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BRIEF REPORT

Rural-urban and within-rural differences in COVID-19 vaccination rates

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Abstract

Purpose: COVID-19 mortality rates are higher in rural versus urban areas in the United States, threatening to exacerbate the existing rural mortality penalty. To save lives and facilitate economic recovery, we must achieve widespread vaccination coverage. This study compared adult COVID-19 vaccination rates across the US rural-urban continuum and across different types of rural counties.

Methods: We retrieved vaccination rates as of August 11, 2021, for adults aged 18+ for the 2,869 counties for which data were available from the CDC. We merged these with county-level data on demographic and socioeconomic composition, health care infrastructure, 2020 Trump vote share, and USDA labor market type. We then used regression models to examine predictors of COVID-19 vaccination rates across the USDA's 9-category rural-urban continuum codes and separately within rural counties by labor market type.

Findings: As of August 11, 45.8% of adults in rural counties had been fully vaccinated, compared to 59.8% in urban counties. In unadjusted regression models, average rates declined monotonically with increasing rurality. Lower rural rates are explained by a combination of lower educational attainment and higher Trump vote share. Within rural counties, rates are lowest in farming and mining-dependent counties and highest in recreation-dependent counties, with differences explained by a combination of educational attainment, health care infrastructure, and Trump vote share.

Conclusion: Lower vaccination rates in rural areas is concerning given higher rural COVID-19 mortality rates and recent surges in cases. At this point, mandates may be the most effective strategy for increasing vaccination rates.

KEYWORDS
COVID-19, rural-urban continuum, vaccination, vaccine

Since late 2020, the cumulative COVID-19 mortality rate has been higher in rural than in urban areas of the United States,[1] threatening to exacerbate the existing rural mortality penalty.[2,3] Achieving high vaccination coverage is the best way to prevent coronavirus spread, promote economic recovery, and save lives. Yet, as of August 2021, only 62% of US adults had been fully vaccinated.[4]

COVID-19 vaccination rates vary substantially across the United States,[4] with some counties nearing 100% vaccination, while others have rates under 5%.[5] Metro status appears to be a key delineator of vaccination rates. Survey data from the Kaiser Family Foundation (KFF) show that by July 2021, 76% of urban residents reported being fully vaccinated, compared to 63% of rural residents.[6] Among those who had not been vaccinated, a larger share of rural adults reported they would get vaccinated only if required or would definitely not get vaccinated. Although useful for gauging hesitancy, surveillance reports do not disaggregate vaccination rates across the rural-urban continuum or describe differences between different types of rural areas. In this brief report, we expand on the existing evidence base by using county vaccination rates from the CDC to describe rural-urban continuum and within-rural differences in rates and identify the major contributors to this variation.

There are several potential explanations for lower vaccination rates in rural areas. Lower vaccination rates are not a new phenomenon for rural areas. Coverage rates are lower in some rural subpopulations for flu, pneumococcal, and human papillomavirus.[7–12] In terms of COVID-19, more limited vaccine information and availability may have mattered early on, but vaccines are now widely available across most of the United States. However, availability does not equate to access. Counties comprising more vulnerable populations, including larger shares of racial/ethnic minorities and higher rates of poverty and uninsured populations, have been found to have lower vaccination rates.[13] Rural residents are on average poorer, have lower rates of insurance coverage, have less robust health care infrastructure, and must travel further distances to venues where vaccines are administered.[14,15] Accordingly, while availability is unlikely to be the main explanation for differences in vaccination rates, access factors may play some role.

Vaccine resistance and hesitancy have been identified as the primary contributors to lower rural vaccination rates.[16] The KFF's vaccine monitor shows that 21% of rural adults reported that they would definitely not get vaccinated compared to 14% of suburban and 12% of urban residents.[6] Vaccine resistance and hesitancy are complex and driven by multiple factors. Lower levels of educational attainment[17] and more conservative political ideologies in rural areas may play important roles. Those with a college degree have a higher self-reported vaccination rate than those without, and Democrats have a higher self-reported rate than Republicans.[6] Rural counties had much higher vote shares for Trump in the 2020 Presidential election, and county Trump vote share is associated with lower vaccination rates.[18] Differences in perceptions of risk and virus severity and differences in attitudes about personal choice versus collective responsibility may also be related. Consistent with this explanation, rural residents have been less likely to adopt COVID-19 prevention behaviors, such as physical distancing, avoiding dining out, and wearing face masks.[19–21] Smaller shares of rural residents report being worried about getting sick, and larger shares say that the severity is exaggerated, getting vaccinated is a personal choice, and believe in at least one myth about the vaccine.[16]

