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COVID-19 vaccine uptake and attitudes towards mandates in a nationally representative U.S. sample

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Abstract Widespread uptake of COVID-19 vaccination is vital to curtailing the pandemic, yet rates remain suboptimal in the U.S. Vaccine mandates have previously been successful, but are controversial. An April 2021 survey of a nationally representative sample (N = 1208) examined vaccine uptake, attitudes, and sociodemographic characteristics. Sixty-seven percent were vaccine acceptors, 14% wait-and-see, and 19% non-acceptors. Compared to wait-and-see and non-acceptors, acceptors were more likely to have a household member over age 65, have received a flu shot, have positive COVID-19 vaccine attitudes, and view COVID-19 vaccination as beneficial. Mandate support was higher among respondents who were vaccine acceptors, had positive views about COVID-19 vaccines, believed in COVID-19 preventive strategies, perceived COVID-19 as severe, were liberal, resided in the Northeast, were non-White, and had incomes < $75,000. Public health campaigns should target attitudes that appear to drive hesitancy and prepare for varying mandate support based on demographics, COVID-19 vaccine attitudes, and the scope of the mandate.

Keywords COVID-19 · Vaccine hesitancy · Vaccine mandates · Vaccination · Vaccine attitudes

Introduction

Widespread uptake of COVID-19 vaccination is vital to curtailing the pandemic, yet, despite their increasing accessibility throughout the United States, vaccination rates remain suboptimal. Public opinion regarding COVID-19 vaccines has evolved rapidly over the course of vaccine testing and rollout (Lin et al., 2020). Previous research on vaccine hesitancy has demonstrated that decision-making across a range of vaccines is generally influenced by factors identified by both the Health Belief Model (HBM) and Theory of Planned Behavior (TPB). HBM illustrates that the likelihood of an individual engaging in a specific health behavior is determined by belief in personal susceptibility to and perceived severity of the illness, and belief in the benefits of the target health behavior over the barriers (Rosenstock, 1974). According to TPB, positive or negative behavioral beliefs (attitudes), social norms, and perceived behavioral control influence intention to perform the target health behavior (Fishbein & Ajzen, 1975).

These well-established theoretical models have recently been applied to identify factors impacting intention to accept COVID-19 vaccines among U.S. adults. One national study conducted in September 2020 found that participants perceived COVID-19 as severe, but had a comparatively lower sense of perceived susceptibility and fear of the disease (Chu & Liu, 2021). Additionally, having positive attitudes towards vaccines in general was associated with COVID-19

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vaccination intention (Chu & Liu, 2021). Similarly, another large survey from July 2020 found that positive attitudes towards COVID-19 vaccines, high perceived susceptibility to COVID-19, positive subjective social norms, and high perceived benefits of vaccination were associated with intention to vaccinate, while safety concerns were negatively associated (Guidry et al., 2021). Additional studies have also found that sociodemographic characteristics (e.g. gender, income, education, race/ethnicity) and attitudes (e.g. political views, low confidence or trust in vaccines overall, concerns regarding COVID-19 vaccine safety and side effects) have been associated with COVID-19 vaccine hesitancy (Kreps et al., 2020; Latkin et al., 2021; Lin et al., 2020; Paul et al., 2021).

Vaccine mandates have historically been an effective public health strategy to increase immunization rates and decrease the incidence of vaccine preventable diseases (Haeder, 2021; Lantos et al., 2010). While there is general public acceptance of childhood vaccines and policies requiring them for school entry (Chevallier et al., 2021; Gowda & Dempsey, 2013), mandates have become more controversial with rising vaccine hesitancy (Gowda & Dempsey, 2013). Given the dire need to increase COVID-19 vaccination rates, the use of mandates has been proposed among some adult population subgroups—e.g. healthcare workers (HCWs), nursing home residents, school teachers and travelers to certain countries. This strategy has already been widely implemented for influenza vaccination through requirements for HCWs, which were enacted to both protect patients from the risk of nosocomial flu transmission and to prevent workforce disruption from illness among HCWs (Klompas, et al., 2021).

Much of the research to date on public attitudes towards COVID-19 vaccines was completed prior to vaccine availability, and measured intention rather than real-time uptake; inevitably, attitudes will change over the course of the pandemic. Understanding this evolution has important implications for approaches to the varying stages of future public health crises. Thus, in a nationally representative sample, we examined attitudes towards COVID-19 vaccines and vaccine mandates at a time when vaccine implementation was in a relatively early stage, with the goal of informing public health strategies to promote vaccination.

Methods

Data were compiled from Ipsos KnowledgePanel®, a national U.S. survey of non-institutionalized adults ages 18 and older. Ipsos recruits this panel using an Address-Based Sampling (ABS) methodology through which members are recruited from the universe of all U.S. residential addresses, secured from the latest Delivery Sequence File (DSF) of the U.S. Postal Service. The panel is stratified to increase the selection rates for household types with historically higher attrition rates, such as households including younger adults and Spanish-only speakers. As needed, Ipsos provides households with complimentary tablets or laptop computers and internet access for survey participation and technical support. By using this national survey company, we were able to survey a respondent panel that is representative of the U.S. population as a whole, and that includes participants who might not otherwise be included due to limited technological access.

The survey was administered April 7–22, 2021. State vaccine eligibility guidelines were rapidly changing at that time; according to the individual state health department websites, 10 states—including California, Illinois, Massachusetts, Missouri, New Jersey, Oregon, Pennsylvania, Vermont, Virginia and Washington—had not yet opened eligibility to all individuals aged 16 and older. In addition, several states had only expanded eligibility to all adults in the weeks immediately prior, and accessibility of vaccine appointments varied widely. Further, to our knowledge, private and public sector vaccination mandates were in discussion, but had not been enacted at the time of data collection. There were 1208 respondents, 50 of whom completed the survey in Spanish. The data for this analysis included both items that are part of the routine data collection for Ipsos and data collected specifically for this study.

Questionnaire

Scales and items measuring experiences and attitudes

For each scale, items were administered in random order to minimize potential ordering effects. Unless otherwise specified, all attitude scale items used a 5-point Likert response format ranging from strongly disagree (1) to strongly agree (5). Table 1 provides the psychometric properties for each scale, including number of items, means, and coefficient alpha values. The full list of survey scale items is shown in Table 2.

