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The Effects of Vaccine Efficacy Information on Vaccination Intentions Through Perceived Response Efficacy and Hope

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Response efficacy information indicating the effectiveness of a recommended behavior in risk reduction is an important component of health communication. For example, many messages regarding COVID-19 vaccines featured numerical vaccine efficacy rates in preventing infections, hospitalizations, and deaths. While the relationship between disease risk perceptions and fear has been well established, we know less about the psychological factors involved in communicating vaccine efficacy information, such as response efficacy perceptions and hope. This study examines the effects of numerical vaccine efficacy information and message framing on vaccination intentions and their relationship to perceived response efficacy and hope, using a fictitious infectious disease similar to COVID-19. Findings suggest that communicating a high efficacy rate of the vaccine in preventing severe illness increased perceived response efficacy, which in turn boosted vaccination intention directly and indirectly through increasing hope. Also, fear about the virus was positively associated with hope about the vaccine. Implications of using response efficacy information and hope appeals in health communication and vaccination promotion are discussed.

To promote risk-reduction/preventive behaviors, health campaign messaging often includes both disease risk information (highlighting threats to people's health) and efficacy information (featuring effective actions that can reduce or control risks) to motivate behaviors by shaping/altering risk and efficacy perceptions (Witte, 1992). Efficacy perceptions have two components: 1) perceived self-efficacy, beliefs about one's ability/capacity to perform the recommended behavior (Bandura, 1997, 2001), and 2) perceived response efficacy, the extent to which one believes that the recommended behavior is effective in leading to the desired outcome (e.g., reducing health risks) (Witte & Allen, 2000; Witte, Cameron, McKeon, & Berkowitz, 1996).

In the context of promoting vaccination behaviors to reduce people's risks to highly infectious diseases, health messages typically use evidence-based communication (World Health Organization, 2020; Yale Institute for Global Health, 2020) featuring the efficacy rates of vaccines in protecting people from disease related infections and/or severe illness (hospitalizations or deaths) (World Health Organization, 2021). For COVID-19 vaccines, efficacy rates tend to be higher for preventing severe illness than for guarding people against infections (Morbidity and Mortality Weekly Report, 2022). During the early phase of vaccine testing, some studies found that the vaccines can be highly efficacious or even 100% efficacious in preventing severe illness (e.g., AstraZeneca, 2021; Cohen, 2020; Pfizer, 2021). Research also showed that the vaccines were around 60% to 95% efficacious/effective in preventing infections depending on the specific brands of the vaccines (Katalla, 2022; Wu et al., 2023).

Moreover, messages featuring vaccine efficacy information may either be framed in terms of protecting one's health against the disease by getting vaccinated or jeopardizing one's health by not getting vaccinated, known as gain versus loss framing (McLeod et al., 2022; Tversky & Kahneman, 1981). While the effects of numerical risk information on readers have received a high volume of attention (for a review, see Fagerlin, Zikmund-Fisher, & Ubel, 2011; Visschers, Meertens, Passchier, & De Vries, 2009), research on the influence of utilizing numerical information to communicate vaccine efficacy has been sparse.

Cognitive evaluations of risks and one's ability to handle it may result in discrete emotions (Lazarus, 1991; Nabi, 2015): while past research has heavily focused on examining the relationship between perceived risks and fear where one's level of risk perceptions predicts fear (Witte & Allen, 2000; Witte, Cameron, McKeon, & Berkowitz, 1996), few research addressed the association between efficacy perceptions and hope, and the role of hope in predicting intentions toward health behaviors. Specifically, based on people's cognitive appraisal (Roseman, 2001), if risk perceptions about facing possible losses in the future are antecedents of fear, then efficacy perceptions that desired outcomes may still be achieved even in adverse situations may evoke hope (Nabi & Myrick, 2019). Also, while meta-analysis

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found that fear was positively associated with adaptive behaviors (Tannenbaum et al., 2015), does hope lead to health behaviors? Or does it enhance the link between fear and adaptive behaviors? What is the relationship between fear and hope? Thus, examining the role of hope will not only enrich our understanding of the underlying psychological mechanisms of communicating disease risk and vaccine efficacy information but also guide health message design regarding using vaccine efficacy information and hope appeals to promote health promotion/risk reduction behaviors (Nabi & Prestin, 2016; Nabi, Gustafson, & Jensen, 2018). This study investigates the effects of vaccine efficacy information and the format in which it is presented (gain/loss framing) in a vaccination promotional message about a fictitious infectious disease (similar to COVID-19) on perceived risks, perceived response efficacy, fear, hope, and their relationships and influence on vaccination intentions.

