



# COVID-19 Vaccine Hesitancy and Its Determinants Among Adults with a History of Tobacco or Marijuana Use

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Accepted: 23 April 2021 / Published online: 6 May 2021

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## Abstract

Decreasing COVID-19 vaccine hesitancy is an urgent challenge in the US. This study aimed to examine COVID-19 vaccine hesitancy among U.S. adults with a history of using tobacco products or marijuana. Data were collected online in 2020–2021 including respondents' willingness to accept a COVID-19 vaccine, factors that may promote vaccine acceptance, and prior history of influenza vaccination. Logistic regression models were conducted to estimate the associations between vaccine hesitancy and demographic characteristics, substance use, the impact of the COVID-19 pandemic, and prior influenza vaccination. Among 387 respondents, 49.1% were willing to receive a COVID-19 vaccine, 26.0% were unwilling, and 24.9% were “not sure.” Blacks, suburban or rural residents, those who lived by themselves or with a family with five members or above, those who were not stressed because of the COVID-19 pandemic were more likely to say “no” to a COVID-19 vaccine. Respondents who never, only once, or during some years received an influenza vaccine were 7.0, 6.2, and 5.2 times more likely to say “no” to a COVID-19 vaccine than respondents who received an influenza vaccination every year or almost every year. The use of cigarettes, e-cigarettes, and marijuana, as well as heavy drinking of alcohol, were not associated with COVID-19 hesitancy. The associations between demographic factors and vaccine hesitancy were roughly similar for COVID-19 and influenza vaccines. Although various demographic groups have different levels of vaccine hesitancy and also have different factors to increase their acceptance, addressing misinformation related to COVID-19 vaccines, particularly concern about the safety of the vaccines is crucial in general.

**Keywords** COVID-19 · Vaccine hesitancy · Influenza vaccination · Tobacco use · Marijuana use

## Introduction

A COVID-19 vaccine may be the ultimate solution to end the ongoing COVID-19 pandemic. To achieve herd immunity against COVID-19, a substantial proportion of the population will need to be vaccinated. The rate of COVID-19

vaccine acceptance in the US, however, is at the lower end of the spectrum compared with other countries [1], ranging between 52 and 75% [2–6]. Promoting vaccine acceptance in the US is an urgent challenge. According to a 3C's framework [7], vaccine hesitancy is influenced by Confidence (i.e., if people do not trust a vaccine or its provider), Complacency (i.e., if people do not perceive the need for a vaccine), and Convenience (i.e., access), among other individual and contextual characteristics. From the perspective of barriers to vaccination uptake, the issues of confidence, complacency, and convenience roughly correspond to mistrust, misinformation, and lack of access, respectively.

Disparities in acceptance and uptake of vaccinations exist across different population groups who may experience diverse barriers to vaccination [8, 9]. In the US, racial/ethnic disparities in vaccination coverage persist for most vaccines [10]. Minority groups tend to have higher rates of mistrust including concerns about perceived safety, skepticism about the trustworthiness of vaccination, and cultural

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or religious beliefs discouraging vaccination. People with low educational attainment and limited health literacy are more likely to have issues of misinformation and limited knowledge about the disease or the benefits of vaccination. Lack of access to the vaccine is more likely to be a barrier for people living in poverty, rural residents, and older adults. According to a recent survey and several studies on COVID-19 vaccine hesitancy in the US population [2, 4–6, 11, 12], Blacks and Hispanics, those with low socioeconomic status, and rural residents were less likely than their counterparts to say they have received a COVID-19 vaccine or be willing to take a vaccine. These findings were consistent with the hesitancy patterns reported for most other vaccines such as influenza vaccine.

It is not clear to what extent hesitancy to receive a COVID-19 vaccine differs from hesitancy for other vaccines. Compared with other vaccines, influenza vaccines may be most comparable to COVID-19 vaccine because both vaccines are applicable to the whole population rather than to specific groups. In the US, less than half of the adult received an influenza vaccine in 2019 [13]. To date, few studies have examined the existence of a relationship between the uptake of influenza and COVID-19 vaccines. One study [11] found not having received the influenza vaccine in the prior year was associated with heightened COVID-19 vaccine hesitancy while another study [4] found a significant demographic difference between people who had an influenza vaccine and those indicating that they would obtain a COVID-19 vaccine.

