Geographic Heterogeneity in Behavioral and Social Drivers of COVID-19 Vaccination

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Introduction: Little is known about how drivers of COVID-19 vaccination vary across the U.S. To inform vaccination outreach efforts, this study explores geographic variation in correlates of COVID-19 non-vaccination among adults.

Methods: Participants were a nationally representative sample of U.S. adults identified through random-digit-dialing for the National Immunization Survey-Adult COVID Module. Analyses examined the geographic and temporal landscape of constructs in the Behavioral and Social Drivers of vaccination (BeSD) Framework among unvaccinated respondents from May to December 2021 (n=531,798) and sociodemographic and geographic disparities and BeSD predictors of COVID-19 non-vaccination from October to December 2021 (n=187,756).

Results: National coverage with at least 1 dose of COVID-19 vaccine was 79.3% by December 2021, with substantial geographic heterogeneity. Regions with the largest proportion of unvaccinated persons who would probably get a COVID-19 vaccine or were unsure resided in the Southeast and Midwest (Health and Human Services Regions 4 and 5). Both regions had similar temporal trends regarding concerns about COVID-19 and confidence in vaccine importance, though Region 4 had especially low confidence in vaccine safety in December 2021, lowest in Florida (5.5%) and highest in North Carolina (18.0%). The strongest BeSD correlate of not receiving a COVID-19 vaccination was lower confidence in COVID-19 vaccine importance (aPR=5.19, 95% CI=4.93, 5.47; strongest in the Northeast, Southwest, and Mountain West, and weakest in the Southeast and Midwest). Other BeSD correlates also varied by region.

Conclusions: Contributors to non-vaccination showed substantial geographic heterogeneity. Strategies to improve COVID-19 vaccination uptake may need to be tailored regionally.
INTRODUCTION

COVID-19 vaccine first became available in the U.S. in December 2020, and vaccine eligibility had expanded to all persons aged 16 years and older by April 19, 2021. In the first year of vaccine availability, 84.2% of U.S. adults received at least 1 dose of COVID-19 vaccine.\textsuperscript{1,2} Progress in COVID-19 vaccination coverage slowed after April 2021, with wide geographic variation in vaccine uptake.\textsuperscript{3–6} Millions of Americans remained unvaccinated as cases reached all-time highs due to the Omicron variant in December 2021.\textsuperscript{7} Despite high national vaccination coverage, spatial heterogeneity in vaccination can contribute to outbreaks in areas with high numbers of unvaccinated individuals.\textsuperscript{8,9}

Analyses of disparities in vaccination coverage show variability by socioeconomic and sociodemographic factors, including reduced vaccination coverage among younger persons,\textsuperscript{10} residents of rural counties,\textsuperscript{10–12} and residents of counties with higher social vulnerability.\textsuperscript{10,13,14} Many of these groups (i.e., those living in rural areas, with lower household income, less education, and Black and Hispanic persons) have greater vaccine hesitancy.\textsuperscript{15} These disparities highlight impacts of systematic underinvestment in public health, unequal access to healthcare services, and multifaceted distrust in vaccines, created in part by structural racism and medical mistreatment of underserved groups.\textsuperscript{15–18}

Behavioral and social drivers of vaccination may play a role in the geographic and sociodemographic heterogeneity of COVID-19 vaccination coverage and intent.\textsuperscript{19,20} Connections between behavioral, social, and practical factors and their impact on COVID-19 vaccination were evaluated using the Behavioral and Social Drivers of Vaccination (BeSD) Framework.\textsuperscript{21,22}
Behavioral factors influence vaccine acceptance or refusal, including vaccine confidence and concerns about vaccine importance, safety, and trustworthiness. Surveys early in the pandemic found that many respondents were hesitant to get vaccinated because they believed sociopolitical pressures may have rushed authorization for COVID-19 vaccines, or lacked trust in vaccines.

Vaccination behavior also responds to social processes, including receiving a recommendation from family and friends, or a healthcare provider, both of which are associated with higher vaccine uptake. Other reasons for non-vaccination may include practical issues such as lack of reliable transportation, fewer vaccination sites, and lack of paid time off to get vaccinated or to recuperate from vaccine side effects.

