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Examining the direct and indirect effects of trust in motivating COVID-19 vaccine uptake

Sixiao Liu, Haoran Chu

Aim to investigate how trust in healthcare providers, public health agencies, politicians, and pharmaceutical companies shaped people's attitudes and behavioral intention associated with COVID-19 vaccination, directly and indirectly via the mediation of vaccine evaluation and emotions.

Methods: A two-wave longitudinal survey (N = 534) was employed in late 2020 and early 2021 to assess the direct and indirect relationships between trust on people's attitude toward the COVID-19 vaccine, vaccination intention, and actual vaccine uptake.

Results: Results show that trust was positively associated with attitude toward the COVID-19 vaccines and vaccination intention, both directly and indirectly via the mediation of vaccine evaluation, hope, and anger. Vaccination intention also mediated trust's influence on vaccine uptake.

Conclusion: Trust in health providers, vaccine manufacturers, and public health agencies are vital to public acceptance of the COVID-19 vaccine.

Practice implications: Healthcare providers and vaccine manufacturers may serve as the most effective source to communicate COVID-19 vaccine-related information. Trusted health communicators need to highlight the effectiveness and safety of the vaccine while maintaining a positive tone.

1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic has severely disrupted societies and economies worldwide. Over 300 million infections and five million deaths have been reported globally as of January 2022. Although preventive measures such as mask-wearing have been enforced by public health authorities, infections and casualties continue to rise. In the face of the dire situation and the spread of new variants, mass vaccination against COVID-19 is needed to address the pandemic. Unfortunately, various vaccine programs have been threatened by vaccine hesitancy. The COVID-19 vaccine as a relatively new vaccine engendered even more challenges. Over one year after implementing the first COVID-19 vaccine, only six countries reach the 80% threshold of herd immunity. In the United States, only 62% of the population was fully vaccinated. While the global vaccination rate (approximately 58%) was even more concerning. There is thus an urgent need to explore factors that could influence public acceptance of the COVID-19 vaccines.

In addition to historical, political, and socio-cultural factors, a growing body of research finds that the decreasing trust in vaccination contributes to reduced vaccination intention. Notably, most of these studies focused on the influence of trust in the health professionals on vaccination intention, while trust in other health authorities and actual vaccination behavior were not examined extensively. To address such a research gap, the current study investigates the impact of trust in public health professionals and agencies (i.e., health professionals, public health agencies, governments, and pharmaceutical companies) on people's vaccination intention and behavior. In addition, previous studies mainly focused on the direct association between trust and vaccination intention, while the psychological mechanism underlying trust's influence remains underexplored. The current study thus examines possible cognitive and affective pathways through which trust may take effects. Specifically, we test if the perception of the COVID-19 vaccines and discrete emotions mediate trust's effects on COVID-19 vaccination-related attitude, behavioral intention, and vaccine uptake.
1.1. Trust and vaccination

Vaccines are valuable measures that safeguard public health and safety. However, vaccine hesitancy, which is the delay or refusal of a scheduled vaccine despite its availability, has been increasingly observed [3,9]. In response to the challenge, researchers have explored factors that may lead to vaccine hesitancy [10]. Among them, trust was identified as one of the most important factors influencing vaccine hesitancy [3,8,9,11]. For example, research shows that trust is positively associated with the intention to receive influenza and HPV vaccines [6-8,12].

In the context of vaccination, public trust often takes forms as trust in the vaccine as a product, trust in the health professionals, and trust in policymakers [9]. In other words, the establishment of public trust in vaccination involves assessment of the competence of the vaccine and the integrity, credibility, and effectiveness of people and institutions involved in the vaccine production, regulation, administration, and recommendation. Unfortunately, a decline in trust has been observed in the U.S. and worldwide [3,7,13,14].

Trust is defined as the “optimistic acceptance of a vulnerable situation in which the trustee believes the trustee will care for the trustor’s interest” [15]. In the vaccination context, individuals hesitant to receive a vaccine tend to be skeptical about the motives of health professionals, healthcare system, and other parties, and thus their “will to trust” remains low [7,11]. Considering that the trustees are often the source of vaccination information, the irremovable relationship between people and health agents may be a fundamental source of vaccine hesitancy.

