Evaluating Rural-Urban Typologies for Use in Healthcare Research

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Abstract

Recent studies on variations in health outcomes across the rural-urban gradient raise questions about the way health scholars classify rurality and urbanicity. Concerns about our existing rural-urban typologies—namely, that they suffer from over- and under-bounding, are inconsistent with one another, and vary by region—make it difficult to draw consistent conclusions about the role of place in health outcomes. This study seeks to provide some clarity by systematically assessing the degree of over- and under-bounding and the inter-typology consistency of 12 popular rural-urban typologies. It then examines the effect of regional variation in the "goodness of fit" of these typologies by testing how well they explain variation in three healthcare outcomes: infant mortality, access to obstetrical care, and access to general practitioners. Understanding how accurate these classifications are and how well they "fit" different outcomes should allow us to better understand the role of place in healthcare outcomes.

In recent years, health research has begun to focus on the role of "place" in health and wellbeing. A growing body of literature suggests that *place matters* for health outcomes—that where people live affects everything from whether individuals can find jobs after they receive a lung transplant (Nau et al. 2016) to whether they are likely to contract a sexually transmitted infection or experience preterm birth (Callaghan 2014). Some of this attention has turned to the differences in outcomes across the rural-urban gradient. For example, one study found a "rural mortality penalty," where a gap exists between rural and urban mortality rates at every age, with rural residents dying at an increasingly higher rate than urban residents, due largely to the fact that urban mortality rates have declined much faster than rural mortality rates since the 1980s (James 2014).

Such studies uncover important patterns in healthcare outcomes, but they also raise questions about how researchers consider and define space and place. While there is great interest in examining health outcomes in rural and urban areas, there is no consensus in the definition of "rural" or "urban." Because of this, two studies examining the same outcome can define rurality in completely different ways and draw opposite conclusions because they have determined that different areas are "rural" (Hart et al. 2005). While that is a serious problem on its own, there are also concerns about the accuracy of the prevailing definitions of rurality. In 2015, the U.S. Department of Agriculture's (USDA) Economic Research Service (ERS), which has devised some of the most popular rural-urban definitions, convened a two-day workshop attended by rurality experts to determine how problematic the definitions are (Wunderlich 2016). In addition, numerous studies have attempted to devise "better" methods of defining rurality out of concern that existing definitions are too inaccurate (see Ricketts and Johnson-Webb 1996 and Waldorf and Kim 2015 for examples).

These issues suggest that we need to pay more attention to how rurality and urbanicity are defined if we are to truly understand the role of place in health outcomes. The current study attempts to address this concern by systematically assessing the rural-urban typologies used in health research, and then determining which typology is the "best fit" for analyses of three outcomes: infant mortality, access to obstetrical care, and access to general practitioners.

Problems with Definitions of Rurality

The concerns about our existing definitions of rurality tend to revolve around three issues, which need to be addressed in any assessment of rural-urban typologies.

1. *Under- and over-bounding.* The biggest issue with rural-urban typologies is their tendency to over- or under-bound rural and urban areas (Hart et al. 2005). This is particularly true at the county level. Consider a large county that contains a city with a population of 60,000, but where the majority of the landmass is covered in forests or farms. Because the county contains a city with 60,000 people, most county classifications would label that county as "urban," even though most of the county's landmass appears to be rural. The rural parts of the county are being "under-bounded"— they are being classified as urban although they are rural in character—while the urban part is being "over-bounded"—more land is being labeled "urban" than is warranted.

Both of these situations can wash out the effects of geography, and make it possible that important associations between place and health are being overlooked.

2. *Consistency across measures.* Hart et al. (2005) examined the relationship between rural-urban taxonomies produced by the US federal government and found that there is little consistency between measures, with some areas being defined as both metropolitan and rural, depending on the definition used. While the individual measures might be consistent, having drastically different categorizations between measures is problematic. If a definition shows little agreement with other measures, it is likely that it is not accurately capturing the degree of rurality or urbanicity in an area and should not be used in analyses.

3. *Regional differences.* The United States is a vast country with significant variation in county size and concepts of "rurality." In the Northeast, where counties are small and cities are closer together, rural areas are much closer to urban amenities that in the West, where counties are massive and cities can be hours apart. The rural experience is very different in these areas, and a good classification system would take these kinds of differences into account. Many, however, do not.

Given these concerns about rural-urban classification schemes, this study addresses four questions:

Question 1: How much does each classification scheme over- or under-bound rurality or urbanicity at the county level?

Question 2: How consistent is each classification scheme with the other classifications of rurality and urbanicity?

Question 3: To what extent does the accuracy of each definition (degree of under-bounding and over-bounding, consistency with other definitions) vary by region?

Question 4: Which classification scheme is most appropriate for studying rural infant mortality, access to obstetrical care, and access to general practitioners across the US, in each region, and by state?