Identifying regions with low COVID-19 vaccination coverage and reasons for low vaccine uptake is crucial to developing more focused public health efforts. The objectives of this study were to: (1) assess time trends in vaccination coverage, intent, and BeSD factors by state; (2) identify HHS Regions and sociodemographic groups facing disparities in vaccination coverage; and (3) use regionally stratified models incorporating BeSD variables to elucidate underlying drivers of observed disparities.

**METHODS**

**Study Sample**

The National Immunization Survey–Adult COVID Module (NIS-ACM) is a nationally representative, random-digit dialed household cellphone survey of U.S. adults aged ≥18 years.
The ACM was added to the NIS\textsuperscript{34,35,36} in April 2021. This paper reports on participants (n=531,798) surveyed from April 22, 2021–December 31, 2021. Response rates were calculated for 7 approximate monthly analytic periods: April 22–May 29 (n=77,162), May 30–June 26 (n=56,749), June 27–July 31 (n=73,512), August 1–August 28 (n=63,193), August 29–September 25 (n=73,426), September 26–October 30 (n=79,636), October 31–November 27 (n=39,508), and November 28–December 31 (n=68,612). Response rates for these time periods ranged from 17.2\% to 23.4\%. Additional information on survey procedures is available in Wolter et al.\textsuperscript{35}

**Measures**

The NIS-ACM assessed vaccine uptake by asking participants: “Have you received at least one dose of a COVID-19 vaccine?” Participants responding “no” were asked about their vaccination intentions: “How likely are you to get a COVID-19 vaccine?” (Definitely will, probably will, probably will not, definitely will not, not sure) Potential correlates of COVID-19 vaccine uptake came from the 3 domains of the BeSD Framework.\textsuperscript{21} Questions from the thinking and feeling domain included risk perception (concern about COVID-19), confidence in vaccine safety, and confidence in vaccine importance. From the social processes domain, NIS-ACM assessed descriptive social norms (how many of one’s family/friends received a COVID-19 vaccine) and provider recommendation for COVID-19 vaccination. From the practical issues domain, the survey assessed whether one’s work or school requires COVID-19 vaccination, and perceived/experienced difficulty of access. Details about the survey questions are available in Appendix Table 1. The following labels were used for HHS Regions: 1:Northeast, 2:NY/NJ, 3:Appalachia, 4:Southeast, 5:Midwest, 6:South, 7:Plains, 8:Mountain West, 9:Southwest, 10:Pacific Northwest.
Statistical Analysis

All percentages and prevalence ratios (PR) (adjusted or unadjusted) are weighted. Data were weighted to represent the non-institutionalized U.S. adult population and calibrated to state-level vaccine administration data by sex and age group at the mid-point of each time-period. First, analyses examined time trends in COVID-19 vaccination first dose coverage, intent, and BeSD variables to capture the geographic and temporal landscapes of these variables. These variables were examined nationally and for each state using percentages and confidence limits for each survey period, broadly represented by month (e.g., April 22–May 29=‘May’); using data from May–December 2021 to support trends over time.

Second, analyses examined correlates of COVID-19 non-vaccination in a national logistic regression model with fixed effects for HHS region and in HHS regionally stratified models. These models used data from October–December 2021 to highlight disparities in vaccination coverage and support inferences about correlates in more recent time-periods. Regionally stratified models were chosen rather than multilevel models due to the complex weighting of the data, and to allow for independence of predictors in each region. Predictors included sociodemographic variables and 5 selected BeSD variables (work/school vaccine requirement, healthcare provider vaccine recommendation, friends and family vaccinated, difficulty getting a COVID-19 vaccine, and confidence in COVID-19 vaccine importance), selected using SAS’s PROC VARCLUS variable reduction algorithm from the 9 variables in the BeSD framework (all variables in Table 1). This paper uses the term ‘drivers’ in alignment with the BeSD

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5 The PROC VARCLUS procedure is a useful SAS procedure for variable reduction. All variables start in 1 cluster, then a principal components analysis is done to determine whether the cluster should be split into 2 clusters. The process ends when the eigenvalues of all current clusters fall below the cutoff. In this analysis, the 9 BeSD items were included in the VARCLUS procedure with a maximum eigenvalue set as 0.75
framework, though this study can only assess correlates of non-vaccination. Initially, the logistic regression analyses were unadjusted. Next, blockwise models entered demographic variables and then added BeSD variables, to compare the effect of each variable block with or without adjustments. Adjusted PRs were generated using logistic regression and predictive marginals.

