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ARTICLE

Vaccine hesitancy as indecision: Creation and evaluation of the Unidimensional Vaccine Hesitancy Scale

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Abstract

Background: Several authors have argued that vaccine hesitancy should be conceptualized as indecision in the vaccination decision-making process, but no established measure with support for its psychometric properties and validity has been created from this operational definition.

Aims: To resolve this tension, this article undergoes a four-study scale development process to create the 4-item Unidimensional Vaccine Hesitancy Scale (UVHS).

Materials and Methods: We conduct four survey studies utilizing a total sample size of 884.

Results: In Studies 1 ($n = 297$) and 2 ($n = 298$), we provide psychometric support for the measure via exploratory and confirmatory factor analysis. In Studies 3 ($n = 193$) and 4 ($n = 106$), we support the concurrent and discriminant validity of the measure by assessing its relations with relevant constructs, such as vaccination readiness and acceptance, and we also provide initial indicators of the scale's possible predictive qualities by testing its time-separated effects with vaccination willingness, receipt and word-of-mouth.

Discussion: We leverage these results to provide a number of theoretical insights and suggestions for future practice. Of note, we highlight that different conceptualizations and operationalizations for the same construct can produce notably differing empirical findings, and vaccine hesitancy is no different.

Conclusion: Our cumulative efforts indicate that the UVHS is an appropriate measure to assess vaccine hesitancy as indecision.

KEYWORDS

factor analysis, measurement, scale development, vaccination, vaccination willingness, vaccine hesitancy, vaccine receipt, vaccine word-of-mouth, validity

BACKGROUND

It is estimated that over 3,000,000 deaths were prevented by COVID-19 vaccines in the United States alone through November 2022 (Fitzpatrick et al., 2022). Despite this powerful figure, more lives could have been saved – and continue to be saved – if more people chose to receive these vaccines (Mutombo et al., 2022; Padamsee et al., 2022), causing the investigation of vaccine hesitancy to be a primary avenue to improve vaccination outcomes during and after the COVID-19 pandemic (Karafillakis et al., 2022; Larson et al., 2022; Leigh et al., 2022). This greater attention towards vaccine hesitancy has resulted in the development of a multitude of theories, models, and frameworks, producing many different perspectives to understand the construct across several fields of study. Possibly due to these varied perspectives, authors have commented that the study of vaccine hesitancy has become disjointed, which has perhaps most importantly become evident in the various conceptualizations and operationalizations of the construct (Dubé et al., 2021; Larson, 2022; Truong et al., 2022; Wang & Liu, 2022).

Bussink-Voorend et al. (2022) conducted a systematic literature review of definitions and measures used to represent vaccine hesitancy in empirical research. The authors found that definitions of vaccine hesitancy could be primarily categorized as either reflecting cognitions/affect, behaviours, or aspects of the decision making process. In reviewing the definitions and categories, Bussink-Voorend et al. (2022) particularly stressed that researchers should certainly not conceptualize vaccine hesitancy as a behaviour, as vaccine receipt or uptake is a separate established concept in the literature (Howard, 2022, 2023; Kwok et al., 2021; Smith et al., 2017). They also argued that researchers should stray from conceptualizing vaccine hesitancy as cognition or affect. Over time, a multitude of other constructs have been developed that represent cognition or affect about vaccines, including concerns, doubts, and perceptions (Geiger et al., 2022; Machida et al., 2023; Rancher et al., 2023). The development of these constructs has gradually caused researchers' adopted definitions of vaccine hesitancy to exclude these elements; while cognitions and affect are integral to understanding vaccine hesitancy, they are not "the core of hesitancy" (Bussink-Voorend et al., 2022, p. 1638). Bussink-Voorend et al. (2022) instead suggested that researchers should conceptualize vaccine hesitancy as solely indecision in the vaccination decision making process, which has been similarly proposed by others (Bedford et al., 2018; Larson, 2013; Peretti-Watel et al., 2015). The authors argued that this definition provides uniqueness beyond related constructs representing cognition and affect, enabling this conceptualization to be better positioned in models and frameworks. Thus, this conceptualization of vaccine hesitancy is expected to become dominant in the future literature.

In reviewing measures of vaccine hesitancy, however, Bussink-Voorend et al. (2022) found two notable concerns. All established measures of vaccine hesitancy with support for their psychometric properties and validity include items that assess vaccine hesitancy as cognitions and/or affect (Freeman et al., 2022; Howard, 2022; Opel et al., 2011; Shapiro et al., 2018). For instance, the Vaccine Hesitancy Scale includes the item, "I am concerned about serious adverse effects of vaccines" (Shapiro et al., 2018, p. 663), and other similar items that reflect perceptions about vaccination (e.g., cognition). These measures cannot represent vaccine hesitancy when conceptualized as solely indecision in the vaccination decision making process. On the other hand, researchers have used an array of one- to three-item measures to assess vaccine hesitancy as indecision; however, robust psychometric and validity support has yet to be provided for any of these measures, and no measure has become particularly widespread (Bussink-Voorend et al., 2022). Possible concerns with these measures may have yet to be discovered, and it is presently unknown whether inferences produced with these measures are reliable and valid (Hinkin, 1995, 1998; Worthington & Whittaker, 2006). Likewise, the use of many different measures could cause inferences to differ from study-to-study based on idiosyncrasies of the applied measure, producing artificial heterogeneity across study results that obfuscate the true nature of relations (Brinkley et al., 2001; Hulleman et al., 2010; Nugent, 2006). Therefore, significant concerns are evident regarding the measurement of vaccine hesitancy as indecision in the vaccination decision making process, potentially hindering the progress of modern research on the topic.

The current article resolves this tension in the current literature. We undergo a four-study scale development process to create a four-item, unidimensional measure of vaccine hesitancy that operationalizes the construct as indecision in the vaccination decision making process, which we label the Unidimensional Vaccine Hesitancy Scale (UVHS). We first report our item generation and pretesting methods, which provide evidence of substantive and content validity. In Studies 1 and 2, we then provide psychometric evidence via exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). In Studies 3 and 4, we provide evidence of concurrent validity, discriminant validity, and possible predictive qualities to ultimately support the UVHS's construct validity. Our intent is to determine whether the UVHS is an appropriate measure of vaccine hesitancy, for which supportive results can strongly encourage its future application.

By achieving our goals, the current article benefits modern research and practice. First, the UVHS enables the accurate assessment of vaccine hesitancy. Researchers can reinvestigate prior findings discovered with less reliable measures of vaccine hesitancy to produce new inferences, opening a broad direction for future research through replication. Second, future researchers can utilize the UVHS rather than an array of one- to three-item measures. Doing so may reduce the heterogeneity of observations across studies, producing a more cohesive and easily interpretable field of study. Third, the UVHS can be easily modified to assess indecision about specific vaccines, which benefits investigations on all types of vaccine hesitancy. Fourth, creating a concise measure enables researchers to accurately measure vaccine hesitancy even when interactions with participants are restricted. The UVHS could identify those who may benefit the most from interventions when participants' time may be limited, providing an efficient approach to maximize benefits (Collins et al., 2004; Wang & Miller, 2020). Fifth, we draw attention to the different operational definitions used to create extant measures of vaccine hesitancy, and our scale development process shows that these measures produce different observed relations. Researchers cannot assume that operationalizations of vaccine hesitancy assess the same construct, and future research must recognize this complexity. Thus, the creation of the UVHS can improve practice and open many avenues for future research.