Earlier research has mostly focused on trust between patients and physicians and individual characteristics that influence such relationships [11]. However, recent studies explored public trust more broadly by looking into trust in health agents such as health professionals, public health agencies, governments, and pharmaceutical companies [6,7,12]. Research indicates that healthcare providers and public health agencies were often considered trustworthy, but public trust in such agencies declined in recent years [6,16]. Pharmaceutical companies often receive the lowest level of trust from the public [7,16], along with politicians [6].

In the context of the COVID-19 vaccines, their unprecedented speed of development and distribution [17] may render trust a more important factor in shaping vaccination intention. People may resist health recommendations due to limited scientific literacy and uncertainty. The situation is exacerbated by the spread of misinformation and declining trust in public health messaging due to politicization and media sensationalism [14,18]. Therefore, people’s trust in health professionals, agencies, politicians, and pharmaceutical companies as their vaccination information sources may largely determine their attitude toward and intention to get the vaccines.

H1: Trust in vaccine-related professionals and organizations will be positively associated with positive attitude toward the vaccine (a) and vaccination intention (b).

Additionally, the theory of planned behavior (TPB) indicates that positive attitude toward a behavior often leads to increased behavioral intention [19]. We thus hypothesize such a positive association between them (H2a). As the theory also suggests behavioral intention often leads to actual behavior [19], we hypothesize that increased intention to get a COVID-19 vaccine will lead to increased vaccination behavior (H2b). Correspondingly, people with higher trust in vaccine-related professionals and agencies may also be more likely to receive a COVID-19 vaccine due to their increased vaccination intention (H2c).

1.2. Trust and perception of the vaccine

Trust may also shape vaccination attitude and behavior by influencing perception of the vaccines. Particularly, as people may not have sufficient knowledge to evaluate the vaccine, they may rely on trusted sources to make a judgment. Indeed, studies show that trust played a crucial role in people’s evaluation of unfamiliar objects, such as new technologies [20,21]. It is likely that trust may also influence people’s evaluation of the COVID-19 vaccine.

Vaccine perception may be operationalized with two constructs, including the perceived effectiveness of and safety concerns associated with the vaccines. The health belief model (HBM) points to the importance of perceived effectiveness in determining people’s intention to adopt health behaviors such as vaccination [22,23]. Specifically, the construct captures people’s evaluation of a health behavior’s ability to protect them from a health threat [24]. As the goal of adopting a health behavior is to avoid the threat, higher perceived effectiveness would lead to more positive attitudes toward the behavior and increased intention to adopt it. Differently, safety concern resembles perceived barriers in the HBM, which are factors that prevent people from performing a health behavior [22,25]. In terms of vaccination, safety concerns may be one of the strongest motivators for vaccine hesitancy [24,25]. Indeed, a multinational survey points to the importance of highlighting vaccine safety in promoting the COVID-19 vaccines [26]. Therefore, it is likely that high safety concerns may also lead to a more negative attitude toward the COVID-19 vaccine and lower intention to receive it.

Based on the reasoning above, we hypothesize that:

H3: Trust in healthcare providers, public health agencies, pharmaceutical companies, politicians will be positively associated with vaccine-related positive attitude/behavioral intentions through the mediation of the perceived effectiveness of and safety concerns associated with the COVID-19 vaccines.

1.3. Trust and emotion

Emotions have long been considered predictors of health behaviors [27–29]. Vaccine hesitancy research also shows that emotions may influence vaccination intention [30,31]. Some suggest that vaccination decision-making tends to be emotionally charged, as people may not make such decisions based on a rational evaluation of a vaccine but are more influenced emotionally by factors associated with the vaccines [31]. Observably, anti-vaccination groups often promote misinformation and create division in vaccination belief through emotional appeals. For example, anti-vaccination activists tend to embed emotional messages in campaigns, such as those instigating worry about the side effects of vaccines [32–34].

Four emotions are particularly relevant to COVID-19 vaccine-related decision-making, including fear, anxiety, anger, and hope. Fear has long been at the center of health communication research [23,28]. It was identified as a strong motivator of health behaviors, but overwhelming fear may also prevent actions [23]. Anxiety is similar to fear but with a stronger sense of uncertainty [35]. Appraisal theories suggest that anxiety and fear differ in action tendencies [35], where an anxious person is more likely to proactively address the situation than a fearful one [36]. Though anger is also a negative emotion, it features different appraisal themes and action tendencies. People tend to feel a stronger sense of control when feeling angry [35,37]. Correspondingly, anger is more likely to stimulate active coping behaviors. Hope is a positive emotion widely studied in health research [28,38]. Increased hope is often positively linked to the adoption of health behaviors [3,28].

