Prior COVID-19 infection: an underappreciated factor in vaccine hesitancy in the USA

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ABSTRACT

Despite tremendous efforts to quickly identify the 'vaccine hesitant' in the USA, what has emerged instead is a complex picture of a highly heterogeneous unvaccinated population. Although numerous factors have been implicated in influencing US COVID-19 vaccine decision-making, the role that prior coronavirus disease 2019 (COVID-19) infection may play in vaccine receipt has been largely uninvestigated. Using data from two separate US national surveys, the US COVID-19 Trends and Impact Survey and the Household Pulse Survey, we find that roughly one-quarter of unvaccinated survey respondents has had a prior COVID-19 infection. Prior COVID-19 infection halves the odds of receiving the vaccine. This information is consequential for ongoing vaccine outreach efforts.

Keywords COVID-19, prior COVID-19 infection, vaccine hesitancy, vaccines, SARs-Cov-2

Roughly one-quarter of eligible Americans (i.e. ages 5+ years) remain unvaccinated.¹ A complex picture of highly heterogeneous groups characterizes the ‘vaccine hesitant’. Age, race/ethnicity, education, geographic residence and political ideology are implicated in influencing coronavirus disease 2019 (COVID-19) vaccine decision-making.² However, the role that prior COVID-19 infection plays in vaccine receipt remains largely uninvestigated.

Although some anecdotal evidence suggests that prior infection discourages individuals from getting vaccinated,³ there are no current estimates for the proportion of unvaccinated individuals who had a prior COVID-19 infection. Nor is it known whether the uneven patterning of prior infection across demographic and geographic subgroups is currently playing a role in uneven vaccine uptake. Determining whether prior COVID-19 infection influences vaccine receipt and estimating the size of this group among the unvaccinated represents a critical piece of missing information in the urgent push to vaccinate the 70 million unvaccinated vaccine-eligible Americans.

Methods

Data
Data come from two separate national surveys designed to monitor the spread and impact of the COVID-19 pandemic and include information on both vaccine receipt and prior COVID-19 infection. The first is The Delphi Group at Carnegie Mellon University US COVID-19 Trends and Impact Survey (CTIS), in partnership with Facebook (Delphi US CTIS).⁴ We use data from wave 11 of the Delphi US CTIS surveys administered from 1 June to 28 July 2021, when vaccines were widely available. In addition, we use data from the 9 June to 5 July 2021 releases of the Census Bureau's Household Pulse Survey (HPS).⁵

All our analyses are survey weighted and restricted to individuals’ ages 18 years or over who have information on all the characteristics listed. This resulted in sample sizes of 466,909 and 87,194 for the Delphi US CTIS and HPS, respectively.

Measures

Both datasets provide information on respondents’ sociodemographic characteristics, including sex, age and education. In addition to these socioeconomic factors, analyses using HPS data also included race/ethnicity, marital status, health insurance and income category. Considerable attention has been given to the politicized nature of vaccine uptake, with individuals who identify as Republican indicating higher vaccine hesitancy and Republican leaning states and counties displaying lower vaccination rates. Neither survey includes information on individual political party affiliation. However,
Table 1  Odds of being vaccinated for COVID-19, unadjusted and adjusted for prior COVID-19 infection and known predictors of vaccine receipt, June–July 2021