A higher vaccine efficacy rate means that the vaccine has better performance in protecting people against disease related infections or severe illness (World Health Organization, 2021). For example, a 60% vaccine efficacy rate at preventing infections means that if 100 people who are unvaccinated are infected, 60 of them would not be infected if they were vaccinated. Different vaccines vary in their efficacy rates against COVID-19, but they have higher efficacy rates in preventing disease related severe illness (i.e., hospitalization or death) than infections (Morbidity and Mortality Weekly Report, 2022). When various COVID-19 vaccines were first introduced, many claimed to be 100% efficacious in preventing severe illness based on data from lab-based efficacy trials (AstraZeneca, 2021; Cohen, 2020; Pfizer, 2021).

Such numerical information can anchor subsequent judgments (Tversky & Kahneman, 1974; Wilson, Houston, Etling, & Brekke, 1996). For example, disease prevalence rates in percentage formats altered people's risk perceptions through adjusting their disease prevalence estimates (Liu & Niederdeppe, 2022; Liu, Lee, McLeod, & Choung, 2019). Also, crime and impaired driving statistics shaped people's perceptions about the severity of these societal problems (Lee, Liu, Choung, & McLeod, 2021). Vaccine efficacy rates reflect the extent to which getting vaccinated may be able to reduce disease risks (a desired outcome of performing the suggested behavior). Specifically, given that there are variations in vaccine efficacy between different types/brands of vaccines (and for different virus variants) and that vaccine efficacy rates tend to be higher in preventing disease related severe illness than infections (Cohen, 2020; Katalla, 2022; Wu et al., 2023), we may expect that compared to a relatively low vaccine efficacy rate (e.g., 60%) in preventing infections, a higher vaccine efficacy rate in preventing infections (e.g., 95%) or severe illness (e.g., 100%) or both may increase perceived response efficacy. Similarly, accompanying a relatively low vaccine efficacy rate in infection prevention with a high vaccine efficacy rate in preventing severe illness may also increase perceived response efficacy. Thus, we propose the following hypothesis regarding the effects of vaccine efficacy information on response efficacy perceptions.

H1: Vaccine efficacy information will affect perceived response efficacy: compared to a relatively low vaccine efficacy rate, the presence of a higher vaccine efficacy rate will increase perceived response efficacy.

The message that promotes vaccination behaviors by featuring vaccine efficacy rates may be framed in terms of either gains from getting vaccinated (e.g., protecting health through reducing disease risks) or losses by not getting vaccinated (e.g., jeopardizing health by failing to reduce disease risks), known as gain vs. loss framing (Tversky & Kahneman, 1981). Gain vs. loss framing presents largely logically equivalent information but formulates/contextualizes it in different lights (Chong & Druckman, 2007; McLeod et al., 2022). Compared to gains, people react more intensely to losses (Kahneman & Tversky, 1979). Risk and efficacy perceptions are subjective in nature (Slovic, 1987; Witte, Cameron, McKeon, & Berkowitz, 1996) and may shift due to the differential framing of the message (Witte, 1992).

While for disease prevention (such as vaccination) that is about enhancing one's health, it may be expected that gain framing will work better because it matches the context emphasizing benefits of performing the recommended behavior (Rothman, Salovey, Antone, Keough, & Martin, 1993). A series of studies has supported this idea (for a review, see Rothman, Bartels, Wlaschin, & Salovey, 2006). However, meta-analyses failed to detect a significant advantage of gain framing over its loss alternative in boosting disease prevention (O'Keefe & Jensen, 2007) and vaccination in particular (O'Keefe & Nan, 2012).

The mechanism behind this lack of significant difference remains unknown. As risk perceptions and efficacy beliefs are both essential antecedents of disease prevention behaviors, it might be possible that portraying the issue in a positive light through the lens of gains (rather than losses) may increase perceived response efficacy but dampen perceived risks at the same time. By comparison, loss framing may have an advantage of increasing people's perceived risk of the disease, but it also runs the risks of decreasing perceived efficacy of vaccination as a solution. That may explain the lack of a clear edge of using one frame over the other. Based on this reasoning, we hypothesize the following:

H2: Message framing will affect perceived response efficacy: relative to gain framing, loss framing will reduce perceived response efficacy.

