

Trends in COVID-19 Vaccination Intentions

KEY POINTS

- As COVID-19 vaccination rates have risen from late April 2021 through early January 2022 in the United States, the number of *unvaccinated* adults still *willing* to vaccinate has decreased from 74 million to 12 million, a decrease of 84 percent.
- Concurrently, many *unvaccinated* adults who indicated they were *unwilling* to vaccinate in earlier periods of the pandemic also received vaccines. The number of *unvaccinated* adults *unwilling* to vaccinate decreased from 45 million to 23 million, a decrease of 49 percent.
- Over time, the remaining unvaccinated population has become less willing to vaccinate. This is consistent with individuals who were previously unvaccinated but willing becoming vaccinated.
- Willingness to vaccinate among unvaccinated adults temporarily increased during COVID-19 surges, suggesting that COVID-19 surges may influence individuals to be more willing to vaccinate.
- Younger, lower income, and less educated populations have consistently been the most willing to vaccinate among unvaccinated adults.
- Black, Hispanic and Asian unvaccinated adult populations have been more willing to vaccinate than the White unvaccinated adult population.
- Despite clinical and observational evidence that COVID-19 vaccines are safe and effective at reducing the risk of COVID-19, unvaccinated adults *willing* to vaccinate most commonly say they have not been vaccinated due to concerns about vaccine side effects and a desire to wait and see whether COVID-19 vaccines are safe. Unvaccinated adults *unwilling* to vaccinate most commonly say they have not been vaccinated due to concerns about vaccine side effects and distrust in COVID-19 vaccines and the government.
- Unvaccinated adults rarely cite vaccine cost or accessibility as reasons for not yet having vaccinated, suggesting these have not been major impediments to vaccine uptake during our period of study.

Introduction

It has been almost two years since the World Health Organization (WHO) declared the international outbreak of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the resulting coronavirus disease

2019 (COVID-19) as a global pandemic.¹ Since the WHO's declaration, the COVID-19 pandemic has resulted in over 338 million cases and 5.56 million deaths globally.² In the United States (U.S.), it has resulted in over 67.9 million cases and 853,000 deaths.⁴

Currently, the public's best defense against the effects of the virus are COVID-19 vaccines. In the U.S., the vaccination roll-out began on December 14, 2020.³ As of January 20, 2022, 87.1 percent of U.S. adults have received at least one dose of a COVID-19 vaccine.⁴ Even with emerging variants of concern, COVID-19 vaccines continue to be safe and effective at reducing the risk of contracting COVID-19, including the risk of severe illness, hospitalization, and death among those who are fully vaccinated.⁵

Despite the progress that has been made in vaccinating the public against COVID-19, vaccination coverage is not evenly distributed across the country.⁶ For example, many states in the Western, Midwestern, and Southern U.S. contain areas where 70% or less of adults have received at least 1 dose of a COVID-19 vaccine. In addition to geographical disparities, there also remains a considerable number of communities who have been disproportionately impacted by the pandemic and have lower vaccination rates such as those communities with higher rates of poverty, racial/ethnic minorities, and people living with disabilities.⁷

Moreover, although shrinking, there is still a substantial number of adults who continue to indicate they are willing to be vaccinated against COVID-19 but have not yet received a vaccine. In light of emerging and circulating COVID-19 variants, including the Delta and Omicron variants, understanding the trends in this population's vaccination intentions as well as their reasons for being unvaccinated may help inform state and local COVID-19 vaccination initiatives and close gaps in vaccination coverage.⁸

¹ World Health Organization, WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020, <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020>, last accessed January 20, 2022.

² Johns Hopkins Center for Systems Science and Engineering (CSSE), COVID-19 Dashboard, <https://coronavirus.jhu.edu/map.html>, last accessed January 20, 2022.

³ The vaccination roll-out began after the Pfizer-BioNTech COVID-19 vaccine received initial emergency use authorization (EUA) from the Food and Drug Administration (FDA) and subsequent recommendation for use by the Centers for Disease Control and Prevention (CDC).³ Currently, there are three COVID-19 vaccines that are available for use in the United States. After initially being authorized for emergency use, the two-dose Pfizer-BioNTech mRNA COVID-19 vaccine received full FDA approval for use in persons 16 and older on August 23, 2021. Moderna's two-dose mRNA COVID-19 vaccine is currently authorized for emergency use in persons 18 and older. Johnson & Johnson's Janssen COVID-19 vaccine is a single dose series viral vector vaccine and is currently authorized for emergency use in persons 18 and older.

⁴ Centers for Disease Control and Prevention, COVID Data Tracker, <https://covid.cdc.gov/covid-data-tracker/#datatracker-home> last accessed January 20, 2022.

⁵ Centers for Disease Control and Prevention. COVID-19 Vaccines Work, Updated December 23, 2021. Available at <https://www.cdc.gov/coronavirus/2019-ncov/vaccines/effectiveness/work.html>, last accessed January 18, 2022.

⁶ Centers for Disease Control and Prevention, COVID-19 Vaccination Equity, <https://covid.cdc.gov/covid-data-tracker/#vaccination-equity>, last accessed January 20, 2022.

⁷ Agency for Toxic Substances and Disease Registry, At A Glance: CDC/ATSDR Social Vulnerability Index, https://www.atsdr.cdc.gov/placeandhealth/svi/at-a-glance_svi.html, last accessed January 20, 2022.

⁸ Centers for Disease Control and Prevention, Trends in Number of COVID-19 Cases and Deaths in the US Reported to CDC, by State/Territory, https://covid.cdc.gov/covid-data-tracker/#trends_dailycases_newhospitaladmissions, last accessed January 25, 2022.

This brief utilizes the U.S. Census Bureau’s Household Pulse Survey (HPS) to examine these trends in unvaccinated adults’ willingness to receive a COVID-19 vaccine from late April 2021 to early January 2022.⁹ We estimate the number of unvaccinated adults willing to vaccinate (“unvaccinated but willing”) has decreased from 74 million to 12 million, a decrease of 84 percent. Concurrently, unvaccinated adults unwilling to vaccinate (“unvaccinated and unwilling”) have also been receiving vaccines in large amounts. We estimate their number has decreased from 45 million to 23 million, a decrease of 49 percent.

As vaccination rates have increased, the shrinking unvaccinated population has become increasingly less willing to vaccinate. This is consistent with individuals who were previously unvaccinated but willing being more likely to vaccinate than those who are unvaccinated and unwilling. However, during the Delta and Omicron surges, the willingness of unvaccinated adults to vaccinate actually increased, suggesting that COVID-19 surges may influence individuals to be more willing to vaccinate.

We further explore how these patterns vary by demographic characteristics through two approaches. First, we compare trends in vaccine willingness of various demographic groups. Second, we employ logistic regressions for select survey weeks of the HPS. Our findings show that among unvaccinated adults the younger, lower-income, and less educated populations were consistently more willing to get vaccinated. Moreover, the Black, Hispanic and Asian populations were more likely to be willing to vaccinate than the White population.

Lastly, we find that the reasons unvaccinated adults said they did not vaccinate remained stable over time, though there were stark differences in responses between those who were willing and unwilling to vaccinate. Despite clinical and observational evidence that COVID-19 vaccines are safe and effective at reducing the risk of COVID-19, including the risk of severe illness, hospitalization, and death¹⁰, according to unvaccinated but willing respondents the most common reasons for not getting vaccinated were being worried about vaccine side effects and wanting to wait and see whether the COVID-19 vaccines were safe. For unvaccinated respondents who were not willing to get vaccinated, the most common reasons for not getting vaccinated were concerns over vaccine side effects and distrust in COVID-19 vaccines and the government. Neither group commonly cited vaccine cost or accessibility as reasons to avoid vaccination, suggesting that during our period of study neither of these have been major impediments to vaccine uptake.

Our analysis builds upon a previous ASPE issue brief which analyzed the unvaccinated adult population who were willing to be vaccinated against COVID-19.¹¹ It explored the sociodemographic factors and geographic patterns associated with this willingness during an earlier phase of the vaccine rollout (late April to early July 2021) when all adults became eligible to get vaccinated in the U.S. This brief extends these analyses by exploring trends in vaccination intentions over a longer period of time and analyzing how these trends vary based on the sociodemographic characteristics of survey respondents.

⁹ U.S. Census Bureau, Household Pulse Survey (COVID-19), available at <https://www.census.gov/programssurveys/household-pulse-survey.html>, last accessed January 21, 2022.

¹⁰ Centers for Disease Control and Prevention. Safety of COVID-19 Vaccines, Updated February 7, 2022. Available at <https://www.cdc.gov/coronavirus/2019-ncov/vaccines/safety/safety-of-vaccines.html>, last accessed February 15, 2022.

¹¹ Beleche, T., Kolbe, A., Bush, L., and Sommers, B. Unvaccinated for COVID-19 but Willing: Demographic Factors, Geographic Patterns, and Changes Over Time. Washington, DC: Office of the Assistant Secretary for Planning and Evaluation, U.S. Department of Health and Human Services. August 2021. Available at <https://aspe.hhs.gov/reports/unvaccinated-willing-ib>, last accessed January 20, 2022.

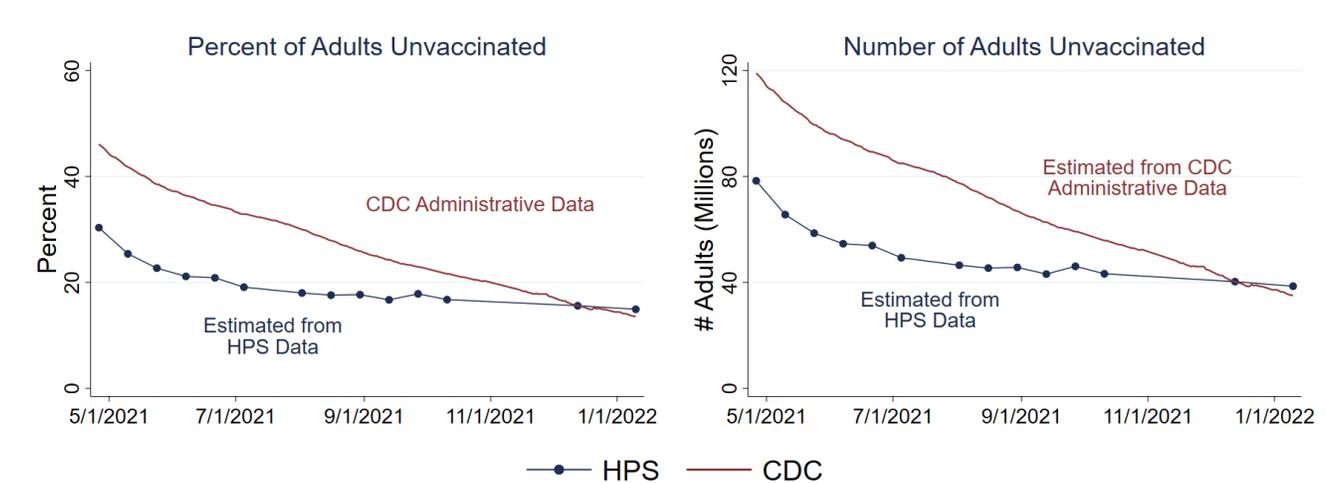
Methods

Data

Our primary data source is the U.S. Census Bureau’s Household Pulse Survey. The HPS is nationally representative and includes information on U.S. residents’ intentions to receive a COVID-19 vaccine, as well as other demographic information. We employ data from the HPS collection periods beginning in Week 28 (conducted from April 14th, 2021 through April 26th, 2021) and ending with Week 41 (conducted from December 29th, 2021 through January 10th, 2022).¹² Each survey during this period was sampled from approximately 1.04 million housing units and had an overall weighted response rate between 6.6 percent (68,913 respondents) and 7.2 percent (74,995 respondents).¹³

There exist discrepancies between vaccination rates estimated from the HPS and administrative data from the Centers for Disease Control and Prevention (CDC), with the HPS historically overestimating vaccination rates (Figure 1).¹⁴ However, this discrepancy has narrowed over time, with the most recent data indicating that vaccination rates estimated from the HPS are approximately similar to those in CDC administrative data. Although the gap in vaccination rates between these sources has narrowed, trends in vaccine uptake and willingness should still be interpreted with caution in light of the potential influence of nonsampling error, especially for earlier phases of the HPS.

