Using Health Behavior Theory to Address COVID-19 Vaccine Hesitancy: A Scoping Review of Communication and Messaging Interventions

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Abstract
Vaccine hesitancy has been among the most vexing challenges during the COVID-19 pandemic, ultimately leading to maladaptive health behaviors such as vaccine delay and refusal. A variety of approaches have been employed to address this problem, including communication and messaging interventions targeting the underlying determinants of vaccine hesitancy. However, there exists no published evidence synthesis examining how such interventions are using health behavior theory to address COVID-19 vaccine hesitancy. The purpose of this study was to conduct a scoping review of health communication and messaging interventions aimed at addressing COVID-19 vaccine hesitancy, and to systematically evaluate the use of health behavior theory in the design of these interventions. The review followed a five-step iterative framework proposed by Levac and colleagues. Comprehensive searches using an exhaustive list of keyword combinations were used across three online databases to identify articles to screen for inclusion. A structured, validated coding scheme was then applied to assess the use of health behavior theory. Additional study data were extracted using a separate structured form. A total of 36 articles published between January 2020 and February 2022 met inclusion criteria and were included in the review. Ten studies (27.7%) did not mention or use health behavior theory at all. Most studies (n = 26) at least mentioned theory or theory-relevant constructs, with 26 different theories and 52 different theoretical constructs represented in the sample. Although theory and

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theoretical determinants of vaccination behavior were often mentioned, few studies used theory to specify and target causal pathways of behavior change, and only one study targeted misinformation as a determinant of vaccine hesitancy. The findings from this review provide critical insight into the state of theory-based intervention design and point to significant gaps in the literature to prioritize in future research.

Keywords
COVID, health behavior theory, vaccine hesitancy

Introduction
Vaccination is considered to be one of the top 10 public health achievements of the 20th century (Centers for Disease Control and Prevention, 1999), and widespread uptake of the COVID-19 vaccine has been identified as a key step toward ending the coronavirus pandemic. However, large gaps in COVID-19 vaccination coverage persist in the United States and globally (New York Times, 2022). While the reasons for low vaccination uptake are varied, socio-psychological factors such as vaccine hesitancy are key contributors (Aw et al., 2021; Bogart et al., 2021; Karlsson et al., 2021; Xiao & Wong, 2020).

Health communication interventions may be ideally suited to address the challenge of vaccine hesitancy, but there remain many unanswered questions about the most effective communication strategies, delivery formats, messengers, timing, and more (Dubé et al., 2015; Jarrett et al., 2015). Furthermore, a review of reviews of interventions in this area found “no strong evidence to recommend any specific intervention to address vaccine hesitancy/refusal” (Dubé et al., 2015), and a systematic review of such approaches found “limited evidence” on how to address the problem (Jarrett et al., 2015). During the coronavirus pandemic, these challenges have been further exacerbated by the existence of an infodemic, defined as “an overabundance of information—some accurate and some not—that occurs during an epidemic” (World Health Organization [WHO], 2020a; WHO, 2020b), resulting in an erosion of trust and persistent fear, anxiety, and vaccine hesitancy (Bullock et al., 2022; Loomba et al., 2021).

A promising way to address these challenges and advance cumulative knowledge is through the use of social and behavioral science theory in intervention design and research, which can guide the selection of intervention techniques, assist in identifying key determinants of behavior, and inform decisions about message tailoring, participant selection, and measurement, as well as provide a framework for synthesizing evidence. To date, however, there is a lack of research on theory-based communication interventions in this area (Dubé et al., 2015; Kenzig & Mumford, 2022). In the current study, we sought to conduct the first scoping review focused on systematically evaluating the use of theory in the design of health communication interventions promoting COVID-19 vaccination, and identifying promising directions for applying theory to create more effective future interventions.
Determinants of Vaccine Uptake and Refusal

Many social and behavioral science theories have been used to explain and predict vaccination behaviors. Some of the most widely used theories include the Theory of Planned Behavior (TPB)/Theory of Reasoned Action (Ajzen, 1999), the Health Belief Model (HBM) (Rosenstock, 1974), the Extended Parallel Process Model (Witte, 1992), Protection Motivation Theory (PMT) (Rogers, 1975), and the “3 Cs” model of vaccine hesitancy (WHO, 2014). Drawing on these theories, a variety of social and psychological constructs have been identified as key determinants of vaccine acceptance and uptake, including knowledge, attitudes, health beliefs, self-efficacy, and perceived behavioral control (Chu & Liu, 2021; Schmid et al., 2017; Xiao & Wong, 2020). In the context of COVID-19, specifically, lower levels of perceived risk and perceived severity related to the virus, as well as safety concerns about the vaccine, have been found to be associated with increased vaccine hesitancy, as have beliefs that COVID-19 is not severe or is not a real disease, or that the threat of COVID-19 has been exaggerated (Aw et al., 2021). Similarly, determinants of COVID-19 vaccine acceptance include perceived severity of COVID-19, perceived benefits of the vaccine, and cues to action, all of which have been shown to be positive correlates of vaccine acceptance, while perceived access barriers and harm were found to be negative correlates (Wong et al., 2021).