Sociodemographics

The survey assessed a range of sociodemographic characteristics (shown in Table 3), including gender, age, race/ethnicity, income, education, region of the country, political views, having someone in the household aged 65 years and older (including themselves). Region of the country is divided into the following categories: Northeast, Midwest, South, and West. Political views were categorized as Liberal/Very Liberal, Moderate/Middle of the road, Conservative/Very conservative, and prefer not to answer. For purposes of the analysis, age was not included in the

Table 1 Psychometric properties of survey scales

Scale name	Number of items	Weighted mean score per item (SE)	Coefficient alpha
General vaccine attitudes	6	3.90 (0.03)	0.94
Perception of COVID-19 severity	7	2.82 (0.03)	0.90
Attitudes toward preventive strategies	6	3.75 (0.03)	0.91
COVID-19 vaccine attitudes	12	3.41 (0.03)	0.95
Reasons to receive a COVID-19 vaccine	8	3.36 (0.03)	0.92
Mandates	7	3.06 (0.04)	0.98

final model due to its substantial overlap with having a household member over age 65, including the respondent themselves.

General vaccine attitudes and influenza vaccine history

Respondents were dichotomized into those who had ever received a flu vaccine versus those who had not. Six items assessed general vaccine acceptability (Betsch et al., 2018; Sturm et al., 2021). Sample items included, 'Vaccines are generally safe', 'I get vaccinated because I can also protect people with a weaker immune system', and 'Vaccination is a collective action to prevent the spread of diseases'.

Risk and experience with COVID-19

Perceived risk was measured by asking if respondents had a health condition they believed would increase their severity of COVID-19 infection (response options: yes, no, not sure). Experiences were measured by whether respondents ever had or believed they ever had COVID-19, and whether they had ever tested positive for COVID-19. Respondents were additionally asked about their perception of COVID-19 being a major problem in their community (response options: yes, no).

Perception of COVID-19 severity

Seven items assessed perceived severity of COVID-19 (Cahyanto, et al., 2016; Head et al., 2020). Sample items included, 'I am scared about getting infected with COVID-19', and 'I am at greater risk of dying if I contract COVID-19 because of my general health'. The following items were reverse scored: 'I don't really worry about getting infected with COVID-19'; 'I don't think I will die if I get sick from COVID-19'. Higher scores indicated that respondents viewed COVID-19 infection as more severe.

Attitudes towards preventive strategies

Respondents were asked about the extent to which they believed behavioral strategies such as social distancing and mask-wearing were protective against COVID-19 (Kasting et al., 2020). Three items assessed the extent to which respondents thought the strategy was effective in *protecting themselves from becoming infected with COVID-19*: 'Wearing a mask any time you leave the house to go out in public'; 'Practicing social distancing by leaving at least six feet between you and other people (this does not include people you live with)'; and 'Frequently washing your hands with hand sanitizer or with warm water and soap for 20 s'. Three additional items assessed the extent to which respondents thought the strategy was effective in *preventing the spread of COVID-19 to other people*: 'Wearing a mask any time you leave the house to go out in public'; 'Practicing social distancing by leaving at least six feet between you and other people (this does not include people you live with)'; and 'Covering your mouth when you cough'. Items were rated on a 5-point Likert scale from not effective at all to extremely effective. Higher scores indicated that respondents viewed behavioral strategies to protect self/others as more effective.

COVID-19 vaccine attitudes

Twelve items measured COVID-19 vaccine acceptability (Helmkamp et al., 2021; Szilagyi et al., 2020). Sample items included, 'Getting a COVID-19 vaccine is a good way to protect me from coronavirus disease'; 'Getting a COVID-19 vaccine is important for the health of others in my community'; and 'The information I receive about COVID-19 vaccines from my healthcare provider is reliable and trustworthy'. The following items were reverse scored: 'COVID-19 vaccines have not been around long enough to be sure they are safe'; 'I am concerned about serious side effects of COVID-19 vaccines'; and 'I think COVID-19 vaccines might cause lasting health problems for me'. Higher scores indicated that the respondent held more positive attitudes towards COVID-19 vaccination.

Table 2 Scale items *(administered in random order)*

Scales	Likert scale
General vaccine attitudes *(adapted from* Betsch, et al., 2018; Sturm, et al., 2021*)*	Strongly Disagree (1) → Strongly Agree (5)
1. I like the idea of vaccines 2. Vaccines are generally safe 3. Vaccines are a way to take good care of myself now and in the future 4. Vaccines are effective 5. I get vaccinated because I can also protect people with a weaker immune system 6. Vaccination is a collective action to prevent the spread of disease	
Perception of COVID-19 severity *(*Cahyanto, et al., 2016; Head et al., 2020*)*	Strongly Disagree (1) → Strongly Agree (5)
1. I am scared about getting infected with COVID-19 2. The possibility of getting infected in the future with COVID-19 concerns me 3. I don't really worry about getting infected with COVID-19 4. I don't think I will die if I get sick from COVID-19 5. I am afraid that I may die if I contract COVID-19 6. I am at greater risk of dying if I contract COVID-19 because of my general health 7. If I got infected or re-infected with COVID-19, it could be threatening to my physical health	*Items 3, 4 were reverse scored*
Attitudes towards preventive strategies *(adapted from* Kasting et al., 2020*)*	Not effective at all (1) → Extremely effective (5)
Protecting themselves from becoming infected with COVID-19: 1. Wearing a mask any time you leave the house to go out in public 2. Practicing social distancing by leaving at least six feet between you and other people (this does not include people you live with) 3. Frequently washing your hands with hand sanitizer or with warm water and soap for 20 s *Preventing the spread of COVID-19 to other people:* 4. Wearing a mask any time you leave the house to go out in public 5. Practicing social distancing by leaving at least six feet between you and other people (this does not include people you live with) 6. Covering your mouth when you cough	
COVID-19 vaccine attitudes *(adapted from*Helmkamp et al., 2021; Szilagyi et al., 2020*)*	Strongly Disagree (1) → Strongly Agree (5)
1. COVID-19 vaccines are important for my health 2. Getting a COVID-19 vaccine is a good way to protect me from coronavirus disease 3. Any COVID-19 vaccine approved by the FDA and recommended by the CDC is effective 4. Getting a COVID-19 vaccine is important for the health of others in my community 5. A COVID-19 vaccine is beneficial to me 6. I do what my doctor or health care provider recommends about a COVID-19 vaccine 7. The information I receive about COVID-19 vaccines from my healthcare provider is reliable and trustworthy 8. The CDC provides trustworthy information on COVID-19 vaccines 9. I trust COVID-19 vaccines because medical organizations recommend them 10. COVID-19 vaccines have not been around long enough to be sure they are safe 11. I am concerned about serious side effects of COVID-19 vaccines 12. I think COVID-19 vaccines might cause lasting health problems for me	*Items 10,11,12 were reverse-scored*
Reasons to receive COVID-19 vaccine *(developed for the purposes of this study)*	Not at all important (1) → Extremely important (5)
1. Getting a vaccine makes me personally less likely to get COVID-19 2. Getting a vaccine makes me personally less likely to get severely sick from COVID-19 3. Getting a vaccine makes me less likely to give COVID-19 to my family 4. It is good for the health of the community for me to get the vaccine 5. Getting a vaccine allows me to return to my normal activities 6. Getting a vaccine helps the economy get back to normal 7. Getting a vaccine allows me to wear a mask less 8. Getting a vaccine allows me to social distance less	