Figure 1. Percent of Adult Population Unvaccinated



Note: Figure 1 shows the percent of adults (18 years or older) in the United States who have not received at least one COVID-19 vaccination over the time period late April 2021 to early January 2022. We estimate these percentages using data from the HPS for survey weeks 28 through 41. Each marker for the HPS time series represents a survey week. We also plot these percentages as reported by the CDC. To estimate the corresponding number of unvaccinated adults, we multiply these percentages by the adult population in the United States in 2021 as reported by the U.S. Census. Data from the CDC are plotted daily.

¹² Table A1 contains the start and end dates for each survey week we analyze.

¹³ U.S. Census Bureau, Household Pulse Survey Technical Documentation, <https://www.census.gov/programs-surveys/household-pulse-survey/technical-documentation.html>, last accessed January 21, 2022.

¹⁴ Bradley, V.C., Kuriwaki, S., Isakov, M. et al. Unrepresentative big surveys significantly overestimated US vaccine uptake. *Nature* 600, 695–700 (2021). <https://doi.org/10.1038/s41586-021-04198-4>

In addition to HPS data, we use two administrative datasets from the CDC. The first are adult vaccination rates. Not only do we use these to compare to vaccination rates estimated from the HPS, as in Figure 1, we also use them to estimate the number of unvaccinated adults, also shown in Figure 1. We do so by multiplying the percentage of the American adult population that has yet to receive one dose of a COVID-19 vaccine by the 2021 adult population of the United States, 258.3 million persons.¹⁵ The second administrative CDC dataset we utilize is the 7-day moving average of COVID-19 cases at the national level, which we employ to compare trends in willingness to vaccinate with COVID-19 surges.

Defining Unvaccinated but Willing

To define unvaccinated but willing, we identify unvaccinated adults who are willing to vaccinate by first limiting our sample to include only individuals who responded “No” to whether they had received a COVID-19 vaccine. We exclude respondents for whom there was no response to this question. For those individuals who responded “No”, they are then asked a follow-up question regarding their vaccination intentions. For Weeks 28-33, the question asked, “Once a vaccine to prevent COVID-19 is available to you, would you...get a vaccine?” For Weeks 34-41, the question was updated to reflect the widespread availability of vaccines, “Now that vaccines to prevent COVID-19 are available to most adults in the United States, will you...” For both the original and revised survey question the following options were: 1) “Definitely get a vaccine”; 2) “Probably get a vaccine”; 3) “Be unsure about getting a vaccine”; 4) “Probably NOT get a vaccine”; 5) “Definitely NOT get a vaccine.” We define the unvaccinated but willing population as those who indicated they were “unsure,” “probably,” or “definitely” going to get a COVID-19 vaccine (Table 1). Individuals who instead responded “probably NOT” or “definitely NOT” we categorize as unwilling to get vaccinated (Table 1).

Table 1. Example Household Pulse Survey Question about Intention to Vaccinate		
Question	Potential Answers	Willingness Categorization
Now that vaccines to prevent COVID-19 are available to most adults in the United States, will you...	1. Definitely get a vaccine	Willing
	2. Probably get a vaccine	
	3. Be unsure about getting a vaccine	
	4. Probably NOT get a vaccine	Unwilling
	5. Definitely NOT get a vaccine	

Note: Table 1 presents possible responses to the HPS question “Now that vaccines to prevent COVID-19 are available to most adults in the United States, will you...” Additionally, we present how we define which unvaccinated adults are willing to vaccinate or unwilling to vaccinate based on their response to this question.

Exploring the Reasons for Not Vaccinating

To explore the trends in the reasons for not getting vaccinated among this population, we utilize the survey question, “Which of following, if any are the reasons that you {probably get a vaccine/unsure about getting a

¹⁵ U.S. Census Bureau, New Vintage 2021 Population Estimates for the Nation, States and Puerto Rico, <https://www.census.gov/newsroom/press-releases/2021/2021-population-estimates.html#:~:text=The%20voting%20age%20resident%20population,of%20the%20population%20in%202021>, last accessed January 21, 2022.

vaccine/probably NOT get a vaccine/definitely NOT get a vaccine}?” This question was not asked of the unvaccinated adult population who stated that they would definitely get a vaccine.

The potential responses for Weeks 28-33 (Table 2) vary from the responses in Weeks 34-41 (Table 3) due to revisions that were made in the survey question during the transition from Phase 3.1 to Phase 3.2 of the HPS. As a result, we explore trends in these two sets of responses separately.

Table 2. Household Pulse Survey Question about Reasons to Not Vaccinate (Weeks 28-33)	
Question	Potential Answers
Which of the following, if any, are reasons that you, {probably get a vaccine, or are unsure about getting a vaccine, or probably NOT get a vaccine, or definitely NOT get a vaccine}	1. I am concerned about possible side effects of a COVID-19 vaccine
	2. I don’t know if a COVID-19 vaccine will work
	3. I don’t believe I need a COVID-19 vaccine
	4. I don’t like vaccines
	5. My doctor has not recommended it
	6. I plan to wait and see if it is safe and may get it later
	7. I think other people need it more than I do right now
	8. I am concerned about the cost of a COVID-19 vaccine
	9. I don’t trust COVID-19 vaccines
	10. I don’t trust the government
	11. Other

Note: Table 2 presents possible responses to the HPS question asking reasons for not getting vaccinated. The sample of respondents is limited to unvaccinated adults who state that they will either probably get a vaccine, are unsure about getting a vaccine, probably will not get a vaccine, or definitely will not get a vaccine. The sample for this set of responses is additionally limited to HPS survey weeks 28 through 33 since the possible responses to this question changed after survey week 33.

Table 3. Household Pulse Survey Question about Reasons to Not Vaccinate (Weeks 34-41)

Question	Potential Answers
Which of the following, if any, are reasons that you, {probably get a vaccine, or are unsure about getting a vaccine, or probably NOT get a vaccine, or definitely NOT get a vaccine}	1. I am concerned about possible side effects of a COVID-19 vaccine
	2. I don't know if a COVID-19 vaccine will protect me
	3. I don't believe I need a COVID-19 vaccine
	4. My doctor has not recommended it
	5. I plan to wait and see if it is safe and may get it later
	6. I am concerned about the cost of a COVID-19 vaccine
	7. I don't trust COVID-19 vaccines
	8. I don't trust the government
	9. I don't think COVID-19 is that big of a threat
	10. It's hard for me to get a COVID-19 vaccine
	11. Other

Note: Table 3 presents possible responses to the HPS question asking reasons for not getting vaccinated. The sample of respondents is limited to unvaccinated adults who state that they will either probably get a vaccine, are unsure about getting a vaccine, probably will not get a vaccine, or definitely will not get a vaccine. The sample for this set of responses is additionally limited to HPS survey weeks 34 through 41 since the possible responses to this question changed after survey week 33.

Analytic Approach

We examine trends in both the percent of the unvaccinated adult population willing to vaccinate, as well as estimate the corresponding number of unvaccinated adults willing to vaccinate. To obtain the former, we estimate the percent of the population willing to vaccinate using probability weights provided by the Household Pulse Survey. To obtain the latter, we multiply this percentage of unvaccinated adults willing to vaccinate by our estimate of the total number of unvaccinated adults. We additionally show how changes in willingness to vaccinate correlate with changes in COVID-19 prevalence by comparing our estimates of vaccine willingness from the HPS to the national 7-day moving average of COVID-19 cases as reported by the CDC.

After analyzing the entire sample of unvaccinated adults, we examine how willingness to vaccinate varies based on demographic characteristics, including sex, age, race/ethnicity, education, household income and Census region. Similar to our examination of the entire sample of unvaccinated adults, we show the proportion of unvaccinated adults willing to vaccinate in each demographic category, and our corresponding estimate of number of unvaccinated adults willing to vaccinate in each demographic category.

We employ logistic regressions to further explore associations between unvaccinated adults' demographic characteristics and willingness to vaccinate. For each regression, our outcome variable is an indicator variable equal to one if an individual is willing to vaccinate, and equal to zero otherwise. Our explanatory variables are indicator variables that capture the universe of possible values for our selected demographic characteristics, including sex, age, race/ethnicity, education and annual household income. Additionally, we include an indicator variable for each state. We estimate our logit model for two cross-sections: the earliest survey week we examine, Week 28 (conducted from April 14th, 2021 through April 26th, 2021), and the most recent survey week we examine, Week 41 (conducted from December 29th, 2021 through January 10th, 2022). Finally, these regressions use replicate weights provided by the HPS. Please see Appendix 1 for a more detailed discussion of these regressions.

Lastly, we explore why unvaccinated adults chose to not vaccinate by analyzing trends in reasons selected for not vaccinating. We estimate the percentage of unvaccinated adults who chose each possible answer. Additionally, we separate our sample into respondents who were willing to vaccinate and unwilling to vaccinate to illustrate the stark difference in reasons for not vaccinating between these two populations.

