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

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Introduction: Little is known about how the 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 nonvaccination 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 Framework among unvaccinated respondents from May 2021 to December 2021 ($n=531,798$) and sociodemographic and geographic disparities and Behavioral and Social Drivers of Vaccination predictors of COVID-19 nonvaccination from October 2021 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, although the Southeast had especially low confidence in vaccine safety in December 2021, lowest in Florida (5.5%) and highest in North Carolina (18.0%). The strongest Behavioral and Social Drivers of Vaccination correlate of not receiving a COVID-19 vaccination was lower confidence in COVID-19 vaccine importance (adjusted prevalence ratio=5.19, 95% CI=4.93, 5.47; strongest in the Northeast, Southwest, and Mountain West and weakest in the Southeast and Midwest). Other Behavioral and Social Drivers of Vaccination correlates also varied by region.

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

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) vaccine first became available in the U.S. in December 2020, and vaccine eligibility had expanded to all

persons aged ≥ 16 years 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.^{1,2} Progress in COVID-19 vaccination coverage slowed after April 2021,

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with wide geographic variation in vaccine uptake.^{3–6} Millions of Americans remained unvaccinated as cases reached all-time highs because of the Omicron variant in December 2021.⁷ Despite high national vaccination coverage, spatial heterogeneity in vaccination can contribute to outbreaks in areas with high numbers of unvaccinated individuals.^{8,9}

Analyses of disparities in vaccination coverage show variability by socioeconomic and sociodemographic factors, including reduced vaccination coverage among younger persons,¹⁰ residents of rural counties,^{10–12} and residents of counties with higher social vulnerability.^{10,13,14} Many of these groups (i.e., those living in rural areas, those with lower household income, those with less education, and Black and Hispanic persons) have greater vaccine hesitancy.¹⁵ These disparities highlight the 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.^{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.^{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.^{21,22} Behavioral factors influence vaccine acceptance or refusal, including vaccine confidence and concerns about vaccine importance, safety, and trustworthiness.^{3,23} 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 vaccines²⁴ or lacked trust in vaccines.²⁵

Vaccination behavior also responds to social processes, including receiving a recommendation from family and friends^{26,27} or a healthcare provider,^{28–30} both of which are associated with higher vaccine uptake. Other reasons for nonvaccination 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.^{31,32}

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 the underlying drivers of observed disparities.

METHODS

Study Sample

The National Immunization Survey—Adult COVID Module (NIS-ACM)³³ is a nationally representative, random-digit-dialed household cellphone survey of U.S. adults aged ≥ 18 years. The Adult COVID Module was added to the National Immunization Survey^{34,35} in April 2021. This paper reports on participants ($n=531,798$) surveyed from April 22, 2021 to 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.³⁶

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?* (response options were *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.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 recommendations 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](#) (available online). The following labels were used for HHS Regions: 1:Northeast, 2:New York/New Jersey (NY/NJ), 3:Appalachia, 4:Southeast, 5:Midwest, 6:South, 7: Plains, 8:Mountain West, 9:Southwest, and 10:Pacific Northwest.

Statistical Analysis

All percentages and prevalence ratios (PRs) (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 the 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 2021 to December 2021 to support trends over time.

Second, analyses examined the 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 to 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 because of 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 (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 cut off. In this analysis, the 9 BeSD items were included in the VARCLUS procedure with a maximum eigenvalue set as 0.75) variable reduction algorithm from the 9 variables in the BeSD framework (all variables in [Table 1](#)). 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. This paper uses the term drivers in alignment with the BeSD framework, although this study can only assess the correlates of nonvaccination.

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 Centers for Disease Control and Prevention policy (45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241[d]; 5 U.S.C. §552a; 44 U.S.C. §3,501 et seq) and followed STROBE guidelines.³⁷

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](#), available online, and [Appendix Table 2](#), available online). The prevalence of those who definitely planned to get vaccinated decreased from 7.1% in May to 1.6% in December, and the prevalence of 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](#), available online). Those who reported that they definitely would not get vaccinated decreased from 17.7% in May to 13.2% in December ([Appendix Table 5](#), available online).