As a new vaccine that requires rapid response, people may rely more on emotions to make decisions related to the COVID-19 vaccines. It is also plausible that the amount of information received from vaccine-related professionals and agencies may influence vaccination intention cognitively and emotionally. Specifically, when people trust vaccine-related professionals and health agencies, they may generate less negative and more positive emotional responses to the vaccines. The reduced negative and increased positive emotions may work as heuristics for more positive attitudes and behavioral intention (H4). In addition to the mediating effects of the valence, discrete emotions’ unique appraisal themes and action tendencies may also lead to variation in
vaccine-related attitudes and behaviors [36,39]. A research question is thus proposed.

RQ2: How do fear, anxiety, anger, and hope mediate the relationship between trust in vaccine advocates and vaccine-related attitude/behavioral intentions.

Fig. 1 summarizes the theoretical framework illustrated above.

2. Methods

2.1. Sample and procedure

Upon IRB approval, a two-wave survey hosted on Qualtrics.com was distributed to participants recruited on Prolific.co, a crowdsourcing platform for research subject recruitment [40]. Research shows that prolific.co participants are generally more naïve and honest than other opt-in respondents such as those from Amazon mTurk. Notably, though prolific.co screens participants to enhance sample representativeness, females and educated individuals tend to be overrepresented on the platform [40,41]. The first survey was distributed in November 2020, a few weeks before the first COVID-19 vaccine became available to the U. S. public \( (N=1001) \). The second survey was fielded in March 2021, when the majority of American adults could get access to a COVID-19 vaccine \( (N=554) \). After providing informed consent, participants responded to the survey questionnaires. Only responses from those who passed all the attention check questions (two in Wave 1 and one in Wave 2) and reported the same gender and age in both waves were retained in the final sample \( (N=534) \). Sample demographics are presented in Table 1.

2.2. Measures

Participants’ trust in the COVID-19 vaccine-related professionals and organizations was assessed with single-item questions. They were asked to report the extent to which they trusted their healthcare providers, government health agencies, such as FDA, CDC, politicians, and pharmaceutical companies that make the COVID-19 vaccines as a source of information about the COVID-19 vaccines. The participants’ responses were recorded on a 5-point Likert scale ranging from 1 (‘not at all’) to 5 (‘a great deal’). Single-item measures were utilized to avoid respondent fatigue as trust in multiple sources of information was measured concurrently.

On a scale ranging from 1 (‘not at all’) to 5 (‘very much’), participants were asked to indicate the extent to which they felt certain emotions when thinking about the COVID-19 vaccines. Four emotions, including fear, anxiety, anger, and hope, were assessed with 12 items in total. Fear was measured with “fearful” “afraid” and “scared” \( (M=2.05, SD=1.19, \alpha=0.94) \). Anxiety was measured with “worried”, “anxious” and “nervous” \( (M=2.46, SD=1.20, \alpha=0.91) \). Anger was measured with “angry”, “mad” and “irritated” \( (M=1.61, SD=1.04, \alpha=0.93) \). Hope was measured with “hopeful”, “optimistic” and “upbeat” \( (M=3.01, SD=1.12, \alpha=0.86) \). These individual items are frequently used in research on emotions [42].

Perceived effectiveness of COVID-19 vaccines was measured with a three-item scale [43]. On a five-point Likert scale \( (1=\text{strongly disagree}; \ 5=\text{strongly agree}) \), participants responded to questions such as “COVID-19 vaccines will be effective in preventing COVID-19” \( (M=3.73, SD=0.86, \alpha=0.92) \). Perceived safety about COVID-19 vaccines was assessed with a three-item scale on a five-point Likert scale \( (1=\text{strongly disagree}; \ 5=\text{strongly agree}) \) [44]. Sample question includes “I have concerns about
possible side effects of COVID-19 vaccines ($M = 3.33$, $SD = 1.24$, $\alpha = 0.89$).

On a scale ranging from 1 (very unlikely) to 5 (very likely), COVID-19 vaccination intention was measured with a four-item scale [25]. Participants were asked to provide responses to questions, such as “please indicate the likelihood that you will consider getting COVID-19 vaccines. ($\alpha = 0.97$).