Results

Trends in Vaccination Willingness of Unvaccinated Adults

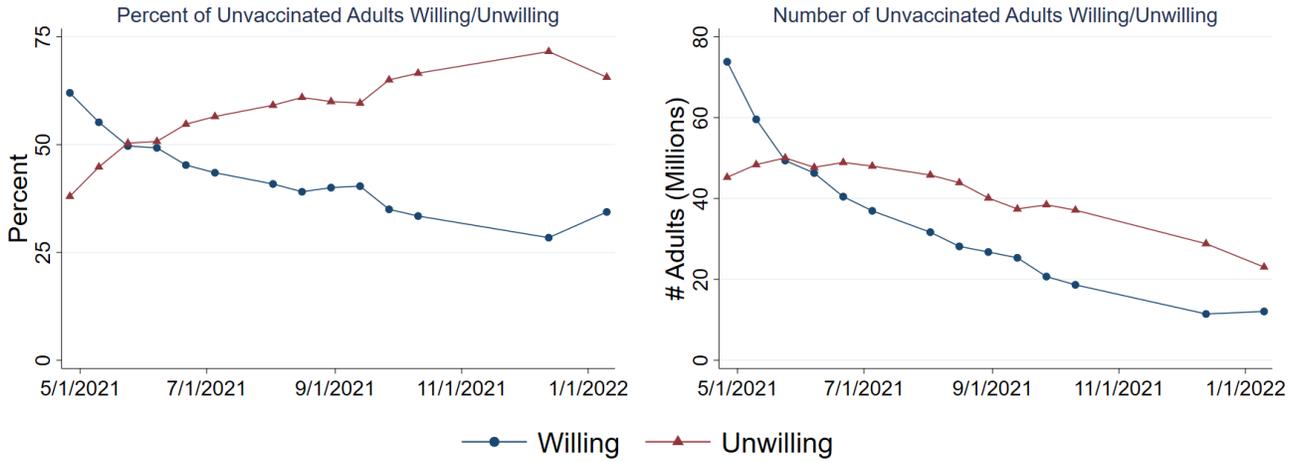
We first find that as vaccination rates have increased, the remaining unvaccinated adults have been less likely to be willing to vaccinate. Figure 2 shows the percent of unvaccinated adults who are willing and unwilling to vaccinate over time.¹⁶ In early summer 2021, 62 percent of the unvaccinated adult population was *willing* to get vaccinated, while 38 percent of the unvaccinated adult population was *unwilling* to get vaccinated. Over time the percent of the adult unvaccinated population willing to vaccinate steadily decreased, while the percent unwilling to vaccinate increased. By early January 2022, 66 percent of the unvaccinated adult population was unwilling to vaccinate, while only 34 percent of the unvaccinated adult population was willing to vaccinate.

In terms of numbers of adults, both unvaccinated adults *willing* to vaccinate *and* unvaccinated adults *unwilling* to vaccinate received vaccines in large numbers. In early summer 2021, 74 million unvaccinated adults were willing to vaccinate. By early January, there were only 12 million remaining unvaccinated adults willing to vaccinate. Similarly, in early summer 2021, there were 45 million unvaccinated adults who were unwilling to vaccinate. By early January, there remained only 23 million unvaccinated adults unwilling to vaccinate, an approximate 49 percent decrease in the number of unvaccinated adults unwilling to vaccinate.

This is not to say that the drop in unvaccinated adults unwilling to vaccinate necessarily translates to all of these individuals choosing to receive a vaccine. It is possible that some of these individuals remained unvaccinated while switching to being willing to vaccinate. But even at the extreme of this behavior—if in January 2022 all remaining unvaccinated but willing individuals had previously stated they were unwilling—large numbers of individuals who had previously stated they were unwilling to vaccinate still would have received vaccines.

¹⁶ Please see Figure A1 for an illustration of trends in vaccine willingness and unwillingness disaggregated by original survey responses. These potential responses include whether an unvaccinated adult will definitely vaccinate, probably vaccinate, is unsure whether will vaccinate, probably not vaccinate, and definitely not vaccinate.

Figure 2. Vaccine Intentions of Unvaccinated Adults

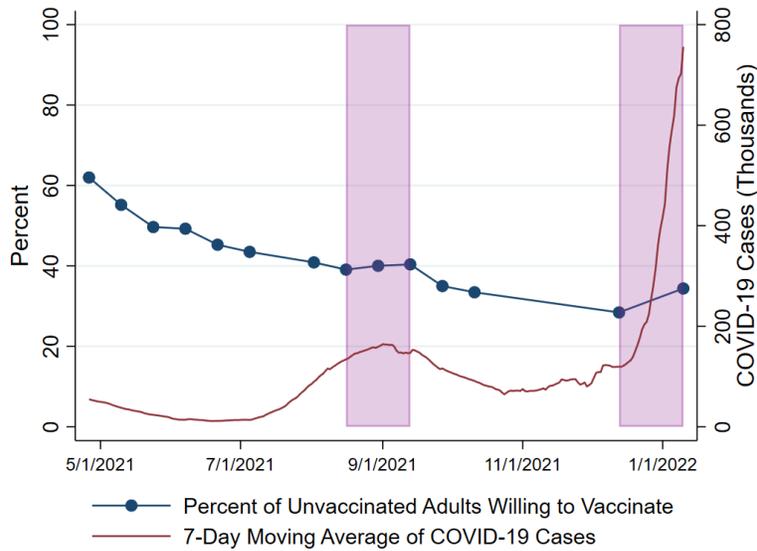


Note: Figure 2 shows the percent of unvaccinated adults (18 years or older) in the United States who report being willing or unwilling to get a COVID-19 vaccine over the time period late April 2021 to early January 2022. We estimate these percentages using data from the HPS for survey weeks 28 through 41. Each marker represents an HPS survey week. We also estimate the corresponding number of adults in each category by multiplying these percentages by our estimates of the number of unvaccinated adults using CDC data as shown in Figure 1.

While the willingness of unvaccinated adults to vaccinate steadily decreased, there were time periods in which willingness temporarily increased. Figure 3 highlights these time periods—late August to early September, and late December to early January. These time periods coincided with surges in COVID-19. As show in Figure 3, the 7-day moving average of COVID-19 cases sharply increased during both of these time periods as the United

States experienced surges from the Delta and Omicron variants, respectively. This timing suggests that surges in COVID-19 may influence the unvaccinated public’s willingness to vaccinate.

Figure 3: Vaccine Willingness Among Unvaccinated Rises during COVID-19 Surges

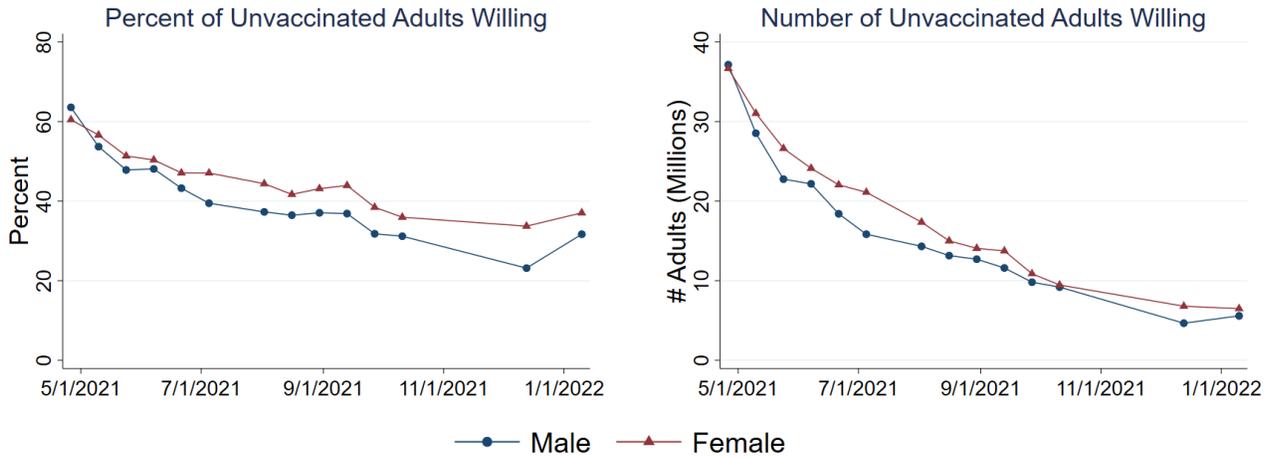


Note: Figure 3 shows the percent of unvaccinated adults (18 years or older) in the United States who report being willing to get a COVID-19 vaccine over the time period late April 2021 to early January 2022. We estimate these percentages using data from the HPS for survey weeks 28 through 41. Each marker represents an HPS survey week. The shaded areas highlight the time periods when reported willingness increased. Additionally, we also plot the 7-day moving average of COVID-19 cases (thousands) as reported by the CDC. This figure shows that increases in willingness to vaccinate among unvaccinated adults coincided with surges in COVID-19.

Trends in Vaccination Willingness of Unvaccinated Adults by Demographic Groups

We additionally analyze trends in willingness to vaccinate for unvaccinated adults disaggregated by demographic characteristics. In terms of sex, Figure 4 shows that for almost the entire time period under examination, women were more willing to vaccinate than men. In late spring 2021, approximately 62 percent of unvaccinated adult males and 60 percent of unvaccinated adult females were willing to vaccinate. During the rest of 2021, the percentage of females willing to vaccinate was consistently higher than the percentage of males. By early January 2022, approximately 39 percent of unvaccinated females and 33 percent of unvaccinated males were willing to get vaccinated. The number of unvaccinated adults willing to vaccinate reflects a similar pattern. In late spring 2021, approximately 37 million unvaccinated male adults and 36 million unvaccinated female adults were willing to get vaccinated. By early January 2022, these numbers had decreased to approximately 7 million unvaccinated female adults and 6 million unvaccinated male adults willing to vaccinate.

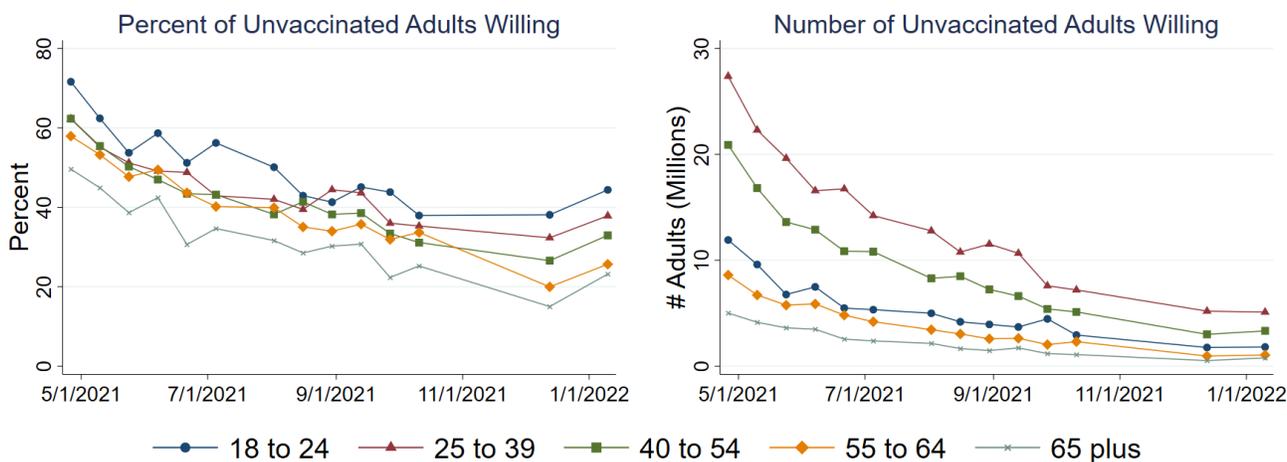
Figure 4. Vaccine Willingness Among Unvaccinated Adults (by Sex)



Note: Figure 4 shows the percent of unvaccinated American adults (18 years or older) disaggregated by sex who report being willing to get a COVID-19 vaccine over the time period late April 2021 to early January 2022. We estimate these percentages using data from the HPS for survey weeks 28 through 41. Each marker represents an HPS survey week. We also estimate the corresponding number of adults in each category by multiplying these percentages by our estimates of the number of unvaccinated adults using CDC data as shown in Figure 1.