Examining COVID-19 vaccine hesitancy among smokers is also important. Although smoking may be associated with a higher mortality rate and suffering more severe consequences of COVID-19 [14, 15], some evidence indicates that current smoking is associated with a reduced risk of COVID-19 infection [16]. These seemingly controversial findings, together with misleading information on social media, may confuse the public, particularly smokers, thus may influence their acceptance of a COVID-19 vaccine. Nonetheless, evidence for other vaccines such as influenza suggests that smokers may be less likely than others to be vaccinated [17, 18]. Accordingly, understanding which subgroups of smokers might be more or less likely to be vaccinated for COVID-19 would permit the development of more targeted interventions aimed at boosting vaccine uptake among users of tobacco and perhaps marijuana.

The aims of this study to examine COVID-19 vaccine hesitancy among U.S. adults who had a history of using tobacco products or marijuana, including (1) the prevalence and distribution of vaccine hesitancy, and individual characteristics that are associated with vaccine hesitancy; (2) factors that may promote vaccine acceptance; and (3) the association between COVID-19 vaccine hesitancy and influenza vaccination.

## Methods

Data were collected using Amazon Mechanical Turk (MTurk), an online crowdsourcing platform. Data were obtained during December 2020 and January 2021 from one wave of a longitudinal survey regarding substance use, and all respondents at baseline had used either tobacco products and/or marijuana in 2019. The Institutional Review Board at the University of Memphis approved this study.

For the major outcome of vaccine hesitancy, we asked “If a fully FDA-approved COVID-19 vaccine becomes widely available, will you get it?” with three optional answers including yes, no, and not sure. Additionally, we explored factors that may help to mitigate COVID-19 vaccine hesitancy by asking “what would make it more likely that you would get a COVID-19 vaccine?” as a multiple-choice question. Response options included information-related factors such as “Studies show the vaccine prevents COVID-19”, trust-related factors such as “My personal health care provider says to get the vaccine”, and access and perceived risk of COVID-19 infection. Finally, we asked respondents about prior influenza vaccination.

Respondents reported demographic information and residential zip code that allowed us to link neighborhood poverty and urbanization (urban, suburban, or rural areas). Respondents reported their substance use including the use of cigarettes, e-cigarettes, marijuana, and heavy drinking during the past 30 days. For the impact of the COVID-19 pandemic, respondents reported if they or their family had been infected by COVID-19, if there were COVID-19 deaths among their social network, and if they experienced stress because of the pandemic.

Descriptive statistics were used to describe the demographic characteristics of study respondents and the proportions of vaccine acceptance status (i.e., yes, no, or not sure) were presented across groups. Logistic regression models were conducted to estimate how respondents' vaccine hesitancy was associated with their demographic characteristics, neighborhood characteristics, substance use history, the impact of the COVID-19 pandemic, and prior influenza vaccination. Additional regression models were conducted that excluded prior influenza vaccination initially, and then further excluded the impact of the COVID-19 pandemic. For comparison purposes, a regression model was conducted to estimate the association between respondents' prior influenza vaccination and their demographic characteristics. Additionally, the percentages of respondents who agreed that various factors may promote vaccine acceptance are presented with stratified results by prior influenza vaccination history.

## Results

As Table 1 shows, most respondents were female (53.5%), middle-aged adults (53.2% aged 30–49 years old), non-Hispanic White (74.9%), living in urban areas (81.9%), smoking (70%), and felt stressed because of the COVID-19 pandemic (60.5%). For prior flu vaccination, 30.1% of respondents received a flu vaccine every year, 28.0% had never received a flu vaccine, and the remaining 41.9% ranged from almost every year to only once. Overall, about 49.1% of respondents indicated a willingness to receive a COVID-19 vaccine, 26.0% were not willing, and 24.9% respondents were “not sure”. According to a Chi-square test, the acceptance of COVID-19 vaccine differed across gender, race/ethnicity, educational attainment, household income, family size, urbanization, smoking status, if stressed due to COVID-19 pandemic, and prior flu vaccination. The proportion of answering “Yes” to a COVID-19 vaccine was highest among people who received an influenza vaccination every year (75.9%), those with two family members including self (65.6%), with household income \$100,000 or more (60.6%), Asian (60.7%), with household income ranged between \$50,000 and \$74,999 (63.1%), and those with a bachelor or above degree (60.5%). The proportion of answering “yes” to a COVID-19 vaccine was lowest among people who received an influenza vaccine only once (27.3%), never got influenza vaccine (26.9%), were Black (26.2%), and those with five family members or more (27.3%). The percent of answering “no” to a COVID-19 vaccine was as high as 50% among Blacks, 41–43% among people living in suburban and rural areas, and as low as 8.6–12.7% among people who received an influenza vaccination every year or almost every year.

