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Rural Policy Brief

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Spatial Clustering of COVID-19 Mortality Rates across Counties and by Noncore, Micropolitan, and Metropolitan County Characteristics, December 2020–January 2021

Whitney E. Zahnd, PhD; Khyathi Gadag, MHA; Fred Ullrich, BA; Keith J. Mueller, PhD

Purpose

This policy brief examines spatial clusters in county-level COVID-19 mortality rates across rural-urban designations and sociodemographic, health care, and chronic disease prevalence factors. Between December 2020 and January 2021, COVID-19 deaths were at their peak, hospital capacity was stretched, and COVID-19 vaccines were not widely available, making this a critical period to examine. These findings complement those in a previous RUPRI Center brief looking at broader national disparities in deaths and may provide insights to ensure that the health care and social support system can manage the ongoing COVID-19 pandemic and prepare for future health emergencies.

Key Findings

- Spatial clusters of high COVID-19 mortality rates occurred in Iowa, South Dakota, Kansas, Pennsylvania, Texas, and Arizona.
- A higher percentage of clusters of high COVID-19 mortality rates were in noncore and micropolitan counties compared to metropolitan.
- High COVID-19 mortality cluster counties tended to have higher average percentages of Hispanic populations, particularly in micropolitan counties.
- Noncore counties that were high COVID-19 mortality clusters had the highest average nursing home bed density and the highest average proportion of Medicare beneficiaries with multiple chronic conditions.

Background

County-level disparities in COVID-19 outcomes in the U.S. are well documented and linked with demographic, social, and health factors. A recent socioecological study evaluating 481,238 COVID-19 deaths revealed large county-level differences with widespread geographic dispersion.[1] Wide variation between county-level demographics (such as age, insurance, housing, and population density) and pre-existing health conditions (such as chronic lung diseases and cardiovascular diseases) revealed significant differences in COVID-19 mortality rates.[2–4] Additionally, trajectories of COVID-19 mortality are diametrically opposite among poor and affluent counties, indicating progressively higher mortality rates among socioeconomically disadvantaged communities.[5]

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rupri RURAL POLICY RESEARCH INSTITUTE

RUPRI Center for Rural Health Policy Analysis,
University of Iowa College of Public Health,
Department of Health Management and Policy,
145 Riverside Dr., Iowa City, IA 52242-2007,
(319) 384-3830
http://www.public-health.uiowa.edu/rupri
E-mail: cph-rupri-inquiries@uiowa.edu

Disparities in COVID-19 mortality rates between counties have been attributed largely to racial and socioeconomic inequities.[6] Throughout most of the pandemic, counties with high proportions of Hispanic and Black populations had disproportionately high COVID-19 mortality rates. Counties with greater than 40 percent Blacks had six-fold higher death rates than counties with less than 2 percent Blacks.[7] However, other social determinants of health, such as income, seem to be playing a more prominent role than race and ethnicity in COVID-19 mortality rates.[7] Before August 2020, death rates differed little by insurance status, but since then, counties with greater than a 15 percent uninsurance rate had up to two-fold higher mortality rates than counties with less than a 5 percent uninsurance rate.[7] A study on county-level socioeconomic disparities showed that COVID-19 mortality rates were 2.58 times higher in the bottom quintile of counties (most socially disadvantaged) than in the top quintiles.[5] Social vulnerability problems, such as lower socioeconomic status, lack of housing and transportation, and unemployment, are associated with increased rates of COVID-19 mortality rates.[8] A study on county-level association of social vulnerability with COVID-19 deaths revealed a 1.73-fold greater risk of COVID-19 deaths in people from the most socially vulnerable counties compared with those in the least socially vulnerable counties.[8]