Figure 5 depicts the evolution of vaccine willingness by age group. Among unvaccinated adults, the younger population was consistently more willing to vaccinate than the older population. In early spring 2021, approximately 72 percent of unvaccinated adults aged 18 to 24 were willing to be vaccinated, while only approximately 50 percent of unvaccinated adults older than 64 years old were willing to vaccinate. This pattern remained consistent and even strengthened by early January 2022 as for all age groups the younger the age group, the higher the willingness to vaccinate. In terms of the number of unvaccinated adults willing to vaccinate, the population of young adults has consistently dwarfed the population of older adults.

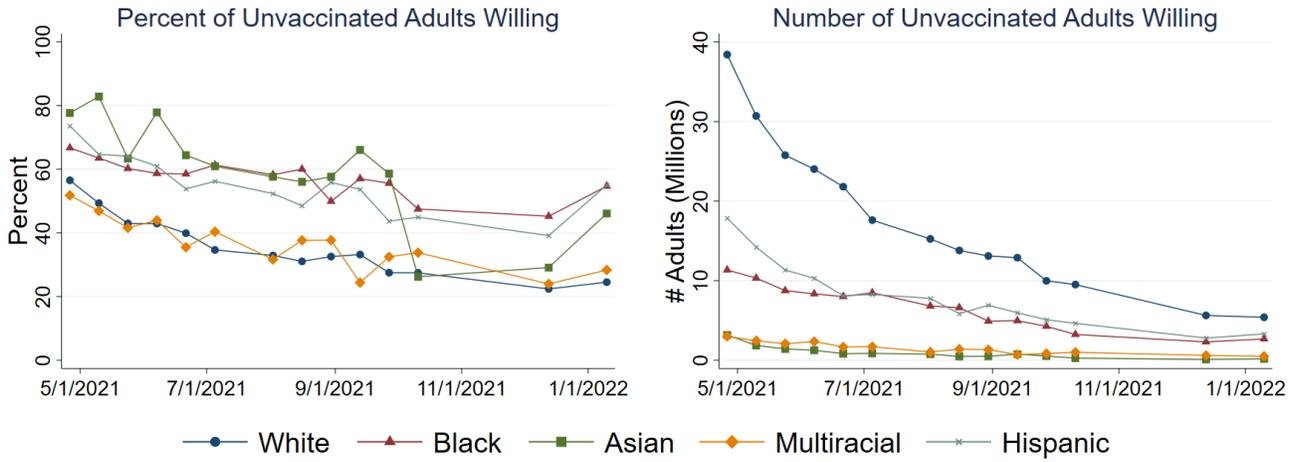
Figure 5. Vaccine Willingness Among Unvaccinated Adults (by Age Group)



Note: Figure 5 shows the percent of unvaccinated American adults (18 years or older) disaggregated by age group who report being willing to get a COVID-19 vaccine over the time period late April 2021 to early January 2022. We estimate these percentages using data from the HPS for survey weeks 28 through 41. Each marker represents an HPS survey week. We also estimate the corresponding number of adults in each category by multiplying these percentages by our estimates of the number of unvaccinated adults using CDC data as shown in Figure 1.

Figure 6 illustrates changes in vaccine willingness by race and ethnicity. The unvaccinated adult Hispanic and Black populations consistently reported a higher willingness to vaccinate than the unvaccinated adult White and Multiracial populations. The willingness to vaccinate of unvaccinated adult Asians relative to other race/ethnicity groups changed over time, though. In late spring 2021, unvaccinated Asian adults were most likely to report being willing to vaccinate. But, by late fall 2021, their willingness dropped to levels similar to the White and Multiracial population, before increasing to a level closer to the Hispanic and Black populations by early January 2022. We note that interpretations of these fluctuations should be made with caution as the Asian population composed only approximately 2 percent of our sample. In terms of numbers of unvaccinated adults willing to get vaccinated, unvaccinated White adults consistently composed the largest portion of the population with Black and Hispanic adults composing the next two most prominent race/ethnicity categories.

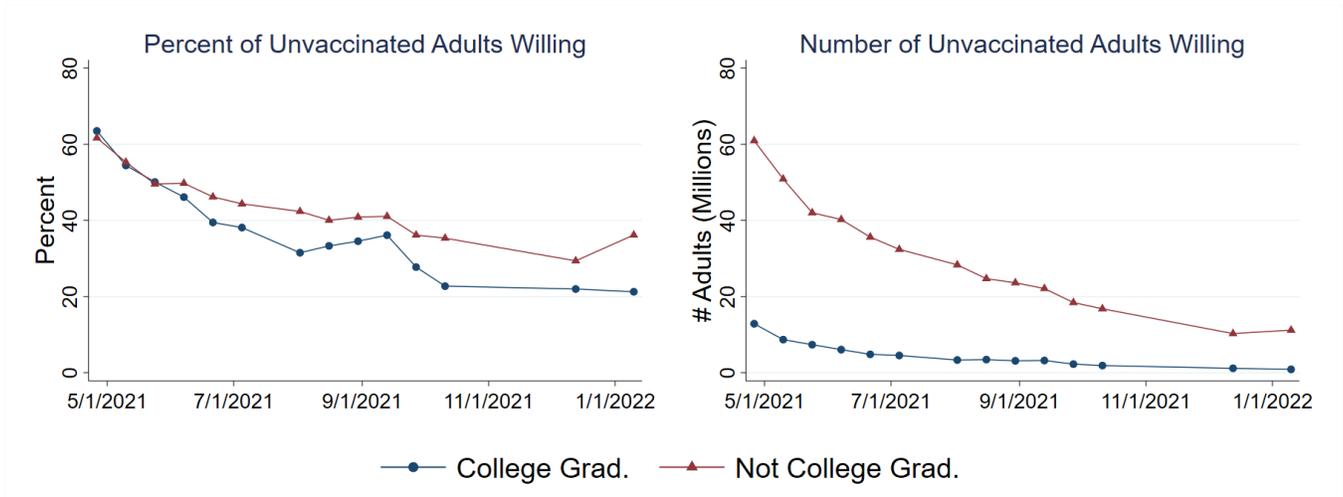
Figure 6. Vaccine Willingness Among Unvaccinated Adults (by Race/Ethnicity)



Note: Figure 6 shows the percent of unvaccinated American adults (18 years or older) disaggregated by race/ethnicity who report being willing to get a COVID-19 vaccine over the time period late April 2021 to early January 2022. We estimate these percentages using data from the HPS for survey weeks 28 through 41. Each marker represents an HPS survey week. We also estimate the corresponding number of adults in each category by multiplying these percentages by our estimates of the number of unvaccinated adults using CDC data as shown in Figure 1. Each marker represents an HPS survey week.

Figure 7 disaggregates these results by education level, comparing those with a college degree to those without a college degree. In the first several survey weeks, the proportion of college graduates and non-college graduates willing to vaccinate were approximately equal; however, over time a higher proportion of non-college graduates remained willing to vaccinate. In terms of the corresponding number of adults, the vast majority of unvaccinated adults willing to vaccinate have been non-college educated. By early January 2022, practically all remaining unvaccinated adults willing to vaccinate were non-college educated.

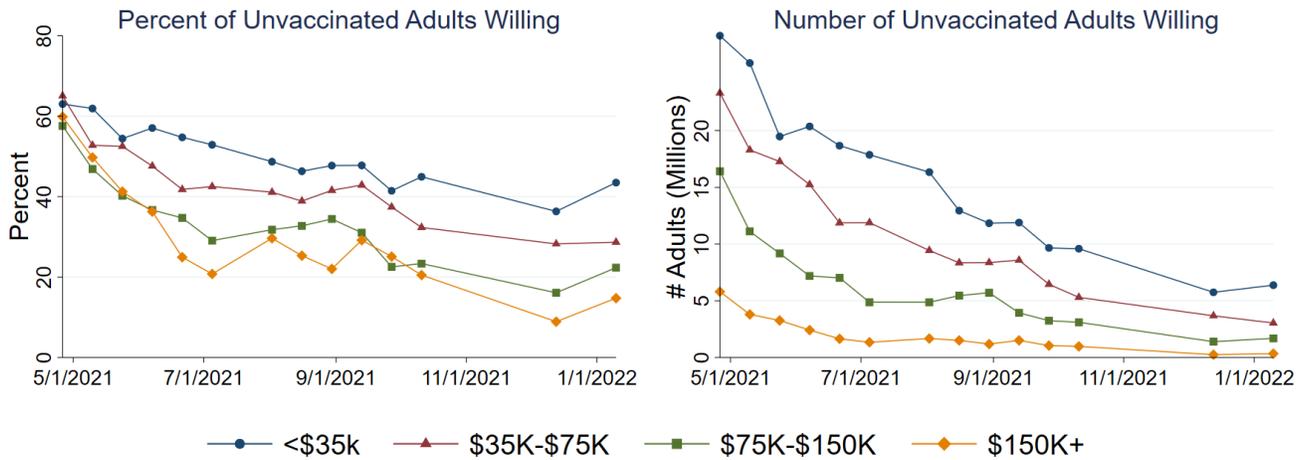
Figure 7. Vaccine Willingness Among Unvaccinated Adults (by Education)



Note: Figure 7 shows the percent of unvaccinated American adults (18 years or older) disaggregated by education who report being willing to get a COVID-19 vaccine over the time period late April 2021 to early January 2022. We estimate these percentages using data from the HPS for survey weeks 28 through 41. Each marker represents an HPS survey week. We also estimate the corresponding number of adults in each category by multiplying these percentages by our estimates of the number of unvaccinated adults using CDC data as shown in Figure 1. Each marker represents an HPS survey week.