H3: Message framing will affect perceived risk of the infectious disease: relative to gain framing, loss framing will increase perceived risks.

Moreover, cognitive appraisal theory suggests that evaluations of issues and situations can trigger discrete emotions (Roseman, 2001; Smith & Ellsworth, 1985). When people face adverse situations and there is a high level of uncertainty (e.g., facing disease risks), cognitive appraisal of threat can lead to fear, a type of emotion in response to possible loss in the future. The association between risk perceptions and fear has been well investigated by past research (Popova, 2012; Witte, 1992). Also, as response efficacy perceptions are beliefs that performing the recommended behavior (vaccination in this case) will help *prevent/reduce* (health) threats/risks, the level of response efficacy perceptions should also be largely dependent upon changes in risk perceptions as the recommended behavioral solution to reduce health risks might become more prominent when perceived probability and severity of the threats increase. In addition, risk perceptions may also play an essential role in predicting health behaviors (Ferrer & Klein, 2015), and meta-analysis showed that perceiving higher infectious disease risks were associated with elevated intentions toward getting vaccinated (Brewer et al., 2007).

By comparison, the potential links between risk/response efficacy perceptions and hope have been rarely addressed in research. The appraisal pattern that may result in hope overlaps with that of fear, such as adversity (a situation inconsistent with one's desired goals) and uncertainty (anticipated future risks). Therefore, as risk perceptions may increase fear, it may also have the potential to increase hope. Hope is also different from fear in that it is rooted in wishes for achieving better outcomes despite the presence of negative and uncertain situations (Lazarus, 1991; Nabi & Prestin, 2016; Nabi, 2015). Thus, hope as a discrete emotion reflects people's desire to maintain good health: perceiving the vaccine to be effective in protecting their health (that their goals may be realized) should boost such feelings, which indicates a positive relationship between perceived response efficacy and hope. Also, perceiving the recommended behavior (e.g., vaccination) to be an effective way of risk-reduction should also increase one's intention toward such adaptive behavior (for a review, see Floyd, Prentice-dunn, & Rogers, 2000).

Apart from the aforementioned links between different perceptions (e.g., risk perceptions and perceived response efficacy) and between perceptions and emotions (e.g., response efficacy perceptions and hope about the vaccine), there might also be an emotional flow (Nabi, 2015) where fear about the virus can lead to hope about the vaccine. On the one hand, when people are more frightened by the potential harm the virus has on their health, they may value more about the available method to reduce virus risks and are more hopeful that it will be effective (Nabi, Gustafson, & Jensen, 2018). On the other hand, physiological arousal is an integral part of emotions, and the physiological arousal triggered by fear may last, making the activation of the feelings of hope easier subsequently, according to the excitation transfer theory (Zillmann, 1983). Based on the arguments above, the following hypotheses are proposed:

H4: Perceived response efficacy will be (a) negatively associated with fear about the virus but (b) positively related to hope about the vaccine and (c) vaccination intention.

H5: Perceived virus risk will be positively related to (a) perceived response efficacy, (b) fear about the virus, (c) hope about the vaccine, and (d) vaccination intention.

H6: Fear about the virus will be positively associated with hope about the vaccine.

In addition, both fear and hope may predict behavioral intention in health risk communication. While some researchers casted concerns that too much fear may make people overwhelmed, rejecting risk messages and reducing adaptive behaviors (Witte, 1992), meta-analyses on this relationship showed otherwise: there is a linear positive association between fear and adaptive behavior where higher levels of fear lead to more intentions toward performing the recommended behavior (Tannenbaum et al., 2015; Witte & Allen, 2000). While the role of hope in health risk communication was insufficiently studied compared to fear, hope might also be positively associated with risk-reduction behaviors because hope has its cognitive origin in "desires" for positive outcomes emphasizing that people want to approach their goals. Finally, we also wonder if there is an interaction between fear and hope on vaccination intention. For example, when hope about the vaccine is high (people are very hopeful that the vaccine will help them achieve their goals of disease prevention), it may enhance the positive relationship between fear about the virus and vaccination intentions because people can then better cope with feelings of fear by desiring for better outcomes through getting vaccinated (engaging in the recommended adaptive behavior). However, this assumption has never been tested and it may also contradict past meta-analysis findings showing a *linear* positive relationship between fear and adaptive behaviors (Tannenbaum et al., 2015). Following this reasoning, we pose two hypotheses and a research question below.