Participants were asked to report if they had received a COVID-19 vaccine when they took the second-wave survey. 291 Participants neither received nor were scheduled to receive any COVID-19 vaccine when taking the survey (54.5%). 206 Participants received at least one dose of the vaccine (38.6%), and 37 were scheduled to receive a vaccine soon (6.9%). Considering that scheduling a vaccine appointment also indicates that the person is proactively engaged in the vaccination behavior, the variable is dummy coded with the latter two categories collapsed into one group (0 = unvaccinated; 1 = vaccinated or scheduled to receive a vaccine).

2.3. Analysis

A structural equation model was computed in MPLus 8.2 to address the hypotheses and research questions. Following the two-step approach suggested by Kline [45], we first conducted a confirmatory analysis (CFA) of the latent variables to assess the fit of the measurement model that includes the latent variables (i.e., oval-shaped variables in Fig. 1) and their indicators. According to conventional criteria [46], results of the CFA indicate that the model fit the data well ($\chi^2$ (271) = 423.32, CFI = 0.99, TLI = 0.98, RMSEA = 0.032, SRMR = 0.032). A structural model was thus tested. As the model involves a binary outcome variable (i.e., vaccine uptake), we utilized Weighted Least Square Mean and Variance Adjusted (WLSMV) estimator to model the influence of the predictors on vaccine uptake through the probit link [47]. The structural model also fit the data well ($\chi^2$ (462) = 622.06, CFI = 0.96, TLI = 0.95, RMSEA = 0.025, SRMR = 0.028). Path coefficient estimates and standard errors for the structural model are presented in Table 2 and Table 3. The confidence intervals of the indirect effects are modeled with bootstrapped random subsamples (N = 2000). Significant indirect effects are reported in Tables 4–6. Probability level for statistical significance was set at $p < 0.05$ as the parameters in the structural equation model were correlated. The demographic variables served as controls in the structural model.

3. Results

In general, our participants showed relatively high trust in healthcare providers ($M = 3.78$, $SD = 1.08$) and governmental health agencies ($M = 3.14$, $SD = 1.25$). However, trust in pharmaceutical companies ($M = 2.60$, $SD = 1.09$) and politicians ($M = 1.44$, $SD = 0.66$) were lower than the scale mid-point. Participants also expressed relatively strong intention to get vaccinated ($M = 3.96$, $SD = 1.26$) at Time 1, and 243 (44.5%) have received at least of one dose the vaccine at Time 2.

Table 2

| Perceived effectiveness | Safety concerns | Fear | Anxiety | Anger | Hope |
|-------------------------|-----------------|------|---------|-------|------|
| Trust in healthcare providers | 0.25 (0.04)*** | -0.14 (0.06)* | -0.22 (0.07)** | -0.12 (0.07) | -0.17 (0.06)** |
| Trust in public health agencies | 0.12 (0.03)** | -0.09 (0.05) | -0.11 (0.05)* | -0.11 (0.05)* | -0.15 (0.04)** |
| Trust in politicians | -0.02 (0.05) | -0.01 (0.07) | 0.09 (0.08) | 0.02 (0.08) | 0.13 (0.06)* |
| Trust in pharmaceutical companies | 0.16 (0.04)** | -0.3 (0.06)** | -0.12 (0.06) | -0.13 (0.06)* | -0.09 (0.05) |
| Female¹ | -0.13 (0.06)* | 0.32 (0.09)** | 0.47 (0.10)** | 0.37 (0.10)** | 0.16 (0.08)* |
| Other Gender¹ | 0.22 (0.22) | 0.13 (0.48) | 0.51 (0.97) | 0.45 (0.86) | 0.25 (0.25) |
| White² | 0.1 (0.070) | -0.24 (0.11)* | -0.23 (0.12) | -0.26 (0.11)* | -0.03 (0.09) |
| Education | 0.03 (0.02) | -0.02 (0.04) | 0.01 (0.04) | -0.02 (0.04) | 0.01 (0.02) |
| Income | 0.02 (0.02) | -0.04 (0.03) | -0.05 (0.03)* | -0.04 (0.03) | 0.02 (0.02) |

Note. ¹ Dummy-coded with male as reference group; ² Dummy coded with non-White groups as reference group; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; Significant effects are in bold.