Reasons to receive a COVID-19 vaccine

Eight items developed for this study measured reasons for deciding to get a COVID-19 vaccine. Sample items included, 'Getting a vaccine makes me personally less likely to get severely sick from COVID-19'; 'Getting a vaccine helps the economy get back to normal'; and 'Getting a vaccine allows me to wear a mask less'. Items were rated on a 5-point Likert scale from not at all important to extremely important. Higher scores indicated that

Table 3 Demographic and health-related characteristics of survey respondents, bivariate multinomial and final multinomial logistic regression models for vaccine uptake (N = 1208)[1,2]

Categorical variables	Raw *n*	Weighted *n* (%)	Wait and see vs. acceptor		Non-acceptor vs. Acceptor	
			Bivariate unadjusted OR [95% CI]	Final model adjusted OR [95% CI]	Bivariate unadjusted OR [95% CI]	Final model adjusted OR [95% CI]
Gender						
Male	610	583.1 (48.3%)	Ref	Ref	Ref	Ref
Female	598	624.9 (51.7%)	1.08 [0.75, 1.55]	0.84 [0.47, 1.50]	1.10 [0.79, 1.53]	0.93 [0.46, 1.87]
Age (years)						
60+	462	357.6 (29.6%)	Ref	–[3]	Ref	–
45–59	322	299.4 (24.8%)	1.45 [0.88, 2.38]	–	**1.18, 2.78]***	–
30–44	270	308.2 (25.5%)	**3.57 [2.21, 5.74]****	–	**2.24, 5.31]****	–
18–29	154	242.8 (20.1%)	**2.36 [1.33, 4.20]***	–	**3.25 [2.0, 5.39]****	–
Race/ethnicity						
Non-Hispanic White	847	760.9 (63.0%)	Ref	Ref	Ref	Ref
Non-Hispanic Black	113	142.7 (11.8%)	1.65 [0.95, 2.84]	1.15 [0.42, 3.15]	1.47 [0.86, 2.52]	0.47, 4.21]
Hispanic	150	199.1 (16.5%)	0.93 [0.54, 1.60]	0.69 [0.28, 1.71]	0.62 [0.36, 1.06]	0.60 [0.17, 2.14]
2 + races or other, non-Hispanic	98	105.3 (8.7%)	0.66 [0.33, 1.34]	0.81 [0.23, 2.81]	**0.30 [0.13, 0.69]***	0.43 [0.08, 2.38]
Annual income						
More than $150,000	285	240.5 (19.9%)	Ref	Ref	Ref	Ref
$100,000–149,999	224	224.7 (18.6%)	1.51 [0.82, 2.78]	0.69 [0.30, 1.59]	1.63 [0.93, 2.84]	0.38, 4.09]
$75,000–99,999	178	169.4 (14.0%)	1.61 [0.85, 3.07]	0.66 [0.24, 1.79]	**1.93 [1.09, 3.43]**	0.61 [0.16, 2.33]
$50,000–74,999	230	209.6 (17.4%)	**2.31 [1.29, 4.11]***	1.04 [0.43, 2.50]	**2.13 [1.24, 3.66]***	%1.%20.31, 3.55]
Less than $50,000	291	363.9 (30.1%)	**2.42 [1.38, 4.23]***	1.03 [0.44, 2.42]	**3.59 [2.20, 5.86]****	3.41 [1.01, 11.52]
Education						
Bachelor's degree or higher	426	379.4 (31.4%)	Ref	Ref	Ref	Ref
Some college	376	362.4 (30.0%)	**3.05 [1.89, 4.92]****	1.71 [0.85, 3.46]	**3.73 [2.33, 5.98]****	2.35 [0.94, 5.88]
High school degree or less	406	466.2 (38.6%)	**3.23 [2.01, 5.20]****	1.64 [0.74, 3.66]	**4.15 [2.62, 6.59]****	2.83 [1.04, 7.66]
Political views						
Very Liberal/Liberal	248	256.2 (21.5%)	Ref	Ref	Ref	Ref
Moderate/Middle of the Road	445	446.0 (37.4%)	1.32 [0.75, 2.30]	0.74 [0.29, 1.90]	**2.12 [1.10, 4.07]**	1.46 [0.31, 6.93]
Very Conservative/ Conservative	390	357.3 (30.0%)	**2.15 [1.24, 3.73]***	0.83 [0.31, 2.27]	**4.79 [2.55, 9.00]****	2.17 [0.43, 11.06]
Prefer not to answer	111	131.8 (11.1%)	**2.57 [1.23, 5.37]**	0.53 [0.17, 1.65]	**7.76 [3.75, 16.07]****	2.02 [0.37, 10.96]
Region of country						
Northeast	224	209.4 (17.3%)	Ref	Ref	Ref	Ref
Midwest	262	250.4 (20.7%)	1.58 [0.89, 2.79]	1.11 [0.49, 2.53]	1.55 [0.89, 2.69]	0.47, 4.33]
South	446	459.8 (38.1%)	1.17 [0.68, 2.02]	1.02 [0.45, 2.31]	**1.72 [1.06, 2.79]**	0.58, 6.19]
West	276	288.5 (23.9%)	0.94 [0.51, 1.73]	0.72 [0.29, 1.81]	1.037 [0.59, 1.81]	0.87 [0.24, 3.18]
Household member ≥ age 65						
Yes	481	418.4 (35.0%)	Ref	Ref	Ref	Ref
No	717	778.6 (65.0%)	**2.50 [1.67, 3.75]****	**2.64 [1.46, 4.76]***	**2.28 [1.59, 3.26]****	**2.50 [1.17, 5.33]**
Ever had a flu vaccine						
Yes	928	896.0 (74.3%)	Ref	Ref	Ref	Ref

Table 3 (continued)