Table 2 shows the results of logistic regression models. According to the full model, COVID-19 vaccine hesitancy was not significantly associated with gender, age, substance use, and other impacts of COVID-19 pandemic except being stressed. Blacks, residents of suburban or rural areas, and those who were not stressed because of COVID-19 pandemic were more likely to say “no” to COVID-19 vaccine compared with their counterparts. Compared with people who lived by themselves and people who lived with a family with five members or above, people who lived with a family of between two and four were about 30–40% more likely to say “no” to COVID-19 vaccine. A dose–response relationship existed between COVID-19 vaccine hesitancy and prior influenza vaccination, with those who had never, only once, or in some years received an influenza vaccine being 7.0, 6.2, and 5.2 times more likely to say “no” to COVID-19 vaccine than people who received an influenza vaccination every year or almost every year.

After the prior influenza vaccination item was removed from the regression model, the results were little changed compared with the full model, except relative hesitancy, increased among Blacks and decreased among people with more education (odds ratio = 0.59, 0.34–1.04 of 95% CI). After the impact of COVID-19 was further removed from the regression model, we found some moderate changes including an increase in hesitancy among Blacks and among people with a family size between 2 and 4. Compared with the third COVID-19 vaccine model, the influenza vaccination model had roughly similar results: Blacks, people with less education, and higher household incomes were less likely to receive an influenza vaccine compared with their counterparts. Prior influenza vaccination was not significantly associated with gender, age, living environment, and substance use.

Table 3 reported the percent of respondents who agreed that some factors would make her/him more likely to get a COVID-19 vaccine. Overall, ranked by the percent of agreement, the top three factors were (1) studies show the vaccine is safe (62.8%); (2) studies show the vaccine prevents COVID-19 (54.5%), and (3) studies show the vaccine lessens how sick people get from COVID-19 (38.0%). They were all related to information. The least important factors are (1) the media or social media sites that I read say to get the vaccine (3.4%); and (2) family, co-workers, or friends say to get the vaccine (12.7%). For almost all factors, people who said “yes” to COVID-19 vaccine were more likely to be influenced, and people who said “no” to COVID-19 vaccine were less likely to be influenced, compared with those who reported “not sure”. Among people who said “no” to COVID-19 vaccine, the percent of those who stated that nothing can make them more likely to get a COVID-19 vaccine was as high as 36.4% compared with 2.1% among people who said “yes” to COVID-19 vaccine. Stratified results by prior influenza vaccination among people who said “no” or “not sure” to a COVID-19 vaccine showed that for all factors related to information, people who were more likely to have prior influenza vaccination were more likely to be influenced, but other factors were inconsistent. Among people indicating “no” or “not sure” to COVID-19 vaccine and who also never had an influenza vaccination, the percent of those that claimed that nothing can make them more likely to get a COVID-19 vaccine was as high as 41.8%.