During the first year of the pandemic, limited access to testing, and high risk of severe disease among those living in institutional settings (e.g., nursing homes) contributed to rural disparities in COVID-19 outcomes. However, factors contributing to localized geographic differences in COVID-19 mortality rates during the period of peak cases and deaths may differ from factors earlier in the pandemic. Further, local racial/ethnic composition, exposure-related and treatment-related health care access characteristics, and chronic disease prevalence may have impacted COVID-19 mortality rates across counties. We anticipate that during the surge of cases in November through December 2020, this strain on healthcare resources may have subsequently further contributed adversely to mortality rates in December 2020 through January 2021, especially as this time pre-dates the widespread availability of vaccines. Many studies have examined county-level disparities in COVID-19 prior to the widespread availability of vaccines or over longer periods. However, as a complement to our national and state-based analysis in a previous brief, our objective in this study was to examine the county-level clusters of COVID-19 mortality during this period and how characteristics of counties with high and low mortality rates during the study period varied. [5,8]

Data and Methods

County-level COVID-19 mortality data were extracted from the Johns Hopkins COVID-19 Data Repository by county for December 1, 2020, through January 31, 2021.[9] Measures of racial/ethnic composition were derived from 2015-2019 American Community Survey (ACS) five-year estimates.[10] Data on county-level health care characteristics most relevant to COVID-19 mortality included ICU bed density (as a measure of capacity to care for hospitalized patients with severe complications due to COVID-19) and nursing home bed density (as a measure of high risk for exposure and concentration of high-risk populations). The number of ICU beds within each county was compiled from the 2019 American Hospital Association Survey, and nursing home bed counts were taken from 2020 CMS Nursing Home Compare Data.[11,12] Densities of both ICU beds and nursing home beds were calculated per 100,000 population within the county. Chronic disease prevalence rates were obtained from the Centers for Medicare & Medicaid Services and the Centers for Disease Control and Prevention. [13,14]

We examined county-level crude mortality rates per 100,000 population and performed empirical Bayes smoothing of rates for mapping purposes.[15] This method "borrows" from adjacent counties to help stabilize rates when counts are low, as is the case when examining a two-month time frame among many low-population counties. We also performed local indicators spatial autocorrelation analyses using GeoDa software to identify whether county-level crude mortality rates were clustered during this time and if so, where these clusters occurred.[16] Local spatial autocorrelation identified the following geographic patterns:

- nonsignificant, indicating rates that were neither higher or lower than expected;
- high-high clusters, indicating areas where rates were higher than expected;
- low-low clusters, indicating areas where rates were lower than expected;

- high-low outliers, indicating areas of rates higher than expected surrounded by areas of rates lower than expected; and
- low-high outliers, indicating areas of rates lower than expected surrounded by areas of rates higher than expected.

We focused on areas of high-high and low-low clusters, as these demonstrate areas of notable similarity. Finally, we compared characteristics of counties in high-high clusters across rurality with characteristics of counties in low-low clusters across rurality. Urban Influence Codes (UICs) were used to categorize counties as metropolitan, micropolitan, or noncore.[17]

Results/Findings

Figure 1 shows quartiles of empirical Bayes smoothed crude mortality rates across the contiguous 48 states. The highest rates were found in the Midwest and parts of the South. Figure 2 shows the spatial clustering of rates. Clusters of high rates occurred in Iowa, South Dakota, Kansas, Pennsylvania, Texas, and Arizona. Clusters of lower rates occurred in Maine, New Hampshire, Vermont, California, Washington, and Oregon. A higher proportion of noncore (13.2 percent) and micropolitan (9.1 percent) counties were high clusters, while notably more than one in five (22.8 percent) metropolitan counties were low clusters (Figure 3).

