Examining four types of anti-vaccination attitudes prior to and during the COVID-19 pandemic

Ho Phi Huynh[1]

Abstract

People hold different anti-vaccination attitudes. Having an understanding of how these attitudes have changed prior to and during the COVID-19 pandemic is critical for combatting anti-vaccination attitudes and increasing vaccine intention and uptake. Data were collected from different samples in the United States at three time points prior to ($n = 840$) and four time points during ($n = 1543$) the pandemic. All participants completed a multi-dimensional measure of anti-vaccination attitudes (VAX Scale) through an online platform. Results showed that, when it comes to vaccines, worries about unforeseen side effects, concerns about commercial profiteering, and preference for natural immunity were higher during the COVID-19 pandemic than they were prior to it. However, mistrust of vaccine benefit was *lower* during the COVID-19 pandemic than prior to it. These differences were found even after controlling for the potential effects of participant sex, education, socioeconomic status, age, and race/ethnicity. Additionally, worries about unforeseen side effects, concerns about commercial profiteering, and preference for natural immunity increased linearly alongside the persistence of COVID-19; whereas, mistrust of vaccine benefit showed no change. Although it might be intuitive to emphasize vaccines' effectiveness to increase uptake, the public's trust in vaccine effectiveness did not appear to be the major concern. Thus, public health efforts to increase uptake of vaccines should also focus on reducing concerns about potential side effects from the vaccine, tempering the attention on financial benefits to pharmaceutical companies, and rebuffing the overreliance on natural immunity.

Keywords Anti-vaccination attitudes · Coronavirus · COVID-19 · Vaccine hesitancy · Vaccine

As of June 2022, there have been more than 500 million confirmed cases of COVID-19 worldwide and more than 86 million cases in the United States alone (John Hopkins University, 2020). Vaccines can combat the spread and harm of COVID-19 (CDC, 2021). However, anti-vaccination attitudes (Martin & Petrie, 2017) may thwart public health efforts by limiting vaccine intention and uptake (Hopkins & Wood, 2013; McCoy, 2020; Ogueji & Okoloba, 2022). Anti-vaccination sentiment is not new. For example, these attitudes were evident with the small pox program, and openly displayed with diphtheria, tetanus, and pertussis (DTP) and human papillomavirus (HPV) vaccines. More recent and notorious, the measles, mumps, and rubella (MMR) vaccine was falsely believed to cause autism leading to significantly lower uptake (for a review/history of vaccine hesitancy and anti-vaccination sentiment, see Dubé et al., 2021). The COVID-19 pandemic has only heightened awareness of the multifaceted factors that predict vaccination intention and uptake. For example, even prior to the COVID-19 pandemic, the World Health Organization identified the reluctance to receive recommended vaccines as one of the top 10 threats to global health (WHO, 2019).

Despite public health officials' recognition of the harm posed by these attitudes (e.g., WHO, 2019), discussions about these attitudes in the public domain as they relate to COVID-19 lack specificity and nuance. It appears from public discourse that these attitudes are indistinguishable and uniformly growing alongside the COVID-19 pandemic (e.g., Bertin et al., 2020; Palamenghi et al., 2020). However, that assumption may not be true. Martin and Petrie (2017) identified four key types of anti-vaccination attitudes: mistrusting the benefits of vaccination, worrying about unforeseen

✉ Ho Phi Huynh
  hhuynh@tamusa.edu

1   Texas A&M University - San Antonio, One University Way, 78224 San Antonio, TX, USA

side effects, having concerns about pharmaceutical companies profiteering, and preferring natural immunity. According to functional theories of attitudes (Katz, 1960; Shavitt, 1989), attitudes perform practical functions for the individual; for instance, they help people organize and structure the external world and lead them to strive for consistency in their decisions. Thus, anti-vaccination attitudes are related to vaccine intentions (Kahn et al., 2003; Paul et al., 2021), and vaccine intentions are strongly related to vaccine uptake (i.e., theory of planned behavior, Ajzen, 1991; Patel et al., 2012; Wang et al., 2022). Moreover, vaccine attitudes vary with beliefs in conspiracy theories, political orientation, and psychological malleability (Featherstone et al., 2019; Huynh & Senger, 2021; Martinez-Berman et al., 2020).

Additionally, some demographic factors have been identified as predictors of vaccine intention and uptake that should be considered in analyses examining anti-vaccination attitudes. Prior research has demonstrated that vaccination uptake is lower in women than in men and increases with age (Rodríguez-Rieiro et al., 2011; Setbon & Raude, 2010). Relatedly, older people are disproportionately affected by COVID-19 (CDC, 2021). Additionally, education and subjective socioeconomic status have been found to be significant predictors of influenza vaccine uptake (Maurer, 2016; Quin et al., 2017). Of course, in relation to COVID-19, race/ethnicity is critical to consider because communities of color have been disproportionately affected by COVID-19; for example, Black and Latinx Americans disproportionately account for both diagnoses and deaths (Millett et al., 2020).