However, rural areas are not homogenous. Just as COVID-19 mortality rates and health behaviors and outcomes in general vary across different types of rural communities,[1,2,22,23] vaccination rates are likely to vary within rural America. Accordingly, the factors described above may also contribute to within-rural differences in vaccination rates. In addition, labor markets may play an important role. Rural counties vary drastically in their labor market contexts. Rural counties dominated by mining and farming have historically been more politically and religiously conservative,[24–26] potentially driving lower vaccination rates in these types of communities. Conversely, residents of recreation-dependent rural counties tend to be more politically liberal,[24] due in large part to recent "creative class" urban migration to these areas.[27] Recreation counties also attract older and wealthier retirees,[24] which may portend higher vaccination rates in these counties. Although these potential explanations are not exhaustive, they are a starting point for thinking about why vaccination rates may vary across different types of rural areas.

METHODS

We retrieved county-level COVID-19 vaccination rates as of August 11, 2021, for adults ages 18+ from the CDC.[5] Although vaccines are now approved for ages 12+, approval occurred only recently. Vaccination rates were available for 2,869 counties. Rates were unavailable for 86 metro and 187 nonmetro counties, including all counties in Texas and Hawaii, 8 counties in California, and 6 in Virginia. Texas currently has an adult vaccination rate of 55.9%,[4] which is lower than the national rate. Given that 67% of Texas's 254 counties are rural (N = 170), the actual average rural vaccination rate may be lower than what is reported in this study.

Vaccination rates were normally distributed, so we used ordinary least squares (OLS) regression. Our first model compares vaccination rates by USDA Economic Research Service (ERS) rural-urban continuum code (RUCC) for the United States overall. The RUCC is a 9-category classification scheme that distinguishes 3 categories of metropolitan counties by the population size of their metro area and 6 categories of nonmetropolitan counties by degree of urbanization and adjacency to metro areas.[28] The second model includes several county-level factors that may explain rural-urban variation in vaccination rates: sociodemographic composition (percent age 65+, percent non-Hispanic [NH] Black, percent Hispanic, percent age 25+ with a bachelor's degree or more, median household income, and percentage without health insurance) from the 2015–2019 American Community Survey,[29] health care resources (health professional shortage area and physicians per capita) from the Area Health Resources Files,[30] and the 2020 Trump vote share from Dave Leip's Atlas of US Elections to account for political ideology and partisanship.[31] Percent NH Black, percent Hispanic, and physicians per capita are not normally distributed; we recoded them to quartiles for regression. We z-score standardized all continuous variables so that model coefficients represent the change in the vaccination rate for a 1-standard-deviation change in the predictor variable. Online Appendix Table A1 shows mean values for all predictors for the United States overall and by RUCC. There were no concerns with multicollinearity.

We then subset our analysis to rural counties (N = 1,789) to examine within-rural variation in vaccination rates. In addition to the predictors above, we added the USDA ERS economic dependence typology to examine differences across different types of rural labor markets: farming, mining, manufacturing, government, recreation, and nonspecialized (reference group).[32] The first set of regression results show coefficients for each predictor unadjusted for the other predictors. We then present fully adjusted models predicting vaccination rates within rural counties. All models control for state fixed effects to account for the clustering of counties within states and unobserved state-level

TABLE 1 OLS regression models predicting COVID-19 vaccination rates for US counties