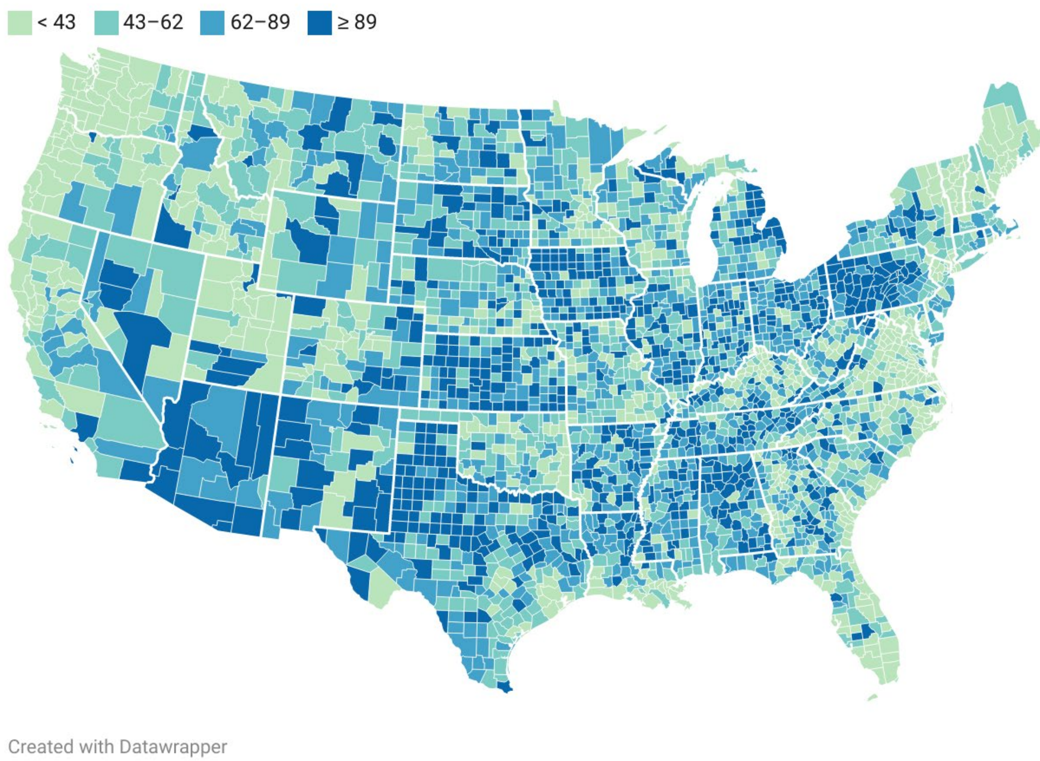

Figure 1: Empirical Bayes Crude Mortality Rates per 100,000, December 2020–January 2021 Quartiles