The current paper aimed to provide a report of specific anti-vaccination attitudes in the U.S. before and during COVID-19 (July 2019 - October 2020). It tested whether assumptions about uniformed increases in anti-vaccination attitudes related to the occurrence and persistence of COVID-19 are valid. To that end, the author tested the following hypotheses, with the default assumption that all four types of anti-vaccination attitudes would behave similarly:

Hypothesis 1 Anti-vaccination attitudes were higher during the COVID-19 pandemic than they were prior to the onset of COVID-19.

Hypothesis 2 Anti-vaccination attitudes steadily increased as the pandemic progressed.

Method

Participants

The data in this study came from seven different collections from July 2019 to October 2020. This paper employs secondary analyses on these data, which were collected from 2,383 unique participants. The original purpose for the data collection varies by data collection and includes investigations into anti-vaccination attitudes and the seasonal flu, celebrity admiration, intellectual humility, openness to persuasive messages, intentions to vaccinate against COVID-19, and mask use during the COVID-19 pandemic. A total of 2,555 participants participated in the data collection, but 172 (6.73%) were excluded from the data analyses because they did not provide responses to the VAX Scale. A summary of participant demographics are presented in Table 1. Table 2 provides more information about the rate of deletion and purpose of each data collection effort.

All participants were recruited through Amazon Mechanical Turk (MTurk), a popular online crowdsourcing website used in the social sciences where people complete various surveys/tasks in exchange for a fee. MTurk participants tend to be more representative of the U.S. population than other samples of convenience even during the COVID-19 pandemic (Moss et al., 2020) and they tend to provide quality data on critical topics (Mellis & Bickel, 2020). Participants elected to participate in the study by clicking on a link that was posted on MTurk. It is not possible to know number of people who saw the link but did not click on it, thus it is not possible to provide a response rate, in terms of people who were recruited compared to people who responded to the survey. Information about participant compensation is provided in Table 2 for each data collection.

Procedures

All participants clicked on a link through the MTurk network that led them to a survey. Although the surveys differed in content based on their original data collection purpose, all of the surveys had the same flow. The first page of the survey presented information about the study and asked participants to indicate their consent prior to advancing to the study measures. Following this consent page, participants completed the main study measures, including the VAX Scale. Then, participants proceeded to provide demographic information. After that, participants read a debriefing statement and viewed contact information of the primary investigator. Finally, participants proceeded to collect a code, which would allow them to claim their fee for completing the study. All data collection efforts were approved by the author's Institutional Review Board.

Table 1 Summary of Participant Demographics and Study Measures Across Data Collection Dates

Data Collection Dates	July 2019[A]	Sept 2019[A]	Oct 2019[A]	April 2020[B]	June 2020[B]	Oct 4, 2020[B]	Oct 30, 2020[B]	Total
N	115	42	683	372	436	372	363	2383
% Female	28.95	42.86	40.5	41.9	38.3	34.7	37.8	38.8
Age (SD)	38.18 (9.16)	39.38 (9.56)	36.72 (11.14)	37.15 (11.5)	36.07 (10.22)	40.12 (11.71)	38.78 (11.97)	37.67 (11.24)
Race/Ethnicity %								
White/Caucasian	82.30	69.05	68.91	73.39	75.00	67.04	75.84	72.20
Black/AA	4.42	9.52	15.40	8.60	10.42	20.78	8.15	12.50
Asian/P.I.	4.42	11.90	5.98	4.57	3.24	3.88	7.02	5.10
Hispanic/Latino	2.65	4.76	4.48	6.72	6.94	2.77	5.34	5.10
Multiracial/Other	6.19	4.76	5.23	6.72	4.40	5.54	3.65	5.10
Anti-Vaccination Attitudes M (SD)								
Mistrust of vaccine benefit^	2.55 (1.27)	2.58 (1.41)	2.67 (1.11)	2.37 (1.05)	2.50 (1.01)	2.23 (0.91)	2.33 (0.99)	2.46 (1.11)
Worries about unforeseen effects*	3.35 (1.49)	3.4 (1.38)	3.11 (1.35)	3.56 (1.34)	3.69 (1.19)	4.452 (1.14)	4.35 (1.13)	3.70 (1.29)
Concerns about commercial profit*	2.61 (1.56)	2.58 (1.62)	2.67 (1.42)	3.13 (1.52)	3.38 (1.45)	4.18 (1.38)	4.14 (1.36)	3.24 (1.47)
Preference for natural immunity*	2.73 (1.54)	2.63 (1.37)	2.79 (1.42)	3.23 (1.48)	3.53 (1.36)	4.32 (1.33)	4.24 (1.32)	3.35 (1.40)

Notes: [A] = prior to COVID-19; [B] = during COVID-19; Hypothesis 1: * = [B] > [A], $p < .05$; ^ = [B] < [A], $p < .05$. Hypothesis 2: * = [B] increased linearly, $p < .05$; ^ = no change in [B]