Among persons who remained unvaccinated, changes in behavioral characteristics from May to December were apparent ([Figure 1](#) and [Appendix Tables 5–8](#), available online) because the pool of unvaccinated persons was increasingly populated by those with attitudes unfavorable toward vaccination. Nationally, 29.7% of unvaccinated persons had a high-risk perception about

COVID-19 in May compared with 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 at around 30% from May to December ([Figure 2](#) and [Appendix Table 9](#), available online), whereas 23.6% of unvaccinated respondents reported that they received a provider recommendation for COVID-19 vaccination in May versus 33.3% in December. 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 ([Appendix Table 10](#), available online). Unvaccinated respondents in the Plains and Mountain West reported lower supportive social norms and prevalence of provider recommendations. Few unvaccinated respondents reported a work or school COVID-19 vaccine requirement ([Appendix Table 11](#), available online), or anticipated difficulty in getting a COVID-19 vaccine: 15.6% in May and 11.9% in December ([Appendix Table 12](#), available online).

Unadjusted bivariate associations ([Table 1](#)) between sociodemographic covariates and nonvaccination highlight disparities in vaccination coverage, with a higher prevalence of nonvaccination among younger respondents in all regions: PR for age 18–49 years versus age ≥65 years: 5.71 (95% CI=5.18, 6.29; range=3.59 [Mountain West]–17.73 [Northeast]). Hispanic persons had a higher prevalence of nonvaccination than 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 a higher prevalence of nonvaccination than 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

Table 1. Correlates of COVID-19 Nonvaccination Among Adults Aged ≥ 18 Years, National Immunization Survey—Adult COVID-19 Module, October 2021–December 2021

