removing duplicates, we screened 6281 records based on their title and abstracts. We excluded 6163 records that did not meet the prespecified inclusion criteria. Of the remaining 118 full texts, we excluded a further 26 studies for specific reasons. Finally, we included 92 studies in this review. Of those, 49 studies were included in a synthesis, 26 studies were still ongoing and 17 studies were classified as awaiting classification as they were completed, withdrawn or provided insufficient details on the intervention, without published data (supplement pp 7–33, online supplemental tables S3–S5). 25 studies provided data for the meta-analyses. The study selection is summarised in figure 1.

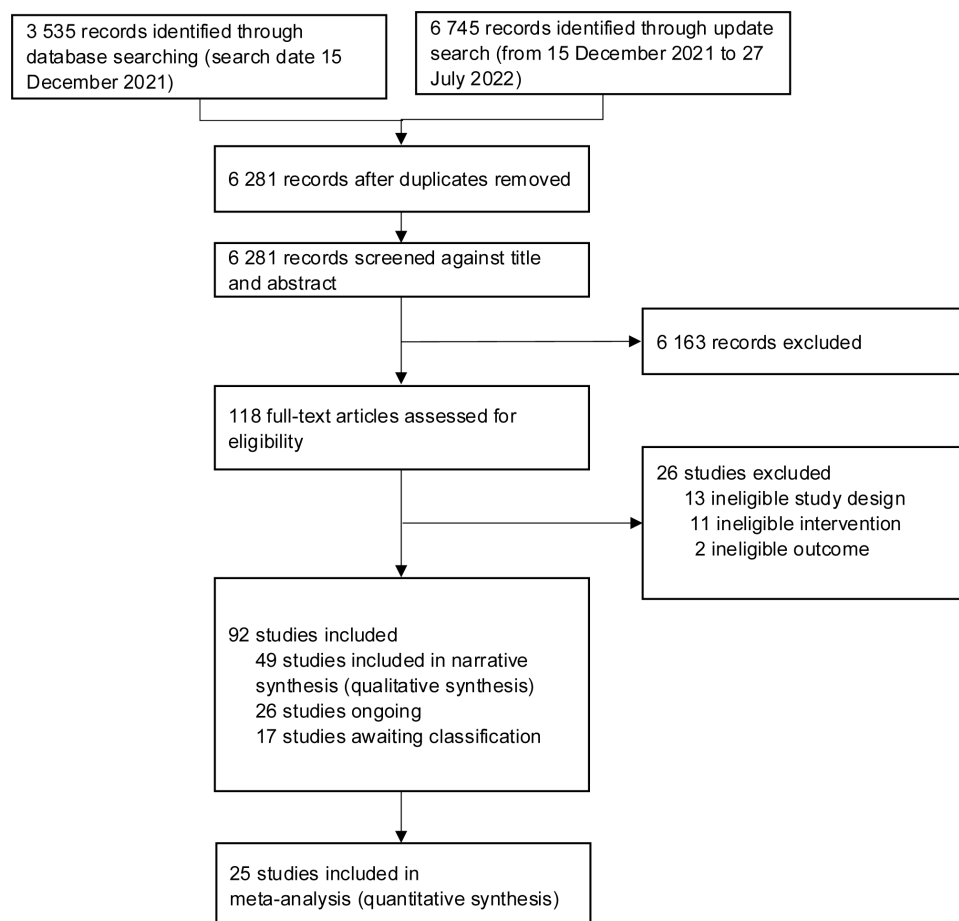
### Study characteristics

Of the 49 identified studies, 22 studies were conducted in the USA,<sup>27–48</sup> 4 in the UK,<sup>49–52</sup> 4 studies were carried out in multiple country settings spanning countries globally, 3 in China,<sup>53–55</sup> 2 in Canada,<sup>56 57</sup> 2 in Italy,<sup>58 59</sup> 2 in Japan,<sup>60 61</sup> 2 in Jordan,<sup>62 63</sup> 1 in Australia,<sup>64</sup> 1 in Denmark,<sup>65</sup> 1 in France,<sup>66</sup> 1 in Germany,<sup>67</sup> 1 in Ireland,<sup>68</sup> 1 in Malaysia<sup>69</sup> and 1 in Pakistan.<sup>70–74</sup>