## Discussion

Overall, less than half (49.1%) of respondents indicated that they will get a COVID-19 vaccine when it is available, and the percent of respondents who said “no” and “not sure” to COVID-19 vaccine was 26.0% and 24.9%, respectively. The rate of COVID-19 vaccine acceptance from our study

**Table 1** Characteristics of respondents (N = 387) and the proportions of vaccine hesitancy across groups

Category	Item	Percent	Acceptance of COVID-19 vaccine			
			Yes, N = 190	No, N = 101	Not sure, N = 96	P value
All		100	49.1	26.0	24.9	
Gender	Male	46.5	56.7	24.4	18.9	0.01
	Female	53.5	43.0	26.6	30.4	
Age	18–29	27.4	45.3	30.2	24.5	0.59
	30–49	53.2	49.0	24.8	26.2	
	50 and above	19.4	56.0	21.3	22.7	
Race /ethnicity	White	74.9	52.1	22.8	25.2	0.007
	Black	10.9	26.2	50.0	23.8	
	Asian	7.2	60.7	17.9	21.4	
	Hispanic	7.0	44.4	25.9	29.6	
Educational attainment	High school and below	12.1	36.2	29.8	34.0	0.0006
	Above high school and below bachelor	38.8	39.3	32.7	28.0	
	Bachelor and above	49.1	60.5	19.0	20.5	
Household income	Less than \$24,999	17.6	33.8	25.0	41.2	0.001
	\$25,000 to \$49,999	27.4	46.2	31.1	22.6	
	\$50,000 to \$74,999	21.7	63.1	21.4	15.5	
	\$75,000 to \$99,999	16.3	41.3	33.3	25.4	
	\$100,000 or more	17.1	60.6	15.2	24.2	
Family size	1	17.8	42.0	37.7	20.3	0.0002
	2	31.5	65.6	18.9	15.6	
	3	22.2	48.8	23.3	27.9	
	4	17.1	42.4	24.2	33.3	
	5 and above	11.4	27.3	31.8	40.9	
	Urbanization	Urban	81.9	51.6	22.2	
Suburban	14.5	39.3	41.1	19.6		
Rural	3.6	35.7	42.9	21.4		
Neighborhood poverty	Low: < 10%	37.2	57.6	19.4	22.9	0.082
	Middle: ≥ 10% and < 20%	39.5	46.4	26.8	26.8	
	High: ≥ 20%	23.3	41.1	33.3	25.6	
If smoking	Yes	70.0	46.9	29.2	24.0	0.048
	No	30.0	55.2	17.2	27.6	
If using e-cigarettes	Yes	46.5	48.9	28.9	22.2	0.281
	No	53.5	49.8	22.7	27.5	
If using marijuana	Yes	41.4	47.7	27.1	25.2	0.831
	No	58.6	50.4	24.6	25.0	
If heavy drink at least once in past 30 days	Yes	41.3	44.4	30.6	25.0	0.13
	No	58.7	52.9	22.0	25.1	
If stressed because of COVID-19 pandemic	Yes	60.5	53.0	18.8	28.2	0.0007
	No	39.5	43.8	36.0	20.3	
If infected by COVID-19	Yes	5.4	42.9	33.3	23.8	0.696
	No	94.6	49.7	25.1	25.1	
If some family member infected by COVID-19	Yes	19.9	48.1	28.6	23.4	0.787
	No	80.1	49.7	24.8	25.5	
If any COVID-19 death among social network	Yes	15.8	47.5	31.2	21.3	0.514
	No	84.2	49.7	24.5	25.8	
If lost job because of COVID-19 pandemic	Yes	8.8	35.3	32.4	32.4	0.229
	No	91.2	50.7	24.9	24.4	

**Table 1** (continued)

Category	Item	Percent	Acceptance of COVID-19 vaccine			
			Yes, N = 190	No, N = 101	Not sure, N = 96	P value
Prior influenza vaccination	Every year	30.1	75.9	8.6	15.5	< .0001
	Almost every year	18.3	56.3	12.7	31.0	
	Some years	15.2	42.4	33.9	23.7	
	Only once	8.5	27.3	39.4	33.3	
	Never	28.0	26.9	43.5	29.6	

is relatively low compared to the 52% to 75% as indicated in other recent studies [2–6]. One possible reason for this discrepancy is that prior studies used representative samples of US residents, while respondents in our study either currently or previously used tobacco/nicotine or marijuana products. In addition, we asked about COVID-19 vaccine acceptance in a different way than some of these prior studies. Some studies asked about acceptance of COVID-19 vaccine including conditions such as “if it was free or covered by health insurance” [5] and “If a vaccine was available that would prevent coronavirus infection” [19]. These conditions may increase vaccine acceptance.