Before reporting our scale development process, attention should be given to the merits of creating a concise unidimensional measure of vaccine hesitancy. Prior scales typically utilize definitions akin to negative perceptions regarding vaccines, which is inherently multidimensional (Freeman et al., 2022; Howard, 2022; Opel et al., 2011; Shapiro et al., 2018). The UVHS is instead created to specifically match the conceptualization of indecision in the vaccination decision making process, which is a relatively narrow unidimensional construct (Bussink-Voorend et al., 2022). For this reason, creating a unidimensional measure better ensures construct validity due to our applied operational definition, but it also enables the created scale to capture an increasingly popular conceptualization that is presently unassessed in the literature.

The benefits of a unidimensional measure of vaccine hesitancy can also be emphasized via the bandwidth-fidelity dilemma (Salgado, 2017; Thielmann et al., 2020). This notion refers to the tendency of narrow measures to more strongly relate to relevant outcomes, whereas broad measures tend to significantly relate to more outcomes overall. Multidimensional measures may be broader assessments of vaccine hesitancy, and they may more broadly relate to vaccination-related outcomes and other preventive behaviours; however, the narrower measure created in the current article may more strongly relate to relevant outcomes associated with indecision in the vaccination decision making process, which is particularly beneficial when considering both the growing importance of this conceptualization and the lack of extant measures. Creating this novel and narrower measure may enable the improved prediction of relevant outcomes.

We were also thoughtful about creating a four-item measure. Many scale development guides recommend that researchers should have an a priori expectation for the number of items within their final measures (Clark & Watson, 2016; Hinkin, 1995, 1998; Howard & Henderson, 2023; Rossiter, 2002; Worthington & Whittaker, 2006). Certain decisions made during the scale development process will partially be influenced by the number of desired items in the final measure, and a certain number of items may be necessary to ensure sufficient content coverage while minimizing participant burdens in responding to the developed measures.

Many authors have supported that constructs can be effectively assessed with four-items, as scales of this length can produce appropriate psychometric and validity evidence (Hinkin, 2005; Robinson, 2018; Rouquette & Falissard, 2011). This support has caused several authors to recommend developing scales with at least four-items, such as Robinson (2018) that suggests, "it is prudent to include a minimum of four items in a scale–where practical" (p. 741) and Hinkin (2005) that states, "a quality scale composted of four to six items could be developed for most constructs" (p. 166). Scales with fewer than four items (such as those presently used to gauge indecision in the vaccination decision making process) tend to provide significantly worse psychometric evidence, and they regularly fail to produce convergent solutions in confirmatory factor analyses (Harvey et al., 1985; Marsh et al., 1998; Robinson, 2018). These very short scales also cause idiosyncratic effects arising from individual items to have a disproportionate influence on observed results (Hinkin, 2005; Robinson, 2018). At the same time, including too many items could reduce data quality by increasing participant fatigue and careless responding (Bowling et al., 2021), and it would also increase the potential for construct contamination (DeVellis & Thorpe, 2021; Hinkin, 1995, 1998). Because four-item unidimensional scales have been supported to be sufficient for assessing well-defined constructs (such as the currently applied operational definition), we chose to create a four-item scale.

Item development

We developed an over-representative item list to be subsequently reduced via exploratory factor analysis (EFA), as recommended by scale development guides to ensure appropriate construct coverage (Hinkin, 1995, 1998; Howard, 2019; Worthington & Whittaker, 2006). Because we intended for our final measure to be a concise four-item, unidimensional scale, we initially created eight items while abiding by three primary considerations. First, we ensured that each item specifically reflected indecision about receiving vaccines to maximize construct validity and minimize construct contamination. Second, we ensured that each item specifically referenced receiving vaccines. For example, participant responses to the item, "I am hesitant about vaccines", could refer to receiving vaccines, recommending vaccines to others, or a general apprehension towards vaccines. By specifically referencing the receipt of vaccines, we ensure that participants respond with a common frame-of-reference. Third, we ensured that items could be modified to assess specific types of vaccine hesitancy. For instance, the item, "I am hesitant about getting vaccinated", cannot be easily modified to measure COVID-19 vaccine hesitancy, as participants may not understand the item, "I am hesitant about getting COVID-19 vaccinated"; however, the item, "I am hesitant about receiving vaccines", can be easily modified to measure COVID-19 vaccine hesitancy, as participants can understand the item, "I am hesitant about receiving the COVID-19 vaccine." By abiding by these considerations, we ensured that our items appropriately measured vaccine hesitancy. Table 1 presents our initial item list.

Further, we underwent a defined process to develop our initial item list with these considerations in mind. We provided the operational definition of our applied conceptualization for vaccine hesitancy to subject-matter experts, and they recommended both potential items and specific words that could be included within our items. We modified these items to match our considerations above, and we supplemented them to ensure sufficient coverage of the entire criterion space for our applied conceptualization of vaccine hesitancy. We reviewed these items for any that should be immediately removed, as some recommended items were tangential to our operational definition. We were careful not to prematurely remove any items, as we believed that our subsequent EFA and confirmatory factor analysis (CFA) would eliminate any items that do not gauge our construct of interest. After this process, we felt that our final item list was sufficiently comprehensive and representative of the utilized operational definition.

For all studies, approval was granted by the Institutional Review Board of the primary author's institution [ID 1663301] and informed consent signatures were not obtained. Instead, participants were provided with an information page at the beginning of each survey, and they clicked a button to indicate their agreement to participate. This procedure ensured maximum confidentiality and anonymity, as signatures would be the sole information tying participants' identities to the studies. All data and analyses are provided in supplemental materials and the following OSF link: https://osf.io/dxs62/?view_only=1afa91ce176e41469c6a22e8ac719914.

TABLE 1 Initial items of over-representative item list.

Item number	Item wording for general version	Item wording for COVID-19 version
Item 1*	I am hesitant when it comes to receiving vaccines	I am hesitant when it comes to receiving the COVID-19 vaccine
Item 2	**I am unsure about whether to receive vaccines**	**I am unsure about whether to receive the COVID-19 vaccine**
Item 3	**I am generally undecided about receiving vaccines**	**I am generally undecided about receiving the COVID-19 vaccine**
Item 4*	I am unresolved about whether to receive vaccines	I am unresolved about whether to receive the COVID-19 vaccine
Item 5*	I am reluctant when it comes to receiving vaccines	I am reluctant when it comes to receiving the COVID-19 vaccine
Item 6	**I feel uncertain about whether to receive vaccines**	**I feel uncertain about whether to receive the COVID-19 vaccine**
Item 7	**I am indecisive about whether to receive vaccines**	**I am indecisive about whether to receive the COVID-19 vaccine**
Item 8*	I feel indecision about receiving vaccines	I feel indecision about receiving the COVID-19 vaccine

Note: Bolded and underlined items are included in the final version of the Unidimensional Vaccine Hesitancy Scale. Items indicated with * were removed during the scale development process.