10 of the included studies took place before official approval of any COVID-19 vaccine in the region of interest, and all of them were conducted in 2020.<sup>27 29 30 33 34 36 39 48 58 72</sup> 37 studies took place after a COVID-19 vaccine was approved in the region of interest for emergency use at least.<sup>43–48 51 52 54–57 59 61 63–65 67–69 73 74</sup>

Five studies reported actual COVID-19 vaccine uptake as an outcome,<sup>28 32 46 59 63</sup> no studies reported self-reported COVID-19 vaccine uptake as an outcome, 40 out of the 49 included studies reported COVID-19 vaccine intention as an outcome,<sup>27 29–41 43 45 47–51 53 55 56 58 60–67 69–72 74 75</sup> and 9 studies reported COVID-19 vaccine confidence as an outcome.<sup>30 40 51 58 66 67 70–72</sup>

Most studies measured the change in outcome right after the intervention.<sup>35–37 39–42 47 48 50 52 54–57 60 61 65 68 71–74</sup> Abdel Qader *et al* measured the outcome directly after the intervention and a month after the intervention. Berry measured vaccine uptake during 1 month. Dai *et al* considered vaccine uptake within 6 days post-intervention as their primary outcome and a scheduled vaccine



**Figure 1** Study selection (adapted from Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2009 flow diagram).

appointment within 4 weeks as the secondary outcome. Similarly, Mehta *et al* assessed the primary outcome within a month and the secondary outcome within 2 months. Mottelson assessed the outcome immediately after the study, as well as 1 week later. Santos assessed the outcome within 3 days of the intervention. Tentori started measuring the outcome 3 days post-intervention for 19 days.

### Risk of bias

Summaries of the assessment for each included study and for each risk of bias domain are presented in the supplement (supplement pp 64–65, online supplemental figure S1 and S2). Overall, 15 studies were judged to have a low risk of bias.<sup>31 38 40 48–51 56 59 61 64 65 69 71 75</sup> 27 studies were judged to have an overall unclear risk of bias due to insufficient information regarding randomisation, allocation, blinding, incomplete outcome data or there was no protocol available.<sup>30 32–37 39 41 42 44–47 52–55 57 58 60 67 68 70 72–74</sup>

Seven studies were judged to have an overall high risk of bias mostly due to lack of blinding, missing outcome data or retrospective registration.<sup>27–29 43 62 63 66</sup> We included studies in the meta-analysis regardless of their risk of bias assessment and considered it in the certainty of the evidence assessment (GRADE).

### Effectiveness of communication strategies

The study results are summarised by intervention category and reported on an outcome level, together with the certainty of the evidence. An overview of the included studies by intervention, reported outcome and comparison is presented in [table 1](#).

### Education and information strategy versus no intervention alone or with placebo

13 studies compared an education and information (E&I) strategy, aiming to empower and transform as well as inform people on topics related to COVID-19 vaccine, to no intervention, of which 9 are included in a meta-analysis (supplement pp 35–40, online supplemental table S6) and 4 in a narrative synthesis. We present the results in the summary of findings in [table 2](#).

### Vaccine uptake

Two studies with three different interventions reported actual COVID-19 vaccine uptake (uptake) for 56 440 participants. An education or information-based strategy increased uptake (RR 1.23, 95% CI 1.17 to 1.28;  $I^2=6\%$ ; high-certainty evidence; online supplemental figure S3), considering that the live health coaching given in the