Our finding regarding COVID-19 vaccine hesitancy and various demographic characteristics are consistent with previous studies specific to COVID-19 vaccine and related vaccine literature in general. It is well-documented that vaccine hesitancy is more prevalent among Blacks than Whites due to historical distrust of medicine and systemic racism in the US [20–22]. Unfortunately, racial/ethnic minorities are disproportionately affected by COVID-19 [23–25]. Vaccine hesitancy is higher among respondents from suburban or rural areas compared to those from urban areas; possible reasons include under-resourced health facilities and differing political views (e.g., tend to see the vaccination as a personal choice rather than a social responsibility). In addition, a recent survey showed that rural residents tend to think their risk of exposure to COVID-19 is smaller than residents in urban areas due to lower population density and less use of public transport, and are more likely to believe that the seriousness of the coronavirus has been exaggerated [26]. One noteworthy finding in our study is that people who lived by themselves or lived with a large size family ( $\geq 5$ ) were less likely to indicate that would be vaccinated for COVID-19 compared with people who lived in family size between 2 and 4. One recent study [11] also found that larger family size was associated with a higher likelihood of vaccine hesitancy. People who lived by themselves were more reluctant to get a COVID-19 vaccine, perhaps because they believe their risk of exposure to COVID-19 is relatively small and they are more discretionary in their activities

(e.g., no family errands). Among several factors related to the impact of the COVID-19 pandemic, the only factor that was found to be significantly associated with vaccine hesitancy was stress related to the pandemic. People who feel stressed may be more eager for the pandemic to end, and see the vaccine as a crucial way to return to “normal” life circumstances.

We found people who were less likely to have received prior influenza vaccination were less likely to accept a COVID-19 vaccine. The removal of prior influenza vaccination from the regression model changed little about the associations among COVID-19 vaccine hesitancy and demographics and the impact of COVID-19 pandemic. The results from the model for those who never got an influenza vaccination and the third model for COVID-19 vaccine hesitancy were roughly consistent. This suggests that demographic characteristics play a similar role in hesitancy for both vaccines. Our results are consistent with one previous study [11] that reported that not having received an influenza vaccine in the prior year was associated with a higher likelihood of COVID-19 vaccine hesitancy. Another study [4] compared the demographics of those who reported influenza vaccine uptake in the prior year and those who accepted COVID-19 vaccine. The rates of accepting COVID-19 were higher than the rates of uptake of the influenza vaccine in the prior year in almost all groups and the difference was roughly consistent among most groups. It should be noted that the two studies [4, 11] assessed influenza vaccine in the prior year as a dichotomous measure and thus did not capture the comprehensive prior history of influenza vaccination as in our study.

COVID-19 vaccine hesitancy was not associated with the use of cigarettes, e-cigarettes, marijuana, and heavy drinking of alcohol. For each substance, our use of a dichotomous variable (e.g., if smoking or not) may be too simple to capture the behavior, and we may need to differentiate never, former and current smokers as well as the frequency of use among current smokers. Recently, CDC [27] recommended that smokers under the age of 65 be eligible for the vaccine in the early phases of distribution, and several states are currently offering the vaccine to smokers regardless of their age.

**Table 2** Results of four logistic regression models: the first, second and third models are for the hesitancy of COVID-19 vaccine, and the outcome are “no” to COVID-19 vaccine compared with “yes” and “not sure”