Pretests

We performed two pretests on our initial item list. The goals of these pretests were to ensure that each item was easily understood and that the overall item list demonstrated appropriate substantive validity. We first conducted a small number of cognitive interviews with our initial item list using a convenience sample, wherein we asked participants to speak their thoughts aloud while responding to the items (Beatty & Willis, 2007; Willis, 2004). By doing so, we could determine if any items or phrases caused significant confusion for participants. None were noted, indicating that our items were understandable.

We then conducted two item-sort tasks (Anderson & Gerbing, 1991; Howard, 2019), one for the items written to reference general vaccination indecision ($n = 20$) and one for the items written to reference COVID-19 vaccination indecision ($n = 22$). In this process, we provided participants our operational definition of vaccine hesitancy and the definitions of a set of related constructs, namely the eight dimensions of the Multidimensional Vaccine Hesitancy Scale (MVHS). Because this scale and its dimensions were created from the conceptualization of vaccine hesitancy as negative perceptions regarding vaccines, the substantive validity of our item list can be supported by demonstrating that participants can reliably distinguish our items as representing indecision rather than negative perceptions. We then asked participants to sort each item of our item list and the MVHS into one of the nine presented categories. Each of our created items exceeded the cutoffs recommended by Howard (2019), and participants correctly identified the appropriate category for each of our items a statistically significant number of times (both ≥18). Therefore, the substantive validity of our initial item list was supported, thereby providing initial evidence that further assessment of these items is appropriate.

STUDY 1

The goal of Study 1 is to reduce our initial item list to a concise measure of four items. To achieve this goal, we use EFA to identify the items that most strongly load onto a common latent factor, which also provides psychometric support.

Participants

Participants ($Age_{\bar{x}} = 37.14$, $Age_{SD} = 13.15$, 53% female, 100% located in the United States) were recruited from Prolific in return for monetary compensation. Prolific is an online platform that connects researchers with participants, and prior research has supported that results obtained from Prolific samples are valid if certain precautions are taken (Douglas et al., 2023; Eyal et al., 2021; Stanton et al., 2022). We took those precautions in the current article. We restricted participation to only those fluent in the English language, and we removed participants that failed any attention checks (i.e., "Please mark agree to show that you are paying attention"). This resulted in the removal of five participants, producing a final sample size of 297.

Measures

Item list

We administered two versions of the item list. The first gauged vaccine hesitancy in general, whereas the second gauged hesitancy regarding COVID-19 vaccines.

Procedure

Participants enrolled via the Prolific platform and completed the survey online.

Results

We utilized the recommendations of modern guides to conduct our EFAs (Howard, 2016; Howard & Henderson, 2023; Reio & Shuck, 2015; Watkins, 2018). For both EFAs, we utilized a principal axis factoring method with an oblimin rotation. The general vaccine hesitancy items produced a KMO value of .92 and a statistically significant Bartlett's test ($p < .01$), supporting the use of EFA. A visual scree plot analysis indicated that one factor should be retained, and a parallel analysis indicated that two factors should be retained. The two lowest loading items in the one-factor solution were also the only two items to load onto the second factor in the two-factor solution, indicating that both solutions would produce the same results once the item reduction process began. For this reason, we began by removing these two items. We then removed two more items based on their factor loadings and clarity of language. The final four items had very strong factor loadings (≥.90) (Table 2), and a Cronbach's alpha of .96.

The COVID-19 vaccine hesitancy items produced a KMO value of .92 and a significant Bartlett's test ($p < .01$), supporting the use of EFA. A visual scree plot analysis indicated that one or two factors should be retained, and a parallel analysis indicated that two factors should be retained. Again, the two lowest loading items in the one-factor solution were the only two items to load onto the second factor in the two-factor solution, and we began by removing these two items. After removing items by factor loadings and clarity, the same four items were obtained. These items had very strong factor loadings (≥.91) (Table 2), and a Cronbach's alpha of .97.

Discussion

We identified four items that loaded strongly onto a common latent factor when assessing both general and COVID-19 vaccine hesitancy, providing support for their psychometric properties. These items are included in Appendix A, which we label the UVHS.

TABLE 2 Final exploratory factor analysis (EFA) results of Study 1 and final confirmatory factor (CFA) analysis results of Study 2.

General vaccine hesitancy		
	EFA factor loadings (Study 1)	**CFA factor loadings (Study 2)**
Item 1	.93	.88
Item 2	.95	.89
Item 3	.96	.93
Item 4	.90	.89
COVID-19 vaccine hesitancy		
	EFA factor loadings (Study 1)	**CFA factor loadings (Study 2)**
Item 1	.91	.92
Item 2	.94	.96
Item 3	.94	.91
Item 4	.97	.95

Note: All values are standardized factor loadings.

STUDY 2

The goal of Study 2 is to perform a CFA to confirm the factor structure of the UVHS, which provides further psychometric support.

Participants

Participants ($Age_{\bar{x}} = 27.67$, $Age_{SD} = 7.63$, 47% female, 20% located in South Africa, 17% Portugal, 16% Mexico, 16% Poland, and 31% other countries) were recruited from Prolific in return for monetary compensation. We restricted participation to those fluent in English and did not participate in Study 1. We removed those that failed any attention checks, resulting in the removal of five participants. The final sample size was 298.

Measures

UVHS

We administered two versions of the UVHS, one to measure general vaccine hesitancy (UVHS) and the other to measure COVID-19 vaccine hesitancy (UVHS-COVID-19).

Procedure

Participants enrolled via the Prolific platform and completed the survey online.

Results

We adhered to modern guidelines to conduct our CFAs (Brown, 2015; Kline, 2023). Following recommendations of Hu and Bentler (1999), we considered adequate model fit to be a SRMR value below .08

and a CFI value above .95. For both CFAs, we modelled the four items to load onto one latent factor. The UVHS produced satisfactory fit (SRMR = .01, CFI = 1.00), and each item loaded strongly onto the latent factor (≥.88) (Table 2). The Cronbach's alpha was .94. The UVHS-COVID-19 also produced satisfactory fit (SRMR = .02, CFI = .96), and each item loaded strongly onto the latent factor (≥.91) (Table 2). The Cronbach's alpha was .96.

Discussion

We further supported the UVHS's psychometric properties via CFA when used to assess general and COVID-19 vaccine hesitancy. These results encourage its further application.

STUDY 3

The goal of Study 3 is to investigate the concurrent validity, discriminant validity, and possible predictive qualities of the UVHS, which provides support for the scale's construct validity. We assess the scale's concurrent validity by testing its relations with other measures of vaccine hesitancy utilizing alternative conceptualizations, such as the MVHS. We assess the scale's discriminant validity by testing whether it is sufficiently distinct from prior measures of vaccine hesitancy, which was particularly important to support because several constructs exist that are similar to our applied conceptualization of vaccine hesitancy as indecision. A novel conceptualization of any construct is worthless if it is not distinct from existing constructs, as researchers would be inadvertently committing the jangle fallacy (Porter, 2023; Prayag, 2023). By supporting this type of discriminant validity, we could help ensure that this fallacy is not being committed. Lastly, we assess the scale's predictive qualities by testing whether it relates to vaccination willingness, receipt, and word-of-mouth when measured 1 week apart. We expect the UVHS to positively relate to other measures of vaccine hesitancy and negatively relate to our selected outcomes – apart from an expected positive relation with negative word-of-mouth.