Data and Methods

Rural-Urban Classification Schemes
To conduct this analysis, we engaged in an extensive review of the health and place literature and made a comprehensive list of definitions of rurality and urbanicity used in those articles. We then excluded classification schemes from consideration based on four criteria. First, some typologies include characteristics (i.e., socioeconomic status and poverty) that, while tied to rurality, do not determine whether an area is rural or urban (for examples, see Ricketts and Johnson-Webb 1996; Beynon, Crawley, and Munday 2016). We excluded such classifications because they have the potential to confound outcomes and explanatory factors. Second, we excluded definitions that only apply to small portions of the US, like the "frontier areas"

designation (counties with ≤ 6 people per square mile (Ricketts and Johnson-Webb 1996; Hart et al. 2005)), which applies almost exclusively to the West, or the "cow/deer to person ratio" (Jones and Ewald 2017), which likely only applies to Wisconsin. Third, we exclude definitions that are no longer in use, like the Veteran's Health Administration's rural-urban classification system, which has been replaced by the Rural-Urban Commuting Area (RUCA) codes (Waldorf and Kim 2015). Finally, we only consider definitions that are based on either counties or census tracts. We include this limitation for two reasons. First, most analyses that consider rurality or urbanicity occur at either the county or census tract level, so examining other definitions would be of limited utility. Second, census tracts aggregate cleanly to the county level in a way that ZIP codes or Zip Code Tabulation Areas (ZCTAs) do not, and our method for testing the degree to which a definition over-bounds or under-bounds rurality (described below) depends on the relationship between tract classifications and county classifications. After these exclusions, 12 classification schemes remain, which compose our analysis. These schemes are presented in Table 1.

Table 1: Rural-Urban Classification Schemes Considered in this Analysis

Census Rural-Urban Status	ERS Typology Codes
Frontier and Remote Area Codes (FAR)	Housing Assistance Council (HAC) rural tract classifications
Index of Relative Rurality (IRR)	National Centers for Health Statistics (NCHS) classification scheme
OECD Typology	Office of Management and Budget (OMB) Metropolitan/Micropolitan Classifications
Population Density	Rural-Metropolitan Interface Levels
Rural-Urban Continuum Codes (RUCC)	Rural-Urban Commuting Area Codes (RUCA)

Data
Our analysis depends primarily on three sources of data: the 2010-2014 American Community Survey (ACS) 5-year sample at the county and census tract level, 2016-2017 Area Health Resource File (AHRF), and geocoded NCHS linked (cohort) birth and infant death records ("birth/death records") for 2010-2014. While many of the rural-urban definitions we use are provided by government agencies or research organizations, they are almost exclusively provided at a single level. Because our method of examining under- and over-bounding (discussed below) depends on a cross-level comparison, we need to recreate these definitions at either the census tract or county level. We use data from the ACS to recreate these schemes.

The AHRF and birth/death records allows us to address our fourth question: which classification scheme is most appropriate for studying rural infant mortality, access to obstetrical care, and access to general practitioners across the US, in each region, and by state? The AHRF provides county-level information on the availability of a wide range of healthcare services and healthcare access. We will use it to measure access to obstetrical care and access to general practitioners. The birth/death records, provided through a data use agreement by the National Association for Public Health Statistics and Information Systems (NAPHSIS), link the birth and death records of

each infant that dies within the first year after birth. We will use this data to measure the infant mortality rate at the county level.

Analysis Plan
We have devised a new method to address our first question—how much does each classification scheme over- or under-bound rurality or urbanicity at the county level? To examine this question, we recreate, to the extent possible, the classification scheme at the census tract level (or the county level, if it was originally a tract-level measure) using ACS data and manipulations in ArcGIS as necessary. Because census tracts are geographically smaller, they are much less likely to over- or under-bound a classification than a county. Measuring rurality or urbanicity at the tract level thus provides a more accurate definition. This allows us to then correlate the county- and tract-level measures to determine how closely aligned the classifications are, and thus the degree to which they over- or under-bound rurality or urbanicity.

The second major concern with rural-urban typologies is that they tend to be inconsistent with one another. To examine this, we will create two-way and three-way frequency tables between all potential combinations of classification schemes to determine their level of agreement. We will then generate a value indicating the degree to which the typologies agree with one another, which is another way of assessing how accurate the classification is. After completing this analysis, we will rerun the analyses for questions 1 and 2, clustering at the Census region-level to address question 3—to what extent does the accuracy of each definition vary by region?

Finally, we will address our fourth question—which classification scheme is most appropriate for studying rural infant mortality, access to obstetrical care, and access to general practitioners across the US, in each region, and by state? –by considering the "goodness of fit" of the classification schemes to each of the three outcomes. Following Goetz and Han (2015), we will measure the "goodness of fit" of the typologies that performed well on our accuracy tests using OLS regressions predicting rural infant mortality, access to obstetrical care, and access to general practitioners. We will run the analysis on the country as a whole, and then on each region and each state. We will compare the adjusted R-square values to see which classification schemes provide the best "fit" in each scenario. This will then allow us to make a recommendation on which typologies should be used in analyses considering these outcomes across the rural-urban gradient.

Expected Findings

Based on our analysis of the literature and some very preliminary examinations, we expect that the typology based on the OMB metropolitan and micropolitan designations will be the least reliable in terms of over- and under-bounding and will have the largest variation in accuracy between regions. We expect that the IRR—the Index of Relative Rurality, and the lone continuous measure considered here—will score relatively well, as will the classifications originally generated at the census tract level (i.e., the RUCA codes). We also expect that there will be variation in which definitions "fit" best by region and outcome. Understanding how accurate these classifications are and how well they "fit" different outcomes should allow us to better understand the role of rural or urban residence on healthcare outcomes moving forward.

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