Categorical variables	Raw *n*	Weighted *n* (%)	Wait and see vs. acceptor		Non-acceptor vs. Acceptor	
			Bivariate unadjusted OR [95% CI]	Final model adjusted OR [95% CI]	Bivariate unadjusted OR [95% CI]	Final model adjusted OR [95% CI]
No	278	309.2 (25.7%)	**4.48 [2.99, 6.71]****	**4.04 [2.15, 7.61]****	**7.29 [5.04, 10.54]****	**6.16 [3.00, 12.68]****
Health condition making COVID-19 more severe						
Yes	346	320.5 (26.5%)	Ref	Ref	Ref	Ref
No	757	771.3 (63.9%)	1.13 [0.75, 1.71]	0.79 [0.40, 1.57]	**2.30 [1.51, 3.51]****	0.53, 3.26]
Not sure	100	110.2 (9.1%)	0.96 [0.48, 1.92]	0.62 [0.21, 1.88]	1.89 [0.95, 3.74]	0.81 [0.21, 3.20]
Tested positive for COVID-19						
Yes	227	240.7 (20.0%)	Ref	Ref	Ref	Ref
No	785	758.2 (63.2%)	**0.45 [0.29, 0.71]***	0.55 [0.26, 1.14]	**0.52 [0.35, 0.77]***	0.27, 1.82]
Not sure	190	201.5 (16.8%)	1.08 [0.63, 1.85]	1.00 [0.42, 2.36]	**0.58 [0.34, 1.00]**	0.56 [0.18, 1.71]
View COVID-19 as a major problem in community						
Yes	624	633.2 (52.8%)	Ref	Ref	Ref	Ref
No	575	566.0 (47.2%)	**1.96 [1.36, 2.83]***	1.18 [0.63, 2.20]	**4.12 [2.84, 5.98]****	1.60 [0.70, 3.63]

Scale variables	*n* obs	Mean Item Score (SE)	Wait and see vs. acceptor		Non-acceptor vs. acceptor	
			Bivariate Unadjusted OR [95% CI]	Final Model Adjusted OR [95% CI]	Bivariate Unadjusted OR [95% CI]	Final Model Adjusted OR [95% CI]
Perceived COVID severity	1191	2.82 (0.03)	**0.63 [0.51, 0.78]****	0.79 [0.53, 1.19]	**0.34 [0.27, 0.42]****	0.68 [0.41, 1.14]
Effectiveness of behavioral strategies to protect self/others	1201	3.75 (0.03)	**0.59 [0.48, 0.72]****	1.58 [1.05, 2.37]	**0.29 [0.23, 0.37]****	1.06 [0.98, 1.15]
General vaccine attitudes	1187	3.90 (0.03)	**0.20 [0.14, 0.27]****	1.00 [0.58, 1.72]	**0.07 [0.05, 0.12]****	0.58 [0.29, 1.15]
COVID vaccine attitudes	1181	3.41 (0.03)	**0.04 [0.02, 0.07]****	**0.05 [0.03, 0.10]****	**0.01 [0.01, 0.02]****	**0.03 [0.01, 0.08]****
COVID vaccine reasons	1168	3.36 (0.03)	**0.32 [0.25, 0.41]****	**0.66 [0.45, 0.97]****	**0.10 [0.07, 0.15]****	**0.29 [0.18, 0.47]****

[1]Referent group in italics

[2]Bolded values are significant at $p < 0.05$, $*p < 0.01$, $**p < 0.001$

[3]Age not included in final model

respondents viewed the benefits of COVID-19 vaccination to be of stronger importance.

COVID-19 vaccine uptake

In assessing vaccine uptake at the time of this survey, respondents were categorized as "vaccine acceptors" if they had received a vaccine or if they said they 'would like to get a COVID-19 vaccine as soon as possible'. Those who answered 'as soon as possible' were grouped with those who had already received a vaccine, given the aforementioned significant variance across states in vaccine eligibility criteria and accessibility at the time of the assessment in early April 2021. Those who had not received or were not intending to get a vaccine as soon as possible were asked if they would 'get a vaccine after there has been more experience with it'. Those that answered 'yes' were categorized as "wait-and-see" and the remainder who answered 'no' were classified as "vaccine non-acceptors".

Mandates

Attitudes towards COVID-19 vaccination mandates were assessed by summing the scores of 7 items that measured support for mandating vaccines among the following demographic groups: (a) all adults, (b) healthcare workers, (c) other essential workers (e.g. firefighters, grocery store employees), (d) high school and college students, (e) those in group settings (e.g. nursing homes), (f) those in institutional

settings (e.g. prisons), and (g) those traveling. Higher scores indicated stronger agreement with mandates.

Data analysis

First, demographics of the study sample were assessed using descriptive statistics, with means and standard deviations for continuous variables and frequency and percentages for categorical variables.

Next, the dimensionality of each experience and/or attitudes scale described above was assessed using exploratory factor analysis with oblique rotation (promax rotation) using the polychoric correlation to account for the Likert nature of the items. Determination of the number of factors was made by examining the scree plot and how many eigenvalues were greater than one. The reliability of each scale was assessed using Cronbach's alpha, with an alpha greater than 0.80 indicating good internal consistency.

Next, each of the potential predictor variables were analyzed in a bivariate model with vaccine uptake (reference group: vaccine acceptors, versus wait-and-see and vaccine non-acceptors) using polytomous logistic regression, and mandate support using linear regression. A common (multivariable) model was built for each outcome.

Additionally, secondary analyses were conducted for two mandate sub-groups: HCWs and travelers on planes/trains. These sub-groups were selected due to the precedence for mandates among both groups, with vaccination requirements for HCWs (e.g. flu, hepatitis B, MMR) and travelers to certain countries (e.g., yellow fever, typhoid). As the individuals who may be most likely to change attitudes towards mandates are those who report they 'neither agree nor disagree' with them, we examined these respondents in comparison to those who 'strongly agreed or agreed' with mandates for HCWs and travelers. Both binary mandate outcomes were then modeled using multiple logistic regression models with the same predictors as the above analyses.

We utilized SAS® Software v. 9.4 (SAS Institute Inc., Cary, NC) for descriptive statistics and all regression models. For all regression analyses, weights provided by Ipsos to account for the complex survey design were used. The psych package for R v. 4.0 (R Core Team, 2020) was used to assess scale dimensionality and compute reliability coefficients (alpha).

Results

The specific demographics are presented in Table 3; the sample was generally representative of the nation prior to weighting.

Dimensionality of scales

Based on the scree plots and eigenvalues, each of the experience and attitudes scales was deemed to be unidimensional. Across all of the scales, factor loadings were consistently above 0.45 for all items. All of the scales showed very good internal consistency with alphas ranging from 0.90 (perception of COVID-19 severity) to 0.98 (mandates). See Table 1 for detailed scale characteristics. Based on these results, simple sum scores were computed for each scale and used for the analyses.

