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A meta-analysis of COVID-19 vaccine attitudes and demographic characteristics in the United States

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ABSTRACT

Objectives: Despite the potential for COVID-19 vaccination to prevent severe disease and death, vaccine hesitancy is common in the United States, with more than a quarter of eligible Americans yet to receive the first dose. We draw on existing published studies on COVID-19 vaccine attitudes to estimate the overall prevalence of vaccine hesitancy and assess how it varies across demographic groups.

Study design: A systematic literature search was conducted to identify and meta-analyze relevant studies, which examined vaccine acceptance and hesitancy in the context of the COVID-19 vaccine.

Methods: We meta-analyzed the prevalence rate of vaccine acceptance across all participants as well as for specific demographic subgroups. To assess time effects, we coded each study for the month during which data were collected and subjected the meta-analytic data to a regression analysis. To assess the magnitude of differences between demographic subgroups, we conducted a separate meta-analysis of odds ratios.

Results: Across the 46 samples, an average of 61% of participants indicated they were willing to receive the COVID-19 vaccine. The biggest demographic differences were found for race and political affiliation, with Black respondents and Republicans reporting significantly higher vaccine hesitancy than White respondents and Democrats.

Conclusions: These results inform current vaccination efforts by identifying the groups that are least likely to get vaccinated and supporting the need for tailored vaccine strategies to alleviate the concerns specific to those populations. Comparing intentions to vaccinate with actual vaccination rates, vaccine hesitancy appears to have declined considerably among women and Black Americans.

Introduction

Despite widespread availability, more than a quarter of eligible Americans have yet to receive the first dose of a COVID-19 vaccine. Given the potential for vaccines to reduce disease severity and transmission, it is critical to understand how to improve vaccine uptake. Vaccine hesitancy, however, is not shared equally among different demographic groups in the United States, and Americans may remain unvaccinated for different reasons, requiring different intervention strategies. The aim of this article was to meta-analytically examine the prevalence of vaccine acceptance both generally and within specific subgroups to determine what proportion of people remain vaccine hesitant and how that varies as a function of demographic group membership.

Vaccine hesitancy, defined by the World Health Organization as “a delay in acceptance or refusal of vaccines despite availability of vaccination services,” exists across social groups in the United States. In the context of COVID-19, early studies have uncovered specific groups at risk of vaccine hesitancy, although no studies have systematically compared COVID-19 vaccine hesitancy across social or demographic groups. This preliminary evidence demonstrates that vaccine hesitancy intersects with vulnerability to COVID-19 and has important implications for reducing the burden of COVID-19 disease in the United States. For example, older adults are the least likely to report vaccine hesitancy and have received vaccinations at rates higher than any other age group. Conversely, long-term care residents and staff are among the most susceptible to infectious diseases such as COVID-19. Yet, states reporting data on long-term care staff have

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indicated that between 30% and 50% of staff accepted the COVID-
19 vaccine when it was first offered.\(^5\)

Racial/ethnic disparities in vaccine uptake are also apparent,
with lower vaccination rates observed among Black and Hispanic
Americans, despite racial/ethnic minorities being at elevated risk
for COVID-19-related mortality. This could reflect vaccine hesitancy
or barriers in accessing vaccines.\(^6,7\) Similarly, low-income, rural
adults and those residing in socially vulnerable communities have
been less likely to receive a COVID-19 vaccination, mirroring pre-
vious research on H1N1 vaccination.\(^5\)

Research indicates that specific social groups remain unvacci-
nated and vulnerable to severe COVID-19 disease.\(^5,10\) No studies,
however, have compared the prevalence of vaccine hesitancy across
different groups and time. The goal of this analysis is to draw on
existing published studies on COVID-19 vaccine attitudes to iden-
tify how vaccine acceptance rates vary across demographic groups.
This meta-analysis will be the first to comprehensively assess the
demographic characteristics associated with COVID-19 vaccine
acceptance, which has important implications for developing suc-
cessful, targeted vaccine uptake interventions.