Table 3

| Coefficient estimates and standard errors for paths predicting the outcome variables. |
|-----------------------------------------------|
| Attitude toward | Intention to receive a COVID-19 vaccine | Vaccine uptake⁻¹ |
| COVID-19 vaccines | Vaccine uptake⁻¹ |
| Trust in healthcare providers | 0.19 (0.05)*** | 0.05 (0.04) |
| Trust in public health agencies | -0.02 (0.04) | 0.04 (0.03) |
| Trust in politicians | -0.03 (0.06) | -0.06 (0.05) |
| Trust in pharmaceutical companies | 0.02 (0.04) | -0.04 (0.04) |
| Perceived effectiveness | 0.7 (0.09)*** | 0.34 (0.09)*** |
| Safety concerns | -0.12 (0.06) * | -0.16 (0.05) ** |
| Fear | -0.16 (0.13) | -0.11 (0.11) |
| Anxiety | 0.17 (0.14) | 0.19 (0.12) |
| Anger | -0.16 (0.06) ** | 0.02 (0.05) |
| Hope | 0.09 (0.05) | 0.16 (0.05) *** |
| Attitude toward COVID-19 vaccines | 0.44 (0.06) *** |
| Intention to receive a COVID-19 vaccine | 0.51 (0.07) *** |
| Female¹ | 0.09 (0.07) | -0.02 (0.06) |
| Other Gender¹ | 0.39 (0.37) | -0.4 (0.19) * |
| White² | 0.02 (0.08) | 0.19 (0.07) ** |
| Education | 0.04 (0.03) | 0.06 (0.02) ** |
| Income | -0.04 (0.02) * | -0.01 (0.02) |

Note: ¯ $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; Significant effects are in bold.

In response to H1, which focuses on the relationship between trust and vaccine-related attitude and behavioral intention, we found that trust in healthcare providers led to a more positive attitude toward the COVID-19 vaccine. However, no other significant effect of trust on attitude or intention was identified. Therefore, H1a was partially supported, but H1b was not.

H2a-b hypothesized positive relationships among positive attitude, behavioral intention, and vaccine uptake. As expected, a positive attitude toward the vaccine was positively associated with behavioral intention, and higher behavioral intention led to an increased vaccine uptake rate. Therefore, H2a and H2b were supported.

H3 hypothesized mediating effects of perceived vaccine effectiveness and safety concerns. Observably, increased trust in healthcare providers and pharmaceutical companies was associated with higher perceived vaccine effectiveness and lower safety concern. Trust in public health agencies was also positively associated with perceived effectiveness, while trust in politicians was not a significant predictor. As expected,
perceived effectiveness was positively associated with favorable attitude toward the vaccine and vaccination intention. Perceived safety concern was negatively associated with favorable attitude and behavioral intention (Table 3). In terms of the mediating effects, both variables mediated trust in healthcare providers and pharmaceutical companies’ impacts on vaccine attitude and behavioral intention. However, only effectiveness perception mediated trust in public health agencies’ effects on attitude and behavioral intention. No significant indirect effect was found for trust in politicians.

H4 and RQ2 are related to the mediating roles of fear, anxiety, anger, and hope in the relationship between trust and the outcome variables. Observably, trust in healthcare providers was negatively associated with fear and anger but positively associated with hope. Similarly, higher trust in public health agencies led to lower fear, anxiety, and anger but higher hope. Trust in pharmaceutical companies was positively associated with hope but negatively related to anxiety. Trust in politicians was positively associated with anger, which was the only emotion negatively associated with favorable attitude toward COVID-19 vaccines. Hope is the only emotion positively associated with vaccination intention. The mediation results showed that anger mediated trust in healthcare providers and public health agencies’ impacts on attitude and behavioral intention, while hope mediated trust in healthcare providers, public health agencies, and pharmaceutical companies’ impacts on vaccination intention. Therefore, H4 was mostly supported.

Lastly, H2c hypothesized positive indirect relationships between trust and vaccine uptake. Similar to the results illustrated above, some significant indirect effects were identified (Table 6). In summary, trust in health providers, public health agencies, and pharmaceutical companies led to more vaccine uptake via the mediation of effectiveness perception, safety concern, anger, and hope.
4. Discussion and conclusion

4.1. Discussion

As expected, trust was an important predictor of positive attitude toward the COVID-19 vaccine and vaccination intention. More importantly, through the mediation of vaccine perception and emotions, trust in healthcare providers, pharmaceutical companies, and public health agencies was significantly associated with people’s actual vaccination behavior. Such findings attest to the critical role of trust in overcoming vaccine hesitancy. As people often rely on trusted sources to make health decisions, especially those related to novel health threats such as the COVID-19, fostering trust in health authorities is crucial to the success of campaigns.