**Table 1** Overview of included studies by intervention category, outcomes reported and comparison

| Intervention category              | Outcome: vaccine uptake (actual)  | Outcome: vaccine uptake (self-reported) | Outcome: vaccine intention   | Outcome: vaccine confidence  | Comparisons   |
|------------------------------------|---|---|--|--|---|
| Education and information strategy | Abdel-Qader <i>et al</i> <sup>62</sup> , Dai <i>et al</i> <sup>32</sup> | None                                    | James <i>et al</i> , <sup>34</sup> Kerr <i>et al</i> , <sup>50</sup> Robertson <i>et al</i> , <sup>47</sup> Thorpe <i>et al</i> , <sup>40</sup> Capasso <i>et al</i> , <sup>58</sup> Rinaldi <i>et al</i> , <sup>73</sup> Witus and Larson, <sup>41</sup> Vivion <i>et al</i> , <sup>56</sup> Freeman <i>et al</i> , <sup>49</sup> Helfers <i>et al</i> <sup>67</sup> , Vlasceanu and coman <sup>48</sup>                                | Thorpe <i>et al</i> <sup>40</sup>                                      | Versus no intervention, no intervention alone or with placebo |
| Social norm-framing strategy       | Dai <i>et al</i> <sup>32</sup>  | None                                    | Chu <i>et al</i> , <sup>31</sup> Freeman <i>et al</i> , <sup>67</sup> Pink <i>et al</i> , <sup>37</sup> Okuhara <i>et al</i> , <sup>61</sup> Moehring <i>et al</i> , <sup>74</sup> Vlasceanu and coman <sup>48</sup> , Dai <i>et al</i> , <sup>32</sup> James <i>et al</i> , <sup>34</sup> Santos <i>et al</i> , <sup>38</sup> Sasaki <i>et al</i> <sup>60</sup> , Robertson <i>et al</i> , <sup>47</sup> Zhu <i>et al</i> <sup>57</sup> | None   | Versus no intervention, no intervention alone or with placebo |
|                                    |   |   | Diament <i>et al</i> , <sup>45</sup> Robertson <i>et al</i> <sup>47</sup>  |  | Versus education and information strategy                     |
| Gain-framing strategy              | None  | None                                    | Freeman <i>et al</i> <sup>67</sup> 2021, Capasso <i>et al</i> , <sup>58</sup> Barnes <i>et al</i> , <sup>64</sup> Sasaki <i>et al</i> <sup>60</sup>  | Capasso <i>et al</i> <sup>58</sup>                                     | Versus no intervention, no intervention alone or with placebo |
|                                    |   |   | Freeman <i>et al</i> <sup>67</sup>   |  | Versus social norm-framing strategy                           |
| Lossframing strategy               | None  | None                                    | Barnes and Colagiuri <sup>51</sup>   | Barnes and colagiuri <sup>51</sup>                                     | Versus loss-framing strategy                                  |
|                                    |   |   | Capasso <i>et al</i> , <sup>58</sup> Kerr <i>et al</i> , <sup>50</sup> Thorpe <i>et al</i> , <sup>40</sup> Barnes <i>et al</i> , <sup>64</sup> Santos <i>et al</i> , <sup>38</sup> Sasaki <i>et al</i> <sup>60</sup>   | Capasso <i>et al</i> , <sup>58</sup> Thorpe <i>et al</i> <sup>40</sup> | Versus no intervention, no intervention alone or with placebo |
|                                    |   |   | Kerr <i>et al</i> , <sup>50</sup> Thorpe <i>et al</i> <sup>40</sup>  |  | Versus education and information strategy                     |
|                                    |   |   | Santos <i>et al</i> , <sup>38</sup> Van Hoecke <i>et al</i> <sup>52</sup>  |  | Versus social norm-framing strategy                           |

Abdel-Quader 2022 study shows an important uptake increase.

Six studies with 15 different interventions reported the COVID-19 vaccination intention (continuous outcome) for 11 156 participants. Evidence from these studies shows that an E&I strategy probably has no impact on intention (SMD 0.02, 95% CI -0.03 to 0.07;  $I^2=23\%$ ; moderate-certainty evidence; online supplemental figure S4). Only an intervention from Capasso 2021 with text message focused on cognitive attitude showed some effect on the outcome. There is no evidence for subgroup differences regarding the conduction of studies before or after vaccine approval (online supplemental figure S5).

### Vaccine intention

Another six studies with 16 different interventions reported intention (dichotomous) for 63 862 participants (low-certainty evidence). Evidence suggests that an E&I strategy results in increased intention compared with no intervention in Abdel-Qader 2021 (RR 2.72, 95% CI 2.17 to 3.42), which delivered interactive pharmacist-based virtual coaching sessions, and in Dai 2021, which provided text or video messages. For James 2021 and Kerr 2021, both having provided text messages, and Robertson 2021

with video messages, the interventions had little or no impact on the outcome. Only in Rinaldi 2022, providing articles about vaccine-related thrombosis, a negative effect on intention was found. Due to this heterogeneity among the studies and an  $I^2>90\%$ , we did not pool the effect estimates (online supplemental figure S6).