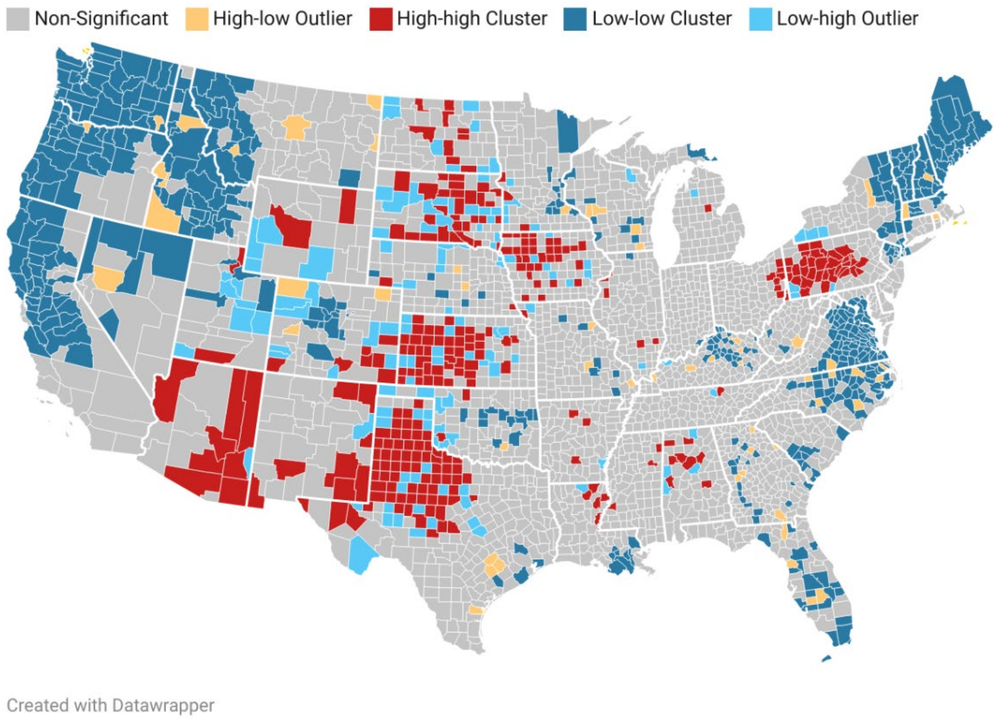

Figure 2: Spatial Clusters of Crude COVID-19 Mortality Rates per 100,000, December 2020–January 2021

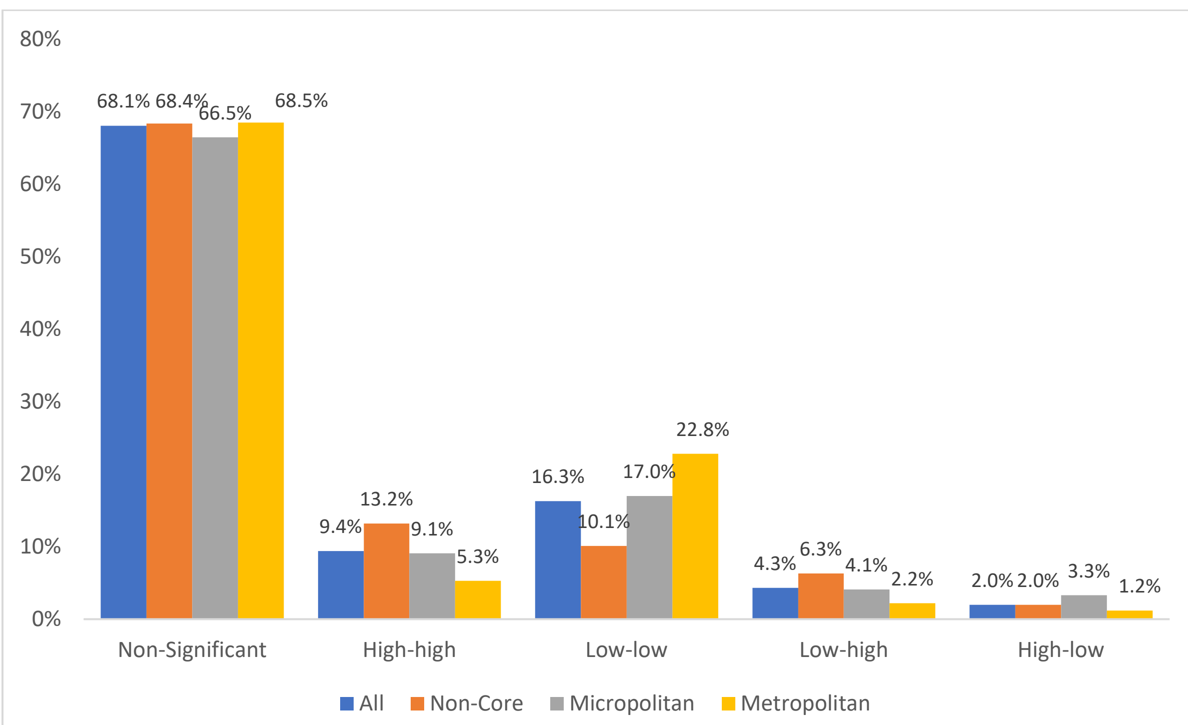

Figure 3: Cluster Status of Crude COVID-19 Mortality Rates across Metropolitan Designation

Among high cluster areas, we found the following (Table 1):