Participants

Participants ($Age_{\bar{x}} = 39.96$, $Age_{SD} = 14.21$, 54% female, 100% located in the United States) were recruited from Prolific for monetary compensation. We restricted participation to those fluent in English and did not participate in Study 1 or 2. We removed those that failed any attention checks, resulting in the removal of 11 participants. The final sample size was 193.

Measures

Unless otherwise noted, all measures used a 1 (Strongly Disagree) to 7 (Strongly Agree) format. All items administered in Study 3 are provided in Appendix B.

UVHS

We administered the UVHS, which assesses vaccine hesitancy as indecision in the vaccination decision making process. The scale had a Cronbach's alpha of .96.

MVHS

We administered the MVHS (Howard, 2022), which has been supported in several studies (Balgiu et al., 2022; Howard, 2023; Howard & Davis, 2023). The MVHS is an eight-dimension measure that assesses vaccine hesitancy as negative perceptions regarding vaccination. Example items are, "Vaccines can cause long-term health issues" (Health Risks) and "People in my physical condition do not need vaccines" (Healthy). Each dimension produced a Cronbach's alpha of .86 or above.

Single-item measure of vaccine hesitancy

We administered a single-item measure of vaccine hesitancy used in several studies, including those conceptualizing vaccine hesitancy as indecision (Corben & Leask, 2018; Gendler & Ofri, 2021; Holeva et al., 2022). This item asked participants, "To what extent would you consider yourself hesitant to vaccination?" Participants responded on a scale from 1 (Not Hesitant at All) to 9 (Extremely Hesitant).

Vaccination willingness

Our measures of vaccination willingness have been used in many studies (Howard, 2022, 2023; Perez et al., 2016; Shapiro et al., 2016). We measured flu vaccination willingness with two items that read, "Please indicate how willing you would be to get a flu vaccine next year if it was [free/US$40]." Their Cronbach's alpha was .81. We measured COVID-19 vaccination willingness with two items that read, "Please indicate how willing you would be to get the COVID-19 vaccine (or booster vaccine shot if already received vaccine) next year if it was [free/US$40]." Their Cronbach's alpha was .86. The response format for these scales was 1 (Extremely Willing) to 7 (Extremely Unwilling).

Vaccine receipt

Our measures of vaccine receipt are commonly used in the present literature. We measured flu vaccine receipt with the item, "Have you received the flu vaccine in the past year?" We measured COVID-19 vaccine receipt with the item, "Have you received any doses of a COVID-19 vaccine?" We measured other vaccine receipt with, "Are you up to date on your vaccines other than the flu and COVID-19 vaccines?"

Vaccination word-of-mouth

Our measures of vaccination word-of-mouth have been used in several studies (Howard, 2022, 2023; Howard & Davis, 2023). We separately measured positive and negative word-of-mouth with three items each. An example positive word-of-mouth item is, "I talk to others about the benefits of vaccines", and the Cronbach's alpha of the scale was .88. An example negative word-of-mouth item is, "I share negative information about vaccines on social media", and the Cronbach's alpha of the scale was .93.

Procedure

Participants enrolled via Prolific and completed the first survey online, which included measures of vaccine hesitancy ($n = 193$). The following week, participants received an invitation to participate in a second

survey, which included measures of vaccination willingness, receipt, and word-of-mouth ($n = 159$). We used all possible participants when calculating our estimates. For example, the analysis sample size was 193 when calculating a correlation between two constructs measured at Time 1 alone, whereas the analysis sample size was 159 when calculating a correlation between two constructs measured at Time 1 and Time 2 (or Time 2 alone).

Results

Table 3 provides correlations and Cronbach's alphas of Study 3. The UVHS produced correlations expected in assessments of concurrent validity with the MVHS dimensions and the single-item measure of vaccine hesitancy, ranging from .16 to .50 (all $p < .05$). We performed heterotrait-monotrait (HTMT) ratio analyses, which is among the most supported approaches to assess discriminant validity (Henseler et al., 2015). Via this approach, two constructs cannot be considered statistically distinct if the HTMT confidence intervals contain the value of 1. The confidence intervals of all HTMT ratio analyses excluded 1 (Appendix S1: C), supporting that the UVHS is distinct from the other constructs. The UVHS also produced significant relations with all studied outcomes, which included a positive relation with negative word-of-mouth ($r = .31$, $p < .01$) and negative relations with flu vaccination willingness ($r = -.34$, $p < .01$), COVID-19 vaccination willingness ($r = -.45$, $p < .01$), flu vaccine receipt ($r = -.27$, $p < .01$), COVID-19 vaccine receipt ($r = -.28$, $p < .01$), other vaccine receipt ($r = -.19$, $p < .05$), and positive word-of-mouth ($r = -.28$, $p < .01$).

Discussion

Our results support that the UVHS produces expected relations with other constructs while still showing empirical distinctness. The measure produced positive and significant correlations with all other measures of vaccine hesitancy, and the HTMT ratio confidence intervals all excluded 1. The UVHS also relates to important outcomes as expected. It negatively related to vaccination willingness, receipt, and positive word-of-mouth, whereas it positively related to negative word-of-mouth. The concurrent validity, discriminant validity, and possible predictive qualities were thus supported, indicating that the UVHS is appropriate for measuring vaccine hesitancy as indecision. Differences in the relations produced by the UVHS and the single-item measure of vaccine hesitancy also speak towards the conceptual positioning and theoretical implications of each conceptualization, which is discussed within our discussion.

STUDY 4

The goal of Study 4 is to assess the relations of the UVHS with related constructs, which can provide support for the scale's concurrent and discriminant validity. We test whether the scale is negatively and significantly related to seven dimensions of vaccine readiness and five dimensions of vaccine acceptance to assess its concurrent validity, whereas we test whether the scale is sufficiently distinct from these 12 dimensions to assess its discriminant validity.

