Rural-Urban Differences in the Associations Between Aging and Disability Services and COVID-19 Vaccination Rates Among Older Adults

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Abstract
Aging services were poised to play an important role in supporting the COVID-19 vaccination rollout for older adults. In this study, we use ordinary least squares regression models of county-level data (N = 3086) to examine if density of aging and disability services is associated with COVID-19 vaccination rates for older adults in rural and urban areas of the United States. We find that net of compositional characteristics, county-level density of aging and disability services is associated with higher older adult vaccination rates. However, in the rural-urban stratified models, this only remained consistently true for rural counties. Given higher risk of COVID-19 mortality for older adults and larger relative shares of older adults in rural areas, rural counties with low vaccination rates should invest in supporting and/or expanding older adult services to facilitate vaccination.

Keywords
COVID-19, health behaviors, rural, aging services

What this paper adds
- County-level aging and disability services are associated with higher older adult vaccination rates.
- The county-level relationship between aging and disability services and vaccination rates is more consistent in rural counties.

Applications of study findings
- In rural counties, investing in aging and disability services may help increase older adult vaccination rates.

Older adults (age 65+) are at higher risk of hospitalization and death from COVID-19 than any other age group (CDC, 2021; Sharma, 2021). Vaccination is a proven method of decreasing morbidity and mortality from COVID-19 for older adults (CDC, 2021b). While the overall older adult vaccination rate is 88.8% in the United States, county-level rates vary substantially across the United States, ranging from 24.2% to 95.0% as of March 1, 2022 (CDC, 2021a). Substantial research shows that lower county-level vaccination rates are associated with larger relative shares of Black residents, smaller shares of Hispanic residents, lower socioeconomic status, fewer physicians, and larger shares of Trump voters (Agarwal et al., 2021; Brown et al., 2021; Callow & Callow, 2021; Sun & Monnat, 2021; Tolbert et al., 2021). However, less attention has been given to if and how the built environment has helped shape disparities in vaccination rates.

Local organizations that serve older adult populations (e.g., Area Agencies on Aging) were poised to play a critical role in promoting and improving access to the COVID-19 vaccine (CDC, 2021d). These local organizations could distribute information, provide transportation, and in some cases act as vaccination sites or operate mobile vaccination sites (CORE, 2021). However, it is not clear if the availability of older adult services in a county is associated with higher vaccination rates among older adults.

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In addition, COVID-19 vaccination rates are lagging in rural America (Sun & Monnat, 2021; Tolbert et al., 2021). This is concerning because rural areas have larger relative shares of older adults, lower access to health care infrastructure, and higher COVID-19 mortality (Putzer et al., 2012; Rogan & Lewis, 2020; Sun et al., 2022). Therefore, understanding if an association between older adult service density and older adult vaccination rates exists across rural and urban contexts has potentially useful policy implications for boosting older adult vaccination rates. Our objectives are to determine if density of older adult services is associated with county-level COVID-19 vaccination rates among older adults and if this association varies by rural-urban status.

Methods

We use a cross-sectional design with county-level publicly available data from the United States to address our research objectives. Specifically, we used older adult (age 65+) vaccination rates from the CDC as of March 1, 2022 (CDC, 2021c) and aging and disability services (ADS) data from the National Neighborhood Data Archive (NaNDA) Social Services and Health Care Services databases (Finlay et al., 2020; Khan et al., 2020). The ADS data include senior centers, adult day care centers, disability support groups, non-medical home care and homemaker services, nursing care, continuing care, and assisted living facilities. NaNDA does not disaggregate aging services from disability services. While aging services specifically target older adults, disability services are typically available to a wider age range, including older adults. We aggregated NaNDA tract-level data to create county-level counts and then calculated an ADS density variable (i.e., per 1000 population).

We used the USDA Economic Research Service Rural-Urban Continuum Codes (RUCC) to classify counties as urban (RUCCs 1–3) and rural (RUCCs 4–9) (USDA ERS, 2020). County-level sociodemographic data are from the 2015–2019 American Community Survey (US Census Bureau, 2021), including older adult population size, percent non-Hispanic [NH] Black, percent Hispanic, percent of residents age 25+ with a bachelor degree or more, median household income, and percent without health insurance. Physician rates (per 100,000 residents) as of 2018 are from the Area Health Resources Files (HRSA, 2020). The county-level share of voters who voted for Donald Trump in the 2020 General Election are from Tony McGovern’s GitHub repository (McGovern, 2021).