Vaccine uptake

Using the weighted data, 67.1% of respondents were classified as vaccine acceptors, 14% wait-and-see, and 18.9% vaccine non-acceptors. Eight responses were missing. All of the predictors for vaccine uptake held statistical significance in the individual models (see Table 3) with the exception of gender, and all were included in the final common model. As noted above, age was not included in the final model due to its relationship with having a household member over age 65, including respondents themselves. In the final model, there were an additional 99 respondents dropped due to missing responses for one or more predictor variables. Thus, the final model predicting vaccine uptake had 1101 responses (weighted 1099.3).

Wait-and-see versus acceptors

In the final model shown in Table 3, respondents who were more likely to be in the wait-and-see group versus acceptors were those who did not have a household member over age 65 (AOR = 2.64, 95% CI = 1.46, 4.76) and had not received a flu vaccine (AOR 4.04, 95% CI = 2.15, 7.61). Respondents were less likely to be in the wait-and-see group versus acceptors if they had more positive attitudes towards COVID-19 vaccination (AOR = 0.05, 95% CI = 0.03, 0.10) and if they viewed COVID-19 vaccination as more beneficial (AOR = 0.66, 95% CI = 0.45, 0.97).

Non-acceptors versus acceptors

In the final model, respondents who were more likely to be non-acceptors versus acceptors did not have a household member over age 65 (AOR = 2.50, 95% CI = 1.17, 5.33), and had not received a flu vaccine (AOR = 6.16, 95% CI = 3.00, 12.68). Respondents were less likely to be non-acceptors versus acceptors if they had more positive attitudes towards COVID-19 vaccination (AOR = 0.03, 95% CI = 0.01, 0.08) and if they viewed vaccination as

more beneficial (AOR = 0.29, 95% CI = 0.18, 0.47) (see Table 3).

Mandates

The mean value for item scores on the 5-point scale for mandates was 3.06 (SD 1.39, Inter-quartile range 1.86, 4.14), with higher scores indicative of more agreement with vaccine mandates. On this scale, 20.1% of responses had a mean value equal to 1, indicating that those respondents strongly disagreed with mandates for all categories of individuals listed, and 13.1% had a mean value of 5, indicating those who strongly agreed with mandates for all subgroups.

Mandate scale responses for individual subgroups are shown in Table 4. For example, 50.6% of respondents strongly agreed/agreed with mandates for healthcare workers and 48.8% strongly agreed/agreed with mandates for those living or working in residential group settings such as nursing homes, versus just 45.4% for plane/train travelers and 32% for all adults.

All of the predictors for mandates held statistical significance in the individual bivariate linear regression models (see Table 5), with the exception of gender and income, and all were included in the final common model; again, age was excluded. There were an additional 118 respondents dropped due to missing responses on one or more predictor variables; thus, the final common model predicting mandates had 1090 responses (weighted 1087.7).

In the final model presented in Table 5, respondents who agreed more strongly with mandates identified as male, had liberal political views, identified as any race other than non-Hispanic White, had annual incomes of less than $75,000, were vaccine acceptors, perceived COVID-19 infection as more severe, viewed behavioral strategies to protect self/others as more effective, and had more positive attitudes towards COVID-19 vaccination.

In the multiple logistic regression models for HCWs and travelers on planes/trains, we included the same variables as in the overarching final model discussed above (Table 5). In the final logistic regression models for the two subgroups (shown in Table 6), the remaining significant predictors for HCWs were gender, political views, education, having a household member over age 65, COVID vaccine attitudes, and vaccine uptake. Therefore, those who were more likely to 'strongly agree or agree' with mandates for healthcare workers in comparison to those who 'neither disagree nor disagree' identified as male, had liberal political views, had a high school degree or less, had a household member over age 65, had more positive attitudes towards COVID vaccines, and were vaccine acceptors. The remaining significant predictors of support for plane/train travelers were gender, political views, and education; those who were more likely to 'strongly agree or agree' with mandates compared to those who 'neither disagree nor disagree' identified as male, had liberal political views, and had some college education.

Discussion

Vaccine hesitancy is not a single construct; therefore, we examined characteristics among those identified as waiting to get vaccinated, as well as those who did not plan to get vaccinated against COVID-19. In this nationally representative sample, 67% of respondents were either already vaccinated or wanting to get vaccinated as soon as possible, 14% were wait-and-see, and 19% were not accepting of COVID-19 vaccines. Thus, while the majority of this sample was not vaccine hesitant, vaccination uptake in the U.S. remains suboptimal and represents an urgent public health challenge, particularly given spikes in COVID-19 infection and hospitalization rates coinciding with the emergence of delta (Mahase, 2021) and omicron variants (Taylor, 2022). While the present study illustrates attitudes during the early months of vaccine rollout to the U.S. public in April 2021, prior to implementation of vaccine mandates, these findings continue to hold relevance for our understanding of public opinion in the rapidly evolving history of this pandemic.

Table 4 Mandate scale reponses by subgroup

Mandate scale item	Weighted mean item score (SE)	Strongly disagree or disagree Weighted % (SE)	Neither agree or disagree Weighted % (SE)	Strongly agree or agree Weighted % (SE)
Health Care Workers	3.26 (0.04)	31.5% (1.4)	17.9% (1.2)	50.6% (1.5)
Residential Group Settings	3.21 (0.04)	32.6% (1.4)	18.6% (1.3)	48.8% (1.5)
Institutional Settings	3.13 (0.04)	33.2% (1.4)	20.9% (1.3)	45.9% (1.5)
Plane/Train Travelers	3.09 (0.04)	34.9% (1.4)	19.7% (1.3)	45.4% (1.5)
Other Essential Workers	*3.12 (0.04)*	*34.3% (1.4)*	20.7% (1.3)	45.0% (1.5)
High School and College Students	2.95 (0.04)	38.2% (1.5)	22.8% (1.3)	39.0% (1.5)
All Adults	2.75 (0.04)	44.5% (1.5)	23.5% (1.3)	32.0% (1.4)

Table 5 Bivariate and final multiple linear regression models for mandates[1,2]