Data were analyzed using SAS (version 9.4) and SUDAAN (version 11.0.1; Research Triangle Institute); figures were generated in R (version 4.0.3). This research was conducted consistent with applicable federal law and CDC policy and followed STROBE guidelines.

RESULTS

Nationally, coverage with at least 1 dose of a COVID-19 vaccine increased from 60.3% in May to 79.3% in December 2021 among U.S. adults aged ≥18 years. State vaccination coverage ranged widely, from 43.5% (Mississippi) to 79.4% (Vermont) in May, to 62.5% (West Virginia) to 92.3% (Connecticut) in December (Appendix Figure 1, Appendix Table 2). The prevalence of those who ‘definitely planned’ to get vaccinated decreased from 7.1% in May to 1.6% in December and those who would ‘probably get vaccinated’ or were unsure decreased from 14.9% in May to 5.8% in December, with considerable variation (Appendix Tables 3 and 4). Those who reported they definitely would not get vaccinated decreased from 17.7% in May to 13.2% in December (Appendix Table 5).

Among persons who remained unvaccinated, changes in behavioral characteristics from May to December were apparent (Figure 1, Appendix Tables 5–8) as the pool of unvaccinated persons

was increasingly populated by those with attitudes unfavorable toward vaccination. Nationally, 29.7% of unvaccinated persons had high risk perception about COVID-19 in May compared to 21.7% in December and 24.2% reported confidence in COVID-19 vaccine safety in May versus 11.6% in December. In December, unvaccinated persons in NY/NJ had the highest COVID-19 risk perception (median: 26.5%), confidence in vaccine safety (median: 15.4%), and confidence in vaccine importance (median: 31.2%). Unvaccinated persons in the Mountain West and Pacific Northwest generally had low risk perception (median: 15.0%), and low confidence in vaccine safety (median: 12.0% and 4.8%, respectively) and importance (median: 12.0% and 22.1%, respectively). Unvaccinated persons in the Southeast had low confidence in vaccine safety (median: 10.0%), and average levels of risk perception and confidence in vaccine importance.

The proportion of unvaccinated respondents who reported highly vaccinated social networks stayed stable around 30% from May–December (Figure 2, Appendix Table 9), while 23.6% of unvaccinated respondents reported they received a provider recommendation for COVID-19 vaccination in May versus 33.3% in December. Few unvaccinated respondents anticipated difficulty getting a COVID-19 vaccine: 15.6% in May, and 11.9% in December (Appendix Table 12). Unvaccinated respondents in the Northeast reported the strongest supportive social norms, as well as the highest prevalence of provider recommendation (December median: 41.2%) for COVID-19 vaccination. Unvaccinated respondents in the Plains and Mountain West reported lower supportive social norms and prevalence of provider recommendation.

Unadjusted bivariate associations (Table 1) between sociodemographic covariates and non-vaccination highlight disparities in vaccination coverage, with a higher prevalence of non-
vaccination among younger respondents in all regions: PR for 18‒49 years vs >65 years: 5.71 (95% CI=5.18, 6.29, range: 3.59 [Mountain West]‒17.73 [Northeast]). Hispanic persons had higher prevalence of non-vaccination compared to Non-Hispanic (NH) White persons in the Northeast, Plains, and Pacific Northwest (PR=1.95, 1.32, and 1.45, respectively), and lower prevalence in the Southeast and South (PR=0.83 and 0.87, respectively). Black NH persons had higher prevalence of non-vaccination compared to White NH persons in the Northeast (PR=1.54, 95% CI=1.09, 2.19) and lower prevalence in the South (PR=0.74, 95% CI=0.64, 0.86).

Rural residents (PR=1.66, 95% CI=1.57, 1.76, range: 1.38 [Midwest]‒1.96 [Southwest]), individuals without health insurance (PR=2.11, 95% CI=2.01, 2.21, range: 1.65 [NY/NJ]‒3.41 [Northeast]), individuals with a high school degree (PR=2.55, 95% CI=2.40, 2.71, range: 2.03 [South]‒6.18 [Northeast]), and those with household income under $75,000/year (PR=1.49, 95% CI=1.41, 1.57, range: 1.26 [South]‒1.78 [Northeast]) had higher prevalence of non-vaccination compared to urban residents, those with health insurance, with a college degree or higher, or making >$75,000 a year, respectively.