The final sample included 3086 U.S. counties (1929 rural; 1157 urban). We dropped 56 counties because of missing data in vacation rates and percent of voters who voted for Trump, including all Alaska and Hawaii counties, 8 California counties, 2 Texas counties, 3 Massachusetts counties, and 9 Virginia counties. Of the dropped counties, 9 are urban counties and 47 are rural.

ADS density, percent of residents age 25+ with a bachelor degree or more, median household income, percent without health insurance, physician rates, and percent Trump vote were recoded as quartiles because of the significant associations between the quadratic terms of these variables and vaccination rates. Quartile breaks were kept consistent across all analyses to allow for comparability. Racial-ethnic composition was modeled as continuous variables (percent NH Black and percent Hispanic). Supplementary Appendix Table 1 presents the numbers of rural and urban counties in each quartile of ADS density. Supplementary Appendix Table 2 provides medians and interquartile ranges for all covariates across quartiles of ADS density.

Because older adult vaccination rates are normally distributed (mean = 78.1; median = 79.7; standard deviation = 11.6), we used ordinary least squares (OLS) regressions to examine the association between older adult vaccination rates and ADS density for all counties. To determine if the relationship varies across rural and urban counties, rural-urban stratified models are also used. We weighted all models by county-level older adult population size and controlled for state fixed effects to account for unobserved state-level variations such as vaccine-related policies. Two sets of sensitivity analyses were conducted: (1) replacing ADS density quartiles with deciles and (2) dropping all counties with vaccination rates more than 3 standard deviations from the mean. Supplementary Appendix Tables 3–6 present the two series of sensitivity analyses. All analyses were performed in Stata 17.0. This manuscript follows STROBE guidelines (Elm et al., 2008). Because data are publicly available and aggregated to the county-level, IRB approval was not required.

Results

Figure 1 presents older adult vaccination rates by ADS density quartiles. Counties with the third quartile of ADS density have the highest vaccination rates, followed by the second and fourth quartiles, while the first quartile is associated with the lowest vaccination rates. This pattern is consistent among rural and urban counties.

Table 1 presents the results of OLS regression models predicting older adult vaccination rates for all counties. The unadjusted model only controls for state fixed effects. Compared to the lowest quartile of ADS density, all other quartiles of ADS density have significantly higher vaccination rates (Q2 $\beta = 2.86, p < 0.001$; Q3 $\beta = 3.93, p < 0.001$; Q4 $\beta = 1.18, p = 0.042$). In the fully adjusted model, only the fourth quartile of ADS density is associated with higher vaccination rates (Q4 $\beta = 1.03, p = 0.026$).

Table 2 presents the results of rural-urban stratified OLS regression models predicting older adult vaccination rates. In the rural models, compared to the lowest quartile of ADS density, rural counties with higher ADS densities have significantly higher older adult vaccination rates. The
Figure 1. Average COVID-19 vaccination rates for older adults by quartiles of ADS density. Note. Rates are unadjusted. Vaccination rates are current as of March 1, 2022. ADS density ranges of four quartiles: 0–1.13, 1.13–1.64, 1.64–2.30, and 2.30–12.99. N = 3086 U.S. counties. Q = quartile.

Table 1. Results from OLS Regression Models Predicting Older Adults’ COVID-19 Vaccination Rates for All Counties.