Categorical variables	Bivariate linear regression coefficient (B)[3] [95% CI]	Final model association (B)[3] [95% CI]
Gender		
Male	Ref	Ref
Female	−0.09 [−0.25, 0.08]	*−0.18 [−0.30, −0.06]**
Age (years)		
60 +	Ref	–[4]
45–59	−0.20 [−0.40, 0.00]	–
30–44	−0.50 [−0.70, −0.29]**	–
18–29	−0.21 [−0.47, 0.05]	–
Race/ethnicity		
Non-hispanic white	Ref	Ref
Non-hispanic black	0.34 [0.08, 0.60]	0.01, 0.42]
Hispanic	0.46 [0.22, 0.70]*	0.19 [0.00, 0.38]
2 + races or other, non-Hispanic	0.65 [0.36, 0.94]**	0.30 [0.06, 0.55]
Income		
More than $150,000	Ref	Ref
$100,000–149,999	−0.08 [−0.35, 0.19]	−0.04, 0.34]
$75,000–99,999	−0.06 [−0.35, 0.22]	−0.03, 0.36]
$50,000–74,999	−0.12 [−0.38, 0.14]	0.08, 0.46]*
Less than $50,000	−0.08 [−0.33, 0.16]	0.31 [0.12, 0.50]*
Education		
Bachelor's degree or higher	Ref	Ref
Some college	−0.45 [−0.65, −0.24]**	0.06 [−0.09, 0.21]
High school degree or less	−0.26 [−0.46, −0.07]*	0.14 [−0.03, 0.32]
Political views		
Very liberal/liberal	Ref	Ref
Moderate/middle of the road	−0.51 [−0.72, −0.30]**	−0.17 [−0.33, −0.02]
Very conservative/conservative	−1.34 [−1.56, −1.13]**	−0.42 [0.61, 0.23]**
Prefer not to answer	−1.14 [−1.45, −0.84]**	−0.35 [−0.58, −0.11]
Region of Country		
Northeast	Ref	Ref
Midwest	−0.38 [−0.63, −0.12]*	−0.19 [−0.38, −0.00]
South	−0.34 [−0.58, −0.11]*	−0.26 [−0.43, −0.09]*
West	−0.14 [−0.40, 0.12]	−0.20 [−0.38, −0.02]
Household member ≥ age 65		
Yes	Ref	Ref
No	−0.38 [−0.54, −0.21]**	−0.04 [−0.17, 0.09]
Ever had a flu vaccine		
Yes	Ref	Ref
No	−0.66 [−0.85, −0.47]**	0.06 [−0.11, 0.23]
Health condition making COVID-19 more severe		
Yes	Ref	Ref
No	−0.35 [−0.54, −0.17]*	0.05 [−0.10, 0.20]
Not sure	0.09 [−0.21, 0.39]	0.18 [−0.04, 0.40]
Tested positive for COVID-19		
Yes	Ref	Ref
No	0.47 [0.25, 0.69]**	−0.05 [−0.22, 0.11]
Not sure	0.11 [−0.17, 0.40]	−0.19 [−0.40, 0.02]
View COVID-19 as a major problem in community		
Yes	Ref	Ref

Table 5 (continued)

Categorical variables	Bivariate linear regression coefficient (B)[3] [95% CI]	Final model association (B)[3] [95% CI]
No	−0.84 [−1.00, −0.68]**	0.01 [−0.13, 0.16]
Vaccine uptake		
Acceptor	Ref	Ref
Waiting	−1.30 [−1.50, −1.10]**	−0.56 [−0.78, −0.33]**
Non-acceptor	−1.92 [−2.09, −1.75]**	−0.54 [−0.80, −0.29]**
Scale variables	Bivariate linear regression coefficient (B) [95% CI]	Final model association (B) [95% CI]
Perceived COVID severity	**0.70 [0.61, 0.78]****	**0.17 [0.07, 0.27]****
Effectiveness of behavioral strategies to protect self/others	**0.80 [0.72, 0.87]****	**0.24 [0.16, 0.33]****
General vaccine attitudes	**0.83 [0.76, 0.90]****	0.09 [-0.03, 0.22]
COVID vaccine attitudes	**1.00 [0.94, 1.06]****	**0.49 [0.32, 0.65]****
COVID vaccine reasons	**0.70 [0.64, 0.76]****	0.03 [-0.07, 0.14]

[1]Referent group in italics

[2]Bolded values are significant at $p < 0.05$, $*p < 0.01$, $**p < 0.001$

[3]Linear regression slope

[4]Age not included in final model

For vaccine uptake, all of the sociodemographic predictors held significance at the bivariate level with the exception of gender, suggesting that these variables are important to consider in understanding population factors associated with vaccine hesitancy. Previous studies (Brandt et al., 2021; Callaghan et al., 2021; Guidry, et al., 2021; Head et al., 2020; Latkin et al., 2021; Reiter et al., 2020) have also found evidence that demographics such as political views, race/ethnicity, and income are related to vaccine uptake. However, in this study's final model, only four predictors of vaccine uptake remained significant: previous acceptance of the flu vaccine, having a household member over age 65, COVID-19 vaccine attitudes, and reasons for receiving a COVID-19 vaccine. This suggests that the above-mentioned sociodemographic markers are closely related to the attitudes that ultimately drive vaccine hesitancy. In this case, public health interventions may better be able to focus vaccine messaging towards modifying vaccine attitudes, rather than focusing on demographic characteristics that are more static and rarely modifiable.

This study's findings shed light on potential content for vaccine messaging that is geared towards changing perceptions or attitudes likely to foster vaccination uptake. For example, given that respondents with a household member over age of 65 were more likely to be vaccinated than those who did not, it appears that protecting older adults is a motivating factor for COVID-19 vaccination. This lends credence to the logic that young, healthy adults may need messages that draw attention to the contact they have with more vulnerable individuals. One example of such messaging was demonstrated in a study of influenza vaccine uptake among college students in upstate New York. After receiving an informational message about the benefit of vaccinating young people against the flu in order to protect vulnerable close contacts (such as elderly family members), 71% of unvaccinated students indicated that this information would make them more willing to get a flu vaccine (Bednarczyk, et al., 2015). Another study, using an experimental interactive vaccination game, found that participants were more likely to get vaccinated against a fictional infectious disease if they perceived a need to indirectly protect unvaccinated individuals with low responsibility for not being vaccinated (e.g. babies and immunocompromised people unable to get vaccinated) (Böhm et al., 2019).

In the present study, respondents who had ever received a flu vaccine were more likely to receive a COVID-19 vaccine. This suggests that people who have previously received the flu vaccine and have not yet received a COVID-19 vaccine are a demographic group with high potential for change. Flu vaccine acceptors may be amenable to individual-level appeals, for example, by their primary care provider, who can answer questions and help assuage personal concerns with medically accurate information. Alternatively, people who have not previously received the flu vaccine may be the group most difficult to convince to receive a COVID-19 vaccine, as this was the strongest predictor of vaccine hesitancy. Other recent studies have shown similarly strong associations between previous influenza vaccination and COVID-19 vaccine acceptance (Paul et al., 2021; Sherman et al., 2021).