	“No” to COVID-19 vaccine versus “yes” and “not sure”			Never got influenza vaccination
	First: full model	Second: exclude prior influenza vaccination	Third: exclude influenza vaccination and impact of COVID-19 pandemic	
<b>Gender</b>				
Male	1	1	1	1
Female	1.04 (0.58, 1.87)	1.15 (0.67, 1.97)	1.11 (0.66, 1.88)	0.81 (0.49, 1.32)
<b>Age</b>				
18–29	1	1	1	1
30–49	0.71 (0.37, 1.39)	0.74 (0.4, 1.39)	0.71 (0.39, 1.31)	1.54 (0.85, 2.78)
50 and above	0.76 (0.3, 1.93)	0.62 (0.26, 1.46)	0.58 (0.25, 1.33)	0.83 (0.37, 1.84)
<b>Race /ethnicity</b>				
White	1	1	1	1
Black	<b>3.1 (1.34, 7.15)**</b>	<b>3.59 (1.65, 7.8)**</b>	<b>4.18 (1.97, 8.88)**</b>	<b>2.62 (1.23, 5.55)*</b>
Asian	1.08 (0.34, 3.39)	1.04 (0.35, 3.12)	1.06 (0.36, 3.1)	1.4 (0.53, 3.7)
Hispanic	1.32 (0.45, 3.91)	1.8 (0.66, 4.93)	1.7 (0.64, 4.53)	1.49 (0.56, 4)
If bachelor degree or above	0.66 (0.36, 1.24)	0.59 (0.34, 1.04)	0.59 (0.34, 1.02)	<b>0.37 (0.22, 0.64)**</b>
If household income \$50, 000 or above	1.13 (0.63, 2.04)	1.24 (0.72, 2.16)	1.26 (0.73, 2.15)	<b>1.81 (1.07, 3.06)*</b>
<b>Family size</b>				
1	1	1	1	1
2	<b>0.33 (0.14, 0.75)**</b>	<b>0.33 (0.16, 0.72)**</b>	<b>0.37 (0.18, 0.78)**</b>	0.71 (0.36, 1.43)
3	<b>0.36 (0.15, 0.85)*</b>	<b>0.36 (0.16, 0.79)*</b>	<b>0.42 (0.19, 0.9)*</b>	0.52 (0.25, 1.08)
4	<b>0.40 (0.16, 1)*</b>	<b>0.36 (0.15, 0.86)*</b>	<b>0.42 (0.18, 0.96)*</b>	0.51 (0.23, 1.14)
5 and above	0.79 (0.29, 2.18)	0.57 (0.22, 1.44)	0.55 (0.22, 1.39)	<b>0.31 (0.12, 0.84)*</b>
If living in urban areas	<b>0.36 (0.18, 0.74)**</b>	<b>0.36 (0.18, 0.69)**</b>	<b>0.35 (0.18, 0.67)**</b>	0.62 (0.33, 1.18)
If living in high poverty neighborhood (>=20%)	1.49 (0.79, 2.8)	1.33 (0.74, 2.39)	1.33 (0.75, 2.36)	0.95 (0.54, 1.69)
If smoking	1.6 (0.8, 3.2)	1.59 (0.84, 3.03)	1.64 (0.87, 3.1)	0.93 (0.53, 1.63)
If using e-cigarettes	1.11 (0.61, 2.02)	1.06 (0.61, 1.86)	1.16 (0.67, 2)	1.04 (0.62, 1.74)
If using marijuana	0.85 (0.47, 1.53)	0.92 (0.53, 1.59)	0.84 (0.5, 1.43)	0.73 (0.44, 1.2)
If heavy drink at least once in past 30 days	1.54 (0.87, 2.74)	1.42 (0.83, 2.44)	1.38 (0.82, 2.34)	1.01 (0.61, 1.66)
If stressed because of COVID-19 pandemic	<b>0.42 (0.24, 0.73)**</b>	<b>0.40 (0.24, 0.67)**</b>		
If infected by COVID-19	1.81 (0.57, 5.76)	1.13 (0.38, 3.42)		
If some family member infected by COVID-19	1.11 (0.56, 2.23)	1.01 (0.53, 1.94)		
If any COVID-19 death among social network	0.77 (0.36, 1.63)	0.81 (0.4, 1.66)		
If lost job because of COVID-19 pandemic	0.89 (0.36, 2.25)	1.22 (0.51, 2.87)		
<b>Prior influenza vaccination</b>				
Every year	1			
Almost every year	1 (0.34, 2.94)			
Some years	<b>5.21 (2.01, 13.52)**</b>			
Only once	<b>6.23 (2.15, 18.01)**</b>			
Never	<b>7.0 (3.06, 16.06)**</b>			

The fourth model is for prior influenza vaccination, and outcome of is “never got influenza vaccine” compared with all the other possible results Boldface indicates statistical significance, with\* for P<0.05, and \*\* for P<0.01