**Methods**

**Literature search and inclusion criteria**

A systematic literature search was conducted in August 2021 to
identify relevant studies, which have examined vaccine acceptance
and hesitancy in the context of the COVID-19 vaccine (this review
was not registered). Given that such studies could be published in a
broad array of journals (e.g. medical journals and social science
journals), we conducted the search using a general search platform
(i.e. ArticlesPlus), which simultaneously draws from all databases.
That is, this search feature does not require authors to select a
predetermined set of databases and instead searches in all data-
bases simultaneously. We paired the following COVID-19-related
search terms, COVID-19 or Sars-Cov-2 or coronavirus, with search
terms related to vaccine acceptance (i.e. vaccine acceptance or
vaccine compliance or vaccine hesitancy or vaccine resistance or
vaccine uptake or vaccine intention or vaccine willingness). We also
included jabs in our search terms to capture studies that used
alternative labels for vaccines. Additional studies were located by
searching Google Scholar and examining the reference lists of the
studies produced through the systematic literature search.

Studies were eligible for inclusion if they measured participants'
willingsness to receive or decline the COVID-19 vaccine, were con-
ducted in the United States, and reported a sample size and the
number of participants who reported they would accept and/or
decline the vaccine. Studies were excluded if they assessed vaccine
acceptance after experimentally manipulating messaging about the
vaccine and/or characteristics about the vaccine, as these estimates
do not reflect people's general vaccine acceptance. Both published
and unpublished studies were eligible for inclusion. The search
procedures described previously yielded a total of 2083 search hits.
Screening was completed by the first author, and Fig. 1 displays the
number of studies that were excluded in the screening process and
the reasons for exclusion. The screening process produced a total of
44 studies with 46 independent samples (N = 167,833) that were
eligible for inclusion in our analyses.

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**Fig. 1.** Flow diagram of the article screening process.
Participant education included two categories, which reflected having educational attainment, which fell below earning a bachelor’s degree or having earned a bachelor’s, professional, or graduate degree. Income was coded as either earning below $60,000 or above $60,000, and this cutoff point was used because it roughly corresponds to the median income in the United States. Location was coded as rural or urban/suburban. Political affiliation included identifying with the two major parties in the United States (i.e. Democrat and Republican). The date of data collection was also recorded, and studies were classified as occurring before and after the COVID-19 vaccine was approved for emergency use. Finally, studies were coded for sampling technique, and studies were categorized as probability samples if participants had an equal and known probability of being in the sample. This information was used to assess the possible risk of bias in individual studies, given that non-probability sampling is more likely to produce non-representative samples. The coded information for each included study is available in Table S1 in supplemental materials.

Each study included in the meta-analysis was independently coded by both study authors. Initial agreement across all coded information was 99%, and any disagreements were discussed until consensus was reached.

**Data coding**

Studies were coded for the total number of participants as well as the number of participants who reported they would accept and/or decline the COVID-19 vaccination. Where available, data were also recorded for demographic subgroups within the sample, including sex, race/ethnicity, age, income, education, location, and political affiliation. Sex was categorized as male and female, and race/ethnicity included White, Black, and Hispanic participants. Age, we examined the youngest age group, which typically ranged from 18 to 29 years in primary studies, as well as the oldest age group, which typically included participants aged ≥60 years. Participant education included two categories, which reflected having educational attainment, which fell below earning a bachelor’s degree or having earned a bachelor’s, professional, or graduate degree. Income was coded as either earning below $60,000 or above $60,000, and this cutoff point was used because it roughly corresponds to the median income in the United States. Location was coded as rural or urban/suburban. Political affiliation included identifying with the two major parties in the United States (i.e. Democrat and Republican). The date of data collection was also recorded, and studies were classified as occurring before and after the COVID-19 vaccine was approved for emergency use. Finally, studies were coded for sampling technique, and studies were categorized as probability samples if participants had an equal and known probability of being in the sample. This information was used to assess the possible risk of bias in individual studies, given that non-probability sampling is more likely to produce non-representative samples. The coded information for each included study is available in Table S1 in supplemental materials.

Each study included in the meta-analysis was independently coded by both study authors. Initial agreement across all coded information was 99%, and any disagreements were discussed until consensus was reached.

**Meta-analytic procedures and analyses**

The coded data were included in two separate meta-analyses. First, we meta-analyzed the prevalence rate of vaccine acceptance across all participants as well as for specific demographic subgroups. Prevalence rates for each primary study were calculated as the total number of participants who reported they would accept the vaccine divided by the total number of participants. We calculated the average prevalence rate across studies using the Metafor package in R, and analyses were conducted using random effects meta-analytic procedures. We also conducted a forest plot and assessed publication bias for the global prevalence rate estimate using the Metafor package. To assess vaccine attitudes over time, we coded studies for the month of data collection (primary studies ranged from March 2020 to May 2021) and subjected the meta-analytic data to a regression analysis wherein the effect size was the dependent variable and date of data collection was the predictor.