|                        | Delphi US CTIS | Household pulse |
|------------------------|---------------|-----------------|
|                        | CTISModel 1   | CTISModel 2     | CTISModel 3   | HPSModel 1 | HPSModel 2 | HPSModel 3   |
| Prior COVID infection  | 0.49[0.47, 0.51] | 0.57[0.55, 0.59] | 0.50[0.42, 0.58] | 0.96[0.86, 1.08] | 0.98[0.87, 1.10] |
| Female                 | 1.36[1.32, 1.39] | 1.36[1.33, 1.40] | 0.96[0.86, 1.08] | 0.98[0.87, 1.10] |
| Age (years)(ref: > = 75) |               |                 |               |            |            |
| 18–34                  | 0.16[0.15, 0.18] | 0.17[0.16, 0.19] | 0.18[0.13, 0.24] | 0.18[0.13, 0.25] |
| 35–54                  | 0.24[0.23, 0.25] | 0.25[0.24, 0.27] | 0.20[0.15, 0.28] | 0.21[0.16, 0.29] |
| 55–74                  | 0.52[0.50, 0.55] | 0.54[0.51, 0.57] | 0.60[0.45, 0.80] | 0.62[0.47, 0.82] |
| Education(ref: 4 Year college or higher) |               |                 |               |            |            |
| Less than high school  | 0.31[0.29, 0.34] | 0.32[0.29, 0.35] | 0.22[0.18, 0.28] | 0.23[0.18, 0.28] |
| High school graduate or some college | 0.42[0.40, 0.43] | 0.42[0.41, 0.43] | 0.36[0.32, 0.40] | 0.36[0.32, 0.40] |
| 2 Year college degree  | 0.48[0.46, 0.50] | 0.49[0.47, 0.51] | 0.44[0.38, 0.50] | 0.44[0.39, 0.51] |
| Metropolitan classification(ref: Metro) |               |                 |               |            |            |
| Nonmetro, urban        | 0.90[0.87, 0.94] | 0.90[0.86, 0.94] |               |            |            |
| Rural                  | 0.94[0.86, 1.02] | 0.93[0.86, 1.01] |               |            |            |
| Proportion of county votes for Trump\(^a\) |               |                 |               |            |            |
|                        | 0.75[0.74, 0.76] | 0.75[0.74, 0.76] |               |            |            |
| Proportion of state votes for Trump\(^b\) |               |                 |               | 0.77[0.72, 0.82] | 0.77[0.73, 0.82] |
| Race/ethnicity(ref: Non-Hispanic White) |               |                 |               | 0.86[0.75, 0.98] | 0.86[0.76, 0.98] |
| Non-Hispanic Black     |               |                 |               | 1.63[1.41, 1.88] | 1.75[1.51, 2.02] |
| Hispanic               | 4.84[3.83, 6.12] | 4.76[3.78, 6.00] |               |            |            |
| Non-Hispanic Asian     | 0.79[0.66, 0.95] | 0.79[0.66, 0.95] |               |            |            |
| Non-Hispanic Other     |               |                 |               | 0.86[0.77, 0.96] | 0.85[0.76, 0.96] |
| Marital status(ref: Married) |               |                 |               | 1.18[1.06, 1.32] | 1.18[1.06, 1.31] |
| Never married          |               |                 |               | 0.86[0.77, 0.96] | 0.85[0.76, 0.96] |
| Divorced/separated     |               |                 |               |            |            |

\(^a\)Proportion of county votes for Trump: OR of voting for Trump in county of residence divided by OR of voting for Trump in state.

\(^b\)Proportion of state votes for Trump: OR of voting for Trump in state divided by OR of voting for Trump in nation.
Delphi US CTIS includes county identifiers and HPS includes state identifiers. We link the county and state percent of Donald Trump voters in the 2020 election to the Delphi US CTIS and HPS data, respectively.\(^6\) We also add the US Department of Agriculture’s 2013 Rural–Urban Continuum Codes for counties to the Delphi US CTIS data.\(^7\)

Our outcome variable for both surveys is self-reported COVID-19 vaccination.

We first generate bivariate statistics of the proportion of COVID-19 infection among unvaccinated individuals, which is currently unknown. For each survey, we then estimate a series of logistic regression models predicting the likelihood of having received at least one dose of vaccination for COVID-19 (Models 1–3).\(^8\)

### Results

We find that fully 25 and 29% of Delphi US CTIS and HPS unvaccinated respondents, respectively, indicated that they have had a prior COVID-19 infection, in contrast to 17 and 18% overall. Results from the logistic regression models are presented in Table 1. Delphi US CTIS unconditional analysis (CTSI Model 1) indicates that those with prior COVID-19 infection have 51% lower odds of being vaccinated, compared with those who have not been infected. Consistent with other studies, males, younger age groups and lower education predict lower likelihood of being vaccinated (CTSI Model 2).\(^2\) Further, those in nonmetro urban areas, compared with metros, have 10% lower odds of being vaccinated. Each 10% point increase in the county percentage of Trump voters decreases the odds of being vaccinated by 25%. Accounting for prior COVID-19 infection (CTSI Model 3) does not change the magnitude of these associations. Similarly, accounting for individual and area characteristics only nominally increases the odds for someone with a prior infection to be vaccinated (OR = 0.49 unadjusted versus OR = 0.57 adjusted).

Results from the HPS show an almost identical pattern. The lower odds of being vaccinated were relatively stable across unadjusted and adjusted models (OR = 0.50 unadjusted versus OR = 0.54 adjusted). Again, lower education, younger individuals and those residing in states with higher proportion of Trump voters predicted lower odds of being vaccinated (HPS Model 2). However, in the HPS data, we find no association between sex and the likelihood of being vaccinated, whereas in the Delphi US CTIS analysis females were more likely to be vaccinated. Net of other covariates, non-Hispanic Blacks had an ~14% lower odds of being vaccinated while Hispanics and non-Hispanic Asians were more