Participants

Participants ($Age_{\bar{x}} = 28.13$, $Age_{SD} = 9.14$, 54% female, 18% located in Portugal, 17% Poland, 12% South Africa, 9% Mexico, 8% Italy, and 36% other countries) were recruited from Prolific in return for monetary compensation. We restricted participation to those fluent in English and did not participate in

TABLE 3 Study 3 correlations and Cronbach's alphas.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. UVHS	.96																
2. SIMVH	.43**	–															
3. Health risk	.44**	.77**	.95														
4. Cost	.16*	.12	.20**	.86													
5. P. Pain	.17*	.20**	.15*	.31**	.90												
6. Inconv.	.33**	.31**	.32**	.40**	.34**	.92											
7. P. Reactions	.50**	.56**	.51**	.17*	.03	.27**	.94										
8. Access.	.40**	.13	.16*	.43**	.15*	.41**	.35**	.92									
9. Healthy	.37**	.64**	.64**	.21**	.13*	.54**	.34**	.30**	.96								
10. Forget	.30**	.23**	.15*	.22**	.27**	.59**	.23**	.29**	.38**	.92							
11. Flu Will.	−.34**	−.61**	−.57**	−.13	−.20*	−.35**	−.31**	−.14	−.62**	−.28**	.81						
12. C19 Will.	−.45**	−.67**	−.63**	−.11	−.23**	−.41**	−.37**	−.17*	−.61**	−.29**	.81**	.86					
13. Flu Rec.	−.27**	−.49**	−.42**	−.14	−.24**	−.24**	−.30**	−.07	−.46**	−.34**	.72**	.58**	–				
14. C19 Rec.	−.28**	−.61**	−.61**	−.09	−.05	−.31**	−.33**	−.16*	−.62**	−.17*	.57**	.60**	.47**	–			
15. Other Rec.	−.19*	−.44**	−.30**	−.17*	−.27**	−.29**	−.20*	−.16	−.38**	−.38**	.45**	.45**	.50**	.31**	–		
16. Pos. WoM	−.28**	−.42**	−.42**	−.06	−.15	−.35**	−.19*	−.14	−.45**	−.21**	.56**	.58**	.41**	.44**	.29**	.88	
17. Neg. WoM	.31**	.64**	.68**	.17*	.09	.37**	.43**	.17*	.64**	.13	−.46**	−.48**	−.25**	−.48**	−.25**	−.27**	.93

Note: Rows 3 through 10 represent the dimensions of the Multidimensional Vaccine Hesitancy Scale. Rows 11 through 17 represent outcomes. Cronbach's alphas are listed on diagonal.

Abbreviations: Access., Accessibility; C19 Rec., COVID-19 Vaccine Receipt in the Past Year; C19 Will., COVID-19 Vaccination Willingness; Flu Rec., Flu Vaccine Receipt in Past Year; Flu Will., Flu Vaccination Willingness; Health Risk, Health Risks; Incov., Inconvenience; Neg. WoM, Negative Word-of-MouthM; Other Rec., Other Vaccine Receipt; P. Pain, Physical Pain; P. Reactions, Personal Reactions; Pos. WoM, Positive Word-of-Mouth; SIMVH, Single-Item Measure of Vaccine Hesitancy; UVHS, Unidimensional Vaccine Hesitancy Scale.

*$p < .05$. **$p < .01$.

Studies 1, 2, or 3. We removed those that failed any attention checks, resulting in the removal of seven participants. The final sample size was 106.

Measures

Unless otherwise noted, all measures used a 1 (Strongly Disagree) to 7 (Strongly Agree) format. All items administered in Study 3 are provided in Appendix C.

UVHS

We administered the UVHS, which had a Cronbach's alpha of .96.

Vaccination readiness

We administered the 7C Scale (Geiger et al., 2022), which includes the seven dimensions of vaccination confidence, complacency, constraints, calculation, collective responsibility, compliance, and conspiracy. Despite their labels, each of these dimensions represent positive perceptions about vaccines and the importance of vaccination. An example item is, "Vaccination side effects occur rarely and are not severe for me" (Confidence). Each dimension had a Cronbach's alpha equal to or greater than .74, apart from the calculation dimension. After removing one item, this dimension had a Cronbach's alpha of .53.

Vaccine acceptance

We administered Sarathchandra et al.'s (2018) vaccine acceptance scale, which includes five dimensions: perceived safety of vaccines, perceived effectiveness and necessity of vaccines, acceptance of selection and scheduling of vaccines, positive values and affect towards vaccines, and perceived legitimacy of authorities to require vaccinations. An example item is, "Vaccines are safe" (Perceived Safety of Vaccines). Each dimension had a Cronbach's alpha equal to or greater than .77.

Procedure

Participants enrolled via the Prolific platform and completed the survey online.

Results

Table 4 provides correlations and Cronbach's alphas. The UVHS produced correlations with the 12 dimensions expected in assessments of concurrent validity, ranging from −.29 to −.65 (all $p < .01$). The confidence interval of all HTMT ratio analyses excluded 1 (Henseler et al., 2015) (Appendix S1: D), supporting that the UVHS is distinct from the other constructs.

Discussion

We provided added support for the UVHS by producing additional concurrent and discriminant validity evidence. The scale (as expected) produced negative and significant correlations with the 7C

TABLE 4 Study 4 correlations and Cronbach's alphas.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. UVHS	.96												
2. Confidence	−.64**	.78											
3. Complacency	−.52**	.57**	.83										
4. Constraints	−.56**	.56**	.63**	.74									
5. Calculation	−.29**	.26**	.26**	.28**	.53								
6. Coll. Respon.	−.57**	.65**	.61**	.63**	.19	.93							
7. Compliance	−.45**	.56**	.60**	.53**	.30**	.64**	.83						
8. Conspiracy	−.59**	.68**	.78**	.43**	.40**	.54**	49**	.81					
9. Safety	−.45**	.76**	.58**	.56**	.30**	.66**	.56**	.86**	.89				
10. Effect./Necess.	−.65**	.72**	.61**	.60**	.26**	.68**	.58**	.72**	.77**	.77			
11. Select./Sched.	−.58**	.60**	.48**	.56**	.27**	.45**	.41**	.71**	.70**	.66**	.86		
12. Values./Affect.	−.62**	.68**	.61**	.59**	.21*	.53**	.44**	.63**	.72**	.70**	.70**	.85	
13. Legitimacy	−.52**	.64**	.58**	.53**	.30**	.54**	.67**	.57**	.64**	.66**	.57**	.52**	.83

Note: Rows 2 through 8 represent dimensions of the 7C Scale, whereas rows 9 through 13 represent dimensions of the vaccine acceptance scale. Cronbach's alphas are listed on diagonal.

Abbreviations: Coll. Respon., Collective Response; Effect./Necss., Perceived Effectiveness and Necessity of Vaccines; Legitimacy, Perceived Legitimacy of Authorities to Require Vaccinations; Safety, Perceived Safety of Vaccines; Select./Schedule., Acceptance of the Selection and Scheduling of Vaccines; UVHS, Unidimensional Vaccine Hesitancy Scale; Values./Affect., Positive Values and Affect Towards Vaccines.

*$p < .05$. **$p < .01$.

dimensions and the vaccine acceptance dimensions, and no HTMT ratio confidence interval included 1. These results even further encourage its future application.

GENERAL DISCUSSION

While vaccine hesitancy has been increasingly conceptualized as indecision in the vaccination decision making process (Bedford et al., 2018; Larson, 2013; Peretti-Watel et al., 2015), no established measure with extant psychometric and validity support has been created from this operational definition (Bussink-Voorend et al., 2022). The goal of the current article was to create a vaccine hesitancy measure based on the operational definition of indecision in the vaccination decision making process. Study 1 reduced our item list into a concise measure of four items, labelled the UVHS, and provided initial psychometric support via EFA. Study 2 provided further psychometric support of the UVHS via CFA. Study 3 supported the concurrent validity, discriminant validity, and possible predictive qualities of the UVHS by assessing its relations with other measures of vaccine hesitancy and important outcomes. Study 4 provided further support by providing concurrent and discriminant validity evidence. Across all four studies, the UVHS produced strong internal consistency estimates. Therefore, this four-study scale development process provided significant psychometric and validity support for a measure of vaccine hesitancy as indecision in the vaccination decision making process – the UVHS.