Figure 8 depicts trends in vaccine willingness based on annual household income. We find that in general unvaccinated adults in lower income groups were consistently more willing to vaccinate than adults in higher income groups. Over the survey weeks, unvaccinated adults with household incomes of \$35,000 or less consistently were the most willing to vaccinate, while respondents with household incomes over \$150,000 consistently were the most willing to vaccinate. Similarly, the number of unvaccinated but willing adults in lower household income groups has consistently been larger than those in higher household income groups. For instance, by early January 2022, there were approximately 6 million unvaccinated adults willing to vaccinate in households with annual incomes lower than \$35,000, while there were almost no remaining unvaccinated adults willing to vaccinate in households with annual incomes higher than \$150,000.

Figure 8. Vaccine Willingness Among Unvaccinated Adults (by Annual Household Income)

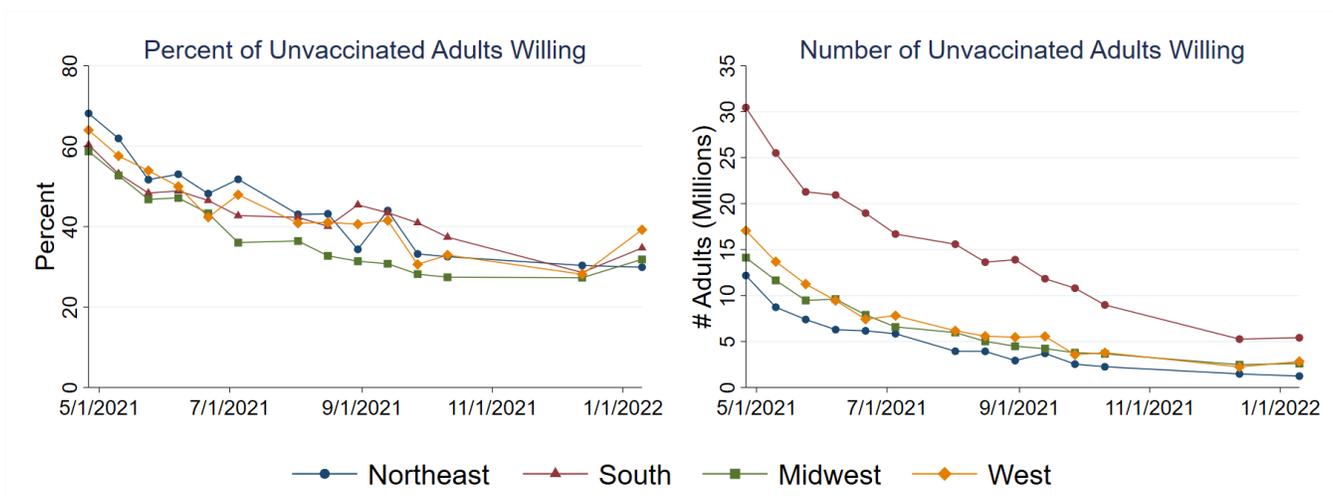


Note: Figure 8 shows the percent of unvaccinated American adults (18 years or older) disaggregated by annual household income who report being willing to get a COVID-19 vaccine over the time period late April 2021 to early January 2022. We estimate these percentages using data from the HPS. We also estimate the corresponding number of adults in each category by multiplying these percentages by our estimates of the number of unvaccinated adults using CDC data as shown in Figure 1. Each marker represents an HPS survey week.

Lastly, Figure 9 illustrates differences in willingness to vaccinate by Census region.¹⁷ The percent of unvaccinated adults willing to vaccinate in each Census region followed similar trends, with unvaccinated adults in the Midwest largely being the least willing to vaccinate. In terms of number of unvaccinated adults willing to vaccinate, the southern Census region consistently housed the largest number.

¹⁷ Census regions house the following states. *Northeast*: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York and Pennsylvania. *Midwest*: Indiana, Illinois, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota. *South*: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Tennessee, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas. *West*: Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, Wyoming, Alaska, California, Hawaii, Oregon and Washington.

Figure 9. Vaccine Willingness Among Unvaccinated Adults (by Census Region)



Note: Figure 9 shows the percent of unvaccinated American adults (18 years or older) disaggregated by Census region who report being willing to get a COVID-19 vaccine over the time period late April 2021 to early January 2022. We estimate these percentages using data from the HPS for survey weeks 28 through 41. Each marker represents an HPS survey week. We also estimate the corresponding number of adults in each category by multiplying these percentages by our estimates of the number of unvaccinated adults using CDC data as shown in Figure 1. Each marker represents an HPS survey week.

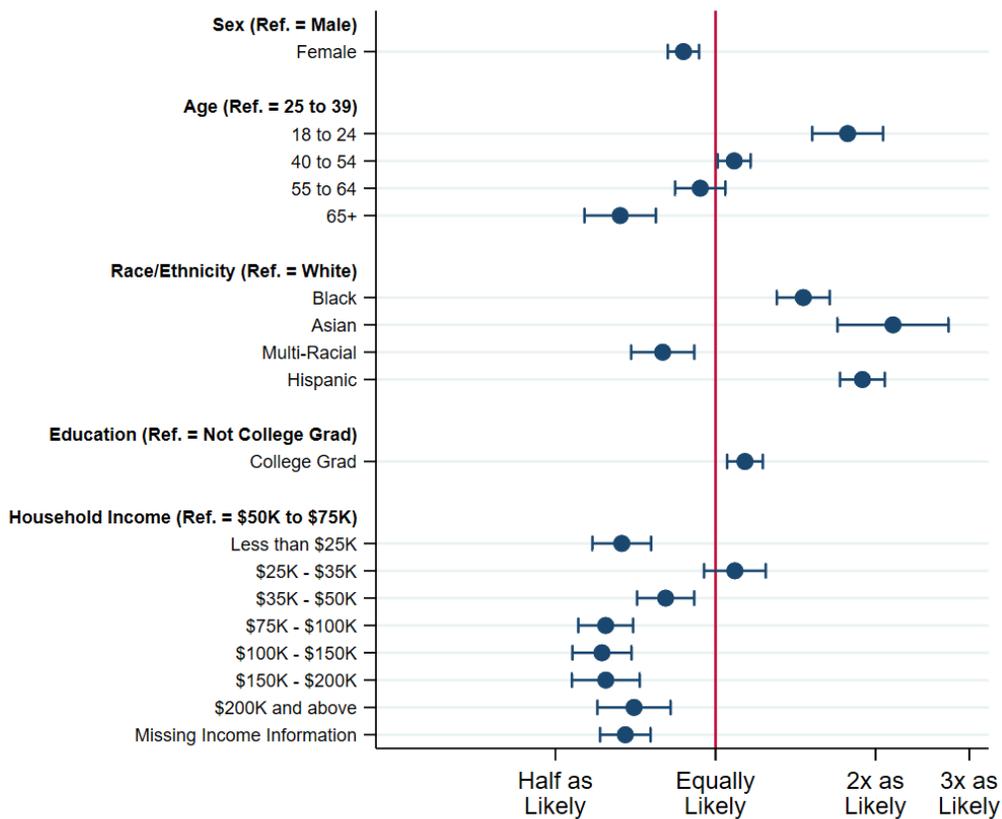
Association between Unvaccinated Adults' Willingness to Vaccinate and Demographic Characteristics

We perform logistic regressions to further explore the relationship between willingness to vaccinate and demographic characteristics. Each of these logistic regressions estimates a set of odds-ratios that describe the association between unvaccinated adults' willing to vaccinate and demographic characteristics while controlling for a set of demographic characteristics. We run the same logistic regression for two different time periods: the earliest survey week in our sample, Week 28 (conducted April 14, 2021 through April 26, 2021), and the most recent week in our sample, Week 41 (conducted December 29, 2021 through January 10, 2022). The resulting odds-ratios and confidence intervals are presented in Figures 10 and 11, respectively. The association between each demographic variable and willingness to vaccinate is considered to be "equally likely" and not statistically significant at the 95 percent level compared to the reference group if the confidence interval of the estimate crosses one, or the "equally likely" line. Confidence intervals that do not cross one are considered to be statistically significant at the 95 percent level. Please see Appendix 1 for a more detailed description of these regressions, Tables A2 and A3 for summary statistics for each regression, and Table A4 for a full list of estimated odds-ratios for each regression.

Figure 10 shows that among unvaccinated respondents surveyed from April 14, 2021 to April 26, 2021, female respondents were significantly less likely than male respondents to be willing to vaccinate, though the magnitude is relatively small. Younger respondents were significantly more likely to be willing to vaccinate than older respondents. For instance, those aged 18 to 24 were almost twice as likely to be willing to vaccinate as those aged 25 to 39, whereas those older than 65 were less likely to be willing to vaccinate than those aged 25 to 39. With respect to race/ethnicity, Black, Asian and Hispanic respondents were significantly more likely to be

willing to vaccinate than White respondents, while Multiracial/Other respondents were significantly less likely to be willing to vaccinate. Out of these race/ethnicity groups, Asians were the most likely to be willing to vaccinate—over twice as likely as Whites. In terms of education, education level was positively associated with willingness to vaccinate as respondents with a college degree were slightly but significantly more likely to be willing to vaccinate compared to those without a college degree. Lastly, respondents with household incomes in the middle of the distribution were generally the most likely to be willing to vaccinate. For instance, those with household incomes of less than \$25,000 were significantly less likely to vaccinate than those with household incomes between \$50,000 and \$75,000. Similarly, household income groups above \$75,000 were all significantly less willing to vaccinate than those with household incomes between \$50,000 and \$75,000.