Table 2 Additional details about each data collection effort

Data Collection	Attempted Survey	N	Deleted	% Deleted	Average Completion Time in mins. (SD)	Compensation (USD)	Original Purpose of Study
July 2019	122	115	7	5.74	15.98 (5.31)	1.5	Anti-vaccination attitudes and attitudes toward the seasonal flu vaccine
Sept 2019	46	42	4	8.70	17.53 (5.95)	1.5	Anti-vaccination attitudes and responses to a brief intervention (pilot)
Oct 2019	763	683	80	10.48	8.79 (6.79)	0.75	Celebrity admiration and anti-vaccination attitudes
April 2020	392	372	20	5.10	13.55 (7.35)	2.5	Intellectual humility and anti-vaccination attitudes
June 2020	476	436	40	8.40	8.01 (3.98)	1.2	Vaccination attitudes and openness to persuasive messages
Oct 4, 2020	383	372	11	2.87	7.18 (6.74)	1	Predictors of intentions to vaccinate against COVID-19
Oct 30, 2020	373	363	10	2.68	7.12 (6.72)	1	Predictors of COVID-19 vaccination and mask use
Total	2555	2383	172	6.73	11.62	1.35	

Measures

Anti-vaccination attitudes were assessed using the Vaccine Attitudes Examination (VAX) Scale (Martin & Petrie, 2017). The original scale was developed and validated using two diverse samples of community-living adults and college students ($N = 409$) and community-living adults ($N = 92$) in the U.SA. An independent replication using UK adults showed that the scale demonstrated good internal consistency, convergent and construct validity (Wood et al., 2019). At the time of writing, the scale had been cited by 140 different publications according to Google Scholar and had been translated into several languages (e.g., Romanian, Huza, 2020; Turkish, Yildiz et al., 2021; Italian,Bruno et

al., 2022). The VAX Scale has four subscales, with three items for each. The subscale is listed with a sample item in parentheses and corresponding reliability score: (1) Mistrust of Vaccine Benefit ("I feel safe after being vaccinated." [R]), $\alpha = 0.88$; (2) Worries about Unforeseen Future Effects ("I worry about the unknown effects of vaccines in the future."), $\alpha = 0.87$; (3) Concerns about Commercial Profiteering ("Vaccines make a lot of money for pharmaceutical companies, but do not do much for regular people."), $\alpha = 0.87$; and (4) Preference for Natural Immunity ("Natural immunity lasts longer than a vaccination."), $\alpha = 0.92$. Participants indicated their (dis)agreement with the 12 statements using a six-point Likert-like scale (1) = strongly disagree and (6) = strongly agree. Higher scores indicate stronger

anti-vaccination attitudes. In addition to the VAX Scale, participants provided information about their age, sex, and race/ethnicity. Means and standard deviations of the VAX scale and demographic information are listed in Table 1.

Data Analysis

Analyses were conducted using IBM SPSS Statistics 27. For all analyses, participants who had missing data were excluded from the analyses (i.e., in SPSS, case-by-case for t-tests; listwise for regression). Missing data were not replaced/inputted in anyway.

To test Hypothesis 1, participants from the three time points prior to COVID-19 were combined into one group (Group A) and participants from the four time points during COVID-19 were combined into another group (Group B). Then, the means of each of the four anti-vaccination attitudes, which were derived from averaging participants' responses to each sub-scale of the VAX Scale (see above), were compared between Group A and Group B via independent samples t-tests. Additionally, the potential effect of participant characteristics (i.e., sex, education, social economic status, age, race/ethnicity) were examined by conducting multiple regression analyses with each anti-vaccination attitude as the outcome, and date of data collection (before vs. during the pandemic) and participant characteristics as predictor variables. To test Hypothesis 2, linear contrast weights (Rosenthal & Rosnow, 1985) were assigned to the four time points during COVID-19. This approach examined the trend in mean scores of each anti-vaccination attitude across the four time points. Thus, the analyses combined Likert categories on the VAX scale by averaging the numeric responses. The alpha for all significance tests were set at 0.05.

Prior to conducting the analyses, assumptions for t-tests were examined. First, data belonged to unique participants, which meets the independence of observations assumption. Secondly, a check for outliers was conducted by checking the z-scores to ensure that no score was larger than 3.29 (absolute value). Third, a test of the normality assumption was conducted by examining the skewness of and kurtosis of anti-vaccination scores. Skewness scores for unforeseen side effects, commercial profiteering, and preference for natural immunity were under 1 (-0.30, 0.02, −0.09, respectively). However, skewness for mistrust of vaccine benefits was 1.25, which was higher than the typical benchmark of 1. In terms of kurtosis, mistrust of vaccine benefits, commercial profiteering, and preference for natural immunity were all above 1 (absolute value; 1.79, -1.34, -1.25, respectively). Kurtosis for unforeseen side effects was − 0.89. Despite the violations of this normality assumption given the skewness and kurtosis scores, independent samples t-test and linear