Use of Theory in Intervention Design

In the field of social and behavioral sciences, the term “theory” generally refers to “a set of interrelated concepts, definitions, and propositions that present a systematic view of events or situations by specifying relations among variables, in order to explain and predict the events or situations” (Glanz et al., 2008, p. 26). Evidence suggests that theory-based interventions, or those that target theoretical mechanisms of behavior change, are more likely to be effective than non-theory-based interventions (Michie et al., 2008; Noar & Zimmerman, 2005). This has been found across a variety of health conditions and behaviors, including physical activity (Taylor et al., 2012), nutrition habits (Lara et al., 2014), and cancer (Albada et al., 2009), as well as Internet-based health behavior interventions (Webb et al., 2010). However, a significant proportion of published interventions still make no reference to a theoretical basis (Albarracín et al., 2005; Davies et al., 2010; Hardeman, et al., 2002; Painter et al., 2008). Furthermore, even when theory is applied, it is rarely used to its full potential, and significant discrepancies exist between reported theory-use and actual application of theory (Dombrowski et al., 2007; Gardner et al., 2010; Orr, 2020; Painter et al., 2008). For example, in a meta-analysis of prenatal behavior change interventions, Orr (2020) found that theory-use was almost exclusively limited to descriptive purposes (as opposed to explanatory or predictive). Similarly, Dombrowski et al. (2007) found that although 44% of the trials in their review reported a theoretical basis for intervention development, none of the studies actually explained how theory was used to
develop the intervention. Furthermore, studies ostensibly drawing on the same theory may leverage different constructs and concepts from the theory, or interpret them in different and sometimes contradictory ways.

To our knowledge, there exist no systematic evaluations of theory-use in the design of health communication interventions aimed at promoting the COVID-19 vaccine. Thus, the objective of this study was to conduct a scoping review of the literature in this area, with a focus on assessing how social and behavioral science theories are being used to inform intervention design. We were particularly interested in how health communication interventions are addressing misinformation as an important determinant of vaccination behavior, given its key role as a driver of vaccine hesitancy during the COVID-19 pandemic.

**Methods**

The review followed a five-step iterative framework proposed by Levac et al. (2010): (1) identification of the research questions; (2) literature search and identification of relevant articles; (3) selection of studies for inclusion; (4) charting the data (including application of Theory Coding Scheme [TCS]); and (5) collating, summarizing, and reporting the results.

The objectives of the review included the following:

1. To systematically evaluate the use of theory in the design and evaluation of health communication interventions aimed at promoting COVID-19 vaccination intentions and/or behaviors. Specific research questions included:
   a. How is theory being used? Is it being used optimally?
   b. What are the most frequently used theories and theoretical constructs/predictors?
   c. How is theory being used to address vaccine-related misinformation and its effects, such as vaccine hesitancy?
2. To identify promising theoretical models and frameworks, as well as discrepancies and/or inconsistent findings, limitations, gaps in the literature, and questions for future research.
   a. Is use of theory associated with intervention success?
   b. What are the most consistent findings and/or promising uses of theory?
   c. Are descriptions of theories and theoretical constructs/predictors consistent? Is there consensus on conceptual definitions and measurement?
   d. What gaps in application of theory suggest potential new research directions?

**Search Strategy**

A literature search was conducted to identify published studies evaluating health communication interventions aimed at increasing COVID-19 vaccination intentions and/or behaviors. The pandemic provided a fixed timeframe for our literature search,
which was limited to studies published since the start of the global pandemic in January 2020 until February 2022. To identify articles, an exhaustive list of keyword pairings (available in Appendix 2) were used across three online databases (PubMed, Google Scholar, and ScienceDirect). MESH terms were utilized for the searches.

**Study Eligibility**

Screening Process: To screen articles for eligibility, we used three levels of review: Level one screening reviewed the titles and dates of all search results. Level two screening reviewed the abstracts of all articles that the search terms returned. Level three screening reviewed the full text of articles to determine their eligibility. After selecting eligible articles, we reviewed the full articles’ reference lists and identified additional articles for possible inclusion.

Inclusion/Exclusion Criteria: To be included in the review, articles must have reported the results of experimental research focused on using health communication strategies to increase COVID-19 vaccine intentions and/or behavior. We included both intentions and behaviors as outcomes because the COVID-19 vaccine is still relatively new, and much of the published research was carried out before the first vaccines were administered. Articles must have been published in English between January 2020 and February 2022. We did not place any geographic limits on the location where the research was conducted or published. Peer-reviewed full-text articles, dissertations, masters theses, scientific reports, and working papers were all considered for inclusion.

**Data Extraction and Synthesis**

A structured data extraction form was used to manually collate data from the included studies. The extracted data included: article type, publication date, study aims, study design and methods, location of study, sample size and participant characteristics, primary and secondary outcomes, mediators/moderators, and key findings. Additional data were extracted during the process of coding for use of theory (described below). Characteristics of studies were summarized individually in tables and described collectively in narrative form. Results from the TCS were analyzed in the same way.

**Data Analysis**

The TCS (Michie & Prestwich, 2010) was used to code for reported theory-use in the design of message-testing experiments and related communication-focused interventions. Items on the TCS are coded categorically (Yes/No/Don’t Know) and demonstrated substantial agreement during initial development and validation (kappa > 0.70 for 18/19 items; kappa = 0.64 for item 19d) (Michie & Prestwich, 2010). Full TCS scoring instructions, as well as information on how it was adapted for use in this review, are included in Appendix 1.
Coding

To establish interrater reliability, two trained coders independently applied the TCS to a set of articles that were not part of the final sample for this review, but which described health communication/messaging interventions targeting flu and/or HPV vaccination intentions. Cohen’s kappa (k) coefficient was used to assess agreement between coders (Cohen, 1960). Once interrater reliability was achieved on this set of non-included articles (k = 0.66), the two coders then independently coded approximately 10% of the articles included in the review to ensure interrater reliability within this sample (k = 0.72). Disagreements between coders were resolved through discussion and further examination of the studies and item content. The remaining articles were each coded by a single coder.