To assess the differences between demographic subgroups, we conducted a separate meta-analysis of odds ratios in which we examined the relative odds of vaccine refusal in each related subgroup (e.g. we conducted an odds ratio to compare men and women). To calculate the odds ratios, we recorded the number of participants in each demographic subgroup who indicated they would refuse and accept the vaccine. We used the Metafor package in R and a random effects model to conduct our meta-analysis of odds ratios, and we present the meta-analytic findings for both the untransformed odds ratios as well as the log-transformed odds ratios (presented in Table 2 only). Odds ratios greater than 1.00...

**Table 1**

Meta-Analytic Results for the Prevalence of Vaccine Acceptance.

| Population          | k  | N       | \( \hat{p} \) | SE | 95% CI Lower | 95% CI Upper | Q          |
|---------------------|----|---------|-------------|----|--------------|--------------|------------|
| General population  | 46 | 167,833 | 0.61        | 0.03| 0.56         | 0.66         | 41,721.46* |
| Largest N removed   | 45 | 94,183  | 0.61        | 0.03| 0.55         | 0.66         | 19,096.41* |
| Random samples      | 8  | 15,796  | 0.71        | 0.06| 0.60         | 0.82         | 2517.46*   |
| Convenience samples | 38 | 152,037 | 0.59        | 0.03| 0.53         | 0.65         | 39,104.77* |
| Before EUA           | 28 | 54,787  | 0.60        | 0.04| 0.53         | 0.68         | 16,808.30* |
| After EUA            | 16 | 112,562 | 0.62        | 0.04| 0.54         | 0.70         | 15,688.47* |
| Healthcare personnel | 9  | 31,007  | 0.55        | 0.05| 0.45         | 0.65         | 1504.34*   |
| Gender               |    |         |             |    |              |              |            |
| Men                  | 19 | 23,204  | 0.68        | 0.04| 0.61         | 0.75         | 4961.00*   |
| Women                | 19 | 37,869  | 0.58        | 0.04| 0.51         | 0.66         | 5489.75*   |
| Race/ethnicity       |    |         |             |    |              |              |            |
| White                | 22 | 112,641 | 0.65        | 0.03| 0.59         | 0.72         | 18,367.91* |
| Black                | 23 | 8,417   | 0.44        | 0.03| 0.37         | 0.50         | 1279.523*  |
| Hispanic             | 13 | 7,824   | 0.57        | 0.04| 0.49         | 0.66         | 1407.88*   |
| Age                  |    |         |             |    |              |              |            |
| Younger adults       | 14 | 5,025   | 0.56        | 0.05| 0.45         | 0.66         | 676.33*    |
| Older adults         | 14 | 12,168  | 0.72        | 0.04| 0.63         | 0.80         | 1200.22*   |
| Education            |    |         |             |    |              |              |            |
| Less than a college degree | 16 | 14,641  | 0.57        | 0.04| 0.48         | 0.66         | 2454.49*   |
| Bachelor’s or graduate degree | 16 | 28,378  | 0.70        | 0.04| 0.63         | 0.78         | 4773.25*   |
| Income               |    |         |             |    |              |              |            |
| Income <$60,000      | 4  | 3,091   | 0.71        | 0.07| 0.57         | 0.85         | 252.09*    |
| Income >$60,000      | 4  | 6,387   | 0.84        | 0.07| 0.71         | 0.97         | 206.11*    |
| Location             |    |         |             |    |              |              |            |
| Urban                | 7  | 21,428  | 0.54        | 0.05| 0.45         | 0.63         | 1149.69*   |
| Rural                | 7  | 1,881   | 0.50        | 0.05| 0.39         | 0.61         | 198.98*    |
| Political affiliation|    |         |             |    |              |              |            |
| Democrat             | 9  | 6,236   | 0.70        | 0.04| 0.62         | 0.78         | 659.98*    |
| Republican           | 9  | 4,075   | 0.49        | 0.04| 0.40         | 0.57         | 268.49*    |

Note: k = the number of independent samples; N = sample size; \( \hat{p} \) = sample size-weighted mean proportion; SE = standard error of the proportion; 95% CI = 95% confidence interval constructed around the mean proportion; Q = estimate of heterogeneity; Younger adults = people aged 18–29 years; Older adults = people aged ≥60 years. * Indicates significance of less than .05.
indicate that the group noted in column 1 of Table 2 is more likely to decline the vaccine than their referent group.

