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Rural Areas Face Higher and Distinct Risks of Serious COVID-19 Outcomes than Urban Areas

The coronavirus disease 2019 (COVID-19) global pandemic in the United States has been confirmed in 524,514 cases resulting in 20,444 deaths at present, but has impacted certain states and subpopulations disproportionately.[1] States with large urban populations have experienced the most cases and deaths, especially New York and New Jersey, while many states in the interior have been minimally impacted thus far.[2] Serious complications from COVID-19 have fallen heavily on people 65 years of age and older, accounting for 50 percent of hospital and ICU admissions, and 80 percent of deaths.[3] Of those hospitalized with COVID-19, 75 percent have some underlying medical condition regardless of their age, typically diabetes, chronic lung, and cardiovascular diseases.[4]

However, current information provides an incomplete picture by relying on state-level aggregations and confirmed case counts. The former does not explore differences across rural and urban contexts at the county-level, as has been done with other public health issues like the opioid crisis.[5] The latter severely undercounts the true number of cases because of test unavailability, laboratory delays, and rules on who is tested.[6] Rural places may still be at risk for COVID-19 even in the absence of cases, as the pandemic may just be taking hold. This makes rural places statistically invisible, creating a false sense of rural immunity. Rural public health officials cannot wait months for official testing and counts to catch up. There is an immediate need to assess the risk of serious COVID-19 complications at the county-level before such cases become widespread. Knowing overall and specific types of COVID-19 risks ahead of time allows local and state health officials to plan and allocate resources accordingly.

To this end, a COVID-19 relative risk scale is created using 10 indicators linked to serious complications of the disease. Indicators are grouped into seven distinct components using factor analysis.[i] Factor one is *population density* per square mile measuring potential community spread. Factor two is *group quarters* as a percent of population measuring people living in institutional settings. Factor three is *seniors and elders* measured by

percent aged 65-84 and aged 85 years and older. Factor four is employment in *elderly care facilities* per 10,000 people. Factor five estimates the *immunocompromised* population using mortality rates per 100,000 from cancer, cardiovascular diseases, and chronic lower respiratory diseases. Factor six is the mortality rate from *diabetes*; and factor seven is the mortality rate from *influenza and pneumonia*. Data are from 2017 and collected for n=3,079 counties in the conterminous U.S., with modifications.[ii]

Several interesting patterns emerge from relative risk scores when disaggregated across modified Core-Based Statistical Areas, which are presented in figures 1 and 2. ***Non-metropolitan counties are more at risk for COVID-19 than metro ones.*** In figure 1 we see that risk of serious complications increases as one progresses from large metropolitan counties (with 1 million or more people) to more completely rural ones (no town over 2.5k). Risk scores are -1.0 standard deviation or more below the national average in large and mid-size metropolitans, while risk scores are about 0.5 standard deviation above the mean in rural and semi-rural places. A large share of non-metropolitan counties have above average or high (4th and 5th quintiles) risk for COVID-19 complications, as evidenced by figure 2. About 31 percent of rural counties fall into the high risk group, as do 27 percent of semi-rural and 21 percent of micropolitan places. Given their low overall relative risk, only 6.5 percent of the nation's largest metropolitan counties are at high risk. The spatial distribution of COVID-19 risk scores by county is presented in figure 3, where high risk communities are concentrated in the Great Plains, Midwest, some Great Lakes states, and in the lower Mississippi Delta.