Scoring

Items on the TCS can be treated individually as well as grouped together to form composite measures reflecting the extent and function of their use. In this analysis, items were analyzed individually and, in some cases, composite measures were created to reflect specific uses of theory. Six composite measures were created based on the scoring criteria developed by Prestwich et al. (2014). The measures reflect the following:

1) “Mention of Theory” was calculated on a scale of 0–4 by summing the scores of four items assessing whether theory and/or theoretical predictors were explicitly mentioned.
2) “Intervention Techniques Linked to Theoretical Constructs” was calculated on a scale of 0–3 by summing the scores of five items assessing whether intervention techniques were linked to relevant theoretical constructs and/or predictors.
3) “Tailored Intervention Techniques” was calculated on a scale of 0–2 by summing the scores of two items assessing whether theory was used to select participants and/or tailor intervention techniques to specific participant characteristics.
4) “Theoretical Constructs Measured” was calculated as the score of a single 1-point item assessing whether the targeted theoretical constructs were measured pre-/post-intervention or post-intervention.
5) “Tested or Refined Theory” was calculated on a scale of 0–4 by summing the scores of four items assessing the extent and nature of theory testing and refinement based on the results.
6) “Overall Use of Theory” was calculated on a scale of 0–14 by summing the totals of the composite measures.

Results

Search Results

A total of 8,293 articles were initially identified across the three database searches. After removing duplicates, 3,191 titles and abstracts were screened, with 205 full-text
articles proceeding to further review. From those 205 articles, a total of 31 were retained for inclusion in the review. Articles were excluded if they did not report an outcome of COVID-19 vaccine intentions or behavior, if they were not experimental in design, if they did not report the results of a health communication intervention, if they were published in a language other than English, or if they were published prior to 2020 or after February 2022. After examining the reference lists of these 31 articles, an additional five articles were determined to be eligible for the review. A total of 36 studies were retained for inclusion in the review based on the criteria described above, including 32 peer-reviewed journal articles, two theses or dissertations, and two working papers or reports. Half of these studies \((n = 18)\) were conducted in the United States and/or online with an American audience. The remainder were conducted in China \((n = 5)\), the UK \((n = 4)\), Nigeria \((n = 1)\), Japan \((n = 1)\), Germany \((n = 1)\), Italy \((n = 1)\), France \((n = 1)\), Switzerland and Sweden \((n = 1)\), Saudi Arabia \((n = 1)\), and Latin America (Argentina, Brazil, Chile, Colombia, México, and Peru) \((n = 1)\). Of these studies, 34 measured COVID-19 vaccine intentions as the primary outcome, one measured intentions and behavior (vaccination), and one measured behavior only (scheduling a vaccine appointment). Nearly all \((n = 34)\) were delivered in an online setting.

**RQ1: How is Theory Being Used? Is it Being Used Optimally?**

Total scores on the 14-point TCS ranged from 0 to 10 \((M = 3.81, SD = 3.30)\), as seen in Figure 1. Ten articles were given a score of zero, while just one achieved a score of 10. Scores on the first subscale (“Was theory mentioned?”) ranged from 0 to 4 \((M = 1.72,
SD = 1.39). Only three studies (8.3%) had a score of 4.0, while 10 articles (27.7%) scored a zero on this subscale, indicating that the studies did not explicitly mention theory or theoretical determinants of vaccination behavior. Scores on the second subscale (“Were relevant theoretical constructs targeted?”) ranged from 0 to 3 (M = 1.39, SD = 1.32), with 15 studies (69.4%) scoring a zero and 8 studies (22.2%) achieving a score of 3.0. None of the studies in the review used any theories in their entirety (by targeting all of the constructs within a specified theory). On the third subscale (“Was theory used to select participants or tailor interventions?”), all studies in the review were given a score of zero, indicating that they did not use theory or theoretical predictors to select participants or to tailor the treatment/experimental content. On the fourth subscale (“Were theory-relevant constructs/predictors measured?”), 15 studies (69.4%) scored a 1.0, indicating that they measured at least one theory-relevant construct or predictor post-intervention or pre- and post-intervention, while 23 studies (63.9%) scored a zero. Scores on the fifth subscale (“Is theory tested or refined?”) ranged from 0 to 3 (M = 0.63, SD = 0.91). More than half of the articles in the review (n = 21; 58.3%) scored a zero on this 4-point subscale, indicating that the studies did not use evidence to support or refute theorized pathways of change and/or relationships between theoretical constructs, and did not conduct mediational analyses of constructs or predictors. Related, explanations for intervention outcomes were usually not situated in the context of theory. Only one study (Borah et al., 2021) made an effort to refine theory by discussing the results in terms of the theoretical basis of the intervention.

In all, 25 studies (69.4%) mentioned a theory or model of behavior in the introduction or methods section, even if the intervention was not guided by it. Most of these studies (n = 21; 58.3%) targeted at least one theory-relevant construct or predictor, and provided evidence from the literature of its relationship with behavior. Only four of these studies (11.1%) were guided by a single theory, while the remainder drew on multiple theories or a combination of theoretical constructs and predictors from multiple theories and/or that were both linked to theory and not linked to theory (Borah, 2022; Borah et al., 2021; Chen et al., 2022; Gong et al., 2021). Nine of the studies in the review were at least partially “theory based.” Theory-based interventions are distinguished from “theory-guided,” “theory-influenced,” or “theory-inspired” interventions by their specification of an explicit causal pathway(s) underlying behavior change (Michie & Abraham, 2004; Michie et al., 2008).