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**Table 1 Continued**

| Household pulse                          | CTIS Model 1 | CTIS Model 2 | CTIS Model 3 | HPS Model 1 | HPS Model 2 | HPS Model 3 |
|------------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Widowed                                  | 1.18 (0.89, 1.56) | 1.19 (0.91, 1.56) | 0.62 (0.52, 0.74) | 1.18 (0.89, 1.56) | 1.19 (0.91, 1.56) | 0.62 (0.52, 0.74) |
| Has health insurance                     | 0.62 (0.52, 0.74) | 0.60 (0.49, 0.73) | 0.60 (0.49, 0.73) | 0.62 (0.52, 0.74) | 0.60 (0.49, 0.73) | 0.60 (0.49, 0.73) |
| Income category ($): Ref: 200,000 or over|              |              |              |              |              |              |
| <$35,000                                 | 0.48 (0.39, 0.58) | 0.49 (0.39, 0.58) | 0.48 (0.39, 0.58) | 0.49 (0.39, 0.58) | 0.49 (0.39, 0.58) | 0.49 (0.39, 0.58) |
| $35,000 to <$75,000                      | 0.60 (0.49, 0.73) | 0.60 (0.49, 0.73) | 0.60 (0.49, 0.73) | 0.60 (0.49, 0.73) | 0.60 (0.49, 0.73) | 0.60 (0.49, 0.73) |
| $75,000 to <$100,000                     | 0.79 (0.62, 1.00) | 0.80 (0.63, 1.01) | 0.79 (0.62, 1.00) | 0.80 (0.63, 1.01) | 0.80 (0.63, 1.01) | 0.80 (0.63, 1.01) |
| $100,000 to <$150,000                    | 0.90 (0.73, 1.11) | 0.90 (0.73, 1.11) | 0.90 (0.73, 1.11) | 0.90 (0.73, 1.11) | 0.90 (0.73, 1.11) | 0.90 (0.73, 1.11) |
| $150,000 to <$200,000                    | 0.96 (0.72, 1.29) | 0.96 (0.72, 1.29) | 0.96 (0.72, 1.29) | 0.96 (0.72, 1.29) | 0.96 (0.72, 1.29) | 0.96 (0.72, 1.29) |

Odds ratios for proportion of county and state votes for Trump represent a unit change of 10 percentage points.
likely to be vaccinated, compared with non-Hispanic whites. Saliently, the increased odds of vaccination for Hispanics became evident only after adjustment, suggesting that their vaccine receipt is heavily influenced by sociodemographic factors. Those with lower income as well as those with no health insurance were less likely to be vaccinated and individuals who have never been married had 18% higher odds of being vaccinated compared to those who were married. Adjusting for prior COVID-19 infection did not alter the associations of these factors significantly (HPS Model 3).

Discussion

Our finding that fully one-quarter of unvaccinated individuals have been infected by COVID-19 and that a prior COVID-19 infection halves the odds of receiving a vaccination, points to the critical role played by prior COVID-19 infection in discouraging vaccination. We also find that prior infection largely operates independently of other known predictors of vaccine receipt, thus representing an overlooked through-line connecting seemingly diverse subpopulations of unvaccinated individuals and one that should be a focus of ongoing vaccine outreach efforts.

There are a few limitations to this study. Both prior COVID-19 infection and vaccination receipt are self-reported. In addition, the surveys have been shown to overestimate vaccination receipt, compared to the CDC data, even after weighting. Hence, results may not be generalizable. However, with few exceptions, inferences were unchanged in a series of sensitivity analyses, which stratified models by county or state 2021 election results, race/ethnicity (for HPS data), education and age.

Prior COVID-19 infection is a powerful predictor of vaccination status and one that is relevant to a substantial portion of the unvaccinated population.

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Conflict of interest

The authors declare no conflict of interest.

References

1. CDC. COVID Data tracker. Cir Dis Control Prev Atlanta, GA: US Department of Health and Human Services, CDC, National Center for Health Statistics. https://covid.cdc.gov/covid-data-tracker (2021).
2. Sparks, Grace, Kirzinger, Ashley, & Brodie, Mollyann. KFF COVID-19 Vaccine Monitor: Profile of the Unvaccinated. San Francisco, CA: KFF (2021). https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-profile-of-the-unvaccinated/.
3. Mejia B. Why haven’t you been vaccinated? With COVID-19 raging, people explain what took so long. Los Angeles Times 2021.
4. Delphi Group. COVID-19 trends and impact survey. Delphi Epidata API. https://cmu-delphi.github.io/delphi-epidata/symptom-survey/.
5. U.S. Census Bureau. Household Pulse Survey Technical Documentation. Washington, D.C.: U.S. Department of Commerce. Census.gov https://www.census.gov/programs-surveys/household-pulse-survey/technical-documentation.html.
6. MIT Election Data and Science Lab. County Presidential Election Returns 2000–2020 Cambridge, MA: Massachusetts Institute of Technology. 2021. https://doi.org/10.7910/DVN/VOQCHQ.
7. USDA. U.S. Department of Agriculture Economic Research Service - Documentation. Rural-Urban Continuum https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/documentation/.
8. CDC. Demographic characteristics of people receiving COVID-19 vaccinations in the United States. Cir Dis Control Prev Atlanta, GA: US Department of Health and Human Services, CDC, National Center for Health Statistics. 2021. https://covid.cdc.gov/covid-data-tracker.
9. Bradley, V.C., Kuriwaki, S., Isakov, M. et al. Unrepresentative big surveys significantly overestimated US vaccine uptake. Nature (2021). https://doi.org/10.1038/s41586-021-04198-4.