Respondents who had more positive attitudes towards COVID-19 vaccination were more likely to be both vaccine acceptors and to support mandates. Additionally, believing

Table 6 Logistic regression models for mandates for healthcare workers and travelers: respondents who strongly agree or agree versus referent group those who neither disagree nor agree[1,2]

Categorical variables	Healthcare workers and those working in a healthcare facility OR [95% CI]	Everyone wanting to travel on a plane or train OR [95% CI]
Gender		
Male	Ref	Ref
Female	**0.47 [0.30, 0.72]*** **	***0.50 [0.32, 0.76]****
Race/ethnicity		
Non-Hispanic White	Ref	Ref
Non-Hispanic Black	0.77 [0.40, 1.49]	1.00 [0.50, 1.20]
Hispanic	1.62 [0.80, 3.26]	1.01 [0.53, 1.92]
2 + races or other, non-Hispanic	1.25 [0.57, 2.72]	1.11 [0.56, 2.22]
Income		
More than $150,000	Ref	Ref
$100,000-149,999	0.96 [0.47, 1.98]	1.13 [0.56, 2.26]
$75,000-99,999	1.17 [0.54, 2.57]	1.18 [0.57, 2.44]
$50,000-74,999	0.71 [0.34, 1.47]	0.81 [0.40, 1.66]
Less than $50,000	0.93 [0.45, 1.92]	0.94 [0.47, 1.89]
Education		
Bachelor's degree or higher	Ref	Ref
Some college	1.38 [0.79, 2.42]	**1.94 [1.14, 3.32]***
High school degree or less	**2.16 [1.17, 4.01]***	1.75 [0.95, 3.21]
Political views		
Very Liberal/Liberal	Ref	Ref
Moderate/Middle of the Road	**0.36 [0.20, 0.67]****	0.62 [0.35, 1.10]
Very Conservative/Conservative	**0.46 [0.22, 0.94]****	0.52 [0.27, 1.01]
Prefer not to answer	**0.24 [0.10, 0.56]****	**0.31 [0.14, 0.70]***
Region of country		
Northeast	Ref	Ref
Midwest	1.26 [0.63, 2.54]	1.17 [0.61, 2.22]
South	0.75 [0.41, 1.37]	0.88 [0.49, 1.57]
West	1.10 [0.59, 2.08]	1.07 [0.60, 1.92]
Household member ≥ age 65		
Yes	Ref	Ref
No	**0.59 [0.38, 0.92]***	0.83 [0.54, 1.26]
Ever had a flu vaccine		
Yes	Ref	Ref
No	0.93 [0.53, 1.61]	1.07 [0.60, 1.89]
Health condition making COVID-19 more severe		
Yes	Ref	Ref
No	0.98 [0.59, 1.62]	0.75 [0.46, 1.21]
Not sure	0.80 [0.38, 1.71]	0.64 [0.32, 1.29]
Tested positive for COVID-19		
Yes	Ref	Ref
No	0.97 [0.54, 1.74]	1.13 [0.65, 1.96]
Not sure	0.96 [0.45, 2.06]	0.78 [0.39, 1.55]
View COVID-19 as a major problem in community		
Yes	Ref	Ref
No	0.71 [0.43, 1.17]	0.81 [0.51, 1.30]

Table 6 (continued)

Categorical variables	Healthcare workers and those working in a healthcare facility OR [95% CI]	Everyone wanting to travel on a plane or train OR [95% CI]
Vaccine uptake		
Acceptor	Ref	Ref
Waiting	0.52 [0.25, 1.07]	0.41 [0.19, 0.92]
Non-acceptor	**0.26 [0.11, 0.62]****	0.69 [0.28, 1.70]
Scale variables	Health care workers and those working in a health care facility OR [95% CI]	Everyone wanting to travel on a plane or train OR [95% CI]
Perceived COVID severity	0.82 [0.59, 1.14]	1.20 [0.88, 1.63]
Effectiveness of behavioral strategies to protect self/others	1.34 [0.96, 1.86]	1.24 [0.90, 1.71]
General vaccine attitudes	1.21 [0.77, 1.89]	1.42 [0.93, 2.17]
COVID vaccine attitudes	**1.88 [1.12, 3.16]***	1.57 [0.91, 2.71]
COVID vaccine reasons	1.06 [0.76, 1.48]	1.33 [0.98, 1.80]

[1]Referent group in italics

[2]Bolded values are significant at *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

strongly in the importance of reasons to get vaccinated was associated with COVID-19 vaccine acceptance, which supports the mission of public health campaigns to disseminate persuasive vaccine education. However, it is still unclear how to best combat rampant misinformation. Previous studies of misconceptions related to human papillomavirus (HPV) vaccination (Zimet et al., 2013) have shown that misinformation, particularly via social media content (Calo et al., 2021), negatively influences intention to vaccinate.

Altogether, these findings suggest that healthcare providers need to make strong recommendations regarding COVID-19 vaccination, as has been shown with other vaccines, including for HPV (Rosenthal et al., 2011) and influenza (Lu et al., 2018). These recommendations could be offered in both individual appointments and small community group settings. However, it is insufficient to simply expect healthcare providers to give strong recommendations; they must be equipped with effective messages and skills (e.g. motivational interviewing) to best communicate the benefits and safety of COVID-19 vaccines to different target audiences. Such training is particularly critical given the challenges of decreased access to primary care visits during the pandemic amidst the rapid progression of COVID-19 vaccine science. Leask et al. developed a framework to guide health professionals in communicating with parents about childhood vaccinations, highlighting strategies to target a spectrum of vaccine attitudes based on principles of motivational interviewing, informed consent, and communication science (2012). For example, for parents categorized as "late or selective vaccinators", they suggest tactics such as using decision aids to present risk/benefit information, and they note this group to be most likely to change their view with time; versus for parents categorized as "refuser", providers should aim to ensure the parent feels their concerns are heard with a brief discussion that leaves the door open to continuing dialogue at the next visit (Leask et al., 2012). Strategies from this framework could be appropriately applied to the "wait-and-see" and "vaccine non-acceptor" groups in the present study.