- High cluster counties had a higher average percentage of Hispanic population in nonmetropolitan counties, with 15.1 percent among noncore counties and 22.1 percent in micropolitan counties.
- Across metropolitan statuses, high-cluster counties had a higher average density of ICU beds and nursing home beds per population aged 65 and older, respectively.
- Metropolitan, high-cluster counties had the highest average ICU bed density, and noncore, high-cluster counties had the highest average nursing home bed density. Across metropolitan statuses, high-cluster counties tended to have a slightly higher average percent of Medicare beneficiaries with multiple chronic conditions, with micropolitan, high-cluster counties having the highest average (68.8 percent).
- Obesity and diabetes prevalence tended to be higher in high-cluster metropolitan and micropolitan counties compared to low-cluster counties, but the prevalence of both obesity and diabetes tended to be lower in noncore, high-cluster counties compared to low-cluster counties.

Among low clusters, we identified the following:

- Across metropolitan statuses, low clusters had a higher percentage of non-Hispanic Black population compared to high clusters

Regardless of high or low cluster status,we identified the following (Table 1):

- noncore counties had lower average median household income, and the highest percentage of the population over age 65 (≥21.7 percent, Table 1).
- Noncore counties in clusters of high rates had the highest average uninsured rate (15.2 percent vs. ≤14.1 percent for all other groups).

Table 1: Characteristics of Counties in High-High and Low-Low COVID-19 Mortality Clusters, December 2020–January 2021

	All		Noncore		Micropolitan		Metropolitan	
	HH (n=292) Mean	**LL (n=505) Mean**	**HH (n=173) Mean**	**LL (n=133) Mean**	**HH (n=58) Mean**	**LL (n=108) Mean**	**HH (n=61) Mean**	**LL (n=264) Mean**
Socioeconomic Characteristics								
Median Household Income	$54,158	$62,781	$50,563	$50,393	$54,719	$56,979	$58,024	$71,397
% in Poverty	14.4%	13.9%	14.4%	16.4%	15.3%	15.0%	13.6%	12.2%
% Uninsured	14.3%	12.0%	15.2%	13.7%	14.1%	12.7%	12.1%	10.9%
Demographic Characteristics								
% 65+ Years of Age	20.4%	19.6%	21.7%	23.3%	17.7%	19.6%	19.2%	17.7%
% Non-Hispanic Black	4.3%	11.2%	3.4%	11.6%	5.6%	7.0%	5.8%	12.8%
% Hispanic	16.0%	11.0%	15.1%	7.1%	22.1%	11.6%	12.5%	12.7%
Healthcare Characteristics								
ICU Bed Density per 100,000	74.6	72.9	46.3	33.9	123.1	76.0	108.9	91.3
Nursing Home Bed Density per	6,086	3,466	6,877	4,292	5,479	449.5	4,421	3,416

	All		Noncore		Micropolitan		Metropolitan	
	HH (n=292) Mean	**LL (n=505) Mean**	**HH (n=173) Mean**	**LL (n=133) Mean**	**HH (n=58) Mean**	**LL (n=108) Mean**	**HH (n=61) Mean**	**LL (n=264) Mean**
100,000 age 65+								
Chronic Disease Prevalence								
% of Medicare beneficiaries with MCC	67.3%	65.4%	65.7%	63.2%	68.8%	62.8%	65.8%	67.2%
Obesity Prevalence	32.9%	31.8%	32.6%	33.2%	33.3%	32.1%	33.5%	31.1%
Diabetes Prevalence	11.9%	11.6%	11.8%	13.3%	12.1%	11.3%	11.8%	10.9%
Abbreviations: HH = High-high clusters; LL = Low-low clusters; MCC = Multiple Chronic Conditions								

Discussion

Between December 2020 and January 2021, clusters of high COVID-19 crude mortality rates were in the Midwest and parts of the South. The greatest proportions of high mortality rate clusters were in noncore and micropolitan counties. High-cluster counties had higher average percentages of Hispanic populations, particularly in micropolitan counties, and higher nursing home bed densities, particularly in noncore counties. Regardless of metropolitan status, high-cluster counties had a higher percentage of Medicare beneficiaries with multiple chronic conditions, with the highest average percentage in micropolitan counties.