**RQ2: What Are the Most Promising Theories and Frameworks? Is Use of Theory Associated with Intervention Success?**

Previous evidence suggests that behavior change interventions based on a single theory may be more effective than those based on multiple theories or a combination of theory and predictors (Prestwich et al., 2014), but we did not find that to be the case in our review. Of the four studies guided by a single theory—all of which tested the effects of gain versus loss framing—only one study reported that the message condition had a significant effect on intentions to vaccinate (Gong et al., 2021). Conversely,
of the 17 studies that drew on multiple theories or combinations of theories and predictors, nine reported significant results for intentions. More broadly, the relationship between theory-use and intervention success was unclear, in large part due to substantial variation in methodology and reporting practices, which made it difficult to compare across all studies and outcomes.

**RQ3: What Are the Most Frequently Used Theories and Theoretical Constructs/Predictors?**

A total of 26 different theories were represented in the sample, as seen in Table 1. Only six of these theories were mentioned in more than one article: Prospect Theory (*n* = 9), TPB (*n* = 4), HBM (*n* = 3), Framing Theory/Framing Effects Theory (*n* = 3), Behavioral Economics (*n* = 2), and PMT (*n* = 2). As seen in Table 2, the most common theoretical constructs used to guide intervention design were self-efficacy/efficacy beliefs (*n* = 5), attitudes (*n* = 5), and risk perceptions (*n* = 5). These theories have in common a focus on psychological phenomena relevant to health attitudes and behavior, including decision-making under uncertainty, risk assessment, and assessment of likely outcomes of potential choices.

Among the articles we examined, theory was used primarily to guide the design of COVID-19 messaging strategies, either by informing the framing of the message(s) such as in the case of gain/loss framing or by guiding the selection of the content or target of the message such as in the case of promoting pro-vaccine social norms or reducing uncertainty. In most instances, however, the theoretical construct(s) targeted by intervention content were not measured separately from outcomes, so it was not possible to determine whether the intervention led to changes in those constructs, nor whether those constructs were associated with vaccine intentions or behavior. For example, Sinclair and Agerström (2021) designed messages to reduce vaccine hesitancy and strengthen COVID-19 vaccine intentions by communicating strong (vs. weak) descriptive norms (information about what most other people are doing) and manipulating the reference group. These messages did not result in increased vaccine

| Uses of theory in intervention design | Yes, n (%) | No, n (%) |
|--------------------------------------|------------|-----------|
| Did the study mention theory or theoretical determinants of vaccination behavior? | 25 (69.5%) | 11 (30.5%) |
| Did the intervention target at least one theoretical determinant of vaccination behavior? | 21 (58.3%) | 15 (41.6%) |
| Did the study use theory to select participants or tailor intervention techniques to participants? | 0 (0%) | 36 (100%) |
| Did the study measure at least one theoretical determinant of vaccination behavior? | 15 (41.6%) | 21 (58.3%) |
| Did the study test or refine theory? | 1 (2.8%) | 35 (97.2%) |
Table 2. Social and Behavioral Science Theories Used as Conceptual Frameworks and/or to Guide Intervention Design.

| Theories                                      | Citations                                                                 | n  |
|-----------------------------------------------|----------------------------------------------------------------------------|----|
| Prospect theory                               | Borah (2022)                                                               | 9  |
|                                               | Borah et al. (2021)                                                        |    |
|                                               | Baumgartner (2020)                                                         |    |
|                                               | Chen et al. (2022)                                                         |    |
|                                               | Hong and Hashimoto (2021)                                                  |    |
|                                               | Huang and Liu (2021)                                                       |    |
|                                               | Motta et al. (2021)                                                        |    |
|                                               | Reinhardt and Rossmann (2021)                                              |    |
|                                               | Sasaki et al. (2022)                                                       |    |
| TPB                                           | Baumgartner (2020)                                                         | 4  |
|                                               | Capasso et al. (2021)                                                      |    |
|                                               | Reinhardt and Rossmann (2021)                                              |    |
|                                               | Ugwuoke et al. (2021)                                                      |    |
| Framing theory/framing effect theory          | Abdel-Raheem and Alkhammash (2021)                                        | 4  |
|                                               | Gong et al. (2021)                                                         |    |
|                                               | Gursoy et al. (2022)                                                       |    |
|                                               | Ye et al. (2021)                                                           |    |
| HBM                                           | Giampaolo (2021)                                                           | 3  |
|                                               | Kerr et al. (2021)                                                         |    |
|                                               | Ye et al. (2021)                                                           |    |
| PMT                                           | Gursoy et al. (2022)                                                       | 2  |
|                                               | Yang (2022)                                                                |    |
| Behavioral economics                         | Sasaki et al. (2022)                                                       | 2  |
|                                               | Strickland (2022)                                                          |    |
| Exemplification theory                        | Ye et al. (2021)                                                           | 1  |
| Elaboration likelihood model                  | Ye et al. (2021)                                                           | 1  |
| Cultural cognition theory                     | Yuan and Chu (2022)                                                        | 1  |
| Social cognitive theory                       | Ugwuoke et al. (2021)                                                      | 1  |
| Social identity theory                        | Sinclair (2021)                                                            | 1  |
| Competence hypothesis for dealing with ambiguity | Simonovic and Taber (2022)                                               | 1  |
| Socioemotional selectivity theory             | Reinhardt and Rossmann (2021)                                             | 1  |
| Terror management theory                      | Motta et al. (2021)                                                        | 1  |
| Collective action theory                      | James et al. (2021)                                                        | 1  |
| Theories of cooperation and prosocial behavior | James et al. (2021)                                                       | 1  |
| Prevention-detection framework                | Hong and Hashimoto (2021)                                                 | 1  |
| Micro–macro framework                         | Giampaolo (2021)                                                           | 1  |
| 3C’s model of vaccine hesitancy               | Giampaolo (2021)                                                           | 1  |
| 5C’s model                                    | Giampaolo (2021)                                                           | 1  |
| Trust and confidence model                    | Giampaolo (2021)                                                           | 1  |
| Construal-level theory                        | Huang and Liu (2021)                                                       | 1  |
| Secondary risk theory                         | Gursoy et al. (2022)                                                       | 1  |
| Uncertainty management theory                  | Huang and Liu (2021)                                                       | 1  |
| Extended parallel processing model            | Yang (2022)                                                                | 1  |
| Affect as information theory                   | Yang (2022)                                                                | 1  |
Table 3. Constructs, Predictors, and Mechanisms of Action From Social and Behavioral Science Theories Used by Studies in the Review.