With regard to mandates, 20% of respondents strongly disagreed with mandates for all of the target groups and 13% strongly agreed across all groups, with the remainder falling somewhere between these extremes. It is important to note again that this survey was conducted prior to implementation of COVID-19 vaccination requirements in public and private settings in the U.S. Although discussion of COVID-19 vaccine mandates has become highly politicized, there is clear evidence demonstrating the prior impact of mandates to successfully increase immunization rates, for example, with flu vaccination among the healthcare workforce (Wang et al., 2017) and HPV vaccination among middle school students (Thompson et al., 2021). Not surprisingly, vaccine acceptors, those with liberal political views, and those residing in the Northeast were more in favor of mandates in the present study. These demographics correlate with areas of the country where people were more likely to engage in wearing masks (Stosic et al., 2021), and with states more likely to have mask mandates (Hao et al., 2021), which have proven to be effective in reducing COVID-19 hospitalization rates (Dasgupta et al., 2021; Joo et al., 2021). This is also consistent with the finding that respondents who believed more strongly in COVID-19 protective behavioral strategies were

more in favor of mandates. Taken together, the results suggest that these individuals may have a firmer understanding of the public health implications of vaccination as a collective solution to the pandemic, and accordingly view mandates as a reasonable approach from this public health perspective.

In addition, among this sample, those who identified as male, those with incomes less than $75,000, and those identifying with racial/ethnic groups other than non-Hispanic White, were also more likely to support mandates overall. These respondents represent groups who experienced a higher burden of COVID-19 infection in the U.S. due to deep-rooted systemic inequities made even more visible in the light of the pandemic. One explanation is that since members of these populations are more likely to be in situations at higher risk of COVID-19 transmission, such as being essential workers or living in crowded housing conditions (Gray et al., 2020), they may favor vaccine mandates that would help safeguard them. Though the present study did not assess respondents' status as essential workers, one previous study showed that those who self-identified as essential workers had significantly higher perceived susceptibility to COVID-19 infection than their counterparts (Chu & Liu, 2021), but that study did not examine support for vaccine mandates. Additionally, perhaps similar to respondents who may have experienced greater disease burden, those in the present study who perceived COVID-19 illness as more severe were also more likely to support mandates.

Though people hold general attitudes towards vaccine mandates, respondents in this survey did differentiate their support for mandates targeting specific subgroups. While approximately half of respondents strongly agreed/agreed with mandates for healthcare workers and those living or working in residential group settings such as nursing homes, there was less agreement regarding mandates for other groups, such as high school and college students (39%) and all adults (32%). A large national survey of U.S. adults conducted in fall 2020 (prior to vaccine rollout), found that the majority supported COVID-19 vaccination mandates in educational settings (daycare, K-12, and university) for faculty, staff and students; however, this support was less favorable than that for traditional school vaccine mandates (Haeder, 2021). Similar to our study, that survey also found political views to be a significant predictor of mandate support—self-identified Republicans showed less support for COVID-19 mandates in schools than Democrats, and this partisan result was stronger for COVID-19 mandates than for general vaccine mandates (Haeder, 2021).

The finding that those who neither agree nor disagree with HCW mandates hold fewer positive attitudes towards COVID-19 vaccines compared to those who strongly agree or agree with mandates suggests that mandate support is influenced by how people feel about the specific vaccine, and not just mandates in general. This reinforces the importance of disseminating clear messages about vaccine safety and efficacy. In comparison, attitudes towards mandates for plane/train travel between the two groups were differentiated only by sociodemographic predictors of gender, education and political views. A national survey conducted in June 2020 (prior to vaccine rollout) also demonstrated women to have lower odds of supporting passports for proof of COVID-19 vaccination, and found higher support for implementation among workers in high-risk jobs, but interestingly did not find socioeconomic status or political views to be predictive of support (Hall & Studdert, 2021).

Overall, these findings highlight several interesting patterns in predictors of support for vaccine requirements, suggesting that attitudes towards mandates are not only driven by demographics and staunch political beliefs, but also by perceptions of the specific vaccine and the scope of the mandate. The finding that people with household members over age 65 were more likely to strongly agree or agree with HCW mandates suggests that, similar to vaccination uptake, individuals recognize the role of mandates in protecting more vulnerable individuals. In proposing mandates for specific settings and population groups, targeted messaging should effectively delineate why certain groups would benefit from a mandate and address individuals' specific concerns about the vaccine.

Limitations

The cross-sectional design of this survey is limited in scope to respondents' attitudes at the time of administration in April 2021, during which COVID-19 vaccines were under emergency use authorization from the Food and Drug Administration (FDA), and mandates were being discussed but had not yet been implemented. Given the rapidly changing landscape of vaccine eligibility and accessibility during this time, it was not feasible to analyze vaccine uptake by age and locality with precision. We cannot know with certainty if respondents who stated they would get a vaccine as soon as possible actually followed through, or whether those who stated they were waiting or would not accept a vaccine converted to acceptors soon after the assessment. Similarly, given potential developments in personal experiences with COVID-19 infection and the evolution of scientific information with regard to virus incidence and vaccine efficacy, there are many factors that could influence vaccine uptake and mandate support that this study is unable to capture.

Conclusions

So how can we focus our collective efforts to convert as many people as possible to become vaccine acceptors?

This study points to experiential and attitudinal factors, particularly prior experience with flu vaccination, having a household member over age 65, and COVID-19 vaccine attitudes, that can be the target of public health campaigns. As the history of this pandemic continues to evolve, these results have important implications for a strategic approach to attitudes at various stages of a public health crisis. Mandates can play an important role in fostering COVID-19 vaccine uptake as they have with previous vaccines, however, varying support for mandates based on demographics, vaccine attitudes and the scope of requirements is relevant to public debate and legal cases challenging their enforcement in various settings. Future work will explore changes in attitudes over time in this representative national sample and the role of financial incentives in persuading vaccine hesitant individuals.

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Availability of data and materials The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Code availability We utilized SAS® Software v. 9.4 (SAS Institute Inc., Cary, NC) for descriptive statistics and all regression models. The psych package for R v. 4.0 (R Core Team, 2020) was used to assess scale dimensionality and compute reliability coefficients (alpha).

Declarations

Conflict of interest Julen Harris, Christine Mauro and Jane Andresen have no conflicts of interest to declare. Gregory Zimet has served as an external advisory board member for Merck and Moderna, and as a consultant to Merck. He also has received investigator-initiated research funding from Merck administered through Indiana University and serves as an unpaid member of the Board of Directors for the Unity Consortium, a non-profit organization that supports adolescent health through vaccination. Susan Rosenthal has received investigator-initiated research funding from Merck Investigator Studies Program administered through Columbia University Irving Medical Center.

Consent to participate All participants in this study are members of the IPSOS KnowledgePanel®. Participants received an information sheet for this study, and completion of the questionnaire indicated consent.

Consent for publication There is no potentially identifiable data presented, and in fact, the authors only had access to de-identified data.

Ethics approval Approval was obtained from the Institutional Review Board of Columbia University Irving Medical Center on December 22, 2020. (IRB-AAAT5154).

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