H7: Hope about the vaccine will be positively associated with vaccination intention.

H8: Fear about the virus will be positively associated with vaccination intention.

RQ: Is there an interaction effect between fear about the virus and hope about the vaccine on vaccination intention?

Methods

Experimental Design

This experiment featured a 5 (vaccine efficacy information) by 2 (gain vs. loss framing) online between-subjects experimental design (plus a control condition). Participants in the experimental conditions were randomly assigned to read a specific version of a vaccination promotional message about a fictitious infectious disease *Sebarisus* (similar to COVID-19). The message was kept constant across experimental conditions except for the vaccine efficacy and gain/loss framing manipulation (see the Appendix for the full message stimuli).

The vaccine efficacy information was constructed based on the efficacy of different COVID-19 vaccines when they were first introduced. These vaccines have higher efficacy rates of preventing severe illness (many claimed to be 100%) than infections (where vaccines may vary in their efficacy but must be above 50% to be approved) (AstraZeneca, 2021; Cohen,

Table 1. Correlation Matrix of the Outcome Variables

	Perceived risks (virus)	Perceived response efficacy (vaccine)	Fear (virus)	Hope (vaccine)	Vaccination intention
Perceived risks (virus)	–	.47***	.52***	.43***	.52***
Perceived response efficacy (vaccine)	–	–	.24***	.43***	.47***
Fear (virus)	–	–	–	.40***	.35***
Hope (vaccine)	–	–	–	–	.54***
Vaccination intention	–	–	–	–	–

Notes. Cell entries are zero-order correlations. ***$p < .001$. We have also run multivariate linear regression analyses (not shown in the Table), and the VIF scores for perceived risks (virus), perceived response efficacy (vaccine), fear (virus), and hope (vaccine) predicting vaccination intention are within acceptable range (between 1.4 and 1.7).

2020; Morbidity and Mortality Weekly Report, 2022; Pfizer, 2021). The message either featured the efficacy rate in preventing infections or severe illness or both. The five different versions of the vaccine efficacy information were as follows: The vaccine has been shown to be (a) 60% effective at preventing Sebarisus infection; (b) 95% effective at preventing Sebarisus infection; (c) 100% effective at preventing severe illness from Sebarisus (e.g., hospitalization or death); (d) 60% effective at preventing Sebarisus infection and 100% effective at preventing severe illness from Sebarisus (e.g., hospitalization or death); (e) 95% effective at preventing Sebarisus infection and 100% effective at preventing severe illness from Sebarisus (e.g., hospitalization or death) in people with no evidence of previous infection.

Gain/loss framing was manipulated in a way that the gain framed appeal highlighted gains by getting vaccinated: "By taking the preventive step of getting vaccinated now, you can protect your health. If you get vaccinated, you will be able to reduce your risk of contracting Sebarisus" whereas the loss framed appeal featured losses by not getting vaccinated: "By not taking the preventive step of getting vaccinated now, you can jeopardize your health. If you do not get vaccinated, you will be at risk of contracting Sebarisus."

384 undergraduate students from a large midwestern university in the United States participated in the experiment in exchange for extra course credits, and 337 respondents completed the study. Following the message stimulus, we asked respondents about their risk perceptions of the disease, perceived response efficacy, fear, hope, and their intention to get vaccinated.

Measures

Risk perceptions about the virus were measured by three items that asked respondents if they were not vaccinated, (a) how likely they think that they would get infected with the Sebarisus virus at some point; (b) how concerned they would be about the Sebarisus virus for their personal health; and (c) how concerned they would be about the Sebarisus virus as a community problem, where 1 = not at all and 7 = extremely. Responses were averaged as the risk perceptions index ($\alpha = .77$, $M = 5.52$, SD = 1.12). This measure was derived based on Slovic (2016).

Perceived response efficacy about the vaccine was measured by three items that asked respondents to rate the effectiveness of the vaccine in preventing Sebarisus (a) infections, (b) hospitalizations, and (c) fatalities, each on a scale from 1 = not at all effective to 7 = extremely effective. Responses to the three items above were averaged to form the response efficacy perceptions index ($\alpha = .81$, $M = 5.89$, SD =.94). This measure was adapted from Katz, Kam, Krieger, and Roberto (2012).