We found spatial clusters of high COVID-19 mortality rates in the Midwest, particularly in noncore and micropolitan counties. The proportion of Hispanic population was twice as high in high-cluster noncore and micropolitan counties as in low-cluster counties. As with our first brief outlining the higher rates of COVID-19 mortality rates, these findings provide more localized information about the impact of the pre-vaccine mortality surge that may inform preparedness efforts and resource allocation for future epidemics and pandemics. Similar analysis applied to surveillance data can help target financial resources and technical support to areas where risk may be highest. Health care systems, public health departments, and other partners should collaborate on preparedness, educational initiatives, and other activities to ensure that populations at greatest risk in their catchment areas receive the information and resources that are needed. Those initiatives and activities should be geared specifically to the populations of greatest need, meaning that educational materials must be in the preferred language, printed material should be easily understood, and activities should be sensitive to different cultures. Further, the social context of receiving information (from trusted sources) and acting on the information (roles of informal care givers and confidants) should be considered.

Of note, areas with clusters of high mortality had higher ICU bed density than areas with clusters of low mortality, regardless of metropolitan status. This finding complements the higher-level analysis of our previous brief, which did not identify a particular pattern at the intersection of rurality and ICU bed density. Our findings here suggest that surge capacity issues may have been of particular concern in areas of greatest access to intensive care services during the peak of deaths. These findings run counter to studies examining the early phase of the pandemic that found higher rates of deaths in areas with lower access to ICU beds. Our findings suggest that care patterns, such as transfer protocols and staffing challenges, may have evolved during the pandemic or during times of critical capacity constraints which have been associated with excess deaths in analyses of longer periods of the pandemic.[18,19] While high-rate COVID-19 mortality clusters in noncore and micropolitan counties had greater ICU bed density than low-rate clusters, they had lower ICU bed density than metropolitan counties regardless of cluster type. These mortality and access to critical care dynamics are an important area for continued assessment.

Regardless of rurality, clusters of high COVID-19 mortality rates had higher densities of nursing home beds than did clusters of low COVID-19 mortality rates. However, there was an increasing average density of nursing home beds with increasing rurality as noncore counties in clusters of high COVID-19 mortality had the highest density of nursing home beds. While our study examined population-level mortality rates, not nursing-home-specific rates, previous studies have shown that staffing shortages in rural nursing homes played a role in accelerated COVID-19 deaths.[20] Staffing shortages would be of particular concern in areas with high nursing home bed density.

Additionally, clusters of high COVID-19 mortality rates corresponded with high average percentages of Medicare beneficiaries with multiple chronic conditions, particularly in the most rural areas. Previous research had predicted that rural areas may be at heightened risk for poor COVID-19 outcomes and greater strain on the health care system due to greater chronic disease burden.[21] With the availability of the initial series of COVID-19 vaccinations and both monovalent and bivalent boosters, it is important to ensure that these populations—older adults with multiple chronic conditions—are targeted for vaccinations to reduce the risk of both poor outcomes to individuals and strain on the health care system. This targeting is particularly important in rural areas, where vaccination uptake has been consistently poorer. [21]

These findings should be interpreted carefully to avoid ecological fallacy—i.e., county-level findings should not be interpreted as applicable to individuals. Additionally, we used area-level data, not data reflective of COVID-19 deaths in hospital or nursing home settings that may more directly indicate the impact of those facilities. Additionally, this is a descriptive analysis, so causal relationships cannot be determined.

It is imperative that the rural health care infrastructure has sufficient resources and staffing to respond to surges in novel viruses and other health care emergencies, especially as these populations have greater risk for severe outcomes. Similarly, it is important to ensure nursing home settings have the resources to provide adequate infection monitoring, isolation procedures, and staffing policies to protect residents and staff. Future work should continue to monitor inequities in COVID-19 deaths in rural areas.

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