In addition to the abovementioned results from studies having reported forest-plot data, two studies reported intention for 3684 participants. Witus 2021 showed an increase in vaccination intention, when being exposed to an animated video explaining how the vaccines work, compared with no intervention and in Vivion 2022 vaccination intention was lower (OR=0.63) for the group receiving disinformation on COVID-19 vaccine, and receiving prebunking information refuting misinformation afterwards (OR=0.80), both compared with no intervention group.

### Vaccine confidence

Two studies reported COVID-19 vaccine confidence for 473 participants. Evidence suggests that an E&I strategy results in little to no impact on confidence (SMD 0.05, 95% CI -0.22 to 0.32;  $I^2=54\%$ ; low-certainty evidence; online supplemental figure S7). Both studies

**Table 2** Summary of findings table: comparison 1

1. Education and information strategy compared with no intervention for increasing COVID-19 vaccine uptake and willingness

Patient or population: increasing COVID-19 vaccine uptake and willingness

Setting:

Intervention: education and information strategy

Comparison: no intervention

| Outcomes   | Anticipated absolute effects* (95% CI)  |  | Relative effect (95% CI) | No of participants (studies) | Certainty of the evidence (GRADE) | Comments  |
|--|---|--|--------------------------|------------------------------|-----------------------------------|---|
|  | Risk† with no intervention  | Risk with education and information strategy   |                          |                              |                                   |   |
| Actual COVID-19 vaccine uptake   | 138 per 1000  | 170 per 1000 (162 to 177)                      | RR 1.23 (1.17 to 1.28)   | 56 440 (3 RCTs)              | ⊕⊕⊕⊕ High                         | Education and information strategy has some favourable impact on actual COVID-19 vaccine uptake.                                  |
| COVID-19 vaccine intention (continuous) (assessed with scale with higher scores indicating higher vaccine intention) | –   | SMD 0.02 SD higher (0.03 lower to 0.07 higher) | –                        | 11 505 (15 RCTs)             | ⊕⊕⊕○ Moderate‡                    | Education and information strategy has probably very little to no impact on COVID-19 vaccine intention                            |
| COVID-19 vaccine intention (dichotomous)   | Education and information strategies showed to increase intention compared with no intervention in Abdel-Qadar (RR 2.72, 95% CI 2.17 to 3.42), which delivered interactive pharmacist-based virtual coaching sessions, and in Dai <i>et al</i> <sup>32</sup> 2021, which provided text or video messages. For James <i>et al</i> <sup>34</sup> 2021 and Kerr <i>et al</i> <sup>50</sup> 2021, both having provided text messages, and Robertson <i>et al</i> <sup>47</sup> 2021 with video messages, the interventions showed to have no or very little impact on the outcome. Only in Rinaldi and Dellino <sup>73</sup> 2022, providing articles about vaccine-related thrombosis, a negative effect on intention was found. Due to this heterogeneity among the studies and an $I^2 > 90\%$ , we did not pool the effect estimates. |  |                          | 63 862 (16 RCTs)             | ⊕⊕○○ Low§                         | Education and information strategy may have a favourable impact on COVID-19 vaccine intention compared with no intervention       |
| COVID-19 vaccine confidence (assessed with: Scale with higher scores indicating higher vaccine confidence)           | –   | SMD 0.05 SD higher (0.22 lower to 0.32 higher) | –                        | 473 (2 RCTs)                 | ⊕⊕○○ Low¶**                       | Education and information strategy may have very little to no impact on COVID-19 vaccine confidence compared with no intervention |
| Self-reported COVID-19 vaccine uptake—not reported   | –   | –  | –                        | –                            | –                                 | –   |

GRADE Working Group grades of evidence: high certainty: we are very confident that the true effect lies close to that of the estimate of the effect. Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

\*The risk in the intervention group (and its 95% CI) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).

†‘Risk’ is the event number of vaccines, the vaccine intention or willingness.