Variables	Unadjusted, PR (95% CI)	Adjusted for demographic variables only, aPR (95% CI)	Adjusted for demographic + BeSD ^a variables, aPR (95% CI)
Sex			
Male	ref	ref	ref
Female	0.82 (0.79, 0.86)	0.88 (0.85, 0.92)	1.00 (0.97, 1.03)
Race/ethnicity			
White non-Hispanic	ref	ref	ref
Black non-Hispanic	1.04 (0.97, 1.10)	0.91 (0.86, 0.97)	1.16 (1.10, 1.21)
Hispanic	0.91 (0.86, 0.97)	0.69 (0.65, 0.73)	1.01 (0.97, 1.05)
Other/multirace	0.90 (0.83, 0.98)	0.85 (0.79, 0.91)	1.09 (1.03, 1.14)
Age, years			
18–49	5.71 (5.18, 6.29)	5.84 (5.27, 6.47)	2.47 (2.28, 2.68)
50–64	2.96 (2.66, 3.29)	3.04 (2.73, 3.39)	1.67 (1.54, 1.82)
≥ 65	ref	ref	ref
Urbanicity			
MSA, principal city	ref	ref	ref
MSA, nonprincipal city	1.06 (1.01, 1.11)	1.10 (1.05, 1.16)	0.99 (0.96, 1.03)
Non-MSA	1.66 (1.57, 1.76)	1.49 (1.41, 1.57)	1.07 (1.02, 1.12)
Insurance status			
Uninsured	2.11 (2.01, 2.21)	1.41 (1.34, 1.48)	1.15 (1.10, 1.20)
Insured	ref	ref	ref
Education level			
High school graduate or less	2.55 (2.40, 2.71)	2.05 (1.93, 2.18)	1.22 (1.17, 1.27)
Some college	2.21 (2.07, 2.35)	1.85 (1.74, 1.97)	1.19 (1.15, 1.24)
College graduate	ref	ref	ref
Household income			
Below poverty ^b	1.93 (1.81, 2.06)	1.45 (1.36, 1.55)	1.24 (1.18, 1.31)
Above poverty, <\$75,000	1.49 (1.41, 1.57)	1.23 (1.17, 1.30)	1.13 (1.09, 1.18)
Above poverty, \geq \$75,000	ref	ref	ref
Unknown income	1.47 (1.39, 1.56)	1.31 (1.23, 1.38)	1.10 (1.05, 1.15)
HHS region ^c			
1, Northeast: CT, ME, MA, NH, RI, VT	ref	ref	ref
2, New York/New Jersey: NJ, NY	1.21 (1.07, 1.37)	1.29 (1.14, 1.45)	1.06 (0.98, 1.14)
3, Appalachia: DE, DC, MD, PA, VA, WV	1.66 (1.49, 1.86)	1.58 (1.42, 1.76)	1.15 (1.07, 1.23)
4, Southeast: AL, FL, GA, KY, MS, NC, SC, TN	2.67 (2.41, 2.94)	2.35 (2.13, 2.59)	1.24 (1.17, 1.33)
5, Midwest: IL, IN, MI, MN, OH, WI	2.85 (2.58, 3.16)	2.52 (2.28, 2.78)	1.37 (1.28, 1.46)
6, South: AR, LA, NM, OK, TX	2.62 (2.37, 2.89)	2.31 (2.10, 2.55)	1.22 (1.14, 1.30)
7, Plains: IA, KS, MO, NE	2.86 (2.55, 3.20)	2.44 (2.18, 2.73)	1.27 (1.18, 1.38)
8, Mountain West: CO, MT, ND, SD, UT, WY	2.37 (2.11, 2.66)	2.01 (1.79, 2.26)	1.20 (1.11, 1.30)
9, Southwest: AZ, CA, HI, NV	1.45 (1.29, 1.63)	1.50 (1.34, 1.68)	1.09 (1.01, 1.17)
10, Pacific Northwest: AK, ID, OR, WA	2.10 (1.85, 2.38)	1.84 (1.63, 2.09)	1.20 (1.10, 1.31)
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)

(continued on next page)

Table 1. Correlates of COVID-19 Nonvaccination Among Adults Aged ≥ 18 Years, National Immunization Survey–Adult COVID-19 Module, October 2021–December 2021 (continued)

Variables	Unadjusted, PR (95% CI)	Adjusted for demographic variables only, aPR (95% CI)	Adjusted for demographic + BeSD ^a variables, aPR (95% CI)
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)

aBeSD includes thinking that a COVID-19 vaccine is important (thinking and feeling domain), healthcare provider recommended vaccine and perceived friends and family vaccinated (social processes domain), difficulty in getting a COVID-19 vaccine, and work or school requires you to get a COVID-19 vaccine (practical issues domain).

^bPoverty defined as the 2021 Federal Poverty Level.

^cPuerto 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 HHS Region 2, and Guam was excluded from HHS Region 9.

AK, Alaska; AL, Alabama; aPR, adjusted prevalence ratio; AR, Arkansas; AZ, Arizona; BeSD, Behavioral and Social Drivers of Vaccination; CA, California; CO, Colorado; CT, Connecticut; DE, Delaware; FL, Florida; GA, Georgia; HI, Hawaii; IA, Iowa; ID, Idaho; IL, Illinois; IN, Indiana; KS, Kansas; KY, Kentucky; LA, Louisiana; MA, Massachusetts; MD, Maryland; ME, Maine; MI, Michigan; MN, Minnesota; MO, Missouri; MS, Mississippi; MSA, metropolitan service area; MT, Montana; NC, North Carolina; ND, North Dakota; NE, Nebraska; NH, New Hampshire; NJ, New Jersey; NM, New Hampshire; NV, Nevada; NY, New York; OH, Ohio; OK, Oklahoma; OR, Oregon; PA, Pennsylvania; PR, aPR, prevalence ratio; RI, Rhode Island; SC, South Carolina; SD, South Dakota; TN, Tennessee; TX, Texas; UT, Utah; VA, Virginia; VT, Vermont; WA, Washington; WI, Wisconsin; WV, West Virginia; WY, Wyoming.