We measured fear toward the virus by asking respondents how (a) fearful; (b) afraid; (c) scared; and (d) anxious they feel when they think about the Sebarisus virus, from 1 = none of this feeling to 7 = a great deal of this feeling. Responses to the four items above were averaged as the fear index ($\alpha = .95$, $M = 4.69$, SD = 1.61). Hope about the vaccine was measured by asking respondents how (a) hopeful; (b) optimistic; and (c) encouraged they feel when they think about the Sebarisus vaccine on the same 7-point scale. Responses were averaged to form the hope index ($\alpha = .93$, $M = 5.31$, SD = 1.59). These emotion measures were adapted from Nabi and Myrick (2019).

Vaccination intention was assessed using three items that asked respondents how likely they would to be to get vaccinated if the vaccine were offered to them (a) today; (b) in the next two weeks; and (c) at some point in the future, from 0% to 100%. We averaged the responses to form the vaccination intention index ($\alpha = .92$, $M =$ 83, SD = 22). This measure was derived based on Head, Kasting, Sturm, Hartsock, and Zimet (2020). A correlation matrix of the measured outcome variables above is shown in Table 1.

Results

Before testing specific hypotheses, a two-way ANOVA was conducted to examine whether there was an interaction between vaccine efficacy information and gain/loss framing. Results showed that there was no significant interaction effect between vaccine efficacy information and framing on any of the measured outcomes (all $ps > .05$).

We tested our hypotheses (H1 through H8) using structural equation modeling (SEM) with the lavaan package in R (Rosseel, 2012). SEM provides a comprehensive analysis of models regarding estimation of coefficients, significance level, and the overall model fit (Kline, 2015). Apart from the paths specified in H1 through H8, we correlated the residuals of the two indicators of perceived response efficacy: preventing "hospitalizations" and "fatalities" as they are both about disease related severe illness (Morbidity and Mortality Weekly Report, 2022). The model showed good fit to the data: χ^2/df = 1.43, CFI =.98, RMSEA =.04, 90% CI [.026, .048], SRMR =.04. The statistical results for the hypothesized paths were reported in Figure 1, including the standardized path regression coefficients and their significance levels.

As is shown in Figure 1, compared to 60% efficacy in preventing infection (reference), communicating 95% efficacy in preventing infection ($\beta = .07$, $p = .30$) or featuring 60% efficacy in preventing infection plus 100% efficacy in preventing severe illness ($\beta = .11$, $p = .13$) did not affect perceived response efficacy. By comparison, communicating 100% efficacy in preventing severe illness ($\beta = .27$, $p < .001$) or featuring 95% efficacy in preventing infection plus 100% efficacy in preventing severe illness ($\beta = .20$, $p = .006$) increased perceived response efficacy. Thus, H1 was partially supported. Compared to gain framing (reference), loss framing did not significantly increase perceived virus risk ($\beta = .01$, $p = .83$), nor did it decrease perceived response efficacy ($\beta = -.09$, $p = .12$). Therefore, H2 and H3 did not receive support.

Perceived response efficacy was negatively associated with fear about the virus ($\beta = -.21$, $p = .047$), and positively related to hope about the vaccine ($\beta = .35$, $p < .001$) and vaccination intention ($\beta = .26$, $p = .009$), supporting H4a, H4b, and H4c. Perceived virus risk was positively associated with perceived response efficacy ($\beta = .70$, $p < .001$), fear about the virus ($\beta = .77$, $p < .001$), vaccination intention ($\beta = .24$, $p = .04$), but not hope about the vaccine ($\beta = .20$, $p = .12$), supporting H5a, H5b, H5d, but not H5c. Fear about the virus was positively associated with hope about the vaccine ($\beta = .19$, $p = .01$), supporting H6.