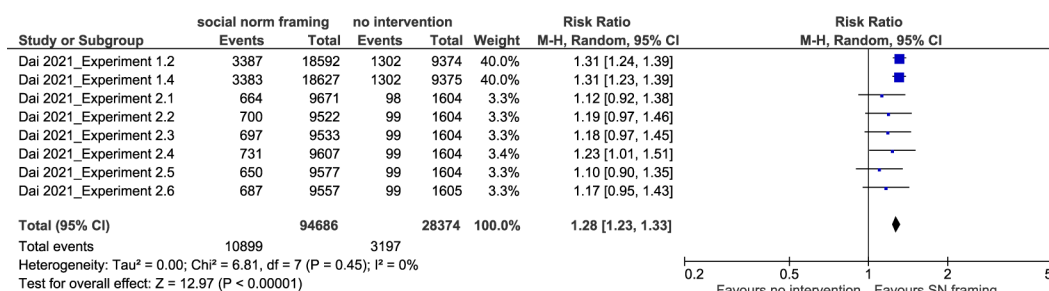
‡Downgraded one level for serious inconsistency because the studies used different measurement scales.

§Downgraded two levels for very serious inconsistency because the studies used different measurement scales and the effect direction are not consistent across studies.

¶Downgraded one level for serious inconsistency because directions of effects are not consistent in both studies.

\*\*Downgraded one level for serious imprecision because of few participants.

RCT, randomised controlled trial; RR, risk ratio; SMD, standardised mean difference.



**Figure 2** Forest plot of comparison. 2 Social norm-framing strategy versus no intervention alone or with placebo, outcome. 2.1 Actual COVID-19 vaccine uptake. Mantel-Haenszel, Random-effects model.

show opposite directions of effect. One study,<sup>58</sup> having provided a text message focusing on cognitive attitude, found a favourable effect on the outcome. There is no evidence for subgroup differences regarding the conduction of studies before or after vaccine approval (online supplemental figure S8).

### Social norm-framing strategy versus no intervention alone or with placebo

17 studies compared a SNF strategy, aiming at appealing to identify, social norms and moral values, to no intervention, of which 7 are included in a meta-analysis (supplement pp 40–42, online supplemental table S7), 10 in a narrative synthesis and 1 in both syntheses. We present the results in the summary of findings (online supplemental table S8) of the supplement (p 43).

#### Vaccine uptake

One study with eight different interventions reported uptake for 123 060 participants. SNF strategies, being all different text messages, increase uptake (RR 1.28, 95% CI 1.23 to 1.33;  $I^2=0\%$ ; high-certainty evidence; figure 2).

#### Vaccine intention

Six studies with 18 different interventions reported intention (continuous outcome) for 377 935 participants. An SNF strategy probably has no impact on intention (SMD 0.03, 95% CI 0.02 to 0.04;  $I^2=17\%$ ; moderate-certainty evidence; online supplemental figure S9). However, Okuhara 2022, providing messages from a former infected patient using the motive of kin care or disease avoidance, has shown an increased impact on intention.

Another six studies with 17 different interventions reported intention (dichotomous) for 135 337 participants (low-certainty evidence). Evidence suggests that an SNF strategy increases intention compared with no intervention for two interventions in the first experiment of Dai 2021 and for Santos 2021, which provided text or video messages and personal emails, respectively. For the other interventions of Dai 2021, James 2021, Robertson 2021 and Zhu 2022, the interventions had some impact on the outcome, and for Sasaki 2022, there is evidence for no impact on intention. Due to this heterogeneity among the studies and an  $I^2>90\%$ , we did not pool the effect estimates, even though data were available (online supplemental figure S10).

In addition to the abovementioned results, five studies reported intention for 10 639 participants using different framing strategies/interventions. Bokemper 2022 found a negative impact on intention. Fox 2021 and Robertson 2022 did not find any effect. In Palm 2021, a positive effect was shown, but only in participants who received a message informing them on vaccine safety and efficacy or suggesting that other people would get vaccinated and in Yuan 2021 when participants received a community-centred message. One study did neither report nor provide any data relevant to our review on request.<sup>37</sup>