| Theoretical constructs                                      | Study authors                                      | n  |
|------------------------------------------------------------|----------------------------------------------------|----|
| Perceived efficacy                                         | Baumgartner (2020)                                 | 5  |
|                                                            | Ye et al. (2021)                                   |    |
|                                                            | Palm (2021)                                        |    |
| Perceived effectiveness                                    | Peng et al. (2021)                                 |    |
| Efficacy beliefs                                            | Kerr et al. (2021)                                 |    |
| Risk perceptions (severity and susceptibility)              | Gursoy et al. (2022)                               | 5  |
|                                                            | Simonovic and Taber (2022)                         |    |
|                                                            | Yang (2022)                                        |    |
|                                                            | Ye et al. (2021)                                   |    |
| Perceived susceptibility (but labeled “perceived risk”)    | Hong and Hashimoto (2021)                         |    |
| Attitudes (about COVID vaccination)                        | Altay et al. (2021)                               | 5  |
|                                                            | Borah et al. (2021)                                |    |
|                                                            | Chen et al. (2022)                                 |    |
|                                                            | Hong and Hashimoto (2021)                         |    |
|                                                            | Reinhardt and Rossmann (2021)                      |    |
| Emotional induction                                        | Yang (2022)                                        | 2  |
| Emotion invocation (embarrassment, guilt, anger)           | James et al. (2021)                               |    |
| Perceived benefits                                         | Borah et al. (2021)                                | 2  |
|                                                            | Ye et al. (2021)                                   |    |
| Social norms                                               | Palm (2021)                                        | 2  |
|                                                            | Sinclair (2021)                                    |    |
| Self-efficacy                                              | Simonovic and Taber (2022)                         | 2  |
|                                                            | Ugwuoke et al. (2021)                              |    |
| Issue involvement                                          | Baumgartner (2020)                                 | 2  |
|                                                            | Reinhardt and Rossmann (2021)                      |    |
| Vaccine hesitancy                                          | Freeman et al. (2021)                              | 2  |
|                                                            | Giampaolo (2021)                                   |    |
| Perceived safety of COVID vaccine                          | Baumgartner (2020)                                 | 2  |
|                                                            | Palm (2021)                                        |    |
| Perceived costs (barriers)                                 | Ye et al. (2021)                                   | 1  |
| Cultural cognition constructs (hierarchy-egalitarianism    | Yuan and Chu (2022)                                | 1  |
| and individualism-communitarianism)                        |                                                    |    |
| Individualism-collectivism                                 | Borah (2022)                                       | 1  |
| Task efficacy                                              | Ugwuoke et al. (2021)                              | 1  |
| Outcome expectancies                                       | Ugwuoke et al. (2021)                              | 1  |
| Outcome certainty/uncertainty                              | Chen et al. (2022)                                 | 1  |
| Anticipated positive affective reactions to COVID-19        | Capasso et al. (2021)                              | 1  |
| vaccination                                                |                                                    |    |
| Anticipated negative affective reactions to COVID-19       | Capasso et al. (2021)                              | 1  |
| vaccination                                                |                                                    |    |
| Health cognitions                                         | Simonovic and Taber (2022)                         | 1  |
| Ambiguity tolerance                                        | Simonovic and Taber (2022)                         | 1  |
| Dispositional optimism                                     | Simonovic and Taber (2022)                         | 1  |
| Cognitive attitudes toward vaccinating against COVID-19    | Capasso et al. (2021)                              | 1  |

(continued)
intelligences compared to standard information, and manipulating the reference group did not produce any significant changes. However, since the study did not measure perceived norms, it is not possible to say whether the lack of significant results reflects a lack of relationship between perceived norms and COVID-19 vaccine intentions, or whether these messages in particular did not influence perceived norms. Similarly, Argote et al. (2021) provided information about vaccine efficacy and social approval but did not measure corresponding constructs such as outcome expectancies, perceived benefits, efficacy beliefs, or perceived norms.