regression are robust enough to handle these violations given the large sample size in our study (see Lumley et al., 2002 for a demonstration). Because of the t-test's robustness against the violation of this assumption, we proceeded with its use. We elected not to transform the data because transformations can lead to non-intuitive interpretations of the outcome. To address the homogeneity of variances assumption, we relied on SPSS's report of Levene's Test of Equality of Variances and reported the adjusted values when this assumption was violated. Moreover, assumptions for multiple regression were tested prior to conducting the analyses. We tested to see whether multicollinearity was an issue among the predictors. The highest variance inflation factor (VIF) value was 1.15, which is lower than the conservative benchmark of 5 (Tabachnick & Fidell, 2007), suggesting that multicollinearity was not an issue. Additionally, P-P plots and residual scatter plots supported linearity and homoscedasticity assumptions. The range for Cook's Distance scores (0 − 0.01) indicated that there were no outliers.

Results

To test Hypothesis 1, independent samples t-tests were used to compare anti-vaccination attitudes prior to ($n = 840$) and during COVID-19 ($n = 1,543$). The analyses revealed that worries about unforeseen future effects were higher during COVID-19 ($M = 4.00$, $SD = 1.26$) than prior to COVID-19 ($M = 3.16$, $SD = 1.47$), $t(2,381) = 15.00$, $p < .0001$, $d = 0.61$. Additionally, concerns about commercial profiteering were higher during COVID-19 ($M = 3.69$, $SD = 1.50$) than prior to COVID-19 ($M = 2.66$, $SD = 1.45$), $t(2,381) = 16.25$, $p < .0001$, $d = 0.70$. Similarly, preference for natural immunity was higher during COVID-19 ($M = 3.82$, $SD = 1.44$) than prior to COVID-19 ($M = 2.77$, $SD = 1.43$), $t(2,381) = 16.86$, $p < .0001$, $d = 0.73$. However, mistrust of vaccine benefit was *lower* during COVID-19 ($M = 2.36$, $SD = 0.99$) than prior to COVID-19 ($M = 2.65$, $SD = 1.15$), $t(2,381) = -6.40$, $p < .0001$, $d = 0.27$. In addition, multiple regression analyses revealed that these differences were present even when accounting for the potential effects of participant demographics (i.e., sex, education, socioeconomic status, age, and race/ethnicity). See Table 3 for a summary of the multiple regression analyses.

To test Hypothesis 2, contrast weights were assigned (-3, -1, 1, 3) to test for a linear trend in the four time points in which data were collected during COVID-19. The analyses revealed that three anti-vaccination attitudes have increased: worries about unforeseen future effects $t(1539) = 11.18$, $p < .0001$, $\eta^2_p = 0.08$; concerns about commercial profiteering $t(1539) = 11.56$, $p < .0001$, $\eta^2_p = 0.08$; and preference for natural immunity, $t(1539) = 11.97$, $p < .0001$, $\eta^2_p = 0.09$.

Table 3 Participant Characteristics as Predictors of Anti-Vaccination Attitudes

Outcome	Model Significance	R Squared	Predictors	B	t	95% CI Lower	95% CI Upper
Side Effects	F(6, 2589) = 82.32, p < .001*	0.16	Prior vs. During	0.78***	14.72	0.68	0.88
			Sex	-0.04	-0.73	-0.14	0.06
			Education	0.04	1.81	0.00	0.08
			SES	0.14***	10.08	0.11	0.16
			Age	0.00	0.70	0.00	0.00
			Race/Ethnicity	-0.25***	-4.35	-0.36	-0.13
Profiteering	F(6, 2589) = 116.70, p < .001*	0.21	Prior vs. During	0.93***	15.90	0.81	1.04
			Sex	0.15**	2.63	0.04	0.26
			Education	0.09***	3.91	0.05	0.14
			SES	0.19***	12.53	0.16	0.22
			Age	0.00	0.83	0.00	0.00
			Race/Ethnicity	-0.23***	-3.64	-0.35	-0.10
Natural Immunity	F(6, 2587) = 116.57, p < .001*	0.21	Prior vs. During	0.91***	15.98	0.80	1.02
			Sex	0.15**	2.76	0.04	0.26
			Education	0.04	1.83	0.00	0.09
			SES	0.20***	13.94	0.17	0.23
			Age	0.00	0.92	0.00	0.00
			Race/Ethnicity	-0.16**	-2.68	-0.28	-0.04
Benefits	F(6, 2590) = 10.68, p < .001*	0.02	Prior vs. During	-0.09*	-2.12	-0.18	-0.01
			Sex	-0.01	-0.29	-0.09	0.07
			Education	-0.04*	-2.39	-0.08	-0.01
			SES	-0.06***	-5.20	-0.08	-0.04
			Age	0.00	-0.88	0.00	0.00
			Race/Ethnicity	-0.02	-0.49	-0.11	0.07

Notes: All values are unstandardized coefficients. *p < .05; ** p < .01; *** p < .001

However, mistrust in vaccine benefits during COVID-19 remained stable, $t(1539) = -1.66$, $p = .10$, $\eta^2_p = 0.002$. That is, scores for mistrust in vaccine benefits did not statistically fluctuate the during-COVID-19 time points assessed. All means and standard deviations for each data collection time are presented in Table 1. See Fig. 1 for a visual summary of the examined trends.