Implications and future research directions

The current article provides several implications for modern research and practice, which enables novel and important directions for future studies. First, the UVHS facilitates the accurate measurement of vaccine hesitancy as indecision. Researchers should reinvestigate prior results discovered with other measures, such as the single-item measure of vaccine hesitancy applied in Study 3. While several authors have used this measure, including to assess vaccine hesitancy as indecision (Corben & Leask, 2018; Gendler & Ofri, 2021; Holeva et al., 2022), our results showed that it is very strongly related to the MVHS dimensions of Health Risks and Healthy, which have been supported as two dominant dimensions when vaccine hesitancy is conceptualized as attitudes or cognitions (Balgiu et al., 2022; Howard, 2023; Howard & Davis, 2023). This finding suggests that participants may perceive the term, "hesitancy", to reflect concerns rather than indecision about vaccination, indicating that this single-item measure does not represent vaccine hesitancy as indecision. In other words, this single-item measure lacks validity for measuring our applied conceptualization of vaccine hesitancy. Therefore, less may be known about vaccine hesitancy as indecision than presently realized, and perhaps even more importantly, our current knowledge may be inaccurate from using this single-item measure to represent indecision. Future studies should clarify prior findings using the UVHS, and an expansive direction for research on vaccine hesitancy may be the replication of prior results.

Second and similarly, single-item measures pose psychometric concerns and often lack criterion validity (Harvey et al., 1985; Marsh et al., 1998; Robinson, 2018). These measures are more susceptible to method and measurement effects, introducing greater bias from these sources into observed relations (Allen et al., 2022; Fisher et al., 2016). They are also more influenced by idiosyncratic interpretations of specific words, which introduce heterogeneity in results (Hinkin, 2005; Robinson, 2018). For these reasons, many authors recommend against single-item scales (Marsh et al., 1998; Robinson, 2018). By including multiple items, the UVHS is more resilient to these effects, and we provided robust psychometric and validity evidence. These findings suggest that the UVHS provides significant benefits beyond single-item measures of vaccine hesitancy. In addition to replicating prior results that utilize single-item scales to assess vaccine hesitancy as indecision, researchers should also use the UVHS to replicate prior investigations that applied a single-item scale to measure vaccine hesitancy – regardless of the operational definition. By doing so, more reliable and accurate inferences may be obtained.

Third, the use of different measures – even those to gauge the same conceptualization – can produce significantly different relations (Brinkley et al., 2001; Hulleman et al., 2010; Nugent, 2006). Future research can have more consistency in the measurement of vaccine hesitancy as indecision by using the UVHS. This scale can reduce the heterogeneity of results across studies, which can produce a more cohesive and easily understandable field of research. The UVHS may enable vaccine hesitancy to be better positioned in associated theories, models, and frameworks by aiding the interpretation of cumulative research findings.

Fourth, researchers have increasingly recognized differences in conceptualizations and operationalizations of vaccine hesitancy (Dubé et al., 2021; Larson, 2022; Truong et al., 2022; Wang & Liu, 2022). By showing that multiple measures of vaccine hesitancy produce differing relations in the current article, we further emphasize the need to recognize these differences. Future interpretations of vaccine hesitancy will depend on which definition becomes more commonplace. If vaccine hesitancy as indecision becomes even more popular, as expected by several researchers (Bedford et al., 2018; Bussink-Voorend et al., 2022; Larson, 2013; Peretti-Watel et al., 2015), alternative conceptualizations of vaccine hesitancy, particularly those as attitudes and cognitions, may instead be antecedents of vaccine hesitancy. That is, attitudes and cognitions about vaccines may lead to people being indecisive about whether to receive vaccines. If this is the case, then respective theories, models, and frameworks would need to distinguish the "core" of vaccine hesitancy from these closely related but distinct antecedent effects.

We presently highlight two possible theoretical alterations. The health belief model is widely used to study vaccination, which proposes that perceptions of the illness (susceptibility and severity) and evaluations of the health behaviour (benefits and barriers) are key antecedents of health behaviours (e.g., vaccination) (Rosenstock, 1974). When conceptualizations of vaccine hesitancy as affect and cognitions are integrated with this model, they are most often included as evaluations of vaccination (Hossain et al., 2021; Limbu et al., 2022; Patwary et al., 2021). The conceptualization of vaccine hesitancy as indecision, however, is not an evaluation, and it is instead a separate aspect of the vaccination decision making process. Vaccine hesitancy as indecision may instead be an explanatory mechanism when integrated with the health belief model, serving as a mediator in the relation of perceptions and evaluations with vaccination. Likewise, the theory of planned behaviour proposes that intention mediates the effects of attitudes, subjective norms, and perceived behavioural control on behaviours (Ajzen, 1991). When conceptualized as affect and cognitions, vaccine hesitancy is often considered an attitude in this theory (Hossain et al., 2021; Patwary et al., 2021); however, vaccine hesitancy as indecision better aligns with intentions, again serving as a key explanatory mechanism of relevant antecedents. Therefore, the positioning of vaccine hesitancy in relevant theories and models depends on the applied conceptualization, and an important direction for future research is to explore how vaccine hesitancy functions differently based on the applied conceptualization.

Fifth, initial inferences regarding these possibilities may be obtained by comparing the results of the UVHS and the single-item measure of vaccine hesitancy in Study 3. The two measures produced similar effects, but the single-item measure often produced partly stronger relations. As mentioned above, the pattern of results suggests that the single-item measure assesses negative perceptions regarding vaccination, whereas the UVHS assesses indecision about vaccination. Our findings suggest that negative perceptions about vaccination may be a stronger predictor of certain constructs and outcomes than indecision. While both are important in the vaccination decision making process, probing this finding further can provide significant theoretical insights. For instance, inferences could be obtained regarding why misinformation is so potent, as it is often focused on altering the perceptions of vaccines rather than sewing indecision alone (Loomba et al., 2021; Whitehead et al., 2023). Distinguishing the applied conceptualization of vaccine hesitancy from other conceptualizations of vaccine hesitancy can allow broader inferences about the vaccination decision making process and its influences.

Sixth and related, these results also provide initial inferences regarding the broader nomological net of vaccination as indecision. Namely, the UVHS was shown to relate more strongly to many of the MVHS and 7C dimensions than the single-item vaccine hesitancy measure. This suggests that indecision about vaccination is more strongly and directly influenced by specific perceptions about vaccines

rather than negative perceptions. Future researchers should recognize this variation in relations, and they should identify whether certain theoretical perspectives associated with more strongly related constructs are necessary to understand vaccination as indecision, such that those used to study certain 7C dimensions.