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 <\$75,000/year (PR=1.49; 95% CI=1.41, 1.57; range=1.26 [South]–1.78 [Northeast]) had higher prevalence of nonvaccination than urban residents, those with health insurance, those with a college degree or higher, or those making >\$75,000 a year, respectively.

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

DISCUSSION

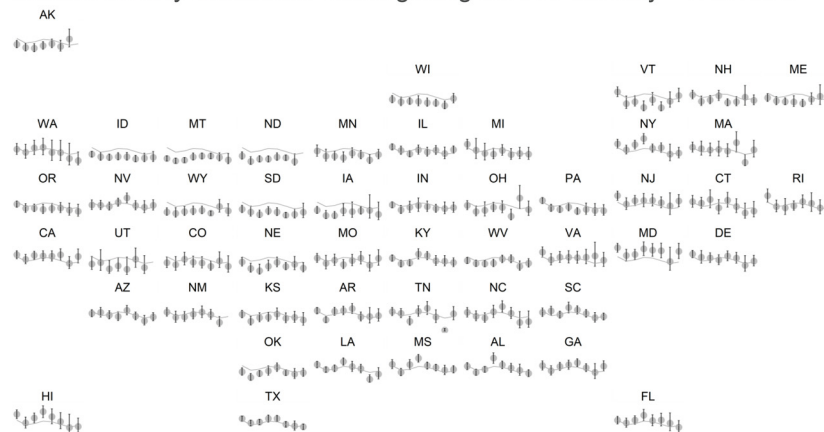
Nationally, COVID-19 vaccination coverage among adults increased by nearly 20 percentage points from

May to December 2021, with just more than 20% of respondents unvaccinated and <6% unsure whether 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.

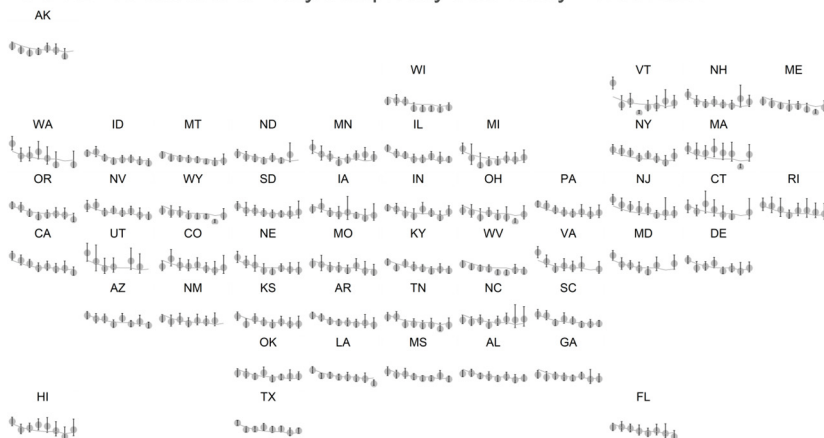
Unadjusted associations highlight the disparities in vaccination coverage in certain geographic and sociodemographic groups. Individuals aged 18–49 years had the lowest prevalence of vaccination, likely highlighting increased hesitancy and perception that COVID-19 is not serious given the lower mortality risk among younger persons, agreeing with findings among child care providers.³⁸ Rural residents were less likely to be vaccinated than urban residents, concurring with published findings,^{12,39} with the largest disparity observed in the Southwest and the smallest in the Southeast and Midwest. Uninsured individuals had a higher prevalence of nonvaccination than insured persons; this disparity is consistent with routine adult vaccinations,⁴⁰ 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.