Discussion

Hypothesis 1, which stated that anti-vaccination attitudes were higher during the COVID-19 pandemic than they were prior to it, was supported by three types of anti-vaccination attitudes. Worries about unforeseen future effects, concerns about commercial profiteering, and preference for natural immunity were higher during the COVID-19 pandemic than they were prior to it. However, mistrust of vaccine benefit was lower during the COVID-19 pandemic than prior to it. Finally, Hypothesis 2, which stated that anti-vaccination attitudes have increased alongside the persistence of the COVID-19 pandemic, was confirmed for three types of anti-vaccination attitudes. Worries about unforeseen future effects, concerns about commercial profiteering, and preference for natural immunity increased with the persistence

of COVID-19. However, mistrust of vaccine benefit has remained statistically unchanged during the persistence of the COVID-19 pandemic. Hypothesis 2 is different from Hypothesis 1 in that Hypothesis 2 only considers anti-vaccination attitudes after the onset of COVID-19. Whereas Hypothesis 1 compares anti-vaccination attitudes people had prior to COVID-19 with anti-vaccination attitudes people had during COVID-19, Hypothesis 2 examined whether people's anti-vaccination attitudes increased from after when COVID-19 began to three time points after that. Thus, results regarding Hypothesis 2 demonstrate that once COVID-19 began, worries about unforeseen future effects, concerns about commercial profiteering, and preference for natural immunity increased, while mistrust of vaccine benefit remained statistically steady.

Taken together, the evidence suggests that many anti-vaccination attitudes have increased alongside the occurrence and persistence of COVID-19. However, not all anti-vaccination attitudes have worsened at the same rate. The data indicate that mistrust of vaccine benefits decreased following the onset of the pandemic (Hypothesis 1), and has not worsened at the same rate as the other three types of anti-vaccination attitudes (Hypothesis 2). This trend signals potentially more trust in vaccines' benefits (or at least not a declining mistrust of benefits) generally. Theoretically,

Anti-Vaccination Attitudes Across Time
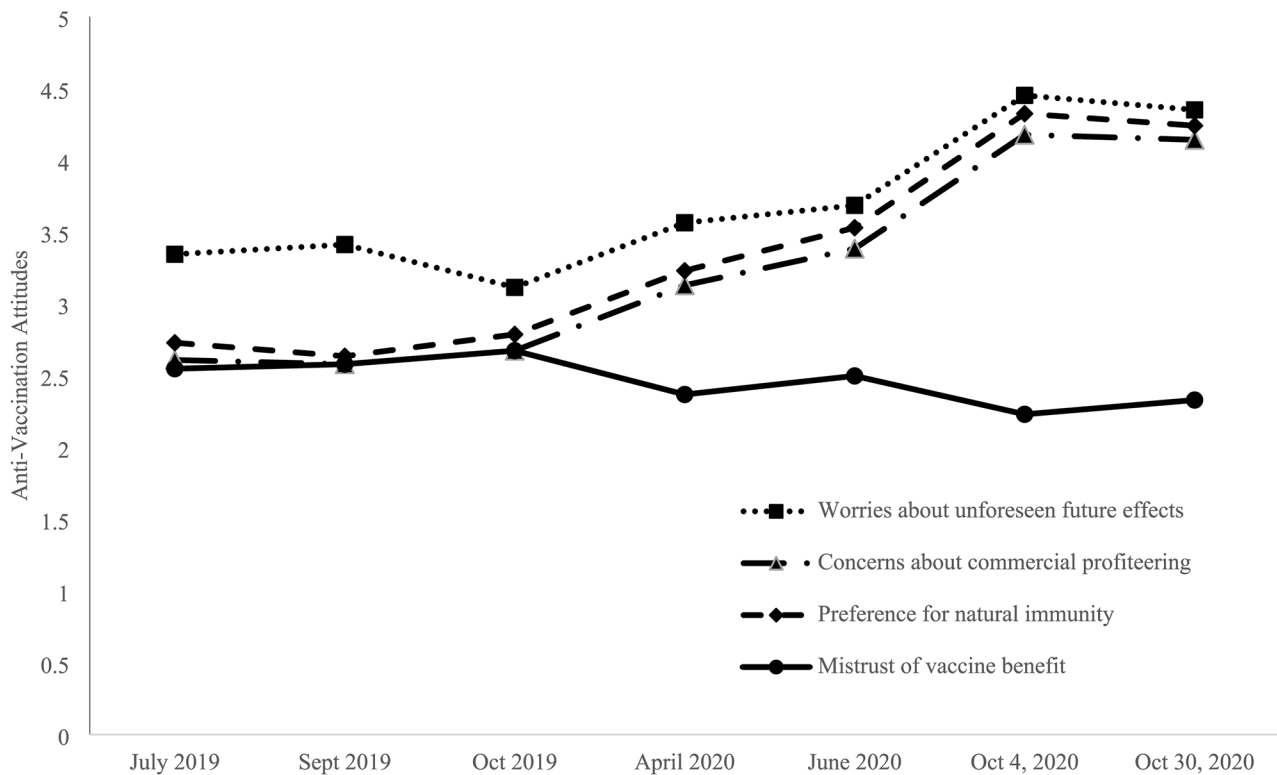
Fig. 1 Anti-vaccination attitudes across time. Mistrust of vaccine benefit is relatively stable over time. Worries about unforeseen future effects, concerns about commercial profiteering, and preference for natural immunity have increased during months when COVID-19 was active