Hope about the vaccine was positively associated with vaccination intention ($\beta = .31$, $p < .001$). Thus, H7 was supported. Fear about the virus was not associated with vaccination intention ($\beta = -.02$, $p = .81$), failing to support H8. Finally, we tested whether there is an interaction between fear about the virus and hope about the vaccine on vaccination intention following the matched pairs procedure to examine latent interactions described in Marsh, Wen, and Hau (2004). Basically, we mean-centered indicators of fear and hope and used 3 matched pair indicators (based on factor loadings) to form the product indicators of the latent interaction factor, adding them to the existing model. Results showed that the interaction between fear about the virus and hope about the vaccine on vaccination intention was statistically non-significant ($\beta = -.08$, $p = .08$) while the pattern of results for all the other paths did not change significantly. Thus, it answered our research question, and we dropped the latent interaction from the model.

Discussion

Health communication studies have heavily focused on addressing the role of risk perceptions, fear, and their effects on health behaviors. However, the link between response efficacy and hope, between fear and hope, and the role of hope in motivating health behaviors have received insufficient research attention. This study examined the effects of numerical vaccine efficacy information and gain/loss framing on vaccination intention through response efficacy perceptions and hope. Findings have important implications for understanding the mechanisms of efficacy/hope appeals and the use of such strategy to guide health message design.

We found that communicating a high efficacy rate of the vaccine in preventing severe illness (i.e., hospitalization or death) increased perceptions about response efficacy. Moreover, this effect held when the high efficacy rate in preventing severe illness was coupled with a high efficacy rate in preventing infections, but the effect disappeared when it was accompanied by a relatively low efficacy rate in preventing infections. As COVID-19 vaccines have higher rates in preventing severe illness (many claimed to be 100% when they were first introduced) than infections, health messages communicating COVID-19 risks may benefit from highlighting vaccine efficacy rates in preventing severe illness compared to infections. More important, as past research on the use of numerical information largely centered on communicating disease risks (Fagerlin, Zikmund-Fisher, & Ubel, 2011; Visschers,

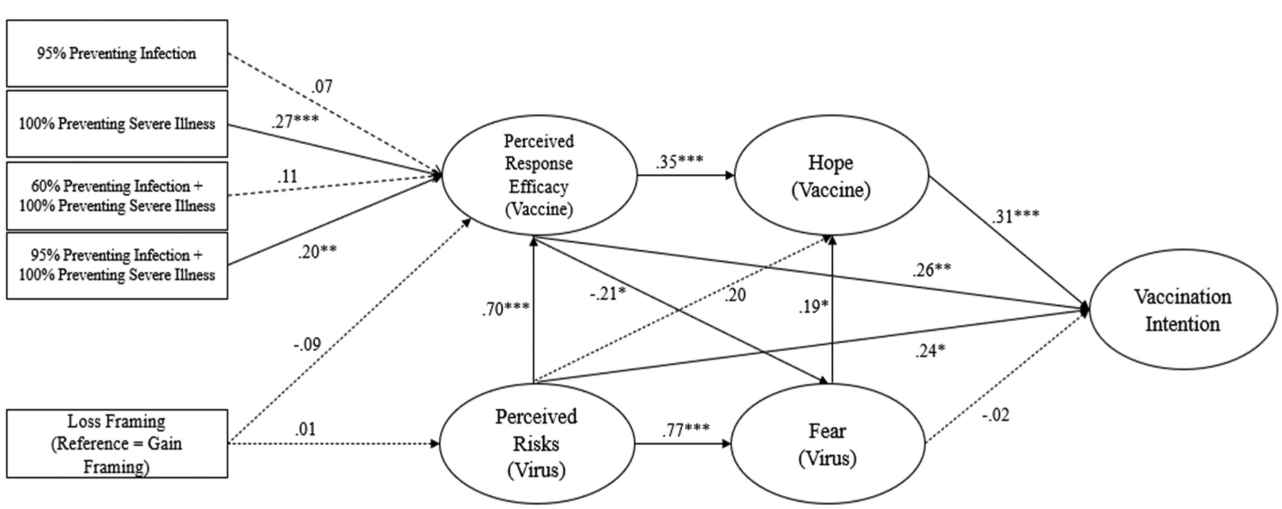

Figure 1. The Structural Equation Model. *Notes*. Vaccine efficacy information: reference = 60% effective at preventing infection. $p^* < .05$; $p^{**} < .01$; $p^{***} < .001$.

Meertens, Passchier, & De Vries, 2009), findings from our study showed the potential of utilizing numerical evidence to communicate efficacy information. The numerical vaccine efficacy information is typically presented in percentage format, future research may look at the effects of other number formats such as absolute/relative frequencies in communicating efficacy.