Trust in healthcare providers and pharmaceutical companies were the consistent predictors of people’s evaluation of the vaccines and emotional response to the vaccines. Variation in evaluation and emotion further led to different attitude toward the COVID-19 vaccine and vaccine uptake. Such findings point to the important role of healthcare providers and vaccine manufacturers in promoting the COVID-19 vaccines. Reassuring information provided by such sources may help reduce uncertainty and promote confidence in the vaccines. Trust in public agencies such as the CDC and FDA was also a significant predictor of vaccine-related attitude and behavioral intention. However, it tends to be more effective in reassuring the public regarding the effectiveness, but not the safety of the COVID-19 vaccines. Such findings may shed light on the communication campaigns launched by the public health authorities, as emphasizing the safety of the vaccines is equally important as highlighting their effectiveness.

Notably, perceived effectiveness and safety of the vaccine mediated the effects of public trust in vaccine-related health agents. As people may not have enough information to assess the efficacy and safety of novel health solutions accurately, they may turn to a trusted source for reassurance. However, it is notable that different sources may also provide different information regarding the vaccines. For instance, healthcare providers and manufacturers may be more effective in building confidence in vaccine effectiveness, while the public may not rely much on public health agencies for information related to vaccine safety. Such finding is somewhat counterintuitive, as agencies such as the FDA are actually in charge of evaluating the safety of products such as the COVID-19 vaccines. Our findings point to the urgent need to restore public trust in the authorities.

Different emotions also functioned differently in mediating trust’s effects. Hope as a positive emotion was the most conducive mediator. Indeed, as hope is often related to active coping with health threats [28], it is likely that trust in professionals and organizations may render individuals more hopeful when facing threats such as the COVID-19. In the meantime, reduced anger as a result of higher trust in healthcare providers and public health agencies also led to a more positive attitude and higher vaccination intention. Such findings indicate that fostering a rapport between the public and the health authorities may help reduce the tension between different groups. Indeed, trust may be a scarce but much-needed resource to bring people together to overcome the challenges in this increasingly polarized world. Fear and anxiety, on the other hand, did not serve as a mediator in most cases. One possible explanation is that fear and anxiety may not be the most critical barrier to people’s vaccination decision-making. As these two emotions often function more prominently in response to risks instead of risk solutions, the lack of a salient effect for fear anxiety may be reasonable.

This study also has its limitations. First, the sample is relatively older and lacks racial diversity than the general population of the U.S. To enhance the generalizability of the findings, future research may replicate this study with a more representative sample. Relatively, the rapid development and distribution of the COVID-19 vaccines may influence participants’ vaccine evaluation and decisions. Though the majority of participants were eligible to receive a COVID-19 vaccine during the Wave 2 survey, some may not be aware of such information. However, we believe that such a possibility does not negate the validity of our findings, as staying informed about the COVID-19 vaccines may also be an integral component of people’s proactive vaccination behavior. Nevertheless, a more updated data set should eliminate such limitations, and we recommend continued tracking of vaccination status. Additionally, we did not adjust for multiple testing to avoid overly conservative results from the structural equation models, in which all parameters are allowed to covary. However, such an approach may lead to Type I error, and caution is needed in interpreting the results. Lastly, trust was measured with single items, which may limit the variables’ variance and validity, leading to the non-significant effects of trust in sources such as politicians. Future research may utilize more established multi-item scales to measure the construct [15].

4.2. Conclusion

In conclusion, the current study expands the existing research and demonstrates the important role of trust in promoting vaccination intention and behaviors. Having strong faith in healthcare providers, public health agencies, and pharmaceutical companies were positively associated with the intention to receive COVID-19 vaccines. Differently, trust in politicians did not influence these variables. This study also provides evidence of trust’s indirect influence on attitude, behavioral intention, and uptake behavior via the mediation of perceptions and emotions.

4.3. Practice implications

This study provides useful implications for the communication of COVID-19 vaccines. First, healthcare providers such as doctors and nurses, as well as vaccine manufacturers, may be the most effective source to deliver information related to the COVID-19 vaccine to the public. Second, these health communicators need to highlight the effectiveness and safety of the vaccines while maintaining a positive tone when interacting with their audience. Additionally, campaigns targeting different segments of the population may utilize trusted sources rather than broad media distribution to approach their key public [48]. Other health professionals and agencies should also make efforts to increase public trust, such as by enhancing their transparency and be more responsive to public inquiries [7,13]. Further, campaigns should strategically emphasize certain aspects of the vaccine (e.g., effectiveness and safety) and use different tones (e.g., anger-reducing or hope-inducing) when interacting with the public.