After adjusting for BeSD variables (Table 1) the association of sociodemographics with non-vaccination was attenuated. The strongest BeSD predictors of COVID-19 non-vaccination were low confidence in COVID-19 vaccine importance (aPR=5.19, 95% CI=4.93, 5.47), no work/school vaccine requirement (aPR=2.02, 95% CI=1.89, 2.16), and non-supportive social norms for vaccination (aPR=1.95, 95% CI=1.87, 2.04). The association between confidence in vaccine importance and non-vaccination was strongest in the Northeast, NY/NJ, Mountain West and Southwest, and weakest in the Southeast, Midwest, South, and Plains (Figure 3). Non-
supportive social norms had a stronger association with non-vaccination in NY/NJ and Appalachia, and a weaker association in the Mountain West. Associations for healthcare provider recommendation and perceived difficulty getting vaccinated did not differ across regions.

**DISCUSSION**

Nationally, COVID-19 vaccination coverage among adults increased nearly 20 percentage points from May to December 2021, with just over 20% of respondents unvaccinated, and less than 6% unsure if they would ultimately get vaccinated (‘reachable’) in December 2021. In December, the largest reachable populations were in the Southeast and Midwest, and those regions will be the focus of the discussion.

Unadjusted associations highlight disparities in vaccination coverage in certain geographic and sociodemographic groups. Individuals aged 18–49 years had the lowest prevalence of vaccination, likely highlighting increased hesitancy and perception that COVID-19 is not serious given the lower mortality risk among younger persons, agreeing with findings among childcare providers. Rural residents were less likely to be vaccinated than urban residents, concurring with published findings, with the largest disparity observed in the Southwest, and the smallest in the Southeast and Midwest. Uninsured individuals had higher prevalence of non-vaccination than insured persons; this disparity is consistent with routine adult vaccinations, although COVID-19 vaccines are available at no-cost. Insurance status may covary with other indicators of social vulnerability, acting as a proxy of barriers to vaccine access. Community vaccination sites may improve accessibility to persons without a primary care provider.
Non-uniform (unadjusted) associations between race/ethnicity and non-vaccination were observed: NH Black persons had increased prevalence of non-vaccination in all regions except for the South, while Hispanic persons had increased prevalence of non-vaccination in all regions except the Southeast and South compared with NH White persons. Data from January–March 2021 found that NH Black persons were less likely to have received or intend to receive vaccination compared to NH White persons, though these differences have decreased over time.

As individuals who viewed vaccination more favorably were ultimately vaccinated by December 2021, a survival bias is apparent where the composition of the unvaccinated group increasingly comprised those reluctant to get vaccinated.

In the Southeast, concern about COVID-19 among the unvaccinated decreased from May to June and sharply increased in August as the region faced a summer surge due to the Delta variant. Concern about COVID-19 in the Midwest followed largely the same pattern. This finding supports research that has shown higher COVID-19 mortality rates at the county level were associated with increased COVID-19 risk perception. Confidence in vaccine safety and importance followed similar trends for the 2 regions; respondents were more confident in COVID-19 vaccine importance than safety, consistent with the KFF November COVID-19 Vaccine Monitor. Unvaccinated persons in the Southeast had low median confidence in vaccine safety in December 2021, ranging from 5.5% (Florida) to 18.0% (North Carolina). The persistently low confidence in vaccine safety highlights the value in tailoring messages to promote safety in regions with higher COVID-19 risk perceptions.
Prior research has highlighted the power of social norms to influence health behavior, with evidence that these results extend to vaccination decisions. Trends in social norms varied widely in the Southeast: the proportion of unvaccinated respondents in North Carolina reporting supportive social norms nearly doubled from May–December 2021, and decreased in Florida. Areas where these trends decreased may highlight strong social clustering of non-vaccination within social networks. The low proportion of unvaccinated respondents reporting supportive social norms of vaccination highlights that many states may contain pockets of low vaccination coverage and be at risk of larger COVID-19 outbreaks.