Nonuniform (unadjusted) associations between race/ethnicity and nonvaccination were observed: NH Black persons had an increased prevalence of nonvaccination in all regions except in the South, whereas Hispanic persons had an increased prevalence of nonvaccination in all regions except in the Southeast and South compared

A) Proportion of unvaccinated respondents reporting they are 'somewhat/very concerned' about getting COVID-19: May – Dec 2021



B) Proportion of unvaccinated respondents reporting they believe the COVID-19 vaccine is 'very/completely safe': May – Dec 2021



C) Proportion of unvaccinated respondents reporting they believe the vaccine is important to protect against COVID-19: May – Dec 2021

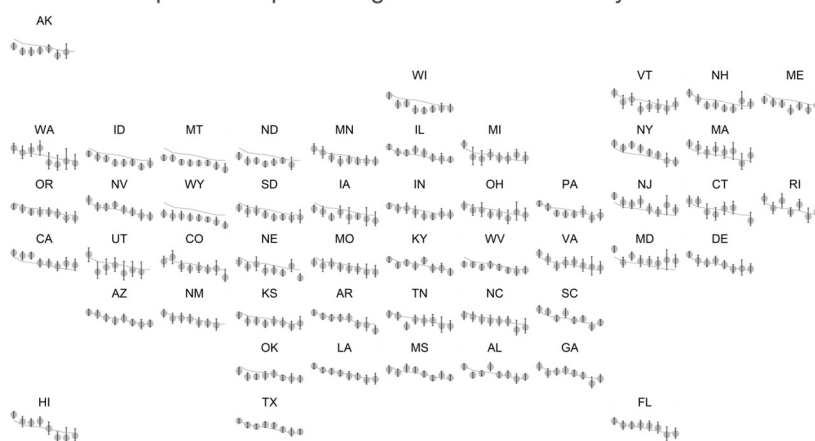


Figure 1. Temporal and state variation in behavioral BeSD variables: (A) concern about getting COVID-19, (B) perception that the COVID-19 vaccine is very/completely safe, and (C) perception that the COVID-19 vaccine is important to protect against COVID-19, with the national average shown in each facet as the gray line, from May 2021 to December 2021.

AK, Alaska; AL, Alabama; AR, Arkansas; AZ, Arizona; BeSD, Behavioral and Social Drivers of Vaccination; CA, California; CO, Colorado; CT, Connecticut; DE, Delaware; FL, Florida; GA, Georgia; HI, Hawaii; IA, Iowa; ID, Idaho; IL, Illinois; IN, Indiana; KS, Kansas; KY, Kentucky; LA, Louisiana; MA, Massachusetts; MD, Maryland; ME, Maine; MI, Michigan; MN, Minnesota; MO, Missouri; MS, Mississippi; MT, Montana; NC, North Carolina; ND, North Dakota; NE, Nebraska; NH, New Hampshire; NJ, New Jersey; NM, New Hampshire; NV, Nevada; NY, New York; OH, Ohio; OK, Oklahoma; OR, Oregon; PA, Pennsylvania; RI, Rhode Island; SC, South Carolina; SD, South Dakota; TN, Tennessee; TX, Texas; UT, Utah; VA, Virginia; VT, Vermont; WA, Washington; WI, Wisconsin; WV, West Virginia; WY, Wyoming.