these findings support the need to discuss the precarious rise in anti-vaccination attitudes with more specificity. It is incomplete to say that anti-vaccination attitudes are uniformly worsening. While most are indeed worsening, one (and potentially more) is not worsening or worsening at the same rate as the others. This nuanced approach enables the potential pursuit of intervention programs to decrease anti-vaccination attitudes and vaccine hesitancy to be more precise and effective.

Practically, these findings are critical to consider for health communication and public health messaging during the distribution of vaccines. Although it might be intuitive to emphasize the vaccines' effectiveness to increase vaccine uptake, the data suggest that the public's trust in vaccines' effectiveness is not the main concern. Thus, public health efforts to increase uptake of the vaccines should also focus on dispelling worries about potential side effects from the vaccine, tempering concerns about the financial benefits to pharmaceutical companies, and rebuffing the overreliance on natural immunity.

Limitations and future directions

There are important limitations to consider when interpreting these results. First, these data report anti-vaccination attitudes that overlap with the existence and persistence of COVID-19. These data cannot explicitly determine whether COVID-19 caused these shifts in anti-vaccination attitudes. Moreover, the final composition of demographics indicated that most of the data came from white, male participants. Future studies can address this issue by stratifying their recruitment efforts. This issue may be especially important because COVID-19 disproportionately affects poorer communities and communities of color (Baquero et al., 2020; Chatters et al., 2020; Kim & Bostwick, 2020; Millet et al., 2020).

Furthermore, anti-vaccination attitudes are complex and related to a host of psychosocial and cultural issues (e.g., intellectual humility, Senger & Huynh, 2020; celebrity worship, Martinez-Berman et al., 2020; political orientation and trust in physicians, Huynh et al., 2021; health literacy, Turhan et al., 2021). In particular, political orientation has emerged as a strong predictor of COVID-related health

behaviors. For example, researchers found that political orientation was the most consistent predictor of intentions to vaccinate for COVID-19 among factors such as sex, age, race, education, socioeconomic status, prior flu shot uptake, subjective health, beliefs about susceptibility, and subjective norms surround COVID-19 vaccinations (Huynh et al., 2021). Unfortunately, the current study failed to account for this important factor because a measure of this construct was not included in early surveys. Thus, future research should address these complex relationships alongside changing anti-vaccination attitudes related to COVID-19 (e.g., Eaton & Kalichman, 2020).

Moreover, it is important to note that the literature links vaccination attitudes to vaccine intentions (Kahn et al., 2003; Paul et al., 2021), and vaccine intentions predict vaccine uptake (Patel et al., 2012; Wang et al., 2022). However, a direct link between vaccine attitudes and vaccine uptake has not been clearly demonstrated in the literature (Brewer, 2021). Therefore, although anti-vaccination attitudes are important to study in their relation to vaccine intentions, further research (e.g.,experiments, longitudinal designs) is necessary to provide a direct link between vaccine attitudes and uptake. Thus, although the study makes an important contribution in terms of knowledge about varied anti-vaccination attitudes related to COVID-19, the results should be interpreted judiciously given the study's limitations.

Data Availability The data that support the findings of this study are available upon reasonable request from the corresponding author.

Declarations

Conflict of interest The corresponding author states that there is no conflict of interest.

Ethics approval The questionnaire and methodology for this study was approved by the Institutional Review Board at Texas A&M University – San Antonio (Protocols #2019-06 & 2020-04).