Unvaccinated respondents in the Southeast had low prevalence of provider recommendation – lowest in North Carolina, South Carolina, and Tennessee, while unvaccinated persons in the Midwest had higher prevalence (highest in Michigan and Ohio). Nguyen et al. showed that adults who received a provider recommendation for COVID-19 vaccination were more likely to be vaccinated and believe COVID-19 vaccines are safe – highlighting that especially in the Southeast, efforts to increase provider recommendations are warranted. Those without a vaccine requirement for work or school were more likely to be unvaccinated, highlighting that vaccine mandates can be effective for increasing vaccination coverage.

Hispanic and other/multi-racial persons had lower prevalence of non-vaccination; while those 64 years or younger, rural residents, those who were uninsured, had less than a college degree, or made less than $75,000/year had higher prevalence of non-vaccination, all in unadjusted analyses. After adjustment for BeSD variables, many of these demographic associations were
attenuated or disappeared, suggesting that BeSD factors may be underlying drivers of non-vaccination to explain these disparities. Persons under 64 years, uninsured persons, those with less than a college degree, and those below poverty continued to have higher prevalence of non-vaccination after adjustment, potentially indicating unmeasured barriers to getting COVID-19 vaccination for these groups or modified associations among the BeSD domains. In regions where sociodemographic factors remained associated with non-vaccination after adjustment for BeSD variables, a rapid community assessment (RCA) and targeted data-driven interventions may be warranted to identify and overcome specific barriers to vaccination, including distrust and vaccine hesitancy. Strategic Partnerships with community partners working with these populations will be important to improve vaccine confidence and rebuild trust.

This study has several strengths. NIS-ACM data includes more complete demographic information than vaccine administration data, along with social and behavioral drivers of vaccination. Additionally, this analysis explicitly assessed constructs theorized to influence vaccination motivation and behavior, which may provide actionable insights for practitioners. Also, assessment of geographic variability of sociodemographic and BeSD factors may allow practitioners and policy makers to home in on actions that would be particularly impactful in their own unique context.

Limitations

Several limitations should be considered when interpreting these findings. First, NIS-ACM has a low response rate, introducing the potential for non-generalizability to the overall U.S. population. Second, COVID-19 vaccination status and intent were self-reported and may be subject to recall or social desirability bias. Survey weights were calibrated to COVID-19 vaccine
administration data to mitigate possible bias from incomplete sample frame, nonresponse, and misclassification of vaccination status. Third, causality cannot be inferred from cross-sectional data, multivariable results may not accurately reflect the complex causal chain among BeSD and sociodemographic factors, the BeSD variables included in the model may represent multiple domains (e.g., confidence in vaccine importance clustering with confidence in vaccine safety), and possible differential associations of BeSD variables with non-vaccination by sociodemographic characteristics were not considered. Finally, the sample was limited to the non-institutionalized adult U.S. population.

CONCLUSIONS

This study identified geographic and temporal trends in vaccination uptake and intent, geographic and demographic disparities in non-vaccination, and underlying behavioral and social drivers of non-vaccination. From October–December 2021, confidence in COVID-19 vaccine importance was the strongest predictor of non-vaccination. As such, focused messaging about the benefits of vaccinations compared to the risks, highlighting the safety of COVID-19 vaccinations, remains a priority. Additionally, adults in rural areas and those with less than a college degree, without insurance, making <$75,000/year, and under 65 years of age had higher prevalence of non-vaccination across all regions while the associations between vaccination and race/ethnicity were variable by region. This analysis demonstrates the importance of population-based surveys to document changes in how people think and feel about COVID-19 vaccines to inform communication strategies. As public health practitioners try to reach more diverse and vaccine hesitant groups, it is essential to understand practical and behavioral barriers to vaccination, and work to gain the public’s trust and confidence in COVID-19 vaccines.
Significant geographical heterogeneity in associations between demographic variables and BeSD variables and non-vaccination support localized interventions.