### Table 3. (Continued).

| Theoretical constructs                                                                 | Study authors                        | n   |
|---------------------------------------------------------------------------------------|--------------------------------------|-----|
| Attitudes (about vaccines in general)                                                | Reinhardt and Rossmann (2021)        | I   |
| Psychological reactance                                                                | Reinhardt and Rossmann (2021)        | I   |
| Recognition accuracy                                                                  | Reinhardt and Rossmann (2021)        | I   |
| Individual awareness (“people’s understanding of COVID-19 and their awareness of observing the government’s epidemic prevention and control measures”) | Peng et al. (2021)                   | I   |
| Social relationship factors (norms, support; % of family and friends who are vaccinated) | Peng et al. (2021)                   | I   |
| Worry (about vaccine side effects)                                                    | Li et al. (2022)                     | I   |
| Concern over side effects (vaccine beliefs, perceived risk)                          | Kerr et al. (2021)                   | I   |
| Concern over safety/ regulatory timeline (vaccine beliefs, perceived risk)           | Kerr et al. (2021)                   | I   |
| Decisional conflict                                                                   | Kerr et al. (2021)                   | I   |
| Vaccine hesitancy (COVID vaccine attitudes)                                           | Kerr et al. (2021)                   | I   |
| Personal health risk (of not vaccinating)                                             | Motta et al. (2021)                  | I   |
| Community health risk (from not vaccinating)                                         | Motta et al. (2021)                  | I   |
| Self-interest                                                                         | James et al. (2021)                  | I   |
| Altruism                                                                              | Gong et al. (2021)                   | I   |
| Personal benefits of getting vaccinated                                               | Freeman et al. (2021)                | I   |
| Community interest                                                                    | James et al. (2021)                  | I   |
| Collective benefits of vaccination                                                    | Freeman et al. (2021)                | I   |
| Cognitive elaboration                                                                 | Hong and Hashimoto (2021)            | I   |
| Numeracy skills                                                                       | Chen et al. (2022)                   | I   |
| Psychological ownership                                                                | Dai et al. (2021)                    | I   |
| COVID-19 vaccine confidence and complacency beliefs (measures collective importance, efficacy, side effects, and speed of development) | Freeman et al. (2021)                | I   |
| Institutional and medical trust                                                        | Giampaolo (2021)                     | I   |
| Psychological uncertainty                                                               | Huang and Liu (2021)                 | I   |
| Behavioral beliefs                                                                    | Huang and Liu (2021)                 | I   |
| Perceived threat (to freedom)                                                         | Huang and Liu (2021)                 | I   |
| Personal freedom                                                                       | James et al. (2021)                  | I   |
RQ4: What Are the Most Consistent Findings and/or Promising Uses of Theory?

The most consistent finding reported across studies was that loss framing (sometimes described as “negative” or “consequences” framing) outperformed gain framing (sometimes described as “positive” or “benefits”), and that the effects of message framing were often moderated by health beliefs. In total, 12 studies performed some type of gain versus loss message testing. Nine of these studies presented evidence that loss framing outperformed gain framing in terms of its impact on intentions to vaccinate. However, the effects of loss framing varied according to factors such as age and health beliefs. Regarding age, Reinhardt and Rossmann (2021) reported that loss framing led to stronger intentions to vaccinate, but only among younger participants. Regarding health beliefs, Ye et al. (2021) found that the effects of loss framing were moderated by perceived severity of COVID-19, perceived benefits of vaccination, and perceived costs of not vaccinating. In addition, Hong et al. (2021) reported that loss framing led to stronger vaccination intentions, but only for those with low perceived risk of COVID-19, while Gursoy et al. (2022) found that perceived vaccination risk fully mediated the effect of gain/loss framing on changes in intentions. In addition, Borah et al. (2021) found that the effects of loss framing were only present for those with higher perceived benefits, while Ye et al. (2021) found that perceived benefits mediated the effects of narrative framing on vaccination intentions. Beyond the implications for message framing, these results also provide support for the explanatory power of HBM constructs, which functioned as mediators in six studies. Also of note, Abdel-Raheem and Alkhammash (2021) reported that framing effects may vary depending on the type of media in which the vaccine-related message is embedded. Specifically, participants were susceptible to framing effects when they read news articles containing vaccine-related messaging, but not when the messaging was embedded within a cartoon.

RQ5: How is Theory Being Used to Address Vaccine-Related Misinformation and its Effects, such as Vaccine Hesitancy?

Very few studies made explicit reference to misinformation or offered strategies to address its effects. An exception was Motta et al.’s (2021) study, which examined the impact of including “prebunking” information as part of a pro-vaccine message. However, the inclusion of such information did not have a significant impact on vaccine intentions. In Chang et al.’s (2021) study of behavioral nudges, one of the message frames was designed to counter misinformation related to vaccination among children, though belief in/exposure to misinformation was not measured. Finally, Huang and Liu (2021) referenced misinformation as a rationale for their study design and objectives, stating that their aim was to help health agencies communicate more effectively on social media by breaking through the noise of misinformation and uncertainty. However, the study did not include any messaging or techniques specifically designed to address or counter misinformation, nor were any misinformation-related variables measured.
However, while the connection was not made explicit, many of the mediators of loss framing described above reflect common themes in COVID misinformation. For example, perceived risk of vaccine side effects seems to reflect the frequency of messaging that exaggerates the commonality and severity of those effects (Nguyen & Catalan, 2020).

RQ6: Are Descriptions of Theories and Theoretical Constructs/Predictors Consistent? Is There Consensus on Conceptual Definitions and Measurement?

Inconsistent terminology and lack of consensus on defining and measuring theory-related concepts were significant challenges that made it difficult to compare and synthesize results. In several instances, studies used different terminology to describe conceptually similar phenomena. For example, Chang et al. (2021) designed messages emphasizing either vaccine safety or the consequences of not vaccinating, labeling these groups “Vaccine Safety” and “Health Consequences.” Conceptually, these are quite similar to loss/gain frames, but the study made no mention of Prospect Theory or loss/gain framing, so it was not coded as such. At other times, theory-relevant constructs appeared to be present but were not labeled as such and were not referenced in the context of theory, so they were not coded as a theoretical construct or predictor. For example, Peng et al. (2021) found that participants in the gain frame condition whose family members and/or friends were vaccinated reported significantly greater intentions to get vaccinated than those who did not have friends or family who were vaccinated. This is a descriptive norm, but it was not labeled or measured as such, so it was not coded as a theoretical construct or predictor.

This seems to reflect the degree to which theoretical concepts in the social sciences often come into common understanding and use within the field, without retaining a consistent connection to the original theory. Many theory-relevant studies miss opportunities both to strengthen intervention design via more systematic reference to a full portfolio of interrelated theoretical constructs and to actively test and refine theories that could benefit the field as a whole.

RQ7: What Gaps in Application of Theory Suggest Potential New Research Directions?