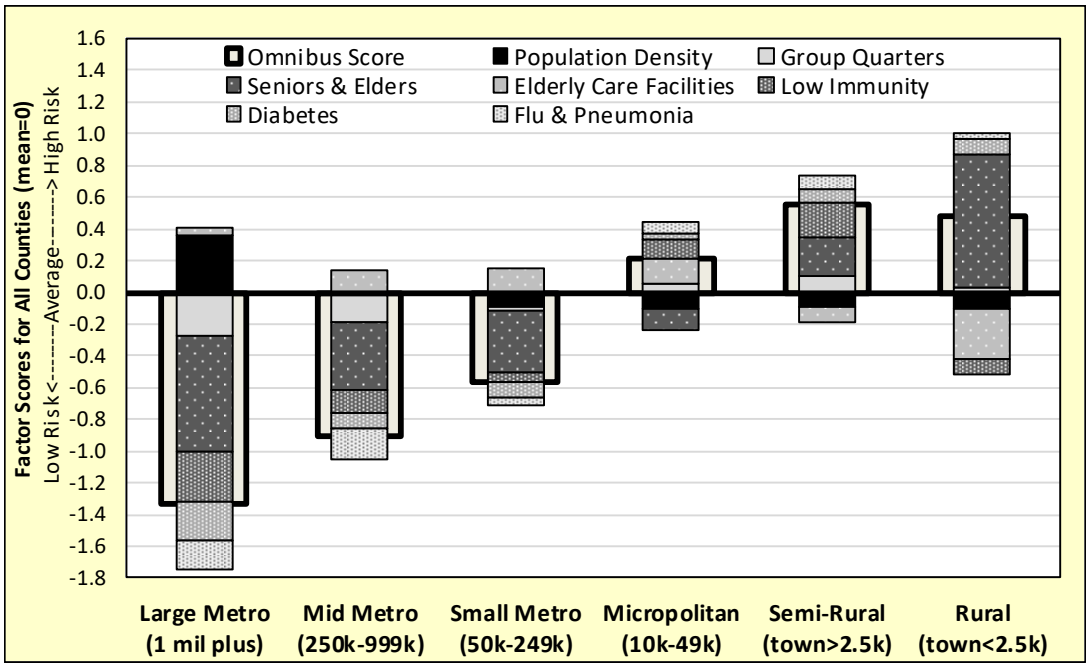

Figure 1. COVID-19 relative risk factor score estimates

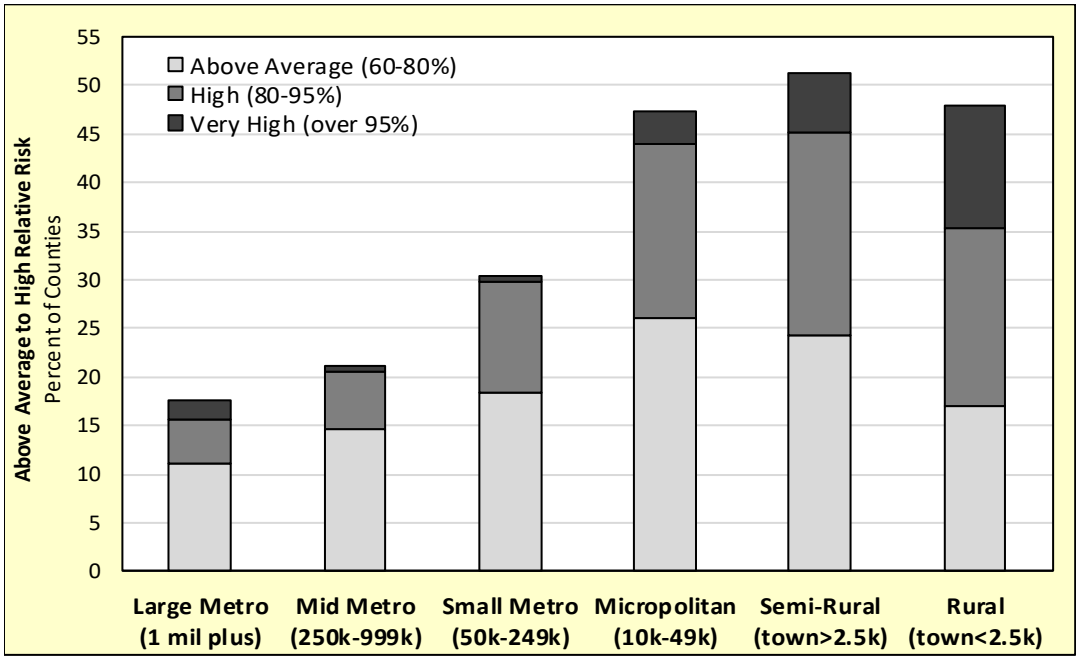

Figure 2. Percent of counties at relative risk percentiles for COVID-19.