### Gain-framing strategy versus no intervention alone or with placebo

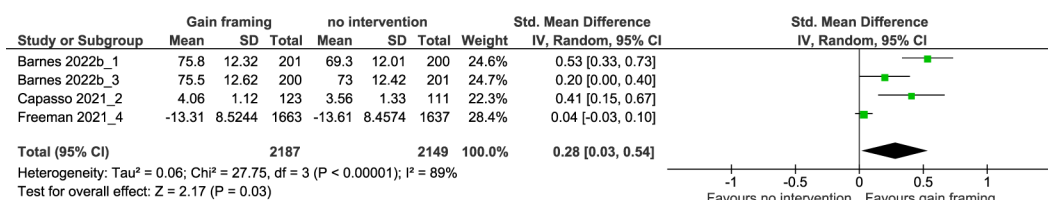
Seven studies compared a GF strategy, focusing on the advantages of adopting a recommended behaviour to no intervention, of which four are included in a meta-analysis (supplement p 44, online supplemental table S9) and three in a narrative synthesis. We present the results in the summary of findings (online supplemental table S10) of the supplement pp 45–46).

#### Vaccine intention

Three studies with four different interventions reported intention (continuous outcome) for 4336 participants. A GF strategy may have little to no impact on intention (SMD 0.28, 95% CI 0.03 to 0.54;  $I^2=89\%$ ; low-certainty evidence; see figure 3 for random-effect model and online supplemental figure S11 for fixed-effect model). When looking at the individual included studies, Capasso 2021 and Barnes 2022 suggested an increase in intention compared with no intervention, but Freeman 2021 showed no effect on intention. There is no evidence for subgroup differences regarding the conduction of studies before or after vaccine approval (online supplemental figure S11).

One study reported intention (dichotomous) for 798 participants. The intervention providing participants with text messages may have no impact on the outcome (RR 1.01, 95% CI 0.93 to 1.09; low-certainty evidence; online supplemental figure S13).

In addition to the abovementioned results, one study reported intention for 654 participants and showed that providing gain-framed messages resulted in higher vaccination intention compared with non-framed messages.<sup>54</sup>



**Figure 3** Forest plot of comparison. 3 Gain-framing strategy versus no intervention alone or with placebo, outcome. 3.1 COVID-19 vaccine intention (continuous). Inverse-Variance, Random-effects model.

Two studies reported intention for 611 participants. Both studies showed a positive effect on intention; Mottelson 2021 investigated the impact of virtual reality interventions, and Palm 2021 provided text message highlighting safety and effectiveness of the COVID-19 vaccine.

#### Vaccine confidence

One study with one intervention reported confidence for 234 participants.<sup>58</sup> A GF strategy may increase confidence (MD 0.36, 95% CI 0.10 to 0.62, low-certainty evidence, online supplemental figure S14).

#### Loss-framing strategy versus no intervention alone or with placebo

Nine studies compared a LF strategy, focusing on the disadvantages of not performing the advocated behaviour, to no intervention, of which four are included in a meta-analysis (supplement pp 46–47, online supplemental table S11) and five additional studies in a narrative synthesis. We present the results in the summary of findings (online supplemental table S12) of the supplement (pp 47–48).

#### Vaccine intention

Four studies with six different interventions reported intention (continuous outcome) for 2521 participants. An LF strategy may have no impact on intention (SMD -0.02, 95% CI -0.13 to 0.08;  $I^2=40\%$ ; low-certainty evidence, figure 4). Capasso 2021 suggests increasing intention compared with no intervention, but Kerr 2021, Thorpe 2021 and Barnes 2022b found very little to no effect (in the opposite direction). There is evidence for subgroup differences regarding the conduction of studies before or after vaccine approval; however, due to the small number of studies included in both subgroup analyses and the large heterogeneity, we are uncertain whether the analyses produced useful findings (online supplemental figure S15).

Three studies with four different interventions reported intention (dichotomous) for 8402 participants

(low-certainty evidence). Evidence from Santos 2021 suggests that an LF strategy which attempts to reframe the risks by explicitly noting the small possibility of serious side effects increases intention compared with no intervention. For Sasaki 2022, the intervention showed to have a very small positive effect on intention, and Kerr 2021 found no impact. Due to this heterogeneity among the studies and an  $I^2>90\%$ , we did not pool the effect estimates, even though data were available (online supplemental figure S16).