Given the unprecedented and ongoing role of misinformation in promoting vaccine hesitancy, it is surprising that more studies did not explicitly target misinformation and/or its effects in the process of intervention design. One promising avenue for future research is to use theory to explore the pathways and mechanisms of action through which misinformation influences health behavior, and then use the findings to identify promising targets for public health messaging. Future research could also explore how theories such as the HBM could be applied to increase public understanding of, and resilience to, susceptibility to misinformation. This could be done as part of a broader effort to encourage people to think more critically about the relationships between misinformation and health, as proposed by Houlden et al. (2021). Furthermore,
future research should seek to operationalize and measure misinformation as the multidi
tidimensional construct it is, capturing dynamics such as exposure to, engagement with, and belief in various forms of misinformation.

It is also surprising that we did not find any health communication interventions specifically targeting COVID-19 vaccination intentions and behaviors among preg
nant persons. Research suggests that pregnant persons have significant concerns about the safety of the COVID-19 vaccine and, as a result, are less likely to get vaccinated (Geoghegan et al., 2021; Levy et al., 2021; Razzaghi et al., 2021). In addition, pregnant persons may be particularly susceptible to misinformation about the COVID-19 vaccine (Sajjadi et al., 2021). As such, there is a pressing need for research aimed at developing effective communication techniques to promote vaccination during preg
nancy. Theoretical frameworks such as Self-Determination Theory and Health Self-Empowerment Theory may be particularly suitable for use in designing messaging targeted toward pregnant persons (Olander et al., 2018; Rockliffe et al., 2021). Relatedly, none of the studies in the review used theory to tailor messages or select participants, suggesting a possible unmet need for communication and messaging campaigns aimed at specific subgroups of the population, such as those who may be particularly susceptible to misinformation and/or who may respond to specific mes
sage content, messengers, and/or channels.

In addition, most studies in the review targeted individual-level determinants of behavior and were unimodal in nature. Given the complexity of vaccination and the influence of organizational, cultural, and societal factors as determinants of vaccine hesitancy and acceptance, individual-level interventions may be limited in their impact. In future studies, theories such as the Social Ecological Model could be used to identify intervention targets beyond the individual to situate health communication campaigns within a broader, community-based approach to vaccine promotion.

Finally, there is a pressing need for more rigorous application of behavior change theory in intervention design and evaluation, including measuring key constructs and testing and/or refining theory. Without this kind of measurement of mediating causal relationships, all we can say about an intervention is whether or not it worked, but not why or how. Improving and standardizing measurement would also facilitate the synthesis and accumulation of evidence in reviews and meta-analyses.

Discussion

The purpose of this review was to evaluate the use of theory in the design of health communication interventions aimed at promoting COVID-19 vaccination. Overall, we found that most studies mentioned theory and targeted at least one theoretical construct or predictor of behavior, but few used theory optimally, none used a theoretical framework in its entirety, none used theory to select participants or tailor message content, and only one made an effort to refine theory. However, nine studies specified one or more pathways through which change was hypothesized to take place, making them at least partially theory based. Finally, only three studies mentioned misinformation, of which only two included intervention content addressing some aspect of misinformation, and only one measured the impact of this intervention content.
Several notable findings emerged from the literature regarding specific uses of theory and theory-relevant constructs and predictors. Prospect Theory was found to be the most widely used theoretical framework, and loss framing consistently outperformed gain-framing in terms of its impact on COVID-19 vaccination intentions. However, these effects were moderated and/or mediated by a variety of demographic and sociopsychological variables, including perceived risk, perceived benefits, attitudes, and age. Evidence from mediation and moderation tests supported the explanatory power of constructs from the HBM, particularly perceived benefits and perceived risk.

We were unable to clearly assess whether use of theory was associated with the success of the interventions, in large part because variation in methodology and outcomes made it difficult to make comparisons of this nature. In addition, some of the models and theories used by studies in the review were not change theories and thus did not specify mechanisms of action or causal pathways through which behavior change is hypothesized to take place.

The results of this review should be interpreted with several limitations in mind. First, in line with the purpose of a scoping review, we did not conduct a quality assessment of the studies. There is significant variation in the methodological rigor of the included studies, which may impact the reliability and validity of the underlying findings. Second, since we used broad inclusion criteria to get a comprehensive view of the literature, there is also significant variation in intervention content and design which limited our ability to make direct comparisons between the studies. Third, 34 of the 36 studies in this review measured vaccine intentions, rather than vaccination. While intentions have been shown to be among the strongest predictors of behavior (Sheeran, 2002), it cannot be assumed that strong intentions will necessarily lead to behavior, particularly with a novel vaccine. Importantly, the one study in our review that measured both intentions and behavior reported that intentions were not strongly associated with vaccination (Chang et al., 2021). As more studies are released which post-date the launch of COVID-19 vaccination campaigns, rather than anticipating them, more evidence on this key relationship will hopefully become available.

To our knowledge, this review provides the first systematic evaluation of the use of theory in health communication interventions aimed at promoting COVID-19 vaccination. The findings from this review provide critical insight into the state of theory-based intervention design and point to significant gaps in the literature to prioritize in future research. We hope this study will serve as a solid foundation to build from as the field of health communication faces the dual challenges of mitigating an infodemic and ending the largest pandemic of our lifetime.