CRediT authorship contribution statement

Sixiao Liu: Conceptualization, Methodology, Validation, Formal analysis, Writing – original draft. Haoran Chu: Conceptualization, Methodology, Formal analysis, Resources, Data curation, Writing – original draft preparation, Visualization.

Declaration of interest

None.

References

[1] Jeffery MM, D’Onofrio G, Paek H, Platts-Mills TF, Soares WE, Hoppe JA, et al. Trends in emergency department visits and hospital admissions in health care systems in 5 states in the first months of the COVID-19 pandemic in the US. JAMA Int Med 2020;180(10):1528–33.
[2] World Health Organization. World Health Organ Corona Dis (COVID-19). Dashboard 2022.
[3] Dubé E, Laberge C, Guay M, Bramadat P, Roy R, Bettinger JA. Vaccine hesitancy: an overview. Hum Vaccin Immunother 2013;9(8):1763–73.
[4] Omer SB, Salmon DA, Gorenstein WA, Dehart MP, Halsey N. Vaccine refusal, mandatory immunization, and the risks of vaccine-preventable diseases. N Engl J Med 2009;360(19):1981–8.

[5] Data OWi. Corona (COVID-19) Vaccin 2021.

[6] Freimuth VS, Jamison AM, An J, Hancock GR, Quinn SC. Determinants of trust in the flu vaccine for African Americans and Whites. Soc Sci Med 2017;193:70–9.

[7] Jamison AM, Quinn SC, Freimuth VS. “You don’t trust a government vaccine”: Narratives of institutional distrust and influenza vaccination among African American and white adults. Soc Sci Med 2019;221:87–94.

[8] Larson HU. The biggest pandemic risk? Viral misinformation. Nature 2018;562(7726):589–10.

[9] MacDonald NE. Vaccine hesitancy: Definition, scope and determinants. Vaccine 2015;33(34):4161–4.

[10] Lennon RP, Block Jr R, Schneider EC, Zephrin L, Shah A, Collaborative TAAR, et al. Underserved population acceptance of combination influenza-COVID-19 booster vaccines. Vaccine 2021.

[11] Larson HU, Jarrett C, Ekersberger E, Smith DM, Paterson P. Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007–2012. Vaccine 2014;32(19):2150–9.

[12] Nan X, Daily K, Richards A, Holt C, Wang MQ, Tracy K, et al. The role of trust in health information from medical authorities in accepting the HPV vaccine among African American parents. Hum Vaccin Immunother 2019;15(7–8):1723–31.

[13] Larson HU. Vaccine trust and the limits of information. Science 2016;353(6305):1207–8.

[14] Van Scoy LJ, Snyder B, Miller EL, Toyoobi O, Grewel A, Ha G, et al. Public anxiety and distrust due to perceived politicization and media sensationalism during early COVID-19 media messaging. J Health Commun 2021;14(4):193–205.

[15] Hall MA, Dugan E, Zheng B, Mishra AK. Trust in physicians and medical institutions: what is it, can it be measured, and does it matter? Milbank Q 2001;79(4):613–39.

[16] Freed GL, Clark SJ, Butchart AT, Singer DC, Davis MM. Sources and perceived credibility of vaccine-safety information for parents. Pediatrics 2011;127(Supplement 1):S107–12.

[17] Schoch-Spana M, Brunson EK, Gwon H, Regenbogen A, Toner ES, Daugherty-Biddison EL. Influence of community and culture in the ethical allocation of scarce medical resources in a pandemic situation: Deliberative democracy study. J Participat Med 2020;12(1):e18272.

[18] Zarecostani J. How to fight an infodemic. Lancet 2020;395(10225):676.

[19] Ajzen I. The theory of planned behavior. Organ Behav Hum Decis Process 1991;50(2):179–211.

[20] Siegrist M. The influence of trust and perceptions of risks and benefits on the acceptance of gene technology. Risk Anal 2000;20(2):195–204.

[21] Frewer LJ, Scholrdeer J, Bredahl L. Communicating about the risks and benefits of genetically modified foods: The mediating role of trust. Risk Anal 2003;23(6):1117–33.

[22] Jann NK, Becker MH. The health belief model: A decade later. Health Educ Q 1984;11(1):1–47.