Figure 10. Odds Ratios for Being Willing to Vaccinate (April 14, 2021 to April 26, 2021)

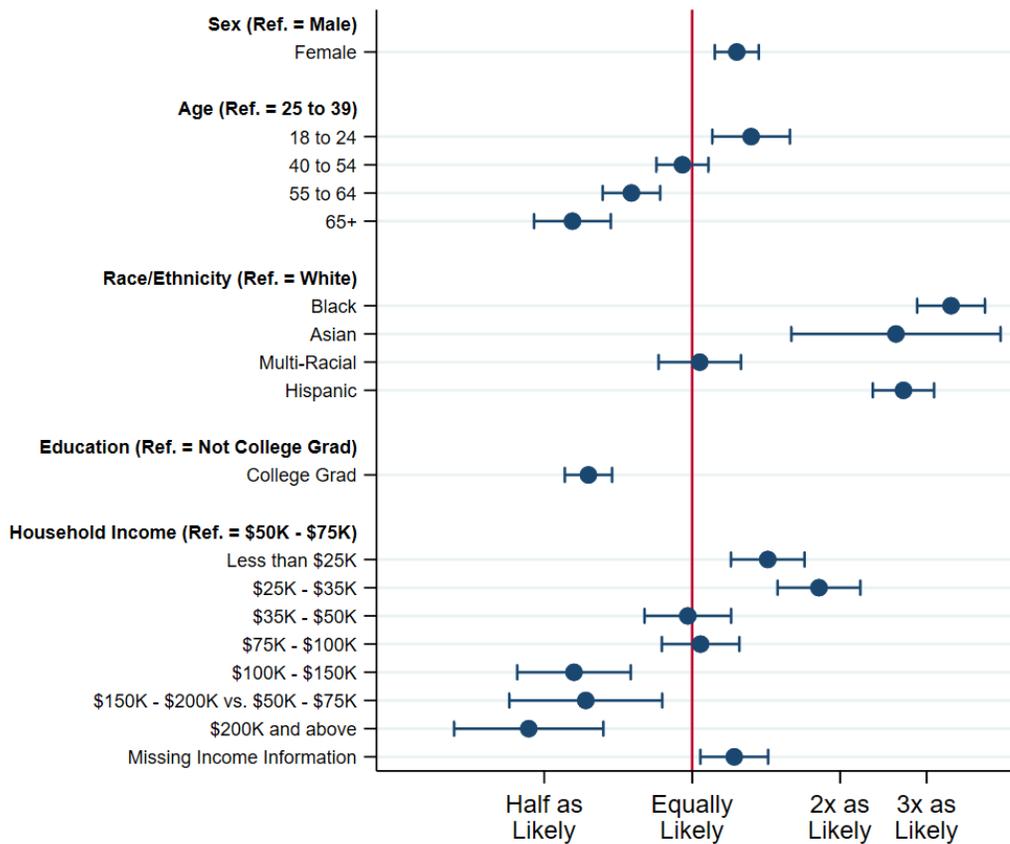


Note: Figure 10 reports odds ratios and 95 percent confidence intervals from a logistic regression where the outcome variable is a dummy variable for whether an unvaccinated adult is willing to vaccinate, and the explanatory variables are all dummy variables representing the universe of responses within the categories sex, age, race/ethnicity, education and annual household income. Our regression additionally includes a dummy variable for each state. The sample is unvaccinated adults from week 28 of the HPS, which was conducted April 14, 2021 through April 26, 2021. Please see Appendix 1 for a more detailed description of this regression and Table A2 for reported odds ratios and p-values.

Figure 11 shows the results for the same regression used in Figure 10, but from responses gathered from December 29, 2021 to January 10, 2022, nearly 8 months after the responses analyzed in Figure 10 and after COVID-19 vaccines were widely available to almost all adults. The associations between willingness to vaccinate and age and race/ethnicity appear similar to those in Figure 10, but now differ in terms of sex, education and household income. Unvaccinated adult women were now significantly more likely to be willing to vaccinate,

though again the magnitude is relatively. Unvaccinated adult college graduates were now significantly less likely to be willing to vaccinate compared to non-college graduates. And unvaccinated adults in lower household income groups were significantly more likely to be willing to vaccinate than those in higher household income groups across the household income spectrum. For instance, unvaccinated adults with household incomes less than \$25,000 were approximately 1.5 times more likely to be willing to vaccinate than unvaccinated adults with household incomes between \$50,000 and \$75,000; whereas those with household incomes greater than \$200,000 were only half as likely to be willing to vaccinate as those with household incomes between \$50,000 and \$75,000.

Figure 11. Odds Ratios for Being Willing to Vaccinate (December 29, 2021 to January 10, 2022)



Note: Figure 11 reports odd ratios and 95 percent confidence intervals from a logistic regression where the outcome variable is a dummy variable for whether an unvaccinated adult is willing to vaccinate, and the explanatory variables are all dummy variables representing the universe of responses within the categories sex, age, race/ethnicity, education and annual household income. Our regression additionally includes a dummy variable for each state. The sample is unvaccinated adults from week 41 of the HPS, which was conducted December 29, 2021 through January 10, 2022. Please see Appendix 1 for a more detailed description of this regression and Table A2 for reported odds ratios and p-values.

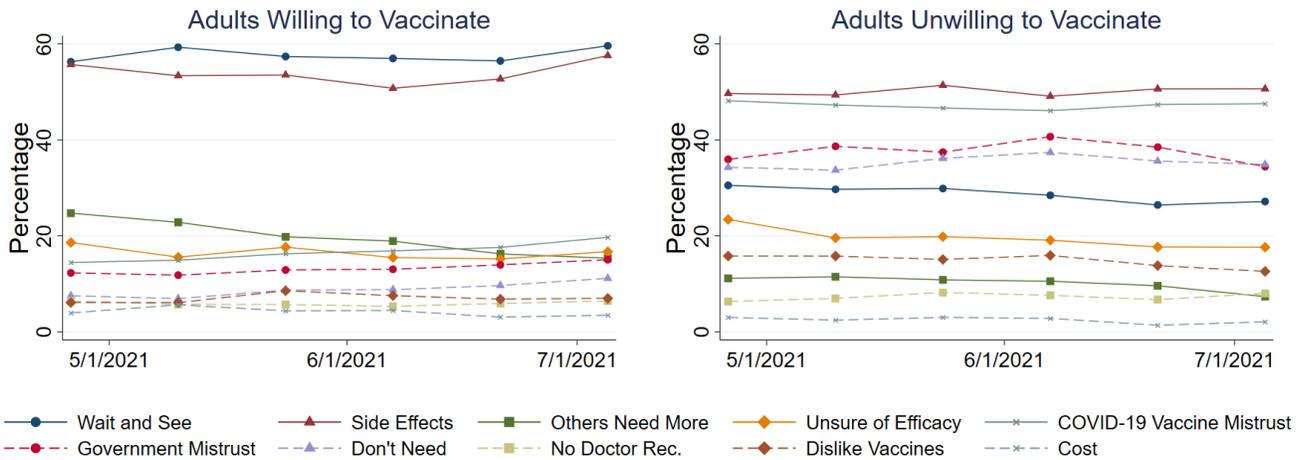
Reasons for Vaccine Avoidance

We dig deeper into unvaccinated adults' reluctance to vaccinate by analyzing trends in their reasons for not getting vaccinated. Since survey respondents were able to select multiple reasons for not vaccinating, we estimate the percent of respondents who chose each reason. Our sample is limited to unvaccinated adults who stated at least one reason for not getting vaccinated, and stated that they would probably vaccinate, were unsure whether they would vaccinate, probably would not vaccinate, or definitely would not vaccinate. Those in the former two categories we classify as willing to vaccinate, and those in the latter two categories we classify as unwilling to vaccinate. We additionally divide our analysis by time period as the available responses changed after Week 33 of the HPS.

Figure 12 depicts trends in reasons to not vaccinate for Weeks 28 through 33, which ran from late-Spring 2021 to mid-Summer 2021. The proportion of respondents who chose each reason remained relatively stable over time. Among unvaccinated adults, the two most common reasons chosen for not vaccinating were wanting to wait and see whether COVID-19 vaccines were safe and worries over COVID-19 vaccine side effects. Each of these reasons were chosen by almost 60 percent of respondents during the entire time period. There was a large gap between these two reasons and the other possible reasons. For instance, the next most commonly cited reason was that others may need a COVID-19 vaccine more, which was consistently chosen by less than 30 percent of respondents.

While adults who were unwilling to vaccinate shared some similar concerns, they emphasized other reasons, especially those related to distrust. COVID-19 vaccine side effects were similarly a worry as it was their most commonly cited reason to not vaccinate. But in contrast to adults willing to vaccinate, reasons related to distrust were the next most commonly cited reasons to not vaccinate. The percentage of respondents who said they had not vaccinated due to distrust in COVID-19 vaccines hovered around 50 percent, and the percentage who chose distrust in government hovered near 40 percent, each substantially higher than the response rate for adults willing to vaccinate.

Figure 12. Reasons for not Getting Vaccinated (Weeks 28-33)

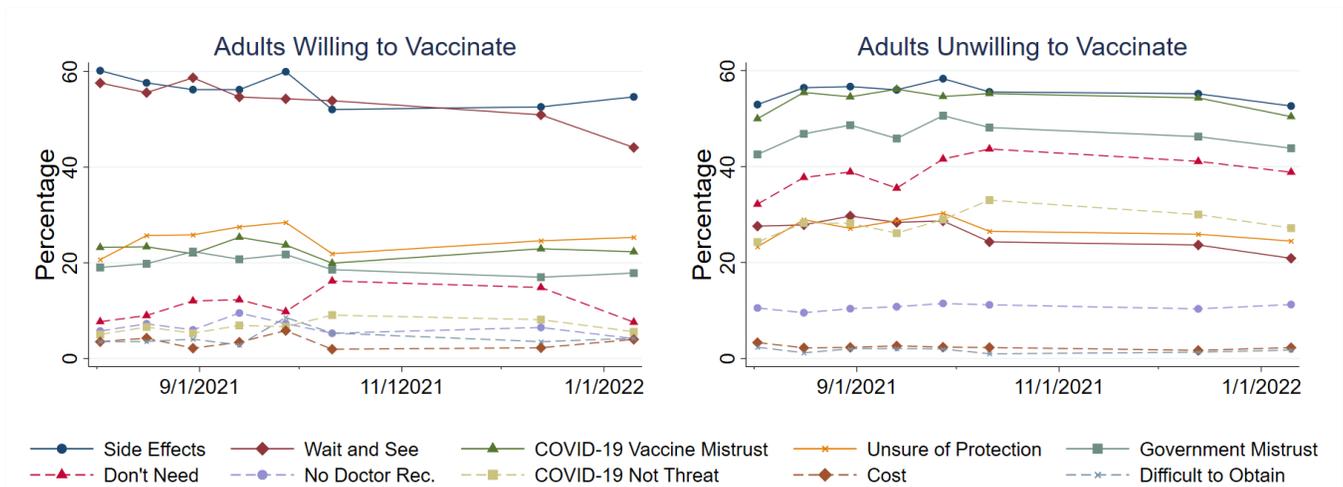


Note: Figure 12 presents the percentage of unvaccinated adults who report a given reason for not getting vaccinated. The sample is limited to survey weeks 28 through 33 of the HPS since the possible reasons for not getting vaccinated changed after survey week 33. We additionally divide the sample into unvaccinated adults who are willing to vaccinate and unvaccinated adults who are unwilling to vaccinate. Due to how the question was asked in the HPS, the sample of adults willing to vaccinate is limited to those who said they would probably get a vaccine or were unsure of when they would get a vaccine. The sample of adults unwilling to vaccinate is adults who would probably not get vaccinated or would definitely not get vaccinated.