We assessed the overall quality of our meta-analytic review using the AMSTAR assessment.12 Our meta-analysis met all criteria provided in the assessment with one exception, which is that the studies produced by the systematic search were only screened by a single person.

Results

Prevalence rate results

The results for the general population suggested that across the 46 included samples, an average of 61% (95% confidence interval [CI] 0.56, 0.66) of participants indicated they were willing to receive the COVID-19 vaccine (Table 1). A forest plot of the effect sizes for each study plotted against the sample size is shown in Fig. 2. The studies were also assessed for publication bias, and the funnel plot is shown in Fig. 3. A test of the asymmetry in the funnel plot was not significant (z = −1.25, P = 0.212), indicating no evidence of publication bias. There was one study with a particularly large sample size (N = 73,650), and a similar prevalence rate was found when that study was removed (P = 0.61, 95% CI 0.55, 0.66).

Finally, although the prevalence rate was higher in studies that used probability rather than non-probability samples, this difference was not significant.

We separately examined studies that assessed vaccine acceptance among healthcare professionals, given their importance in influencing the decisions of, and their high contact with, patients. The results indicated that roughly half of healthcare personnel were willing to receive the vaccine (P = 0.55, k = 9, 95% CI 0.45, 0.65), which suggests that vaccine acceptance among healthcare professionals may lag behind that seen for other groups. Prevalence rates for the demographic subgroups revealed that women were less likely to accept the COVID-19 vaccine (P = 0.58, k = 19, 95% CI 0.51, 0.66) compared with men (P = 0.68, k = 19, 95% CI 0.61, 0.75). The lowest prevalence of vaccine acceptance was found for Black participants (P = 0.44, k = 23, 95% CI 0.37, 0.50) followed by Hispanic participants (P = 0.57, k = 13, 95% CI 0.49, 0.66), and the highest prevalence for any racial/ethnic group was for White participants (P = 0.65, k = 22, 95% CI 0.59, 0.72).

People who were aged 18–29 years also had a lower prevalence rate of vaccine acceptance (P = 0.56, k = 14, 95% CI 0.45, 0.66) compared with people who were over 60 (P = 0.72, k = 14, 95% CI 0.63, 0.80). Comparisons based on education suggested that a greater percentage of those with higher educational attainment were willing to receive the vaccine (P = 0.70, k = 16, 95% CI 0.63, 0.78) than those with lower educational attainment (P = 0.57, k = 16, 95% CI 0.48, 0.66). There was similarly a lower prevalence rate of vaccine acceptance among people who earned <$60,000 (P = 0.71, k = 4, 95% CI 0.57, 0.85) than among people who earned more than $60,000 (P = 0.84, k = 4, 95% CI 0.71, 0.97). For location, slightly more people were willing to receive the vaccine in urban (P = 0.54, k = 7, 95% CI 0.45, 0.63) compared with rural areas (P = 0.50, k = 7, 95% CI 0.39, 0.61). Finally, half of Republicans reported being willing to accept the COVID-19 vaccine (P = 0.49, k = 9, 95% CI 0.40, 0.57), whereas 70% (k = 9, 95% CI 0.62, 0.78) of democrats were willing to receive the vaccine.

The results indicated that when examining the overall prevalence rate of vaccine acceptance, there was a small but non-significant decline in vaccine acceptance over time (b = −0.01, P = 0.484; Table 3). We additionally assessed vaccine acceptance for each specific subgroup (in cases where there were at least five studies), given that the trajectory of vaccine acceptance rates may have differed as a function of demographic group membership. The results were similar for each subgroup, with the exception of Republicans who displayed a significant decrease in vaccine acceptance across time (b = −0.03, P = 0.040) and healthcare professionals who demonstrated decreasing vaccine hesitancy over time (b = 0.16, P < 0.001). We also compared vaccine acceptance prevalence rates before and after the vaccine was approved for emergency use, and the results (Table 1) indicated no significant difference. Finally, Fig. 4 provides a comparison of study prevalence rates with actual vaccination rates.

Odds ratios results

The results indicated there were significant differences based on sex, race and ethnicity, age, education, locale, and political affiliation (Table 2). More specifically, women, Black Americans, Hispanic Americans, younger adults, and people living in rural areas were all significantly more likely to decline the COVID-19 vaccine compared with their counterparts. Furthermore, the largest odds ratios were observed for race (i.e. for comparisons of Black and White participants) and political affiliation.