Consent to participate Informed consent was obtained from all individual participants included in the study.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Baquero, B., Gonzalez, C., Ramirez, M., Chavez Santos, E., & Ornelas, I. J. (2020). Understanding and addressing Latinx COVID-19 disparities in Washington State. *Health Education & Behavior*, *47*(6), 845–849. https://doi.org/10.1177/1090198120963099

Bertin, P., Nera, K., & Delouvée, S. (2020). Conspiracy beliefs, rejection of vaccination, and support for hydroxychloroquine: A conceptual replication-extension in the COVID-19 pandemic context. *Frontiers in Psychology*, *11*, 2471. https://doi.org/10.3389/fpsyg.2020.565128

Brewer, N. T. (2021). What works to increase vaccination uptake. *Academic Pediatrics*, *21*(4), S9–S16. https://doi.org/10.1016/j.acap.2021.01.017

Bruno, F., Laganà, V., Pistininzi, R., Tarantino, F., Martin, L., & Servidio, R. (2022). Validation and psychometric properties of the Italian Vaccination Attitudes Examination (VAX-I) scale. *Current Psychology*, 1–11. https://doi.org/10.1007/s12144-022-03209-5

Chatters, L. M., Taylor, H. O., & Taylor, R. J. (2020). Older Black Americans during COVID-19: Race and age double jeopardy. *Health Education & Behavior*, *47*(6), 855–860. https://doi.org/10.1177/1090198120965513

Centers for Disease Control and Prevention (CDC) (2021, December 23). *COVID-19 vaccines are effective.* https://www.cdc.gov/coronavirus/2019-ncov/vaccines/effectiveness/index.html

Center for Disease Control and Prevention (CDC) (2021, March 29). *COVID-19. Older Adults.* https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/older-adults

Dubé, È., Ward, J. K., Verger, P., & MacDonald, N. E. (2021). Vaccine hesitancy, acceptance, and anti-vaccination: trends and future prospects for public health. *Annual Review of Public Health*, *42*(1), 175–191. https://doi.org/10.1146/annurev-publhealth-090419-102240

Eaton, L. A., & Kalichman, S. C. (2020). Social and behavioral health responses to COVID-19: lessons learned from four decades of an HIV pandemic. *Journal of Behavioral Medicine*, *43*(3), 341–345. https://doi.org/10.1007/s10865-020-00157-y

Featherstone, J. D., Bell, R. A., & Ruiz, J. B. (2019). Relationship of people's sources of health information and political ideology with acceptance of conspiratorial beliefs about vaccines. *Vaccine*, *37*(23), 2993–2997. https://doi.org/10.1016/j.vaccine.2019.04.063

Hopkins, T. G., & Wood, N. (2013). Female human papillomavirus (HPV) vaccination: Global uptake and the impact of attitudes. *Vaccine*, *31*(13), 1673–1679. https://doi.org/10.1016/j.vaccine.2013.01.028

Huynh, H., Zsila, A., & Martinez-Berman, L. (2021). Psychosocial factors associated with vaccination intention against the Coronavirus (COVID-19). *Behavioral Medicine Advance online publication.* https://doi.org/10.1080/08964289.2021.1990006

Huynh, H., & Senger, A. (2021). A little shot of humility: Intellectual humility predicts vaccination attitudes and intention to vaccinate against covid-19. *Journal of Applied Social Psychology*. Online First. https://doi.org/10.1111/jasp.12747

Huza, G. (2020). The psychometric properties of a Romanian version of the Vaccination Attitudes Examination (VAX) scale. *International Journal of HIV/AIDS Prevention Education and Behavioural Science*, *6*(1), 25. https://doi.org/10.11648/j.ijhpebs.20200601.14

John Hopkins University (2020). November).Coronavirus Resource Center. https://coronavirus.jhu.edu/

Kahn, J. A., Rosenthal, S. L., Hamann, T., & Bernstein, D. I. (2003). Attitudes about human papillomavirus vaccine in young women. *International Journal of STD & AIDS*, *14*(5), 300–306. https://doi.org/10.1258/095646203321605486

Katz, D. (1960). The functional approach to the study of attitudes. *Public Opinion Quarterly*, *24*(2), 163–204. https://doi.org/10.1086/266945

Kim, S., & Bostwick, W. (2020). Social vulnerability and racial inequality in covid-19 deaths in Chicago. *Health Education & Behavior*, *47*(4), 509–513. https://doi.org/10.1177/1090198120929677

Lumley, T., Diehr, P., Emerson, S., & Chen, L. (2002). The importance of the normality assumption in large public health data sets. *Annual Review of Public Health*, *23*(1), 151–169. https://doi.org/10.1146/annurev.publhealth.23.100901.140546

Martin, L. R., & Petrie, K. J. (2017). Understanding the dimensions of anti-vaccination attitudes: The vaccination attitudes examination

(VAX) scale. *Annals of Behavioral Medicine*, *51*(5), 652–660. https://doi.org/10.1007/s12160-017-9888-y

Martinez-Berman, L., McCutcheon, L., & Huynh, H. P. (2020). Is the worship of celebrities associated with resistance to vaccinations? Relationships between celebrity admiration, anti-vaccination attitudes, and beliefs in conspiracy. *Psychology Health & Medicine*, 1–10. https://doi.org/10.1080/13548506.2020.1778754

Maurer, J. (2016). Inspecting the mechanism: a longitudinal analysis of socioeconomic status differences in perceived influenza risks, vaccination intentions, and vaccination behaviors during the 2009–2010 influenza pandemic. *Medical Decision Making, 36*(7), 887–899. https://doi.org/10.1177/0272989X15608379