**CRediT Statement:** Nina B. Masters: Conceptualization; Formal analysis; Investigation; Methodology; Visualization; Writing – original draft; Writing - review & editing; Tianyi Zhou: Formal analysis; Methodology; Validation; Lu Meng: Data curation; Formal analysis; Writing - review & editing; Peng-Jun Lu: Conceptualization; Formal analysis; Methodology; Writing - review & editing; Jennifer L. Kriss: Methodology; Writing - review & editing; Carla Black: Methodology; Writing - review & editing; Amel Omari: Methodology; Writing - review & editing; Kwanza Boone: Writing – original draft; Writing - review & editing; Debora Weiss: Writing - review & editing; Rosalind J. Carter: Methodology; Writing - review & editing; Noel T. Brewer: Methodology; Writing - review & editing; James A. Singleton: Conceptualization; Methodology; Writing - review & editing; Supervision
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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the U.S. Centers for Disease Control and Prevention.
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Figure 1. Temporal and state variation in behavioral BeSD variables: (A) Concern about getting COVID-19, (B) perception that the COVID-19 vaccine is very/completely safe, (C) perception
that the COVID-19 vaccine is important to protect against COVID-19, with the national average shown in each facet as the grey line, from May–December 2021.

BeSD, Behavioral and Social Drivers of Vaccination.

Figure 2. Temporal and state variation in BeSD social processes and practical issues variables:

(A) Perceived proportion of friends and family who have been vaccinated against COVID-19,

(B) Proportion who have received a provider recommendation for the COVID-19 vaccine,

(C) Proportion reporting anticipated difficulty getting a COVID-19 vaccine,

(D) proportion reporting they ‘could’ get a COVID-19 vaccine if they wanted to (self-efficacy), with the national average shown in each facet as the grey line, from May–December 2021.
Notes: Region 1, Northeast: CT, ME, MA, NH, RI, VT; Region 2: NJ, NY; Region 3, Appalachia: DE, DC, MD, PA, VA, WV; Region 4, Southeast: AL, FL, GA, KY, MS, NC, SC, TN; Region 5, Midwest: IL, IN, MI, MN, OH, WI; Region 6, South: AR, LA, NM, OK, TX; Region 7, Plain: IA, KS, MO, NE Region 8, Mountain West: CO, MT, ND, SD, UT, WY; Region 9, Southwest: AZ, CA, HI, NV; Region 10, Pacific Northwest: AK, ID, OR, WA.

Figure 3. Dot plots depicting the regional adjusted prevalence ratio (aPR) in grey of 5 BeSD variables with non-vaccination for each HHS region compared to the national aPR, in black, from October–December 2021.

Notes: The BeSD variables included in this figure are: requirement (comparing no vaccination requirement for work or school to having a vaccination requirement), access (those who felt it was/would be ‘somewhat/very difficult’ to get the COVID-19 vaccine compared to those who reported ‘not at all/a little difficult’), social norms (‘No/some family or friends vaccinated’ vs.
‘most/almost all family or friends vaccinated’), recommendation (non-receipt of a healthcare provider recommendation compared to receipt of a recommendation), and importance (those who felt the vaccines were ‘not or only somewhat important’ compared to those who felt they were ‘moderately or very important’). Region 1, Northeast: CT, ME, MA, NH, RI, VT; Region 2: NJ, NY; Region 3, Appalachia: DE, DC, MD, PA, VA, WV; Region 4, Southeast: AL, FL, GA, KY, MS, NC, SC, TN; Region 5, Midwest: IL, IN, MI, MN, OH, WI; Region 6, South: AR, LA, NM, OK, TX; Region 7, Plains: IA, KS, MO, NE Region 8, Mountain West: CO, MT, ND, SD, UT, WY; Region 9, Southwest: AZ, CA, HI, NV; Region 10, Pacific Northwest: AK, ID, OR, WA.
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<th>Adjusted for demographic + BeSDa variables aPR (95% CI)</th>
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<td>1.85 (1.74, 1.97)</td>
<td>1.19 (1.15, 1.24)</td>
</tr>
<tr>
<td>College graduate</td>
<td>ref</td>
<td>ref</td>
<td>ref</td>
</tr>
<tr>
<td>Household income</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below povertyb</td>
<td>1.93 (1.81, 2.06)</td>
<td>1.45 (1.36, 1.55)</td>
<td>1.24 (1.18, 1.31)</td>
</tr>
<tr>
<td>Above poverty, &lt;$75,000</td>
<td>1.49 (1.41, 1.57)</td>
<td>1.23 (1.17, 1.30)</td>
<td>1.13 (1.09, 1.18)</td>
</tr>
<tr>
<td>Above poverty, ≥$75,000</td>
<td>ref</td>
<td>ref</td>
<td>ref</td>
</tr>
</tbody>
</table>
Unknown income  1.47 (1.39, 1.56)  1.31 (1.23, 1.38)  1.10 (1.05, 1.15)