[23] Witte K. Putting the fear back into fear appeals: The extended parallel process model. Commun Monogr 1992;59(4):320–49.

[24] Chu H, Liu S. Integrating health behavior theories to predict American’s intention to receive a COVID-19 vaccine. Patient Educ Couns 2021.

[25] Gerend MA, Shepherd JE. Predicting human papillomavirus vaccine uptake in young adult women: comparing the health belief model and theory of planned behavior. Ann Behav Med 2012;44(2):171–80.

[26] Arce JSS, Warren SS, Meriggi NF, Scacco A, McMurry N, Voors M, et al. COVID-19 vaccine acceptance and hesitancy in low and middle income countries, and implications for messaging, medRxiv 2021.

[27] Chapman GR, Coups EJ. Emotions and preventive health behavior: worry, regret, and influenza vaccination. Health Psychol 2006;25(1):82.

[28] Dillard JP, Nabi RL. The persuasive influence of emotion in cancer prevention and detection messages. J Commun 2006;56(suppl_1):S123–39.

[29] Liu S, Yang JZ. Incorporating Message Framing into Narrative Persuasion to Curb E-Cigarette Use Among College Students. Risk Anal 2020;40(8):1677–90.

[30] Chou W-Y, Budzen A. Considering emotion in COVID-19 vaccine communication: addressing vaccine hesitancy and fostering vaccine confidence. Health Commun 2020;35(14):1718–22.

[31] Dubé E, Vivion M, MacDonald NE. Vaccine hesitance, vaccine refusal and the anti-vaccine movement: influence, impact and implications. Expert Rev Vaccin 2015;14(1):99–117.

[32] Bean SJ. Emerging and continuing trends in vaccine opposition website content. Vaccine 2011;29(10):1874–80.

[33] Broniatowski DA, Jamison AM, Qi S, AliKulal L, Chen T, Benton A, et al. Weaponized health communication: Twitter bots and Russian trolls amplify the vaccine debate. Am J Public Health 2018;108(10):1378–84.

[34] Kara A. Anti-vaccine activists, Web 2.0, and the postmodern paradigm—An overview of tactics and tropes used online by the anti-vaccination movement. Vaccine 2012;30(25):3778–89.

[35] Lazarus RS. Cognition and motivation in emotion. Am Psychol 1991;46(4):352.

[36] Yang JZ, Chu H. Who is afraid of the Ebola outbreak? The influence of discrete emotions on risk perception. J Risk Res 2018;21(7):834–53.

[37] Smith CA, Ellsworth PC. Patterns of cognitive appraisal in emotional response. J Pers Soc Psychol 2001;79(4):806–19.

[38] Liu S, Yang JZ, Chu H. When we increase fear, do we dampen hope? Using narrative persuasion to promote human papillomavirus vaccination in China. J Health Psychol 2021;26(11):1999–2009.

[39] Lerner JS, Kelmer D. Fear, anger, and risk. J Pers Soc Psychol 2001;81(1):146–56.

[40] Palan S, Schitter C. Prolific. ac—A subject pool for online experiments. J Behav Exp Financ 2018;17:22–7.

[41] Spence JC, Rhodes RE, McCurdy A, Mangan A, Hopkins D, Mummery WK. Determinants of physical activity among adults in the United Kingdom during the COVID-19 pandemic: The DUK-COVID study. Br J Health Psychol 2021;26(2):888–905.

[42] Nabi RL, Gustafson A, Jensen R. Framing climate change: Exploring the role of emotion in generating advocacy behavior. Sci Commun 2018;40(4):442–68.

[43] Witte K, Meyer G, Martell D. Effective health risk messages: A step-by-step guide. Sagr., 2001.

[44] Brabin L, Roberts SA, Farzaneh F, Kitchener HC. Future acceptance of adolescent human papillomavirus vaccination: a survey of parental attitudes. Vaccine 2006;24(16):2087–94.

[45] Kline RB. Principles and Practice of Structural Equation Modeling. Guilford Publications; 2015.

[46] Li Hu, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct Equ Model 1999;6(1):1–55.

[47] Mathen B, Mathen L. Mplus: Chapman Hall/CRC 2017.

[48] Smith RA, Myrick JG, Lennon RP, Martin MA, Small ML, Van Scoy LJ, et al. Exploring behavioral typologies to inform COVID-19 health campaigns: a person-centered approach. J Health Commun 2021;26(4):402–13.