	Model 1			Model 2		
Variables	β	SE	P	β	SE	P
RUCC (Ref: 1)						
2	−2.10**	0.77	.007	1.22	0.69	.077
3	−5.18***	0.79	<.001	−0.13	0.73	.858
4	−5.51***	0.91	<.001	0.26	0.85	.757
5	−4.62***	1.27	<.001	0.46	1.14	.684
6	−7.96***	0.71	<.001	0.18	0.72	.805
7	−8.13***	0.79	<.001	0.17	0.81	.835
8	−8.37***	0.93	<.001	1.05	0.93	.259
9	−9.94***	0.82	<.001	0.68	0.88	.442
% Non-Hispanic Black (ref: Q1)						
Q2				−0.40	0.50	.425
Q3				−0.50	0.58	.395
Q4				−4.18***	0.81	<.001
% Hispanic (ref: Q1)						
Q2				0.05	0.50	.927
Q3				0.59	0.55	.276
Q4				1.96**	0.64	.002
% residents age 65+				1.36***	0.22	<.001
% residents age 25+ with bachelor's degree+				0.13	0.35	.713
Median household income				2.78***	0.34	<.001
% No health insurance				−0.22	0.25	.391
Health professional shortage area (ref: no)				0.71	0.58	.219
Physicians per 100,000 population (ref: Q1)						
Q2				2.53***	0.48	<.001
Q3				3.47***	0.51	<.001
Q4				4.87***	0.58	<.001
% Trump vote, 2020				−6.25***	0.29	<.001
Constant	42.67***	1.36	<.001	38.89***	1.50	<.001
Adjusted R^2	0.564			0.690		

Notes: N = 2,869 counties. Q, quartile. Vaccination rates are current as of August 11, 2021. Both models control for state fixed effects.
***$P < .001$,
**$P < .01$.

variation in policies and other characteristics that may influence vaccine uptake.

RESULTS

As of August 11, 2021, 45.8% of adults in rural counties had been fully vaccinated compared to 59.8% in urban counties. Figure 1 shows the percentage of adults vaccinated within each RUCC category (Panel A) and average county-level vaccination rates by RUCC (Panel B). Vaccination rates are highest (62.3%) among large urban counties (RUCC 1) and lowest in metro-adjacent medium and small rural counties (RUCCs 6 and 8) at 43.1% and 40.5%, respectively. A map with county-level vaccination rates is presented in online Appendix Figure A1.

Results from Model 1 (Table 1), which controls only for state fixed effects, show a nearly monotonic relationship between RUCC and vaccination rates. Collectively, state fixed effects and RUCC explain 56% of the county-level variation in vaccination rates (Adj $R^2 = 0.56$). All the rural-urban continuum variation is explained by the predictors added to Model 2. Stepwise models (shown in online Appendix Table A2) demonstrate that lower rural vaccination rates are explained by a combination of lower educational attainment and higher Trump vote share in rural counties. Trump vote share is the largest contributor to county-level variation in vaccination rates. Net of all other factors, a 1-standard-deviation (16 points) increase in Trump vote share is associated with a 6.25 point reduction in the vaccination rate ($P < .001$). Rates are also significantly lower in counties in the highest quartile of