|                                | Unadjusted Model | Full Model |
|--------------------------------|------------------|------------|
|                                | β    | SE  | p     | β    | SE  | p     |
| Aging and disability services per 1000 population (Ref: Q1) |       |     |       |       |     |       |
| Q2                             | 2.86 | 0.36| <0.001| 0.39 | 0.29| 0.178 |
| Q3                             | 3.93 | 0.38| <0.001| 0.61 | 0.32| 0.058 |
| Q4                             | 1.18 | 0.58| 0.042 | 1.03 | 0.47| 0.026 |
| Rural (Ref: urban)             |      |     |       | -0.26| 0.34| 0.456 |
| % Non-Hispanic Black           |      |     |       | -0.10| 0.01| <0.001|
| % Hispanic                     |      |     |       | 0.08 | 0.01| <0.001|
| % Residents age 25+ with bachelor degree+ (Ref: Q1) |       |     |       |       |     |       |
| Q2                             | 0.87 | 0.51| 0.086 | 0.39 | 0.29| 0.178 |
| Q3                             | 1.65 | 0.55| 0.003 | 1.03 | 0.47| 0.026 |
| Q4                             | 3.45 | 0.62| <0.001| 1.03 | 0.47| 0.026 |
| Median household income (Ref: Q1) |       |     |       |       |     |       |
| Q2                             | 1.04 | 0.47| 0.026 | 1.04 | 0.47| 0.026 |
| Q3                             | 1.55 | 0.50| 0.002 | 1.55 | 0.50| 0.002 |
| Q4                             | 2.42 | 0.54| <0.001| 2.42 | 0.54| <0.001|
| % No health insurance (Ref: Q1) |       |     |       |       |     |       |
| Q2                             | -2.55| 0.30| <0.001| -2.55| 0.30| <0.001|
| Q3                             | -4.57| 0.37| <0.001| -4.57| 0.37| <0.001|
| Q4                             | -5.70| 0.54| <0.001| -5.70| 0.54| <0.001|
| Physicians per 100,000 population (Ref: Q1) |       |     |       |       |     |       |
| Q2                             | 2.41 | 0.50| <0.001| 2.41 | 0.50| <0.001|
| Q3                             | 3.06 | 0.50| <0.001| 3.06 | 0.50| <0.001|
| Q4                             | 4.28 | 0.53| <0.001| 4.28 | 0.53| <0.001|
| % Trump vote, 2020 (Ref: Q1)   |       |     |       |       |     |       |
| Q2                             | -3.12| 0.33| <0.001| -3.12| 0.33| <0.001|
| Q3                             | -6.64| 0.47| <0.001| -6.64| 0.47| <0.001|
| Q4                             | -10.56| 0.64| <0.001| -10.56| 0.64| <0.001|
| Constant                       | 74.28| 0.98| <0.001| 80.82| 1.11| <0.001|
| Adjusted R²                    | 0.285|     |       | 0.590|     |       |

Note. N = 3086; Q = quartile; SE = standard error.
Discussion

We used a cross-sectional study design with publicly available county-level data to determine if ADS is associated with higher vaccination rates among older adults and if such a relationship varies across rural and urban counties. We presented unadjusted and fully adjusted models that control for important covariates in order to ensure that a relationship between ADS density and vaccination rates cannot be explained by other factors. Findings show that ADS density is only consistently associated with higher older adult vaccination rates in rural counties, though decile models reveal threshold effects in these associations. In urban counties, ADS density is not significant, net of controls.

These results suggest that higher densities of ADS—which is more common in rural counties (Supplementary Appendix Table 1)—may be playing an important role in