In addition to the abovementioned results, two studies reported intention for 976 participants and both found a negative impact on intention when comparing loss-framed messages to no intervention.<sup>36 54</sup>

#### Vaccine confidence

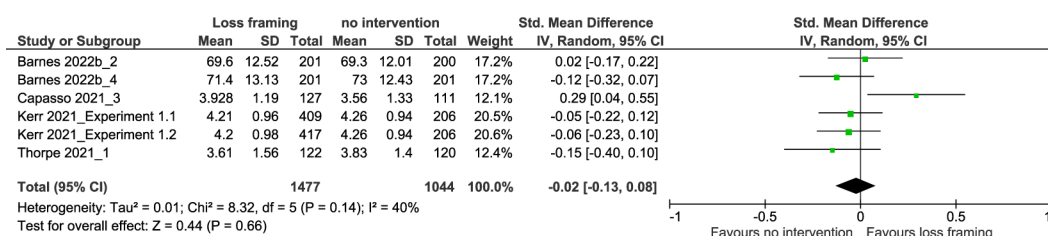
Two studies with two different interventions reported confidence for 476 participants. The evidence is very uncertain regarding the effect of an LF strategy on having no impact on confidence (SMD 0.10, 95% CI -0.16 to 0.36;  $I^2=52\%$ ; very low-certainty evidence; online supplemental figure S17). Both studies show opposite directions of effect. There is no evidence for subgroup differences regarding the conduction of studies before or after vaccine approval (online supplemental figure S18).

The results of further comparisons are presented in the supplement (supplement pp 48–54, online supplemental tables S13–S19 and pp 70–72, online supplemental figure S19–S29) and the summary of findings with the certainty of the evidence for comparison 5–12 are available in the supplement (supplement pp 54–61, online supplemental tables S20–S27).

## DISCUSSION

### Principal findings

Our systematic review investigating the effectiveness of different communication strategies to increase COVID-19



**Figure 4** Forest plot of comparison. 4 Loss-framing strategy versus no intervention alone or with placebo, outcome. 4.1 COVID-19 vaccine intention (continuous). Inverse-Variance, Random-effects model.



vaccine uptake included a total of 49 studies, of which 25 provided data for the meta-analyses. Overall, we found that education and information-based interventions or SNF strategies are most effective compared with no intervention, given that, in particular, they may increase COVID-19 vaccine uptake. The different intervention strategies mostly have little to no impact on vaccine intention; however, there may be a slight increase in vaccine confidence when GF is applied compared with no intervention. Overall, for all different interventions evaluated in meta-analyses, the greatest effect was seen for COVID-19 vaccine uptake and the interventions are less effective on COVID-19 vaccination intention and confidence. From our narrative synthesis, we inferred that an interactive education and information-based intervention of online sessions has in particular shown to be very effective and results in increased intention compared with no intervention. When comparing communication interventions with each other, we found no major differences between these varying strategies.

### Comparison with other studies

The results identified here are comparable to other studies. A systematic review, including 39 studies (RCTs and quasi-experimental studies), found that personalising communications and text messages with reminders affected COVID-19 vaccine uptake.<sup>11</sup> This review categorised its identified interventions in communication content, presentation and delivery, policy and vaccination delivery. Thus, it is questionable whether these categories are comparable to our defined categories of interventions, which are based on the underlying theory and the intention of interventions, rather than the form of delivery and presentation.

Some of the findings discussed here can be explained by theories of behaviour change. The Theory of Planned Behaviour (TPB) posits that behaviour is influenced by intention, which in turn is influenced by attitudes, norms, anticipated regret and perceived control.<sup>76</sup> Furthermore, since humans are socially oriented, their behaviour is influenced by the values and beliefs of their social environment.<sup>77</sup> This can explain our finding that SNF increased COVID-19 vaccine uptake compared with no intervention. In addition, the educational interventions investigated here targeted people's attitudes on vaccines, for example, by highlighting prosocial aspects of getting vaccinated (James 2021), generating affect such as regret (Capasso 2021) or filling gaps in knowledge about the COVID-19 vaccine (Kerr 2021, Witus 2021). Based on the TPB, these changes in attitude can explain the behaviour change of vaccine uptake. Similarly, a Cochrane review with 10 RCTs, assessing interventions promoting non-COVID-19 vaccine uptake, concluded that there is low-certainty to moderate-certainty evidence suggesting that education may improve parents' intention to vaccinate their child.<sup>42</sup> Future research should explore the effectiveness of multifaceted interventions that target

various components of the TPB simultaneously to further enhance vaccine uptake rates.