McCoy, C. A. (2020). The social characteristics of Americans opposed to vaccination: Beliefs about vaccine safety versus views of US vaccination policy. *Critical Public Health*, *30*(1), 4–15. https://doi.org/10.1080/09581596.2018.1501467

Mellis, A. M., & Bickel, W. K. (2020). Mechanical Turk data collection in addiction research: Utility, concerns and best practices. *Addiction*. https://doi.org/10.1111/add.15032

Millett, G. A., Jones, A. T., Benkeser, D., Baral, S., Mercer, L., Beyrer, C., & Sullivan, P. S. (2020). Assessing differential impacts of COVID-19 on black communities. *Annals of Epidemiology*, *47*, 37–44. https://doi.org/10.1016/j.annepidem.2020.05.003

Moss, A. J., Rosenzweig, C., Robinson, J., & Litman, L. (2020). Demographic stability on Mechanical Turk despite COVID-19. *Trends in Cognitive Sciences*. https://www.cell.com/trends/cognitive-sciences/pdf/S1364-6613(20)30138-8.pdf

Ogueji, I. A., & Okoloba, M. M. (2022). Underlying factors in the willingness to receive and barriers to receiving the COVID-19 vaccine among residents in the UK and Nigeria: A qualitative study. *Current Psychology*, 1–12. https://doi.org/10.1007/s12144-021-02498-6

Palamenghi, L., Barello, S., Boccia, S., & Graffigna, G. (2020). Mistrust in biomedical research and vaccine hesitancy: The forefront challenge in the battle against COVID-19 in Italy. *European Journal of Epidemiology*, *35*(8), 785–788. https://doi.org/10.1007/s10654-020-00675-8

Patel, D. A., Zochowski, M., Peterman, S., Dempsey, A. F., Ernst, S., & Dalton, V. K. (2012). Human papillomavirus vaccine intent and uptake among female college students. *Journal of American College Health*, *60*(2), 151–161. https://doi.org/10.1080/07448481.2011.580028

Paul, E., Steptoe, A., & Fancourt, D. (2021). Attitudes towards vaccines and intention to vaccinate against COVID-19: Implications for public health communications. *The Lancet Regional Health-Europe*, *1*, 100012. https://doi.org/10.1016/j.lanepe.2020.100012

Rodríguez-Rieiro, C., Esteban-Vasallo, M. D., Domínguez-Berjón, M. F., Astray-Mochales, J., Iniesta-Fornies, D., Barranco-Ordoñez, D., & Jiménez-García, R. (2011). Coverage and predictors of vaccination against 2009 pandemic H1N1 influenza in Madrid, Spain. *Vaccine, 29*(6), 1332–1338. https://doi.org/10.1016/j.vaccine.2010.10.061

Rosenthal, R., & Rosnow, R. L. (1985). *Contrast analysis: Focused comparisons in the analysis of variance*. CUP Archive.

Senger, A. R., & Huynh, H. P. (2020). Intellectual humility's association with vaccine attitudes and intentions. *Psychology Health & Medicine*, 1–10. https://doi.org/10.1080/13548506.2020.1778753

Setbon, M., & Raude, J. (2010). Factors in vaccination intention against the pandemic influenza A/H1N1. *European Journal of Public Health*, *20*(5), 490–494. https://doi.org/10.1093/eurpub/ckq054

Shavitt, S. (1989). Operationalizing functional theories of attitude. In A. R. Pratkanis, S. J. Breckler, & A. G. Greenwald (Eds.), *Attitude structure and function* (pp. 311–337). Lawrence Erlbaum Associates, Inc.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics (7th edition)*. Pearson.

Turhan, Z., Dilcen, H. Y., & Dolu, Ä. (2021). The mediating role of health literacy on the relationship between health care system distrust and vaccine hesitancy during COVID-19 pandemic. *Current Psychology*, 1–10. https://doi.org/10.1007/s12144-021-02105-8

Wang, J., Zhu, H., Lai, X., Zhang, H., Huang, Y., Feng, H., & Fang, H. (2022). From COVID-19 vaccination intention to actual vaccine uptake: A longitudinal study among Chinese adults after six months of a national vaccination campaign. *Expert Review of Vaccines*, *21*(3), 385–395. https://doi.org/10.1080/14760584.2022.2021076

Wood, L., Smith, M., Miller, C. B., & O'Carroll, R. E. (2019). The internal consistency and validity of the Vaccination Attitudes Examination Scale: A replication study. *Annals of Behavioral Medicine*, *53*(1), 109–114. https://doi.org/10.1093/abm/kay043

World Health Organization (WHO) (2019). *Ten threats to global health in 2019*. https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019

Yildiz, E., Gungormus, Z., & Dayapoglu, N. (2021). Assessment of validity and reliability of the turkish version of the vaccination attitudes examination (VAX) scale. *International Journal of Caring Sciences*, *14*, 261–268.