| Table 2. Results from OLS Regression Models Predicting Older Adults’ COVID-19 Vaccination Rates for Rural and Urban Counties. |
|-------------------------------------------------|
| **Rural Models (N = 1929)**                      |
| **Unadjusted Model**                             |
| **β**   | **SE** | **p**  | **β**   | **SE** | **p**  |
| Aging and disability services per 1000 population (Ref: Q1) |
| Q2     | 2.27   | 0.54  | <0.001 | 1.25   | 0.47  | 0.008 |
| Q3     | 2.91   | 0.54  | <0.001 | 1.72   | 0.48  | <0.001 |
| Q4     | 4.37   | 0.65  | <0.001 | 3.85   | 0.57  | <0.001 |
| % Non-Hispanic Black                             |
| Q2     | 0.09   | 0.02  | <0.001 | 0.09   | 0.02  | <0.001 |
| % Residents age 25+ with bachelor degree+ (Ref: Q1) |
| Q2     | 0.09   | 0.02  | <0.001 | 0.09   | 0.02  | <0.001 |
| % Hispanic                                      |
| Q2     | 1.30   | 0.48  | 0.007  | 0.92   | 1.14  | 0.417 |
| Median household income (Ref: Q1)                |
| Q2     | 2.16   | 0.50  | <0.001 | 0.64   | 0.95  | 0.500 |
| Q3     | 3.27   | 0.59  | <0.001 | 0.96   | 0.99  | 0.334 |
| Q4     | 4.39   | 0.75  | <0.001 | 1.65   | 1.01  | 0.103 |
| % No health insurance (Ref: Q1)                  |
| Q2     | −1.24  | 0.52  | 0.018  | −3.01  | 0.46  | <0.001 |
| Q3     | −2.75  | 0.66  | <0.001 | −5.12  | 0.56  | <0.001 |
| Q4     | −2.73  | 0.78  | 0.001  | −6.75  | 0.87  | <0.001 |
| Physicians per 100,000 population (Ref: Q1)      |
| Q2     | 1.99   | 0.50  | <0.001 | 2.94   | 0.96  | 0.002 |
| Q3     | 3.60   | 0.53  | <0.001 | 3.28   | 0.95  | 0.001 |
| Q4     | 3.94   | 0.61  | <0.001 | 4.75   | 0.99  | <0.001 |
| % Trump vote, 2020 (Ref: Q1)                     |
| Q2     | −6.16  | 0.57  | <0.001 | −2.41  | 0.49  | <0.001 |
| Q3     | −8.52  | 0.71  | <0.001 | −5.99  | 0.76  | <0.001 |
| Q4     | −12.45 | 0.86  | <0.001 | −7.91  | 1.41  | <0.001 |
| Constant | 68.43 | 1.20  | <0.001 | 78.13  | 1.67  | <0.001 |
| Adjusted R² | 0.364 | 0.533 | 0.264 | 0.535 |

Note. Q = quartile; SE = standard error.

reduced effect sizes in the full model indicate that the associations are partially explained by covariates. In the urban models, the second and third quartiles of ADS densities are associated with higher vaccination rates among older adults (Q2 β = 2.03, p < 0.001; Q3 β = 3.19, p < 0.001) (unadjusted model). In full urban model, ADS densities are no longer significant, which means the associations between ADS density and vaccination rates are fully explained by covariates.

Supplementary Appendix Tables 3–6 present the results of sensitivity analyses. After changing the breaks for ADS densities or dropping counties with vaccination rates more than 3 standard deviations from the mean, the results were robust in both sensitivity analyses. However, ADS density deciles are not consistently associated with higher vaccination rates in models for all and for rural counties, which indicates non-linear relationships.
boosting vaccination rates in rural America. These findings affirm ADSs can play an important role in the resilience of rural counties (Peters, 2020), especially for supporting older adult around COVID-19. Rural counties with low vaccination rates and/or sparse aging services should invest in supporting and/or expanding ADSs to facilitate vaccination. This could take many different forms including sharing information on the vaccine, providing transportation to a vaccination location, or through hosting vaccination clinics or providing mobile clinics (Bergal, 2021).

Older adult vaccination rates were not consistently higher in urban counties with higher densities of ADS. Moreover, the effects of ADS density were fully explained by sociodemographic, health care, and political ideology differences. This suggests that in urban counties, other compositional and contextual factors are driving vaccination rates and that policy efforts should be focused on those (e.g., expanding health care resources, working with marginalized communities, and spreading accurate information). This finding may reflect that counties are too large for assessing service seeking in urban contexts.

This study has three important limitations. First, it is ecological. We cannot make conclusions about individual level utilization of ADSs and vaccine uptake. Moreover, counties may not be an appropriate level of analysis for capturing service utilization in urban areas. Second, the variable capacity of ADS is unknown. Understaffing and other challenges facing local residents (e.g., food insecurity and being homebound) may result in vaccination efforts being deprioritized. Third, while previous literature was used to inform the choice of model covariates, other unmeasured factors may be at play. For example, counties with more services may also have more robust public health infrastructure.

COVID-19 is associated with over 557,000 deaths of older adults (NCHS, 2021) and enormous well-being lost. Vaccination is a proven method of decreasing morbidity and mortality from COVID-19 for older adults (CDC, 2021b). The role of ADSs in the vaccination of rural older adults should not be neglected. Federal, state, and local governments with oversight of rural communities should further invest and facilitate in ADS for promoting COVID-19 vaccination.

Declaration of Conflicting Interests
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Supplemental Material
Supplemental material for this article is available online.

Note
1. Since 12/9/2021, CDC has capped vaccination rates at 95% to adjust for overestimates resulting from mismatched records and reporting errors.

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