Seventh, we created the UVHS to be easily modified to assess various types of vaccine hesitancy, and we provided psychometric support for two versions of the UVHS: one assessing general vaccine hesitancy and the other assessing COVID-19 vaccine hesitancy. Researchers have demonstrated an increasing interest in assessing the dynamics of these specific types of vaccine hesitancy, such as HPV vaccine hesitancy (Karafillakis et al., 2019; Simms et al., 2020; Szilagyi et al., 2020), but these investigations have yet to directly compare different types of vaccine hesitancy. This may be because most measures of vaccine hesitancy are relatively lengthy (Howard, 2022; Larson et al., 2015), and researchers may be concerned about participant fatigue. The four-item UVHS, however, enables researchers to measure multiple types of vaccine hesitancy with fewer burdens on participants. This measure may therefore open avenues for future research comparing the effects of general and specific forms of vaccine hesitancy. While general vaccine hesitancy may predict a broader range of outcomes, specific forms of vaccine hesitancy may more strongly predict relevant outcomes. This future research could be guided by prior research on the bandwidth-fidelity dilemma (Rodrigues & Rebelo, 2022), enabling the novel application of theories rarely seen to investigate vaccine hesitancy.

Eighth, the concise UVHS can benefit the creation of interventions to promote vaccination, such as adaptive interventions, as it would minimize necessary resources (e.g., time) and reduce participant fatigue. Adaptive interventions deliver intervention components based on the target characteristics of participants, often resulting in improved outcomes with a reduced cost (Collins et al., 2004; Wang & Miller, 2020). The UVHS could be used at the beginning of an intervention to identify those currently undecided about vaccination. Those who score low on the UVHS could then be excluded from intervention components, whereas those who score high could complete a subsequent measure of vaccine perceptions, such as the MVHS, to determine which intervention components to receive. By doing so, resources would not be wasted on those who may not benefit from the components, and more focused attention could be given to those who would benefit the most. Therefore, the UVHS can produce immediate real-world impacts.

Limitations and future research directions

The current article relied on a single sampling source, Prolific. This source enabled us to obtain a wide range of participants, and we followed recommendations to ensure data quality with this source (Douglas et al., 2023; Eyal et al., 2021; Stanton et al., 2022). Nevertheless, certain people may be less likely to participate in Prolific studies, and future research should replicate our results with different sampling approaches to obtain a broader range of participants.

Because our goal was to create a self-report measure, we relied on the self-report research design. While we utilized a time-separated design in Study 3 to alleviate concerns with common-method bias, the current results should be replicated with different research designs. Future researchers should apply designs that can more robustly assess casual effects when investigating the relation of vaccine hesitancy with outcomes. Panel designs can investigate these relations with appropriate time lags between measurement occasions to observe causal effects, indicating that they may be particularly important to future research.

A common axiom is that the scale development process is never complete. Researchers should continuously reassess the psychometric properties and validity of measures, including the evidence provided in the current article. The MVHS was applied due to its ample prior support (Balgiu et al., 2022; Howard, 2022, 2023; Howard & Davis, 2023), and the single-item vaccine hesitancy measure was applied due to its relatively frequent use (Gendler & Ofri, 2021; Holeva et al., 2022); however, other measures of vaccine hesitancy exist. While similar results are expected with other measures, this cannot

be guaranteed. Similarly, we investigated relevant outcomes of vaccine hesitancy to provide initial indicators of possible predictive qualities, but we did not test antecedent effects. Future research should assess the broader nomological net of vaccine hesitancy using the UVHS, which may open even further directions for future research.

Some of these additional assessments of the UVHS can also provide substantive insights into the nature of vaccine hesitancy. For example, the current article provided multiple assessments of internal consistency reliability, but we did not provide assessments of alternative types of reliability, such as test–retest. We believe that our measure would produce adequate test–retest reliability that reflects the true nature of vaccine hesitancy, but extant research is also unclear regarding the extent that vaccine hesitancy is state- or trait-like. While studies have supported that interventions can alter vaccine hesitancy (Jarrett et al., 2015; Ryan & Malinga, 2021), other studies have also shown that people are relatively consistent in their beliefs about vaccines (Fridman et al., 2021; Hyland et al., 2021). Therefore, conducting these assessments is a clear need in future research, as it could have many implications for practice.

Lastly, we developed a measure for a relatively narrow construct, as we focused on the operational definition of indecision in the vaccination decision making process (Bussink-Voorend et al., 2022). Because our intended construct was well-defined, we created items that closely related to this operational definition, as straying too far from our construct of interest would introduce significant construct contamination into our measure. Also, we wanted to ensure that our measure included four items. As discussed above, authors have supported that constructs can be effectively assessed with four-item unidimensional measures (Harvey et al., 1985; Hinkin, 2005; Marsh et al., 1998; Robinson, 2018). Several psychometric reasons exist for not creating scales of fewer than four items, and including too many items could reduce data quality by increasing participant fatigue and introducing construct contamination. For these reasons, creating a four-item scale with relatively similar items was preferred to either creating a shorter or longer scale. It should nevertheless be recognized that our four items were relatively similar, and each demonstrated strong inter-item correlations across all four studies. While removing any item across the four studies would notably increase our scale's variance (further supporting their inclusion), our Cronbach's alphas were likewise strong across all four studies, and they were not markedly reduced with the removal of any item. This finding within itself is not inherently problematic, especially considering the potential detriments of including fewer than four items; however, future authors should explore whether the criterion space of our conceptualization can be meaningfully expanded relatively to the UVHS, and perhaps a more diverse set of items could represent our construct of interest if deemed to be appropriate.

CONCLUSION

The conceptualization of vaccine hesitancy as indecision in the vaccination decision making process is expected to become even more popular in future research, as this conceptualization enables vaccine hesitancy to be more easily positioned in relevant models, theories, and frameworks by providing greater uniqueness from associated constructs (Bussink-Voorend et al., 2022). The UVHS may prove to be essential to future empirical research on this conceptualization, as it is a well-supported operationalization of vaccine hesitancy as indecision. Therefore, the current article may spark many future studies to further develop this perspective.

AUTHOR CONTRIBUTIONS

Matt C. Howard: Conceptualization; investigation; writing – original draft; methodology; validation; visualization; writing – review and editing; software; formal analysis; project administration; data curation; resources.

CONFLICT OF INTEREST STATEMENT

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

DATA AVAILABILITY STATEMENT

All data is provided as Supporting Information.

ETHICAL APPROVAL

The current research procedures were approved by the University of South Alabama IRB (1663301).

INFORMED CONSENT

Participants were provided an information sheet to maximize confidentiality and anonymity.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A

Unidimensional Vaccine Hesitancy Scale (UVHS)

Please indicate the extent that you disagree to agree with the following statements using the provided scale.

1 – Strongly Disagree
2 – Disagree
3 – Slightly Disagree
4 – Neither Disagree or Agree
5 – Slightly Agree
6 – Agree
7 – Strongly Agree

1. I am unsure about whether to receive vaccines.
2. I am generally undecided about receiving vaccines.
3. I feel uncertain about whether to receive vaccines.
4. I am indecisive about whether to receive vaccines.