Interestingly, gain and loss-framing strategies had no or little effect on COVID-19 vaccine behaviour in the studies investigated here, contrasting evidence from a review on different vaccine types.<sup>78</sup> The effectiveness of framing communication strategies often depends on individual characteristics and environmental attributes.<sup>13</sup> These aspects should be further explored in regard to COVID-19 communication strategies.

### Strengths and limitations

The strengths of this review include our independent dual screening and study selection process, data extraction, risk-of-bias assessment and GRADE appraisal. The evaluated studies included different populations, different countries and various intervention implementation settings. The review PICO, defined at protocol stage, was based on results from a scoping review and discussions of an online workshop with German policymakers. A multidisciplinary stakeholder team of experts conducted the data synthesis and interpretation of findings, which increases credibility and trustworthiness of meaningful recommendations. Also, the GRADE assessment resulted in some high and moderate confidence in certain findings, further supporting the implementation of important results into policy and practice. Limitations of the evidence mainly arose from the interventions reviewed and the field of interest analysed. Due to the heterogeneity of the interventions, it was difficult to classify, compare and synthesise all the results. Regarding the outcome measures, it was challenging to define and report the construct of intention and confidence from the included study results, and thus, we limited the latter to perceived safety and effectiveness of the vaccine. However, this does not always fully translate into behaviour, creating an intention-behaviour gap. Also, we noted that most interventions analysed in our included studies were barely based on theory, and it was difficult to define whether the implemented strategy was solely communication based. Limitations of the review process pertain to the four categories of communication interventions that were developed as a consensus among experts in the field. We think that there is a need for an open discussion in the research community in order to develop and agree on a category system that can be used in future research. Nevertheless, the constructs from our developed categories, educational and information strategy, as well as social norm, GF and LF, were based on existing theory.<sup>20 79–81</sup> Overall, the review is not based on a theoretical model as we could not identify an existing one suiting our concept and research aim.

### Implications

The current evidence included in this review shows some impact of certain types of intervention, but overall rather

small effects could be identified. Due to the abundance of interventions, it may not be easy to make comparisons between the individual interventions. Especially with the knowledge that there are cultural differences in the effectiveness of certain messages and dedicated strategies for increasing intention to vaccinate,<sup>82</sup> the development of culturally sensitive targeted interventions seems to be warranted. It is certainly important to consider whether an intervention meets the needs of the population as reasons for vaccine hesitancy can be manifold.<sup>83</sup> Moreover, we cannot qualitatively assess here whether an intervention has been carried out well. This especially applies to population-based studies in a non-laboratory setting. Researchers should further investigate evidence or theory-based interventions on vaccination intention. It can be discussed whether the included communication interventions are effective only for the COVID-19 vaccine or can be generalised and transferred to other vaccination campaigns. Based on our stakeholder meetings, our findings will have implications for policy decision-making in future vaccination promotion, not only regarding COVID-19. Nevertheless, focusing on communication strategies alone may not be sufficient to achieve measurable effects. This is because other effective measures to increase vaccine uptake have been shown to facilitate action and minimise logistical barriers, for example, using regular reminders, prompts and incentives.<sup>84</sup> An implication for further research could be to update the search of this review to see whether there are new findings that can strengthen the certainty in the current evidence or modify the conclusion.

## CONCLUSIONS

This review has demonstrated that education and information strategies as well as SNF may increase COVID-19 vaccine uptake or intention, but most evidence shows no impact. Policymakers might use this information and rely on these findings to base policies to increase vaccination on the available evidence and on important communication concepts, such as communicating insecurities, using trustful spokespersons, applying layperson language and considering cultural sensitivity.

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and conducted the statistical analysis. CI coordinated the project and wrote the first draft of the manuscript, and NS supervised the work. All authors contributed to editing and critical revision of the manuscript; were involved in the data interpretation and the discussion; had full access to all the data in the study and had final responsibility for the decision to submit for publication. NS is responsible for the overall content and acted as the guarantor.

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**Author note** CI (lead author of this review) affirms that the manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant) have been explained.

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