Appendix 1: TCS Scoring Instructions (Adapted From Michie and Prestwich (2010))

Items on the TCS can be treated individually as well as grouped together to form composite measures reflecting the extent and function of their use. In this analysis, items were analyzed individually and, in some cases, composite measures were created to
reflect specific uses of theory. Six composite measures were created based on the scoring criteria developed by Prestwich et al. (2014). The measures reflect the following:

1) Was theory mentioned?
Four items on the TCS reflect whether theory and/or theoretical predictors of behavior were explicitly mentioned. Item 1 assessed whether the study mentioned a theory, even if theory was not used to inform the intervention. Item 2 assessed whether theoretical predictors of vaccination behavior were explicitly mentioned (and also targeted). Item 3 assessed whether the intervention was based on a single theory (rather than multiple theories or a combination of theoretical predictors). Item 16 assessed whether the results were discussed in relation to theory. A total score was calculated by summing the scores of these four items, where “yes” = 1 and “no” = 0. Thus, total scores for this category ranged from 0 (no mention of theory or theoretical predictors) to 4 (optimal use of theory).

2) Were relevant theoretical constructs targeted?
Five items on the TCS reflect whether relevant theoretical constructs were targeted in the intervention. Item 5 assessed whether intervention techniques were based on a theory, theoretical predictor, or combination of theories and/or predictors. Items 7–10 examined the extent to which the intervention targeted specific theory-relevant constructs. Items 7 and 9 reflect optimal use of theory, indicating that all intervention techniques are linked to a theory-relevant predictor (item 7) and all theory-relevant predictors mentioned in the article text are associated with a specific intervention technique (item 9). Items 8 and 10 reflect less optimal use of theory, indicating an indirect link between intervention techniques and theoretical constructs/predicators (and vice versa). A total score was calculated by summing the scores on item 5 (“yes” = 1; “no” = 0), items 7 and 9, and items 10 and 11. Studies coded “yes” on items 5, 7, and 9 were given a score of 1. Studies coded “yes” on items 8 and 10 were given a score of 0.5. Thus, total scores for this subscale ranged from 0 (no theory-use) to 3 (optimal use of theory).

3) Was theory used to select participants or tailor interventions?
Two items assessed the use of theory to select participants and/or tailor intervention techniques for individual participants. Item 4 assessed whether theory was used to select participants based on their scores or levels on a particular theoretical construct or predictor. Item 6 assessed whether theory was used to tailor the intervention to the needs of individual participants. A total score was calculated by summing the scores on items 4 and 6, where “yes” = 1 and “no” = 0. Thus, total scores ranged from 0 (no use of theory) to 2 (optimal use of theory).

4) Were relevant theoretical constructs measured?
One item (11) assessed whether the targeted theoretical constructs were measured. If at least one of the targeted constructs/predictors was measured pre/
post intervention or post-intervention, the item was coded as “yes.” If the construct/predictor was not measured or if it was only measured pre-intervention, the item was coded as “no.” Thus, total scores for this measure ranged from 0 (no theoretical constructs were measured) to 1 (at least one theoretical construct was measured pre–post or post-intervention).

5) Is theory tested or refined?

Four items on the TCS reflect the extent and nature of theory testing. Item 14 assessed whether the intervention led to significant changes in at least one targeted theoretical construct, and items 15, 17, and 18 assessed whether these changes explained the intervention effect. Item 15 assessed whether the study provided evidence that changes in the theoretical construct led to changes in behavior through mediational analysis. Item 17 assessed whether the results provide appropriate evidence to support or refute the theory. Item 18 assessed whether the results were used to refine theory by either adding or removing constructs, or specifying changes that should be made to the interrelationships between theoretical constructs. A total score was calculated by summing the scores of items 14, 15, 17, and 18, where “yes” = 1 and “no” = 0. Thus, total scores ranged from 0 (no theory testing or refinement) to 4 (optimal theory testing and refinement).

6) Overall use of theory.

A total theory score was calculated by summing the totals of the composite measures, where a score of zero reflected minimum (inadequate) use of theory, and a score of 14 reflected maximum (optimal) use of theory.

TCS Modifications

We made several specifications and minor adaptations to the TCS to modify it for the purposes of this review. First, we agreed to use definitions of “intervention” and “intervention techniques” that focused on communication strategies and message testing. Second, for items that assessed “all theory-relevant constructs or predictors,” such as Item 9 (“All theory-relevant constructs/predictors are explicitly linked to at least one intervention technique”), we interpreted this to mean “all theory-relevant constructs or predictors that were explicitly mentioned in the article,” rather than all possible constructs associated with a given theory. A third modification was made to eliminate one item that assesses whether groups of intervention techniques are linked to groups of theoretical constructs/predictors. Given the nature of the articles in our review, we were unlikely to have studies with multiple intervention techniques, and thus the item was not applicable to our sample. Furthermore, the items assessing “at least one” and “all” intervention techniques were deemed to be sufficient without an additional category. A final modification was made for ease of scoring, and involved assigning a score of “0.5” to two items reflecting less optimal theory-use. The original rubric calls for scoring those items as “1” and increasing the score of another set of items to “2,” but we chose to keep the scale consistent so that a score of “1” indicated optimal theory-use across all items.
Appendix 2

Keywords for Literature Search.

| Communication/messaging search terms | Vaccine search terms |
|--------------------------------------|----------------------|
| Messaging intervention               | COVID vaccine        |
| Messaging campaign                   | COVID vaccination    |
| Mass media intervention              | Coronavirus vaccine  |
| Mass media campaign                  | Coronavirus vaccination |
| Social media intervention             | Pfizer vaccine       |
| Social media campaign                 | Moderna vaccine      |
| Social media messaging                | AstraZeneca vaccine  |
| Mobile technology intervention       |                      |
| Mobile technology campaign           |                      |
| Social marketing                     |                      |
| Media campaign                       |                      |
| Fear appeals                         |                      |
| Persuasive messaging                  |                      |
| Gain/loss framing                     |                      |
| Message framing                       |                      |
| Communication intervention            |                      |

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