UNIDIMENSIONAL VACCINE HESITANCY SCALE – COVID-19 VACCINE VERSION (UVHS-COVID-19)

Please indicate the extent that you disagree to agree with the following statements using the provided scale.

1 – Strongly Disagree
2 – Disagree
3 – Slightly Disagree
4 – Neither Disagree or Agree
5 – Slightly Agree
6 – Agree
7 – Strongly Agree

1. I am unsure about whether to receive the COVID-19 vaccine.
2. I am generally undecided about receiving the COVID-19 vaccine.
3. I feel uncertain about whether to receive the COVID-19 vaccine.
4. I am indecisive about whether to receive the COVID-19 vaccine.

APPENDIX B

List of Constructs and Items Administered in Study 3

Readers should refer to the primary text for citations and references associated with these measures.

Unidimensional Vaccine Hesitancy Scale (UVHS)

1. I am unsure about whether to receive vaccines.
2. I am generally undecided about receiving vaccines.
3. I feel uncertain about whether to receive vaccines.
4. I am indecisive about whether to receive vaccines.

Multidimensional Vaccine Hesitancy Scale (MVHS)

Health Risks

1. Vaccines can cause long-term health issues.
2. Vaccines are unsafe.
3. Vaccines can cause illness.
4. Vaccines can cause certain disorders.

Cost

1. Vaccines cost too much.
2. I am unable to get vaccines because they cost too much.
3. Vaccines are too expensive.
4. Without health insurance, vaccines cost too much.

Physical Pain

1. Needles bother me when receiving a vaccine.
2. I worry about needles when getting a vaccine.
3. Getting a vaccine hurts.
4. I have a phobia of needles when receiving a vaccine.

Inconvenience

1. I am too busy to get a vaccine.
2. Getting a vaccine is too much of a hassle.
3. Getting a vaccine is too much trouble.
4. I do not have the time to get a vaccine.

Personal Reactions

1. I have allergic reactions to most vaccines.
2. I am a high-risk person for having a negative reaction to vaccines.
3. I am allergic to certain ingredients in vaccines.
4. I have a medical condition that prevents me from getting vaccines.

Access

1. Vaccines are unavailable where I live.
2. There is nowhere to get a vaccine.
3. It is difficult to get a vaccine where I live.
4. It is difficult to know where to get a vaccine.

Healthy

1. I do not need vaccines because I rarely get sick.
2. My strong immune system eliminates any need for vaccines.
3. I do not need vaccines because I am a low-risk person.
4. People in my physical condition do not need vaccines.

Forget

1. Getting vaccines often slips my memory.
2. I just forget about getting vaccines.
3. I just never get around to getting vaccines.
4. I accidentally skip getting vaccines.

Single-Item Measure of Vaccine Hesitancy

1. To what extent would you consider yourself hesitant to vaccination?

Vaccination Willingness
Flu Vaccination Willingness

1. Please indicate how willing you would be to get a flu vaccine next year if it was free.
2. Please indicate how willing you would be to get a flu vaccine next year if it was US$40.00.

COVID-19 Vaccination Willingness

1. Please indicate how willing you would be to get the COVID-19 vaccine (or booster vaccine shot if already received vaccine) next year if it was free.
2. Please indicate how willing you would be to get the COVID-19 vaccine (or booster vaccine shot if already received vaccine) next year if it was US$40.00.

Vaccine Receipt
Flu Vaccine Receipt

1. Have you received the flu vaccine in the past year?

COVID-19 Vaccine Receipt

1. Have you received any doses of a COVID-19 vaccine?

Other Vaccine Receipt

1. Are you up to date on your vaccines other than the flu and COVID-19 vaccines?

Vaccination Word-of-Mouth
Positive Word-of-Mouth

1. I share positive information about vaccines on social media.
2. I talk to others about the benefits of vaccines.
3. I talk to others about the positive effects of vaccines.

Negative Word-of-Mouth

1. I share negative information about vaccines on social media.
2. I tell others about the negative effects of vaccines.
3. I talk to others about the downsides of vaccines.

APPENDIX C

List of Constructs and Items Administered in Study 4
Readers should refer to the primary text for citations and references associated with these measures.

Unidimensional Vaccine Hesitancy Scale (UVHS)

1. I am unsure about whether to receive vaccines.
2. I am generally undecided about receiving vaccines.
3. I feel uncertain about whether to receive vaccines.
4. I am indecisive about whether to receive vaccines.

7C Scale of Vaccination Readiness
Confidence

1. Vaccination side effects occur rarely and are not severe for me.
2. Political decisions about vaccinations are scientifically grounded.
3. I am convinced the appropriate authorities do only allow effective and safe vaccines.

Complacency

1. I do not need vaccinations because infectious diseases do not hit me hard.
2. Vaccination is unnecessary for me because I rarely get ill anyway.
3. I get vaccinated because it is too risky to get infected.

Constraints

1. I make sure to receive the most important vaccinations in good time.
2. Vaccinations are so important to me that I prioritize getting vaccinated over other things.
3. I sometimes miss out on vaccinations because vaccination is bothersome.

Calculation

1. I get vaccinated when I do not see disadvantages for me.
2. I only get vaccinated when the benefits clearly outweigh the risks.
3. For each vaccine, I carefully consider whether I need it.

Collective Responsibility

1. I also get vaccinated because protecting vulnerable risk groups is important to me.

2. I see vaccination as a collective task against the spread of diseases.
3. I also get vaccinated because I am thereby protecting other people.

Compliance

1. It should be possible to exclude people from public activities (e.g., concerts) when they are not vaccinated against a specific disease.
2. The health authorities should use all possible means to achieve high vaccination rates.
3. It should be possible to sanction people who do not follow the vaccination recommendations by health authorities.

Conspiracy

1. Vaccinations cause diseases and allergies that are more serious than the diseases they ought to protect from.
2. Health authorities knuckle under the power and influence of pharmaceutical companies.
3. Vaccinations contain chemicals in toxic doses.

Vaccine Acceptance
Perceived Safety of Vaccines

1. Vaccines are safe.
2. Vaccines contain mercury in dangerous amounts.
3. Vaccines contain dangerous ingredients.
4. Vaccines cause autism.

Perceived Effectiveness and Necessity of Vaccines

1. Some vaccines are unnecessary since they target relatively harmless diseases.
2. Diseases provide better immunity than vaccines do.
3. Vaccines are effective at preventing diseases.
4. Many of the illnesses that vaccines prevent are severe.

Acceptance of Selection and Scheduling of Vaccines

1. We give children the right number of vaccines.
2. The timing of current vaccination schedule is appropriate.
3. We give vaccines to children when they are too young.
4. We give children too many vaccines.

Positive Values and Affect Towards Vaccines

1. I am morally opposed to vaccinating my child.
2. Vaccines conflict with my belief that children should use natural products and avoid toxins.
3. Vaccines are a major advancement for humanity.
4. Vaccines are disgusting to me.

Perceived Legitimacy of Authorities to Require Vaccinations

1. The government should not force children to get vaccinated to attend school.
2. My right to consent to medical treatment means that vaccination should always be voluntary.
3. To protect public health, we should follow government guidelines about vaccines.
4. It is legitimate for government to mandate vaccinations.