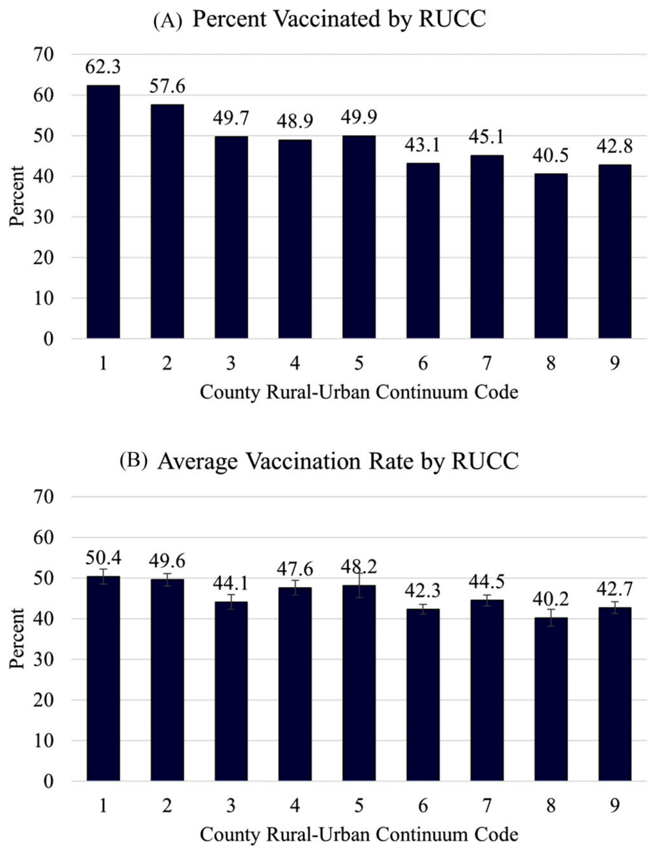

FIGURE 1 COVID-19 vaccination rates by rural-urban continuum code (RUCC) (Panel A) and average county-level vaccination rates by RUCC (Panel B) for adults ages 18+
Note: N=2,869 US counties. Rates are unadjusted. Vaccination rates are current as of August 11, 2021. Panel A represents the percentage of adults ages 18+ who are vaccinated within that RUCC category. Panel B represents the mean vaccination rate for each RUCC category. Error bars represent 95% confidence intervals. RUCCs: (1) *large urban*: counties in metro areas of 1 million population or more; (2) *medium urban*: counties in metro areas of 250,000-1 million population; (3) *small urban*: counties in metro areas of fewer than 250,000 population; (4) *large rural adjacent to metro*: nonmetro county with an urban population of 20,000 or more, adjacent to a metro area; (5) *large rural remote*: nonmetro county with an urban population of 20,000 or more, not adjacent to a metro area; (6) *medium rural adjacent to metro*: nonmetro county with an urban population of 2,500-19,999, adjacent to a metro area; (7) *medium rural remote*: nonmetro county with an urban population of 2,500-19,999, not adjacent to a metro area; (8) *small rural adjacent to metro*: nonmetro county with an urban population of less than 2,500, adjacent to a metro area; and (9) *small rural remote*: nonmetro county with an urban population of less than 2,500, not adjacent to a metro area

percent Black ($\beta = -4.18$, $P < .001$) and significantly higher in counties with higher median household income and more physicians per capita. Collectively, the variables in the full model explain 69% of the variation in vaccination rates across US counties.

Vaccination rates also vary across different types of rural counties. Vaccination rates by economic dependence are shown in online Appendix Figure A2. Unadjusted regression coefficients for each predictor are presented in the first column of Table 2. Net of state fixed effects, farming and mining counties have significantly lower average vaccination rates than nonspecialized counties (farming $\beta = -2.48$, $P < .001$; mining $\beta = -1.87$, $P < .10$), while recreation counties have a significantly higher average rate ($\beta = 4.90$, $P < .001$). Rates are also significantly higher in counties with larger shares of Hispanics, residents with a bachelor's degree or more, and more physicians per capita. Rates are significantly lower in rural counties that are health professional shortage areas and counties with larger Trump vote shares. In the model that includes all covariates, rural vaccination rates are significantly lower in counties in the top quartile of percent Black and in counties with larger Trump vote shares. A 1-standard-deviation increase in Trump vote share is associated with a 7.2 point decline in the vaccination rate. Rates are significantly higher in rural counties with larger shares of Hispanics, residents age 65+, higher median household income, and more physicians per capita.

Stepwise models (shown in online Appendix Table A3) illustrate that lower vaccination rates in farming- and mining-dependent counties observed in the unadjusted model are explained by a combination of lower educational attainment, fewer physicians per capita, and higher Trump vote share in these counties. Higher vaccination rates in recreation counties are driven by higher educational attainment and lower Trump vote share. Two-thirds of the variation in vaccination rates in rural counties is accounted for by the variables in the full model ($R^2 = 0.665$), with Trump vote share contributing the most after state fixed effects.

DISCUSSION

Using county-level data from the CDC, we found that COVID-19 vaccination rates are significantly lower in rural than in urban counties as of August 11, 2021. These findings conform with those based on self-reported survey data.[6] However, we expand on the existing evidence base by comparing rates along the 9-category rural-urban continuum and across different types of rural counties. We found that vaccination rates decline monotonically with rurality. The largest contributors to lower rural vaccination rates are lower educational attainment and higher Trump vote share in the 2020 Presidential election. Within rural counties, average vaccination rates are highest in recreation-dependent counties and lowest in mining- and farming-dependent counties. These differences were also explained by differences in educational attainment and Trump vote share, along with differences in physicians per capita.