Although vaccine efficacy information may be framed in terms of gains by getting vaccinated vs. losses by not getting vaccinated, we found that gain/loss framing did not significantly affect either risk perceptions or response efficacy perceptions. Meta-analysis about message framing effects on vaccination revealed no significant difference between gain vs. loss framing on vaccination attitudes/intentions (O'Keefe & Nan, 2012). As risk and efficacy perceptions are both important antecedents of health behaviors, we hypothesized that gain framing may increase efficacy perceptions but decrease risk perceptions, resulting in a minimal net effect on vaccination intention compared to loss framing which may increase risk perceptions but decrease efficacy perceptions. However, findings suggest that gain vs. loss framing did not affect these essential predictors of behaviors, echoing and further extending the null finding from the meta-analysis in the context of vaccination promotion.

Moreover, findings suggest the important role of discrete emotions, especially hope in motivating risk-reduction/preventive behaviors. We found a significant mediation path where response efficacy perceptions affected hope, and hope in turn influenced vaccination intentions. It echoed the cognitive appraisal theory (Lazarus, 1991; Roseman, 2001), which suggests that emotions are evoked based on how people cognitively appraise the issues/situations at hand. While perceiving oneself as subject to infectious disease risks may generate fear, perceiving that there are effective solutions (vaccines with high efficacy rates) to protect one's health from such threat can evoke hope. This is because while fear and hope share their roots in appraisal patterns regarding adversity and uncertainty, hope also emphasizes the "desire" for positive outcomes facing threats/risks. Knowing that the vaccines are able to successfully reduce disease risks can fuel such desires. Also, hope was positively associated with vaccination intention after considering the association between perceived response efficacy and vaccination intention in the model. It suggests that hope can predict vaccination intention apart from perceived response efficacy, which emphasizes the role of emotions in affecting decision making and behaviors. By comparison, the mediation path of risk perceptions through fear on vaccination intention was not statistically significant. Although fear has been found to be an important predictor of adaptive behaviors (Tannenbaum et al., 2015), it was not associated with vaccination intention in our model (when the path through hope was also included). It further emphasizes the important role of hope as a critical factor contributing to behavioral intention.

While the cognitive appraisal theory focused on the links between perceptions and discrete emotions (Roseman, 2001; Smith & Ellsworth, 1985), the relationship between different discrete emotions has been insufficiently studied. We found that fear about the virus increased hope about the vaccine, showing an emotional flow (Nabi, 2015). While fear and hope are different in their valence, both emotions share a cognitive root in facing threats/risks (Lazarus, 1991). When people are frightened about the potential dangers of the virus, they become more hopeful that the vaccine will work to reduce the risks from the virus. While the fear-to-hope path has also been found in the context of climate change (Nabi, Gustafson, & Jensen, 2018), our measurements of emotions are target specific (fear about the virus and hope about the vaccine instead of fear and hope overall), making us more confident about their causal time order: people may not have strong feelings about the vaccines (the potential solution to the virus threat) if they are not fearful about the virus (the source of the threat). Moreover, the fear-to-hope path also echoed the excitation transfer theory (Zillmann, 1983) where the physiological arousal caused by fear may endure and enhance a later emotional state, such as hope in our case.

Finally, while we found a non-significant effect of fear about the virus on vaccination intention, we also tested whether hope may moderate the influence of fear on vaccination intention given that there is a possibility that the link between fear and vaccination intention may appear or be strengthened when people are especially hopeful that the vaccine will work to reduce virus risks (high levels of hope about the vaccine might make vaccination a more viable way of coping with fear). However, findings showed no interaction effect, which further highlights the independent positive effect of hope on vaccination intentions.