**Table 3** Percent of respondents who agreed that the factors would make her/him more likely to get a COVID-19 vaccine

Factor	All, N = 387	By response to COVID-19 vaccine			Among people who said “no” or “not sure” to COVID-19 vaccine, stratified by the prior history of influenza vaccination			
		Yes, N = 191	Not sure, N = 97	No, N = 99	All, N = 196	Every year or almost, N = 59	Some years, N = 58	Never, N = 79
Studies show the vaccine prevents COVID-19	54.5	75.9	51.6	16.2	33.7	50.9	25.9	26.6
Studies show the vaccine lessens how sick people get from COVID-19	38.0	50.8	29.9	21.2	25.5	42.4	22.4	15.2
Studies show the vaccine is safe	62.8	74.9	71.1	31.3	51.0	69.5	46.6	40.5
My personal health care provider says to get the vaccine	22.7	30.9	17.5	12.1	14.8	28.8	15.5	3.8
Experts say to get the vaccine	30.8	49.2	19.6	6.1	12.8	10.2	20.7	8.9
The media or social media sites that I read say to get the vaccine	3.4	6.3	0	1.0	0.5	0.0	1.7	0.0
Family, co-workers, or friends say to get the vaccine	12.7	17.8	10.3	5.1	7.7	8.5	10.3	5.1
If I am in a group that has a higher chance of getting sick from COVID-19	20.5	29.8	18.6	4.0	11.2	17.0	6.9	10.1
If it was easy to get the vaccine	25.8	41.4	17.5	4.0	10.7	11.9	6.9	12.7
Some other reason that is not listed	8.3	5.2	10.3	12.1	11.2	15.3	8.6	10.1
Nothing	13.7	2.1	13.4	36.4	25.0	8.5	19.0	41.8

These occurred near the end of our survey but its influence on COVID-19 hesitancy among smokers may be observed in future studies.

In terms of factors that may promote the acceptance of a COVID-19 vaccine, factors in the “information” category were agreed to by more respondents than other factors. This highlights the importance of addressing misinformation related to COVID-19 vaccines, particularly concern about the safety of the vaccines. Secondly, the relative importance of factors varies by different groups. Among factors in the trust category, respondents who answered “yes” or “not sure” to a COVID-19 vaccine were more likely to be influenced by an expert, but respondents who answered “yes” or “not sure” to COVID-19 vaccine were more likely to be influenced by a personal health care provider. Third, access was not very important for respondents who answered “not sure” or “no” indicating that for many respondents, misinformation and mistrust need to be addressed first. Lastly, among respondents who said “no” to a COVID-19 vaccine, 36.4% claimed that nothing can make them more likely to get a COVID-19 vaccine; this rose to 41.8% among respondents who said “no” or “not sure” to COVID-19 vaccine and also never had influenza vaccination. This suggests a need for more studies to identify and explore other barriers to vaccination among these groups.

The limitations of this study included the cross-sectional data collection and use of a non-representative sample of U.S. adults. Besides, some related variables were not included in the survey, such as political affiliation, relationship status, and health insurance.

## Conclusions

In our sample, more than half of the respondents either said “no” or “not sure” to a COVID-19 vaccine. This suggests that COVID-19 vaccine hesitancy is a serious and urgent challenge to achieving herd immunity. Our results show that different groups not only have different levels of vaccine hesitancy but also have different factors that may increase vaccine acceptance. These factors could be used to develop vaccination strategies that are tailored to different groups. We also found that the association between demographic factors and vaccine hesitancy was roughly similar between COVID-19 and influenza vaccines. Further studies will be needed to examine the dynamics and interactions between the two diseases and the acceptance and uptake of the two vaccines [28]. For example, one study [29] found that COVID-19 might have boosted the

influenza vaccine uptake rate. Perhaps in the future, vaccines for COVID-19 and influenza could be combined into one shot [30, 31].

**Author Contributions** YY initialized the study, design the survey, collected and analyze the data, and wrote the draft. AD and KW contributed to the survey design, result interpretation, and writing.

**Funding** This research received no external funding.

**Data Availability** We are happy to share the data upon reasonable request.

## Declarations

**Conflict of interest** Authors have no conflicts of interests to declare.

**Consent to Participate** Participants' consent were obtained before the survey.

**Ethical Approval** The Institutional Review Board at the University of Memphis approved this study.

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