Higher vaccination rates in recreation-dependent rural counties should reduce surges from new variants and facilitate business reopening and economic recovery. Low vaccination rates in rural mining and farming counties are concerning, given underlying health vulnerabilities. Mining and farming involve essential work that cannot be done remotely. New COVID-19 variants could lead to surges in workplaces with large shares of unvaccinated workers like in the early days of COVID-19 spread in the United States.[33]

TABLE 2 OLS regression models predicting COVID-19 vaccination rates among rural counties

	Unadjusted models				Fully adjusted model		
Variables	Coefficient	SE	*P* value	R^2	Coefficient	SE	*P* value
Economic dependence (ref: nonspecialized)				0.548			
Farming	−2.48**	0.76	<.001		0.67	0.69	.331
Mining	−1.87	1.02	.066		0.24	0.89	.790
Manufacturing	0.57	0.70	.411		0.86	0.61	.158
Government	1.25	0.81	.123		0.09	0.71	.900
Recreation	4.90***	0.86	<.001		0.46	0.82	.576
Adjacent to metro (ref: not adjacent to metro)	1.25*	0.52	.016	0.533	0.05	0.45	.916
% Non-Hispanic Black (ref: Q1)				0.533			
Q2	0.48	0.64	.451		−0.74	0.55	.182
Q3	1.26	0.76	.095		−0.65	0.67	.337
Q4	1.40	0.06	.227		−5.35***	1.08	<.001
% Hispanic (ref: Q1)				0.536			
Q2	1.36*	0.65	.038		0.28	0.56	.613
Q3	2.22**	0.73	.002		1.29*	0.64	.045
Q4	3.44***	0.85	<.001		2.70**	0.78	.001
% residents age 65+	−0.19	0.26	.465	0.532	1.26***	0.28	<.001
% residents age 25+ with bachelor's degree+	4.90***	0.36	<.001	0.576	0.66	0.46	.152
Median household income	2.14***	0.43	<.001	0.538	2.23***	0.48	<.001
% No health insurance	−0.07	0.29	.805	0.532	0.01	0.27	.983
Health professional shortage area (ref: no)	−2.42**	0.88	.006	0.534	−0.05	0.76	.951
Physicians per 100,000 population (ref: Q1)				0.560			
Q2	2.77***	0.61	<.001		1.69**	0.54	.002
Q3	4.31***	0.64	<.001		2.31***	0.58	<.001
Q4	7.29***	0.71	<.001		3.89***	0.68	<.001
% Trump vote, 2020	−6.73***	0.29	<.001	0.640	−7.22***	0.35	<.001
Constant					40.15***	1.93	<.001
Adjusted R^2					0.665		

Notes: N = 1,789 nonmetro counties. Q, quartile. Vaccination rates are current as of August 11, 2021.
All models control for state fixed effects.
***$P < .001$,
**$P < .01$,
*$P < .05$.

Several interventions are needed to increase vaccine uptake in lagging communities. Large employers in rural communities (farms, plants, and prisons) should hold on-site vaccination clinics for employees and family members and provide employees with paid time off to obtain the vaccine and recover from any side effects. In rural communities where there is already widespread availability and access, community leaders will need to employ strategies to combat misinformation and reduce vaccine resistance, which appears to be most robust in counties with less-educated populations and those with larger Trump vote shares. The National Rural Health Association has provided several tools for rural community, health care, agricultural, and faith leaders, including talking points, op-ed templates, and public service announcements.[34] Rural residents are more likely to trust their primary care physicians (PCPs) to provide reliable information about the vaccine than they are to trust the FDA, CDC, or local public health departments.[16] This makes PCPs key messengers for educating residents about and promoting vaccination in rural communities. However, given that only 10% of a recent KFF sample indicated that their current vaccination intention is "wait and see," combatting misinformation will not be enough.[6] Vaccine mandates will likely be the most effective strategy for increasing coverage rates to a sufficient level to reduce coronavirus spread.

Findings should be considered in light of some limitations. Analyses are ecological, and findings cannot be applied at the individual level. We were unable to examine geographic variation in race-specific vaccination rates given that data are not available at the county level. Rural vaccination rates may be lower among racial/ethnic minorities than among Whites, although some American Indian communities have achieved high vaccination rates,[35] and we show higher vaccination rates in counties with the largest shares of Hispanics.

COVID-19 will have profound long-term implications for US population health. Higher rural COVID-19 mortality rates[1] threaten to exacerbate the already large and growing rural mortality penalty.[2,3] Widespread vaccination has the potential to reduce vulnerability to variants that could lead to new surges and a new wave of COVID-19 deaths. Federal, state, and local governments must reduce misinformation and resistance across the U.S. In rural areas, working more closely with PCPs and faith leaders, who enjoy high levels of trust with rural residents, may be an especially promising strategy, but we may be at the point where vaccine mandates will be the most effective strategy for increasing rates enough to meaningfully reduce spread and save lives.

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