Rural counties are only at risk from large senior and elder populations. The primary risk factor in the most rural communities are from older residents, with some additional risk from those with diabetes complications. Despite an older population, COVID-19 outbreaks are unlikely to originate in care facilities for the elderly due to their absence in remote counties, thereby reducing overall risk. ***Semi-rural places are at risk from senior/elder, health compromised, and institutional populations.*** Severe cases of COVID-19 are likely to be driven by a mix of older residents, immunocompromised individuals, people living in institutional settings, and the prevalence of health issues like diabetes and flu/pneumonia. By having a larger town (2.5k-10k), semi-rural counties typically serve as regional trade centers providing healthcare and education services for surrounding counties. These institutions likely attract residents who fall into at-risk subpopulations, increasing community risk to COVID-19. ***Micropolitans have above average risk due to eldercare facilities and health compromised people, but not from senior citizens.*** Micropolitans have more people employed in community care facilities for the elderly, posing a risk to workers and residents alike. Despite their presence, the senior/elder population is smaller than in rural places, resulting in lower risk overall. One explanation is elder care facilities tend to locate in more urban and younger counties with skilled labor and supporting healthcare services.

By contrast, ***metropolitan counties are at much lower risk due to younger populations and better health outcomes***. In all size classes, metros have fewer shares of seniors/elders, fewer shares of people living in institutions, and lower mortality from diseases that make people

vulnerable to COVID-19. Despite these advantages, ***large metros of a million or more are at risk for community spread of COVID-19 due to high population densities***. About seven percent of the nation's largest metro counties fall into the top quintile of risk scores, including major cities in the northeast (Boston, New York, Baltimore, and Washington, DC) and San Francisco – the current epicenters of COVID-19 outbreaks. This suggests large cities will always be susceptible to viral pandemics due to dense living conditions, even though they have relatively healthy and younger populations. Mid-size and small metros are not at risk due to dense populations, rather COVID-19 outbreaks are likely to occur in care facilities for the elderly.