Discussion

When estimated across the 46 included samples and nearly 170,000 Americans, less than two-thirds of eligible adults reported

| Table 2 |
| --- |
| Meta-analytic results for the relative odds of vaccine refusal. |

| Construct | k | N | OR | SE | 95% CI | ORlog | Q | SElog | 95% CIlog | Q |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Women | 24 | 67,912 | 1.75 | 0.14 | 1.48 | 2.02 | 1332.52* | 0.49 | 0.08 | 0.34 | 0.65 | 459.45* |
| Black | 25 | 124,710 | 3.14 | 0.30 | 2.55 | 3.73 | 3851.26* | 1.00 | 0.10 | 0.80 | 1.21 | 438.91* |
| Hispanic | 12 | 99,564 | 1.58 | 0.18 | 1.22 | 1.94 | 403.35* | 0.37 | 0.12 | 0.12 | 0.61 | 185.28* |
| Older adults | 14 | 31,491 | 0.58 | 0.07 | 0.44 | 0.72 | 135.28* | −0.64 | 0.11 | −0.85 | −0.43 | 305.43* |
| Younger adults | 14 | 19,688 | 1.60 | 0.23 | 1.13 | 2.05 | 132.60* | 0.31 | 0.11 | 0.09 | 0.53 | 494.60* |
| Education | 15 | 39,235 | 2.47 | 0.29 | 1.90 | 3.03 | 510.49* | 0.82 | 0.10 | 0.62 | 1.03 | 84.75* |
| Income | 5 | 12,694 | 2.51 | 0.69 | 1.15 | 3.86 | 514.99* | 0.74 | 0.28 | 0.20 | 1.28 | 175.95* |
| Rural | 7 | 19,058 | 2.02 | 0.30 | 1.43 | 2.62 | 113.39* | 0.63 | 0.13 | 0.37 | 0.89 | 238.90* |
| Republican | 10 | 13,317 | 3.36 | 0.47 | 2.43 | 4.29 | 1736.63* | 1.08 | 0.17 | 0.75 | 1.41 | 303.70* |

Note: k = the number of independent samples; N = sample size; OR = sample size-weighed mean odds ratio; SE = standard error of the odds ratio; 95% CI = 95% confidence interval constructed around the mean odds ratio; Q = estimate of heterogeneity; ORlog = log-transformed mean sample-weighted odds ratio; SElog = standard error of the log-transformed odds ratio; 95% Cllog = 95% confidence interval constructed around the mean log odds ratio; Women — reference group is males; Black and Hispanic — reference group is White, non-Hispanic respondents; Older adults — compares people aged >60 years to people aged <60 years; Younger adults — compares people aged 18–29 years to people aged >29 years; Education — compares people who earned less than a bachelor’s degree to people who earned a bachelor’s degree or higher; Income — compares people who earn <$60,000 to those who earn >$60,000; Rural — reference group is urban/suburban; Republican — reference group is democrats.

* Indicates significance of less than .05.
they were willing to accept the COVID-19 vaccine. The proportion willing to receive the vaccine, however, varied substantially across demographic subgroups. Indeed, women, Black and Hispanic Americans, younger adults, people with lower educational attainment, people with lower incomes, people living in rural areas, and Republicans were less inclined to receive the COVID-19 vaccine than their counterparts mirroring national polls from the same period.13,14 This variation across demographic groups helps explain why a third of eligible Americans remain unvaccinated. Moreover, vaccine hesitancy among healthcare professionals lagged behind most demographic groups.

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Fig. 2. Forest plot of the proportions extracted from included studies.

Fig. 3. Funnel plot assessing publication bias in the meta-analysis of proportions.
or general complacency may also have played a role in changing vaccine attitudes.\textsuperscript{15} In contrast to the trend observed across all participants, however, healthcare professionals demonstrated an increase in vaccine acceptance over time, whereas republicans demonstrated a significant decrease.

National polls indicate that, since May 2021, vaccine attitudes have continued to improve,\textsuperscript{1} but these improvements are not shared equally across demographic groups. Looking at actual vaccination rates (Fig. 4), we find that although women were substantially less likely than men to report a willingness to vaccinate, more women than men actually received COVID-19 vaccination. Despite the widespread, and at times stereotypical, portrayal of Black Americans as vaccine hesitant, we find that the vaccination rate among Black Americans exceeds initial willingness estimates, suggesting that hesitancy may be declining in this group. Conversely, fewer White Americans received vaccinations compared with the percentage who reported being willing to accept the vaccine. These data provide additional context for indexing how vaccine acceptance rates have changed over time and suggest that for women, Black Americans, and people aged >65 years, hesitancy appears to be declining while hesitancy remains stable or is potentially increasing among other groups, including men, Hispanic Americans, and those aged <65 years.