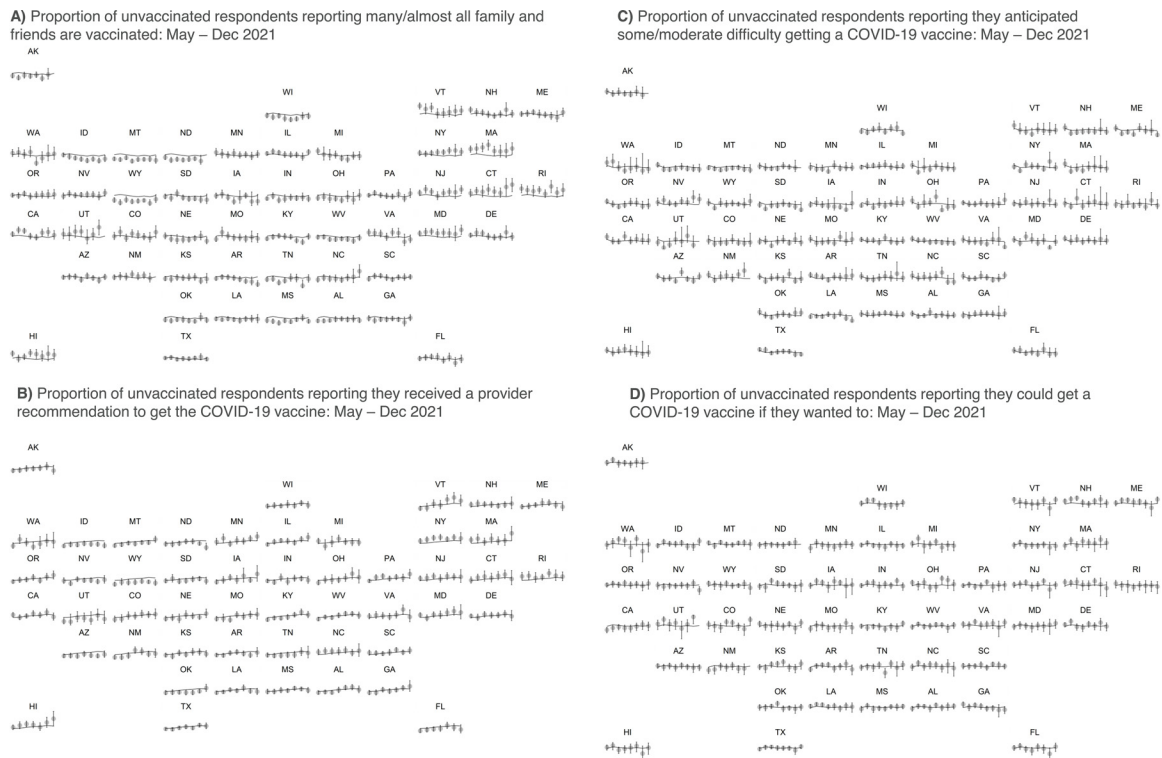


Figure 2. Temporal and state variation in BeSD social processes and practical issues variables: (A) perceived proportion of friends and family who have been vaccinated against COVID-19, (B) proportion who have received a provider recommendation for the COVID-19 vaccine, (C) proportion reporting anticipated difficulty in getting a COVID-19 vaccine, (D) proportion reporting that they could get a COVID-19 vaccine if they wanted to (self-efficacy), with the national average shown in each facet as the gray line, from May 2021 to December 2021.

Note: 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, n.d., SD, UT, WY; Region 9, Southwest: AZ, CA, HI, NV; and Region 10, Pacific Northwest: AK, ID, OR, WA.

AK, Alaska; AL, Alabama; AR, Arkansas; AZ, Arizona; BeSD, Behavioral and Social Drivers of Vaccination; CA, California; CO, Colorado; CT, Connecticut; DE, Delaware; FL, Florida; GA, Georgia; HI, Hawaii; IA, Iowa; ID, Idaho; IL, Illinois; IN, Indiana; KS, Kansas; KY, Kentucky; LA, Louisiana; MA, Massachusetts; MD, Maryland; ME, Maine; MI, Michigan; MN, Minnesota; MO, Missouri; MS, Mississippi; MT, Montana; NC, North Carolina; ND, North Dakota; NE, Nebraska; NH, New Hampshire; NJ, New Jersey; NM, New Mexico; NV, Nevada; NY, New York; OH, Ohio; OK, Oklahoma; OR, Oregon; PA, Pennsylvania; RI, Rhode Island; SC, South Carolina; SD, South Dakota; TN, Tennessee; TX, Texas; UT, Utah; VA, Virginia; VT, Vermont; WA, Washington; WI, Wisconsin; WV, West Virginia; WY, Wyoming.