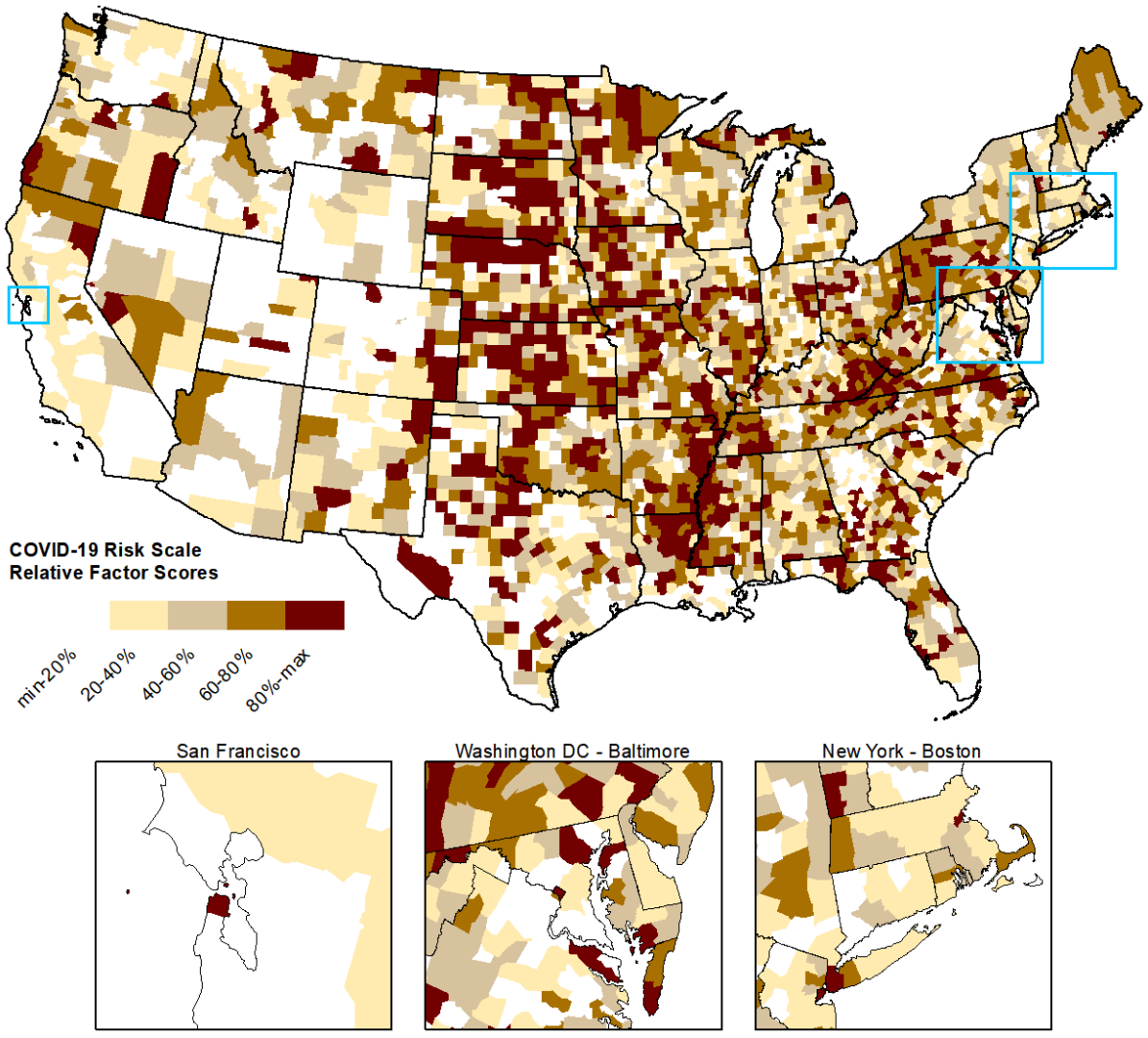

Figure 3. Spatial distribution of COVID-19 relative risk scores by quintiles.

In conclusion, this commentary demonstrates the pressing need and potential utility of a county-level COVID-19 risk scale, permitting comparisons of risk components across the rural-urban continuum. From the simple analysis presented here, it is clear rural communities are at higher risk for serious complications of the current pandemic; and that COVID-19 risks facing rural places are distinct from ones facing urban communities, necessitating different responses. For example, in rural communities it may be necessary to quarantine or disperse specific vulnerable populations, like seniors/elders, immunocompromised persons, and those living in institutions. Being sparsely populated the risk of community spread may be low, suggesting general shelter-in-places orders may have little impact. By contrast, in densely populated cities such orders may be the only means to slow the pandemic. While national attention is rightly focused on the sheer number of cases occurring in large metros, it is equally important to keep in mind that rural communities may experience larger proportional impacts. An outbreak of 5 severe cases requiring ICU hospitalization in a rural county will far outstrip local resources, but not make national headlines. There is a danger needed resources will not flow to rural places if decisions are based on absolute counts instead of relative risk scores. Any state or national response to the pandemic will be hindered by the scale at which rural healthcare operates. There are logistical barriers in deploying healthcare providers and supplies quickly to where they are needed over a large geographic area. There are also organization barriers in coordinating responses among many small rural hospitals, as well as a multitude of local government jurisdictions. Knowing ex ante pandemic risks would allow prior coordination plans and stockpiling in rural areas.

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Endnotes

i. Principal components extraction and varimax rotation is used to combine the 10 indicators into 7 distinct factors accounting for 85.6 percent of the original variance in the data. All assumptions of factor analysis are met, with low factor correlations supporting use of orthogonal rotation. Since the purpose is scale construction, the number of factors was determined by maximizing explained variance and factor validity, instead of more typical criteria. Most factors exhibit high factor loadings ($\lambda>0.8$) and all indicators show high communalities ($h^2>0.7$), indicating a robust factor solution.

ii. Population data from U.S. Census American Community Survey 2013-2017. Mortality data from CDC National Vital Statistics System. Elderly care employment from U.S. Census County Business Patterns estimated by the Upjohn Institute for Employment Research. Small Virginia independent cities are merged back to their respective with their counties; and Broomfield County, Colorado was disaggregated back to its original counties using population weighted shares.

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