**Public health implications**

This meta-analysis primarily addressed two research questions: (1) how many people intended to get the COVID-19 vaccine and (2) what subgroups are more or less willing to receive the vaccine. These questions can inform interventions to improve COVID-19

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### Table 3

Data collection month predicting vaccine acceptance rates.

| Variable                  | k | B    | SE   | Q     | P     | R²   |
|---------------------------|---|------|------|-------|-------|------|
| General population        | 44| -0.01| 0.01 | 26.01 | 0.484 | 0.02 |
| Healthcare workers        | 8 | 0.16 | 0.03 | 32.10*| <0.001| 0.74 |
| Men                       | 19| -0.01| 0.01 | 12.30 | 0.293 | 0.09 |
| Women                     | 19| -0.02| 0.01 | 17.74 | 0.147 | 0.12 |
| White                     | 22| -0.01| 0.01 | 11.42 | 0.461 | 0.05 |
| Black                     | 23| -0.01| 0.01 | 13.21 | 0.423 | 0.05 |
| Hispanic                  | 13| 0.01 | 0.02 | 6.76  | 0.769 | 0.01 |
| Younger adults            | 14| -0.02| 0.01 | 16.67 | 0.155 | 0.12 |
| Older adults              | 14| -0.02| 0.02 | 8.73  | 0.150 | 0.24 |
| Less than a college degree| 16| -0.01| 0.01 | 14.01 | 0.343 | 0.06 |
| Bachelor's or graduate degree | 16 | -0.01| 0.01 | 10.89 | 0.460 | 0.05 |
| Urban                     | 7 | -0.02| 0.02 | 4.86  | 0.330 | 0.20 |
| Rural                     | 7 | -0.03| 0.02 | 7.21  | 0.098 | 0.38 |
| Democrat                  | 9 | -0.03| 0.02 | 7.37  | 0.085 | 0.40 |
| Republican                | 9 | -0.03| 0.01 | 11.65 | 0.040 | 0.36 |

Note: k = number of effect sizes in the meta-analysis; B = unstandardized regression coefficient for data collection month; Q = estimate of heterogeneity; P = significance value; R² = proportion of variance explained.

* P < .05.

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**Fig. 4.** Comparison of prevalence and actual vaccination rates for selected demographic groups. Estimates of the reported prevalence rates were derived from the current meta-analytic estimates of the prevalence of vaccine acceptance across demographic groups in the United States. Estimates of the actual vaccination rates were calculated by dividing the number of people in each demographic group who are fully vaccinated by the total number of people in that demographic group who are eligible to receive the vaccine (i.e. the number of people who are aged ≥12 years). Estimates of the total number of people who have received the vaccine were taken from the Centers for Disease Control and Prevention COVID Data tracker. In cases of missing data (i.e. cases where people did not report their demographic information), we multiplied the total number of cases where demographic information was missing by the proportion of that demographic group in the population to approximate the number of cases that were missing from each demographic subgroup. We then added the estimate of missing data to the total of known vaccination cases. Estimates of the total population aged ≥12 years for each demographic group were taken from the US Census Bureau’s American Community Survey 2019 population estimates. Because the US Bureau reports information for Americans aged ≥65 years, we used 65 as the cutoff to calculate the actual and intended vaccination rates. This differs from our primary analyses in which ≥60 years was used as a cutoff to preserve the maximum number of studies measuring age and vaccine intentions.
vaccine uptake by identifying the scope of the problem (i.e. estimating how many people indicate they are vaccine hesitant or would refuse the vaccine), the populations that are most in need of intervention, and the concerns that a potential vaccine campaign should address. Importantly, a sizable portion of Americans remains hesitant to receive COVID-19 vaccination, which places strain on the US healthcare system and creates disruptions to many social, educational, and economic institutions.17,18