<table>
<thead>
<tr>
<th>HHS Region</th>
<th>No. 1, Northeast: CT, ME, MA, NH, RI, VT</th>
<th>ref</th>
<th>ref</th>
<th>ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>NY/NJ: NJ,NY</td>
<td></td>
<td>1.21 (1.07, 1.37)</td>
<td>1.29 (1.14, 1.45)</td>
<td>1.06 (0.98, 1.14)</td>
</tr>
<tr>
<td>Southeast: AL,FL,GA,KY,MS,NC,SC,TN</td>
<td></td>
<td>1.66 (1.49, 1.86)</td>
<td>1.58 (1.42, 1.76)</td>
<td>1.15 (1.07, 1.23)</td>
</tr>
<tr>
<td>Midwest: IL,IN,MI,MN,OH,WI</td>
<td></td>
<td>2.67 (2.41, 2.94)</td>
<td>2.35 (2.13, 2.59)</td>
<td>1.24 (1.17, 1.33)</td>
</tr>
<tr>
<td>South: AR,LA,NM,OK,TX</td>
<td></td>
<td>2.85 (2.58, 3.16)</td>
<td>2.52 (2.28, 2.78)</td>
<td>1.37 (1.28, 1.46)</td>
</tr>
<tr>
<td>Plains: IA,KS,MO,NE</td>
<td></td>
<td>2.62 (2.37, 2.89)</td>
<td>2.31 (2.10, 2.55)</td>
<td>1.22 (1.14, 1.30)</td>
</tr>
<tr>
<td>Mountain West: CO,MT,ND,SD,UT,WY</td>
<td></td>
<td>2.86 (2.55, 3.20)</td>
<td>2.44 (2.18, 2.73)</td>
<td>1.27 (1.18, 1.38)</td>
</tr>
<tr>
<td>Southwest: AZ,CA,HI,NV</td>
<td></td>
<td>2.37 (2.11, 2.66)</td>
<td>2.01 (1.79, 2.26)</td>
<td>1.20 (1.11, 1.30)</td>
</tr>
<tr>
<td>Pacific Northwest: AK,ID,OR,WA</td>
<td></td>
<td>1.45 (1.29, 1.63)</td>
<td>1.50 (1.34, 1.68)</td>
<td>1.09 (1.01, 1.17)</td>
</tr>
</tbody>
</table>

**Thinks a COVID-19 vaccine is important**

| Not at all/a little important | 10.10 (9.65, 10.57) | – | 5.19 (4.93, 5.47) |
| Somewhat/very important | ref | – | ref |

**Healthcare provider recommended vaccine**

| No | 1.68 (1.61, 1.76) | – | 1.02 (0.99, 1.06) |
| Yes | ref | – | ref |

**Friends and family vaccinated**

| No/some family or friends vaccinated | 6.63 (6.33, 6.95) | – | 1.95 (1.87, 2.04) |
| Many/Almost all family or friends vaccinated | ref | – | ref |

**Difficulty getting a COVID-19 vaccine**

| Very/somewhat difficult | 0.89 (0.83, 0.95) | – | 1.09 (1.04, 1.14) |
| A little / not at all difficult | ref | – | ref |

**Work or school requires you to get a COVID-19 vaccine**

| No | 4.19 (3.84, 4.57) | – | 2.02 (1.89, 2.16) |
| Yes | ref | – | ref |
| Unemployed/NA | 1.77 (1.58, 1.98) | – | 1.98 (1.82, 2.15) |

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BeSD = Behavioral and Social Drivers (includes thinks a COVID-19 vaccine is important [thinking and feeling domain], healthcare provider recommended vaccine and perceived friends and family vaccinated [social processes domain], difficulty getting a COVID-19 vaccine, and work or school requires you to get a COVID-19 vaccine [practical issues domain]).

aPoverty defined as the 2021 Federal Poverty Level.
Puerto Rico, U.S. Virgin Islands, and Guam were not included in the models, and thus Puerto Rico and U.S. Virgin Islands were excluded from Health and Human Services (HHS) Region 2, and Guam was excluded from HHS Region 9.