Figure 13 repeats the same analysis but for a later time period, from mid-Summer 2021 to early January 2022. Again, the percentage of respondents that chose each reason remained relatively stable. For unvaccinated adults willing to vaccinate, the most common reasons chosen were consistently worries over COVID-19 side effects and wanting to wait and see whether COVID-19 vaccines were safe, though the prevalence of the latter decreased over time. In mid-Summer 2021, 58 percent of respondents said they wanted to wait and see whether COVID-19 vaccines were safe. But by early January 2022, only 44 percent of respondents chose the same reason. For unvaccinated adults unwilling to vaccinate, the prevalence of their reasons to not vaccinate were relatively similar as prior time periods—the most commonly cited reasons were worries over COVID-19 vaccine side effects, followed by distrust in COVID-19 vaccines and the government.

These later survey weeks included an additional potential reason for not vaccinating—that vaccines were difficult to obtain. This reason along with worries over the cost of vaccinating were the two reasons least likely to be chosen by the two groups of unvaccinated adults. For adults willing to vaccinate, both of these reasons were consistently chosen by less than 10 percent of respondents. For adults unwilling to vaccinate, both of these reasons were consistently chosen by even less—5 percent—of respondents. This suggests that vaccine access and cost have not been the main impediments to vaccine uptake.

Figure 13. Reasons for not Getting Vaccinated (Survey Weeks 34-41)



Note: Figure 13 presents the percentage of unvaccinated adults who report a given reason for not getting vaccinated. The sample is limited to survey weeks 34 through 41 of the HPS since the possible reasons for not getting vaccinated changed after survey week 33. We additionally divide the sample into unvaccinated adults who are willing to vaccinate and unvaccinated adults who are unwilling to vaccinate. Due to how the question was asked in the HPS, the sample of adults willing to vaccinate is limited to those who said they would probably get vaccinated or were unsure of whether they would get vaccinated. The sample of adults unwilling to vaccinate is adults who would probably not get vaccinated or would definitely not get vaccinated.

Discussion

Our analysis of trends in COVID-19 vaccination willingness illuminates a number of key facts. First, as vaccination rates have increased, the number of unvaccinated adults willing to vaccinate has substantially decreased. Between April 2021 and January 2022, the number of unvaccinated adults willing to vaccinate decreased by approximately 62 million adults, an 84 percent drop from the original 74 million in late spring 2021. Even with this large drop, as of early January 2022, there is still a substantial number of adults willing to vaccinate, 12 million.

Second, concurrently a large number of unvaccinated adults who said they were unwilling to vaccinate have actually also been getting vaccinated. Over the same time period, the number of unvaccinated adults unwilling to vaccinate has decreased by 22 million, a drop of 49 percent from the original 45 million in late spring 2021.

Third, as more adults have been receiving vaccines, the remaining unvaccinated population has been composed of an increasingly higher proportion of individuals unwilling to vaccinate—and in turn, a progressively lower proportion of individuals willing to vaccinate. This is consistent with adults who were previously unvaccinated but willing being more likely to vaccinate than those who were unvaccinated but unwilling. Consequently, as more unvaccinated but willing adults drop from the sample of the unvaccinated, the remaining sample of unvaccinated adults has an increasingly larger percentage of unwilling individuals.

Additionally, there is also evidence that individuals' willingness to vaccinate may have changed. The temporary increases in willingness to vaccinate among the adult unvaccinated population coincided with COVID-19 surges during the Delta and Omicron waves. This suggests that changes in vaccine willingness among unvaccinated

adults may have been driven by changes in individual preferences to vaccinate, and not just by changes in the sample of unvaccinated adults. Since adults willing to vaccinate are more likely to drop from the sample of unvaccinated adults in progressive survey waves, an increase in vaccine willingness suggests that preferences themselves may also be changing.

This finding is in line with others who have found disease outbreaks to increase vaccination confidence and uptake. Cacciatore et al. (2016) find that vaccine confidence increased after a 2014-2015 Disneyland measles outbreak, and Oster (2018) finds that vaccine uptake increased after pertussis outbreaks in the United States.^{18,19} It also coincides with survey data that indicate the threat of the Omicron variant increased overall individual concern that one may become seriously ill from COVID-19, with 42% of unvaccinated individuals expressing concern over serious illness.²⁰ Moreover, 12 percent of unvaccinated adults reported that news of the Omicron variant made them more likely to get vaccinated. Furthermore, we find that among adults willing to vaccinate, the proportion of those who reported their reasons for not vaccinating as “wait and see” or “don’t need a COVID-19 vaccine” both decreased between Survey Weeks 40 and 41, which may be influenced by widespread news of the effects of the Omicron variant.

Fourth, the relative willingness to vaccinate among different demographic groups has remained largely consistent. The younger, less educated and lower income populations have consistently been the most willing to vaccinate among unvaccinated adults, with these patterns becoming more pronounced over time. Moreover, the Black, Hispanic and Asian unvaccinated adult populations have been more willing to vaccinate than the unvaccinated adult White population, suggesting that these populations may be most receptive to vaccine outreach. While earlier studies have highlighted these groups as having higher unwillingness and hesitancy towards getting vaccinated^{21,22,23}, our findings are in line with more recent data that indicate a decrease in these attitudes for these populations.^{24,25}

Lastly, there were differences in reasons for not getting vaccinated between the willing and unwilling groups. Willing adults were more likely to be concerned about COVID-19 vaccine side effects or wanting to wait and see

¹⁸ Cacciatore, Michael A., Glen Nowak, and Nathaniel J. Evans. "Exploring the impact of the US measles outbreak on parental awareness of and support for vaccination." *Health Affairs* 35.2 (2016): 334-340.

¹⁹ Oster E. Does disease cause vaccination? Disease outbreaks and vaccination response. *J Health Econ.* 2018 Jan; 57:90-101. doi: 10.1016/j.jhealeco.2017.10.003. Epub 2017 Nov 2. PMID: 29182938; PMCID: PMC6522133.

²⁰ Kirzinger A, Kearney A, Hamel L, Brodie M. KFF COVID-19 Vaccine Monitor: Early Omicron Update, Available at <https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-early-omicron-update/>, last accessed January 28, 2022.

²¹ Guidry JPD, Laestadius LI, Vraga EK, et al. Willingness to get the COVID-19 vaccine with and without emergency use authorization. *Am J Infect Control.* 2021;49(2):137-142. doi:10.1016/j.ajic.2020.11.018

²² Yasmin F, Najeeb H, Moeed A, et al. COVID-19 Vaccine Hesitancy in the United States: A Systematic Review. *Front Public Health.* 2021;9:770985. Published 2021 Nov 23. doi:10.3389/fpubh.2021.770985

²³ Luo H, Qu H, Basu R, Rafferty AP, Patil SP, Cummings DM. Willingness to Get a COVID-19 Vaccine and Reasons for Hesitancy Among Medicare Beneficiaries: Results From a National Survey. *J Public Health Manag Pract.* 2022;28(1):70-76. doi:10.1097/PHH.0000000000001394

²⁴ King WC, Rubinstein M, Reinhart A, Mejia R. Time trends, factors associated with, and reasons for COVID-19 vaccine hesitancy: A massive online survey of US adults from January-May 2021. *PLoS One.* 2021;16(12):e0260731. Published 2021 Dec 21. doi:10.1371/journal.pone.0260731.

²⁵ Hamel L, Lopes L, Sparks G, et al. KFF COVID-19 Vaccine Monitor: September 2021, Available at <https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-september-2021/>, last accessed January 28, 2022.

whether COVID-19 vaccines are safe, suggesting that outreach emphasizing the safety of COVID-19 vaccines may be particularly efficacious. Unwilling adults were more likely to report reasons related to mistrust in government and COVID-19 vaccines, which may be more difficult to address with COVID-19 specific outreach as they suggest a more entrenched reluctance.

Willing and unwilling groups also shared patterns in their responses. Within each of these groups, the percentage of respondents choosing each reason remained largely stable over time, even as the number of individuals in each of these groups substantially decreased. Moreover, both groups were least likely to choose concerns over vaccine costs and availability as reasons for not vaccinating.

It remains an open question why there remain 12 million unvaccinated but willing adults. Our analysis shows that vaccine cost and availability have not been major impediments to vaccine uptake. Instead, respondents are most likely to express concerns over COVID-19 vaccine side effects and a desire to wait and see whether COVID-19 vaccines are safe, despite there already existing a large body of clinical and observational evidence that COVID-19 vaccines are safe and effective. There are a number of possibilities for this. It may be these individuals' concerns over vaccine safety and side effects have not been addressed sufficiently to induce them to become vaccinated. It may be that vaccine misinformation has led to vaccine mistrust and avoidance of vaccination.²⁶ It may be these individuals plan to get vaccinated, but don't perceive the need to be imminent. It also may be that respondents who say they are willing to vaccinate may not actually be willing to vaccinate, for instance due to social desirability bias. Future work may further analyze why these unvaccinated but willing individuals have yet to vaccinate, and how best to increase their vaccine uptake.

Limitations

There are two primary limitations for our analysis. First, the HPS may not be fully representative of all adults in the United States. For instance, due to nonsampling error the HPS has historically overestimated vaccination rates. Additionally, our sample for some subpopulations of unvaccinated adults may be relatively small. Consequently, interpretations of our estimates should be made in conjunction with awareness of issues inherent to the HPS. A full discussion of these and other limitations associated with the HPS can be found in the survey's technical documentation.²⁷

Second, our regressions should be interpreted as conditional associations between willingness to vaccinate and demographic characteristics. We do not propose a strategy to identify a causal relationship between the two sets of variables, nor do we attempt to include all potential demographic or other variables that may be related to vaccine willingness among unvaccinated adults. For example, other research has pointed to a relationship between political affiliation and willingness to get a COVID-19 vaccine.²⁸ Since political affiliation is not included in the HPS, it is not included in our analysis. Consequently, its omission may bias our regression results.

²⁶ Kricorian K, Civen R, Equils O. COVID-19 vaccine hesitancy: misinformation and perceptions of vaccine safety. *Hum Vaccin Immunother.* 2022;18(1):1950504. doi:10.1080/21645515.2021.1950504

²⁷ US Census Bureau (2021). Source of the Data and Accuracy of the Estimates for the Household Pulse Survey Phase 3.3. Available at https://www2.census.gov/programs-surveys/demo/technical-documentation/hhp/Phase3-3_Source_and_Accuracy_Week40.pdf, last accessed December 30, 2021.

²⁸ Hamel L, Lopes L, Sparks G, et al. KFF COVID-19 Vaccine Monitor: October 2021, Available at <https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-october-2021/>, last accessed February 14, 2022.

Conclusion

Our analysis shows that substantial progress has been made in increasing COVID-19 vaccination coverage in the United States. While most of the increase in vaccination coverage has been among the population willing to vaccinate, there have also been substantial gains among the unwilling population.