with NH White persons. Data from January–March 2021¹⁵ showed that NH Black persons were less likely to have received or intend to receive vaccination than NH White persons, although these differences have decreased over time.⁴¹

Because individuals who viewed vaccination more favorably were ultimately vaccinated by December 2021, a survival bias⁴² 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 because of the Delta variant. Concern about COVID-19 in the Midwest followed largely the same pattern. This finding supports research that has shown that higher COVID-19

mortality rates at the county level were associated with increased COVID-19 risk perception.⁴³ 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.⁴⁴ 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.

Previous research has highlighted the power of social norms to influence health behavior, with evidence that these results extend to vaccination decisions.⁴⁵ Trends in social norms varied widely in the Southeast: the

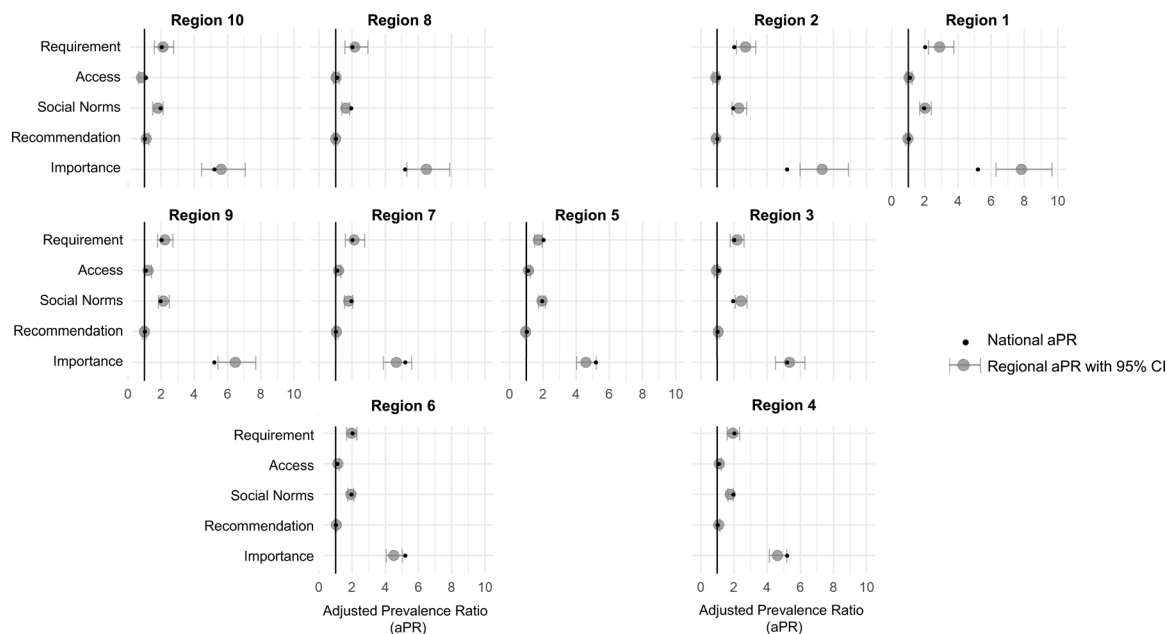


Figure 3. Dot plots depicting the regional aPR in gray of 5 BeSD variables with nonvaccination for each HHS region compared with the national aPR in black, from October–December 2021.