Taking the groups with the highest odds of refusing COVID-19 vaccination during the study period as an example, Americans identifying as Republican or Black provides evidence that the factors that undergird hesitancy differ between these and other demographic groups. Studies have demonstrated that key vaccine concerns among Republicans include a lack of trust in government and science10 as well as exposure to misinformation.15 Black Americans, by contrast, are more likely to cite a lack of trust in medicine stemming from long-standing mistreatment and exploitation in medical settings.20–22 Interventions to improve vaccine uptake, accordingly, should take a tailored approach to address the concerns specific to demographic subgroups, and our findings help illuminate which groups should be prioritized for interventions to reduce vaccine hesitancy.14 Others that would likely benefit from targeted interventions include young adults and Americans with lower income or educational attainment. Studies suggest that key concerns in these groups relate to misinformation about infertility and misperceptions that the COVID-19 vaccine is not free and that they may be billed later for the appointment.24–26

Limitations

There are important limitations of the current meta-analysis. First, most of the included studies were cross-sectional, and our analyses would have been strengthened by primary studies that tracked vaccine attitudes across time. Second, there are subgroups of interest that we could not examine in our analyses because of an absence of data. For example, Americans without health insurance and pregnant women may be particularly vulnerable to vaccine hesitancy, and future studies should consider these populations. Finally, there was variability in the measurement of vaccine hesitancy across included studies, and the way in which questions are worded may affect responses. It is possible that such variations therefore altered our estimates of vaccine acceptance.

Conclusion

Despite widespread availability of COVID-19 vaccines, many Americans remain unvaccinated and vulnerable to severe COVID-19 illness. The findings from the present study provide meta-analytic estimates of Americans’ willingness to receive the COVID-19 vaccine as well as estimates of how vaccine acceptance varies across demographic subgroups. These results can inform current vaccination efforts by identifying groups that are less likely to get vaccinated and support the development of tailored vaccine strategies to alleviate specific vaccine concerns.

Author statements

Ethical approval

Because this study did not constitute human subjects research, no approval was required from an institutional review board.

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This study was not financially supported.

Competing interests

The authors have no conflicts of interest to report.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpuhe.2022.03.012.