Despite this progress, vaccine hesitancy continues to challenge attempts to increase vaccine uptake. Our estimates suggest that as of early January 2022, 12 million willing adults and 23 million unwilling adults remained unvaccinated. We demonstrate that the groups of unvaccinated most willing to vaccinate have consistently been the younger, lower income, and less educated unvaccinated adult populations. Moreover, Black, Hispanic and Asian unvaccinated adults have consistently been more willing to vaccinate than White unvaccinated adults.

We further explore reasons for not vaccinating. Cost and accessibility have not been prominent reasons for not vaccinating. Instead, the willing emphasize concerns over COVID-19 vaccine side effects and wanting to wait and see whether COVID-19 vaccines are safe. The unwilling similarly point to concerns over side effects, but additionally point to distrust of COVID-19 vaccines and the government.

Our findings highlight that vaccine willingness and reasons for not vaccinating vary among different populations. As vaccine willingness changes over time, outreach efforts and policy choices not only need to demonstrate the safety and efficacy of COVID-19 vaccines, but also tailor their approaches to address the varying needs of these different populations, such as addressing concerns over vaccine side effects, or rebuilding trust among those who distrust COVID-19 vaccines and the government. Future work may seek to better understand these differences in willingness and sources of vaccine reluctance, and how to best address them in an effort to further raise vaccine uptake.

Appendix 1

We employ the following binary logistic regression to estimate the association between unvaccinated adults' willingness to vaccinate and demographic characteristics:

$$(1) \text{logit}(y_{it}) = \alpha + X_{it}\beta + e_i$$

Where y_{it} is equal to one if unvaccinated adult i is willing to vaccinate in survey week t , and equally to zero otherwise; and X_{it} is a vector of demographic characteristics for unvaccinated adult i in survey week t . Each of these demographic variables are dummy variables that represent the universe of possible values for each demographic characteristic. These demographic characteristics include dummy variables for sex (female), age (18-24, 40-54, 55-64, and 65+), race/ethnicity (non-Hispanic Black, non-Hispanic Asian, non-Hispanic Multiracial, and Hispanic), education (college degree or higher), and annual household income (less than \$25K, \$25K to \$35K, \$35K to \$50K, \$75K to \$100K, \$100K to \$150K, \$150K to \$200K, and \$200K and above). We additionally include a dummy variable for respondents with missing annual household income information since approximately 31 percent of our sample was missing this information. Moreover, we also include a dummy variable for each state to capture geographic characteristics.

Please Table A2 and A3 for summary statistics and Table A4 for a full list of estimated odds-ratios and p-values.

Appendix 2

Table A1. Household Pulse Survey Weeks and Dates		
Survey Week	Start Date	End Date
28	April 14, 2021	April 26, 2021
29	April 28, 2021	May 10, 2021
30	May 12, 2021	May 24, 2021
31	May 26, 2021	June 7, 2021
32	June 9, 2021	June 21, 2021
33	June 23, 2021	July 5, 2021
34	July 21, 2021	August 2, 2021
35	August 4, 2021	August 16, 2021
36	August 18, 2021	August 30, 2021
37	September 1, 2021	September 13, 2021
38	September 15, 2021	September 27, 2021
39	September 29, 2021	October 11, 2021
40	December 1, 2021	December 13, 2021
41	December 29, 2021	January 10, 2022

Note: Table A1 lists the time periods that each survey week of the HPS was conducted.

Table A2. Summary Statistics				
	Mean	Min	Max	N
Willing to Vaccinate	.599	0	1	14,135
Sex				
Male	.383	0	1	14,135
Female	.617	0	1	14,135
Age				
18 to 24	.056	0	1	14,135
25 to 39	.296	0	1	14,135
40 to 54	.356	0	1	14,135
55 to 64	.181	0	1	14,135
65+	.111	0	1	14,135
Race/Ethnicity				
White, non-Hispanic	.691	0	1	14,135
Black, non-Hispanic	.100	0	1	14,135
Asian, non-Hispanic	.034	0	1	14,135
Multiracial/Other	.054	0	1	14,135
Hispanic	.120	0	1	14,135
Education				14,135
No College Education	.637	0	1	14,135
College Education	.363	0	1	14,135
Household Income				
Less than \$25,000	.126	0	1	14,135
\$25,000 to \$34,999	.078	0	1	14,135
\$35,000 to \$49,999	.082	0	1	14,135
\$50,000 to \$74,999	.117	0	1	14,135
\$75,000 to \$99,999	.093	0	1	14,135
\$100,000 to \$149,999	.102	0	1	14,135
\$150,000 to \$199,999	.040	0	1	14,135
\$200,000 and above	.045	0	1	14,135
Missing Information	.316	0	1	14,135

Note: These are descriptive statistics for the logistic regression that employs data from Week 28 of the HPS (conducted April 14, 2021 through April 26, 2021). See Appendix A1 for a description of this regression, and Table A4 for this regression's results. The means presented in this table are unweighted.

Table A3. Summary Statistics

	Mean	Min	Max	N
Willing to Vaccinate	.280	0	1	7,199
Sex				
Male	.385	0	1	7,199
Female	.614	0	1	7,199
Age				
18 to 24	.048	0	1	7,199
25 to 39	.336	0	1	7,199
40 to 54	.344	0	1	7,199
55 to 64	.158	0	1	7,199
65+	.115	0	1	7,199
Race/Ethnicity				
White, non-Hispanic	.723	0	1	7,199
Black, non-Hispanic	.100	0	1	7,199
Asian, non-Hispanic	.011	0	1	7,199
Multiracial/Other	.056	0	1	7,199
Hispanic	.113	0	1	7,199
Education				
No College Education	.715	0	1	7,199
College Education	.285	0	1	7,199
Household Income				
Less than \$25,000	.175	0	1	7,199
\$25,000 to \$34,999	.100	0	1	7,199
\$35,000 to \$49,999	.100	0	1	7,199
\$50,000 to \$74,999	.135	0	1	7,199
\$75,000 to \$99,999	.098	0	1	7,199

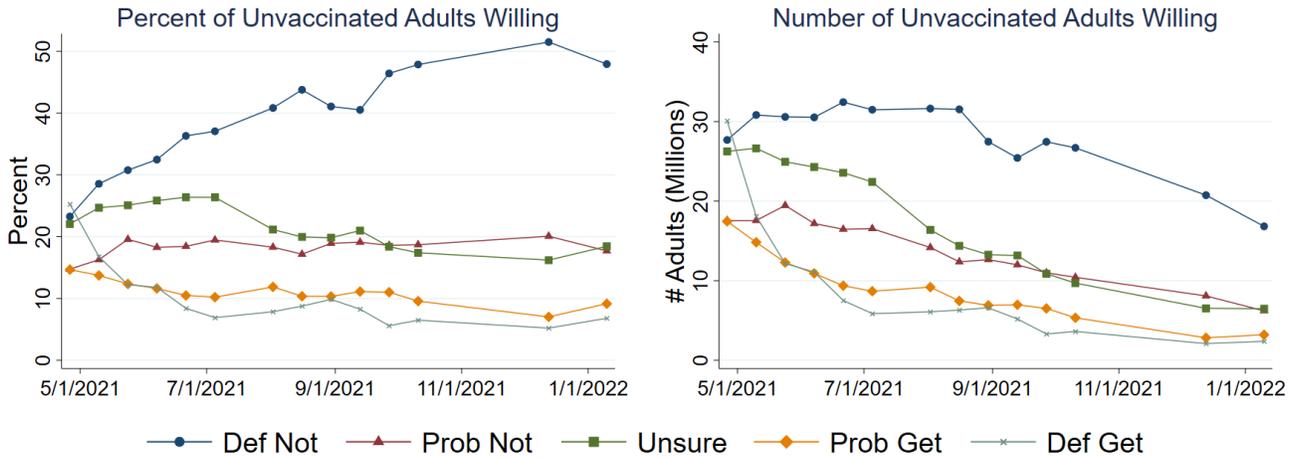
\$100,000 to \$149,999	.096	0	1	7,199
\$150,000 to \$199,999	.038	0	1	7,199
\$200,000 and above	.030	0	1	7,199
Missing Information	.228	0	1	7,199

Note: These are descriptive statistics for the logistic regression that employs data from survey Week 41 of the HPS (December 29, 2021 through January 10, 2022). See Appendix A1 for a description of this regression, and Table A4 for this regression's results. The means presented in this table are unweighted.

Table A4. Association between Vaccine Willingness and Demographic Characteristics		
	Outcome: Willingness to Vaccinate	
	Apr. 14, 2021 – Apr. 26, 2021	Dec. 29 2021 – Jan. 10, 2022
Sex		
Male	Ref.	Ref.
Female	0.870***	1.233***
Age		
18 to 24	1.772***	1.318***
25 to 39	Ref.	Ref.
40 to 54	1.084**	0.956
55 to 64	0.936	0.752***
65+	0.662***	0.571***
Race/Ethnicity		
White, non-Hispanic	Ref.	Ref.
Black, non-Hispanic	1.462***	3.365***
Asian, non-Hispanic	2.156***	2.599***
Multiracial/Other	0.796***	1.036
Hispanic	1.888***	2.692***
Education		
No College Education	Ref.	Ref.
College Education	1.136***	0.615***
Household Income		
Less than \$25,000	0.667***	1.425***
\$25,000 to \$34,999	1.087	1.812***
\$35,000 to \$49,999	0.806***	0.980
\$50,000 to \$74,999	Ref.	Ref.
\$75,000 to \$99,999	0.622***	1.040
\$100,000 to \$149,999	0.612***	0.575***
\$150,000 to \$199,999	0.622***	0.607***
\$200,000 and above	0.703***	0.465***
Missing Information	0.677***	1.218**
N	14,135	7,199

Note: Table A2 reports odds-ratios from logistic regressions where the outcome variable is a dummy variable for whether an unvaccinated adult is willing to vaccinate, and the explanatory variables are all dummy variables representing the universe of responses within the categories sex, age, race/ethnicity, education and annual household income. Each regression additionally includes a dummy variable for each state. The sample in column (1) is unvaccinated adults from week 28 of the HPS, which was conducted April 14, 2021 through April 26, 2021. The sample in column (2) is unvaccinated adults from week 41 of the HPS, which was conducted December 29, 2021 through January 10, 2022. * p-value <0.10; ** p-value <0.05; *** p-value <0.01.

Figure A1. Vaccine Intentions of Unvaccinated Adults



Note: Figure A1 shows the percent of unvaccinated adults (18 years or older) in the United States who report that they will definitely not get, probably not get, are unsure of whether they will get, will probably get, or will definitely get a COVID-19 vaccine. Our sample covers the time period late April 2021 to early January 2022. We estimate these percentages using data from the HPS for survey weeks 28 through 41. Each marker represents an HPS survey week. We also estimate the corresponding number of adults in each category by multiplying these percentages by our estimates of the number of unvaccinated adults using CDC data as shown in Figure 1.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

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