Note: The BeSD variables included in this figure are requirement (comparing no vaccination requirement for work or school with having a vaccination requirement), access (those who felt that it was/would be somewhat/very difficult to get the COVID-19 vaccine compared with those who reported not at all/a little difficult), social norms (no/some family or friends vaccinated versus most/almost all family or friends vaccinated), recommendation (nonreceipt of a healthcare provider recommendation compared with receipt of a recommendation), and importance (those who felt that the vaccines were not or only somewhat important compared with those who felt that 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; and Region 10, Pacific Northwest: AK, ID, OR, WA.

AK, Alaska; AL, Alabama; aPR, adjusted prevalence ratio; AR, Arkansas; AZ, Arizona; BeSD, Behavioral and Social Drivers of Vaccination; CA, California; CO, Colorado; CT, Connecticut; DE, Delaware; FL, Florida; GA, Georgia; HI, Hawaii; IA, Iowa; ID, Idaho; IL, Illinois; IN, Indiana; KS, Kansas; KY, Kentucky; LA, Louisiana; MA, Massachusetts; MD, Maryland; ME, Maine; MI, Michigan; MN, Minnesota; MO, Missouri; MS, Mississippi; MT, Montana; NC, North Carolina; ND, North Dakota; NE, Nebraska; NH, New Hampshire; NJ, New Jersey; NM, New Mexico; NV, Nevada; NY, New York; OH, Ohio; OK, Oklahoma; OR, Oregon; PA, Pennsylvania; RI, Rhode Island; SC, South Carolina; SD, South Dakota; TN, Tennessee; TX, Texas; UT, Utah; VA, Virginia; VT, Vermont; WA, Washington; WI, Wisconsin; WV, West Virginia; WY, Wyoming.

proportion of unvaccinated respondents in North Carolina reporting supportive social norms nearly doubled from May to December 2021 and decreased in Florida. Areas where these trends decreased may highlight strong social clustering of nonvaccination 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.^{6,46,47}

Unvaccinated respondents in the Southeast had a low prevalence of provider recommendation (lowest in North Carolina, South Carolina, and Tennessee), whereas unvaccinated persons in the Midwest had a 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 to believe that COVID-19 vaccines are safe—highlighting that especially in the

Southeast, efforts to increase provider recommendations are warranted.²⁸ 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.⁴⁸

Hispanic and other/multiracial persons had a lower prevalence of nonvaccination, whereas those aged ≤ 64 years, rural residents, those who were uninsured, those who had less than a college degree, or those who made $< \$75,000/\text{year}$ had a higher prevalence of nonvaccination, all in unadjusted analyses. After adjustment for BeSD variables, many of these demographic associations were attenuated or disappeared, suggesting that BeSD factors may be the underlying drivers of nonvaccination to explain these disparities. Persons aged < 64 years, uninsured persons, those with less than a college degree, and those below poverty continued to have higher prevalence of nonvaccination 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 nonvaccination after adjustment for BeSD variables, a rapid community assessment⁴⁹ 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 include more complete demographic information than vaccine administration data, along with social and behavioral drivers of vaccination. In addition, this analysis explicitly assessed constructs theorized to influence vaccination motivation and behavior, which may provide actionable insights for practitioners. In addition, 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 nongeneralizability 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 nonvaccination 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 nonvaccination, and underlying behavioral and social drivers of nonvaccination. From October to December 2021, confidence in COVID-19 vaccine importance was the strongest predictor of nonvaccination. As such, focused messaging about the

benefits of vaccinations compared with the risks, highlighting the safety of COVID-19 vaccinations, remains a priority. In addition, adults in rural areas and those with less than a college degree, those without insurance, those making <\$75,000/year, and those aged <65 years had a higher prevalence of nonvaccination across all regions, whereas the associations between vaccination and race/ethnicity were variable by region. This analysis shows 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 geographic heterogeneity in associations between demographic variables and BeSD variables and nonvaccination support localized interventions.

CREDIT AUTHORSHIP CONTRIBUTION 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, Supervision, Writing – review & editing.

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at <https://doi.org/10.1016/j.amepre.2022.06.016>.

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