This study has limitations. First, because COVID-19 vaccines are more effective in preventing severe illness than infections (Morbidity and Mortality Weekly Report, 2022), we modeled our efficacy information manipulation in a similar way. However, such design (although having high ecological validity) makes us less certain whether the effects can be solely attributed to the differences in efficacy rates (60% vs. 95% vs. 100%) as these efficacy rates are typically associated with different vaccination outcomes (preventing infection vs. preventing severe illness). For example, during the early phase of vaccine testing, while some research showed that the vaccine can be 100% efficacious in preventing disease related severe illness, the efficacy rates for preventing infections are around 60% to 95%, depending on specific brands. Second, although student samples are common in research examining psychological mechanisms, older people are more susceptible to infectious disease related severe illness and may focus more on disease risks and benefit more from vaccination. Thus, future research may test the generalizability of the study findings with different population segments. Third, considering that respondents may have already been vaccinated against COVID-19 at the time of the experiment, we chose to use a fictitious disease context ("Sebarisus virus") formulated similar to COVID-19, but not the actual disease. Also, we used a posttest only design and we did not measure respondents' baseline COVID-19 vaccination attitudes or records prior to message exposure in case these pretest measures may sensitize respondents toward the purpose of the study (undermining our use of a fictitious disease context) and prime/skew their responses. Future research might want to use a real disease topic and adopt a pretest-posttest design to consider people's baseline vaccination attitudes and experience in the analysis to see if our findings can be replicated.

Although not addressed in this study, people who believed in COVID-19/vaccination related myths and those who do not prioritize health promotion efforts may be especially difficult to be persuaded. On the one hand, the proliferation of COVID-19 and vaccination related misinformation online has made fighting the COVID-19 infodemic an urgent task for health educators and media professionals (Hotez et al., 2021). While communicating accurate vaccine information (such as depicting vaccine efficacy rates) may serve as an effective way to counter misinformation, it may also be important to develop and adopt various communication strategies specifically targeted at misinformation correction (Vraga & Bode, 2020). On the other hand, some people may not prioritize health promotion efforts based on their values and ideologies. For example, people may weigh the importance of economic security and freedom of choice more than disease prevention. For vaccine hesitant people, if it is not the health-related concerns that determine their vaccination intentions, then maybe other types of value appeals will work better than simply communicating vaccine efficacy information (Nan, Iles, Yang, & Ma, 2022).

In closing, while past research has established the role of fear in health communication where risk perceptions (shaped by health risk information) affect adaptive behaviors directly or indirectly through evoking fear, our research contributed to the literature by specifying the role of hope where response efficacy perceptions (shaped by vaccine efficacy information) increased vaccination intentions directly or indirectly by raising hope about the vaccine. Moreover, as fear about the virus is also positively related to hope about the vaccine, emphasizing disease risks to increase fear may also increase hope, which can in turn enhance vaccination intentions. However, the use of gain/loss framing may not have significant effect on risk or response efficacy perceptions. Thus, findings suggest that hope should be included as a critical factor in health communication effects models, and health educators and media professionals may benefit from including numerical efficacy information (a high vaccine efficacy rate associated with preventing severe illness from the disease in particular) and hope appeals apart from emphasizing disease risks in messages promoting vaccination behaviors. The use of gain/loss framing may not have a persuasive advantage in vaccination promotional messages though.

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Appendix. Message Stimuli

(The bolded content in brackets represents message manipulation and other parts of the message are kept constant.)

The Sebarisus virus is highly contagious and is transmitted in much the same way as the virus that causes COVID-19 (SARS-CoV-2). The symptoms of Sebarisus include congestion, runny nose, fever, chills, cough, shortness of breath and difficulty breathing. In some cases, the condition can worsen, resulting in severe lung problems that lead to hospitalization, and even death.

Fortunately, a Sebarisus vaccine has been developed and is now available. By **[taking/not taking]** the preventive step of getting vaccinated now, you can **[protect/jeopardize]** your health. If you **[get/do not get]** vaccinated, you will be **[able to reduce your risk/at risk]** of contracting Sebarisus.

The vaccine has been shown to be **[60% effective at preventing Sebarisus infection/95% effective at preventing Sebarisus infection/100% effective at preventing severe illness from Sebarisus (e.g., hospitalization or death)/60% effective at preventing Sebarisus infection and 100% effective at preventing severe illness from Sebarisus (e.g., hospitalization or death)/95% effective at preventing Sebarisus infection and 100% effective at preventing severe illness from Sebarisus (e.g., hospitalization or death)]** in people with no evidence of previous infection.

The vaccine may have some side effects, which are signs that the vaccine is at work. Possible side effects may include pain and redness on the arm where you got the vaccine, and tiredness, headache, muscle pain, chills, fever, or nausea. Some people have no side effects.

The state department of health recommends that everyone gets vaccinated for the Sebarisus virus. To make a vaccination appointment, you will need to register online to receive your first dose at a local vaccination site. One month later, you will need to get the second dose of the vaccine.