References

1. Kirzinger A, Sparks G, Hamel L, et al. KFF COVID-19 vaccine monitor: July 2021. Kaiser Family Foundation Vaccine Monitor. Published July 2021. https://www.kff.org/coronavirus-covid-19/poll-findings/kff-covid-19-vaccine-monitor-july-2021/. [Accessed 27 August 2021].
2. MacDonald NE, The SAGE Working Group on Vaccine Hesitancy. Vaccine hesitancy: definition, scope and determinants. Vaccine 2015;33(34):4161–4. https://doi.org/10.1016/J.VACCINE.2015.04.036.
3. Utsumi M, Makimoto K, Kurosli N, Ashida N. Types of infectious outbreaks and their impact in elderly care facilities: a review of the literature. Age Ageing 2010;39(3):299–305. https://doi.org/10.1093/AGEING/AFQ029.
4. Chason R, Tan R, Portnoy J, Cox E. Nursing home workers opt out of coronavirus vaccine in Maryland. Virginia: D.C. The Washington Post; 2021. Published January 27, https://www.washingtonpost.com/local/nursing-homes-vaccine-decline/2021/01/27/22a602fc-56e2-11eb-9a1a127d146_story.html. [Accessed 31 August 2021].
5. Abdul-Mutakabbir JC, Casey S, Jews V, et al. A three-tiered approach to address barriers to COVID-19 vaccine delivery in the black community. Lancet Glob Health 2021;9(6):e749–50. https://doi.org/10.1016/S2214-109X(21)00099-1.
6. Momplaisir F, Haynes N, NKwihoreze H, Nelson M, Werner RM, Jemmott J. Understanding drivers of COVID-19 vaccine hesitancy among blacks. Clin Infect Dis An Official Publication of the Infectious Diseases Society of America 2021. Published online February 9. https://doi.org/10.1093/CID/CIA1022.
7. Gessen M. How vaccine hesitancy is driving breakthrough infections in Nursing home workers opt out of coronavirus vaccine in Maryland. Virginia: D.C. The Washington Post; 2021. Published online April 27. https://www.washingtonpost.com/local/nursing-homes-vaccine-decline/2021/01/27/22a602fc-56e2-11eb-9a1a127d146_story.html. [Accessed 31 August 2021].
8. Alaei S, Abdollahi M, Mokhtari S. Covid-19 vaccine hesitancy: a longitudinal study. 2021. Published online. https://doi.org/10.1371/journal.pone.0250123.
9. PD S, JD KM. Comparing meta-analytic moderator estimation techniques under realistic conditions. J Appl Psychol 2002;87(1):96–111. https://doi.org/10.1037/0021-9010.87.1.96.
10. Shea BJ, Grimshaw JM, Wells GA, et al. Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. BMC Med Res Methodol 2007;7:1:1–7. https://doi.org/10.1186/1471-2288-7-10. 2007 7:1.
11. Kaiser Family Foundation. KFF COVID-19 vaccine monitor dashboard | KFF. Published. https://www.kff.org/coronavirus-covid-19/dashboard/kff-covid-19-vaccine-monitor-dashboard/?utm_campaign=KFF-2021-polling-surveys&utm_medium=email&utm_content=2a_hsmi-%26_hsenec-p2ANgztz-HVehoeT01Duc6t70OwL1SBSh599KeQyovR3kJhVn3j991714nhNaPldRBCy-xWc2ICZVehyAboZfle (Col_AA&utrm_content=2&utm_source=hs_email, 2022. [Accessed 11 March 2022].
12. Strategies for building confidence in the COVID-19 vaccines. Strategies for Building Confidence in the COVID-19 vaccines 2021:1–21. https://doi.org/10.17226/26568. Vaccines. Published online February 3.
13. Sizlagy PG, Thomas K, Shah MD, et al. National trends in the US public’s likelihood of getting a COVID-19 vaccine—April 1 to December 8, 2020. JAMA 2021;325(4):206–8. https://doi.org/10.1001/jama.2020.26410.
14. Hamner CC, Cristea V, Dub T, Sivela J. High but slightly declining COVID-19 vaccine acceptance and reasons for vaccine acceptance, Finland April to December 2020. Epidemiol Infect 2021;149. https://doi.org/10.1017/S0950268821001114.
15. Gessen M. How vaccine hesitancy is driving breakthrough infections in Nursing home workers opt out of coronavirus vaccine in Maryland. Virginia: D.C. The Washington Post; 2021. Published online April 27.
16. Schnell M, Vakil C. At least 90,000 students have had to quarantine because of COVID-19 so far this school year. The Hill. 2021. August 26.
17. Hornsey MJ, Finlayson M, Chatwood G, Begeny CT, Donald Trump and vaccination: the effect of political identity, conspiracist ideation and presidential tweets on vaccine hesitancy. J Exp Soc Psychol 2020;88(April 2019):103947. https://doi.org/10.1016/j.jesp.2019.103947.
18. Quinn SC, Jamison AM, An J, Hancock GR, Freimuth VS. Measuring vaccine hesitancy, confidence, trust and flu vaccine uptake: results of a national survey of White and African American adults. Vaccine 2019;37(9):1168–73. https://doi.org/10.1016/j.vaccine.2019.01.033.
19. Bogart LM, Ojikutu BO, Tyagi K, et al. COVID-19 related medical mistrust, health impacts, and potential vaccine hesitancy among black Americans living with HIV. J Acquir Immune Defic Syndr 2021;86(2):200. https://doi.org/10.1097/QAI.0000000000002570. 1990.
22. Savoia E, Piltch-Loeb R, Goldberg B, et al. Predictors of COVID-19 vaccine hesitancy: socio-demographics, co-morbidity and past experience of racial discrimination. medRxiv. Published online January 13, 2021:2021.01.12.21249152. https://doi.org/10.1101/2021.01.12.21249152.

23. Ferdinand KC. Overcoming barriers to COVID-19 vaccination in African Americans: the need for cultural humility. Am J Publ Health 2021;111(4): 586–8. https://doi.org/10.2105/AJPH.2020.306135. https://doi.org/102105/ AJPH2020306135.

24. Hsu AL, Johnson T, Phillips L, Nelson TB. Sources of vaccine hesitancy: pregnancy, infertility, minority concerns, and general skepticism. Open Forum Infect Dis. Published online August 18, 2021. https://doi.org/10.1093/ofid/OFAB433.

25. Morris D. COVID vaccine: nearly 7 million Americans might not get a COVID-19 vaccine because they don’t know it’s free. Published March 10, 2021, https://fortune.com/2021/03/10/covid-vaccine-free-people-not-getting-coronavirus-vaccines-cost-price/ [Accessed 31 August 2021].

26. US Census Bureau. Household pulse survey. COVID-19 vaccination tracker. Published August 25, 2021, https://www.census.gov/library/visualizations/interactive/household-pulse-survey-covid-19-vaccination-tracker.html. [Accessed 31 August 2021].