Identifying, Analyzing, and Communicating Rural: A Quantitative Perspective

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Defining rural is a critical task for rural education researchers, as it has implications for all phases of a study. However, it is also a difficult task due to the many ways in which rural can be theoretically, conceptually, and empirically operationalized. This article provides researchers with specific guidance on important theoretical and operational considerations relevant to conducting quantitative rural education research: identifying a rural definition, selecting appropriate analytic methods, and thoroughly communicating rural details to situate the findings within the broader rural literature base. In addition, this article uses the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K) and three rural definitions to illustrate how parameter estimates and substantive interpretations are impacted by the statistical model, rural definition, and exclusion/inclusion of covariates. We believe that informed consideration and implementation of the article's guidelines will enhance and clarify the quantitative literature on rural education.

"Rural" is a theoretical construct, so identifying a theoretical perspective of rural is a critical first step in conducting research on rural education. However, an equally critical (and closely related) step is identifying an operational definition of rural, which is necessary for conducting quantitative rural research. Numerous theoretical and operational definitions have been proposed across a wide array of disciplines, and each of these definitions has its own strengths and weaknesses. Although the challenges of defining rural are well-documented (e.g., Coladarci, 2007; Cromartie & Bucholtz, 2008; Hart, Larson, & Lishner, 2005; Howley, Theobald, & Howley, 2005; Isserman, 2005), discussions have primarily occurred at a theoretical level or do not delve into the issues that arise once a definition has been chosen. Concrete examples and guidelines are needed to ensure that researchers fully understand the extent to which the rural definition impacts the study's sampling design, analysis plan, and generalizability.

The purpose of this article is twofold. First, we aim to remind (or potentially inform) rural researchers how to (a) identify an operational definition of rural given their theoretical perspective and the context and goals of their study, (b) appropriately analyze their data given the chosen operational definition, and (c) accurately communicate their findings given the chosen operational definition. Upon examining several quantitative articles recently published in JRRE, we were generally encouraged by JRRE authors'

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careful attention to defining and discussing rural at both the theoretical and operational levels. Our goal is to explicate and thus foster and sustain this good practice by providing a comprehensive guide for education researchers seeking to identify, analyze, and communicate rural phenomena. Second, we use data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K; developed by the U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics [NCES], n.d.-a) to illustrate the impact of the rural definition on statistical results and substantive inferences.

It is important to acknowledge that our discussion is primarily intended for researchers conducting quantitative research. Some of our recommendations may not apply to, or may even counter what is recommended for, qualitative research. We believe that both forms of research, in addition to mixed-methods research, are important for understanding rural issues. Thus, we strongly encourage other researchers to advise the field on rural definition issues in the context of qualitative and mixed-methods research.

Identifying, Analyzing, and Communicating Rural

Identifying an Appropriate Definition

Choosing a rural definition influences the entire scope of a study. At the initial planning stages of a study, the definition affects the selection of a sampling design and statistical analysis plan. At the concluding stages of a study, the definition affects the generalizability of the research findings. In this section we provide guidance on identifying an appropriate operational definition of rural given a particular theoretical perspective, while taking into account practical considerations.

Theoretical perspectives. First and foremost, operationalizing rural requires formulating a theoretical perspective of rural. Numerous theories of rural have been postulated. In following the organization scheme of Brown and Schafft (2011), such theories can be broadly classified into one of two groups: place-based theories (e.g., demographic, population, spatial, political economic, and socio-cultural theories) and social constructivist theories.[1] We briefly touch on each of these theories below. A full discussion is beyond the scope of this article, so we strongly encourage researchers to consult the original sources and seek out additional references for a deeper and more comprehensive understanding of rural theory.

One means for conceptualizing rural is in terms of "population and settlement structure and landscape" (Brown & Schafft, 2011, p. 5), where emphasis is placed on demographic characteristics such as population density and size, and spatial delimiters. Demographic and population density-based definitions of rural largely date back to Emile Durkheim's 1893 work, *The Division of Labor in Society*. Durkheim differentiated societies by the nature of their solidarity, which he theorized to be a direct function of population density (Durkheim, 1964). According to Durkheim, low population density societies (i.e., rural societies) lend themselves to a mechanical form of solidarity characterized by collectivist orientations, homogeneous backgrounds and belief systems, and agrarian lifestyles. In contrast, high population density societies (i.e., urban societies) increasingly demonstrate an organic form of solidarity characterized by an interdependency among others that stems from the division of labor. Along with population characteristics such as size and density, rural places are often spatially defined. Spatial conceptualizations of rural focus on the *where* (i.e., space, distance, and relationship to the city) of places (Lobao, Hooks, & Tickamyer, 2007) and highlight issues of spatial inequality or spatial disparities in the allocation of resources.

Most operational definitions of rural used in quantitative research are grounded in the demographic and spatially based theories, as these theories provide a straightforward means for classifying geographies. However, just because a theory readily enables classification (which in turn enables quantification) does not mean it is superior. Other place-based theories that emphasize political-economic and socio-cultural distinctions have also garnered attention. With respect to these alternative theories, Brown and Schafft (2011) note that although "the focus is not on the space (or place) itself ... locales often create a powerful context for collective identity and social interaction" (p. 39) such that demographic and spatially based classifications can sometimes serve as proxies for getting at these alternative (and generally harder to operationalize) ways of thinking about rural.

As the name suggests, political-economic theories of rural focus on distinctions among sectors that are primarily politically and economically driven (Cloke, 2006). Such distinctions include the tendency for rural economies to be more specialized (Deavers, 1992) and more dependent on the government sector (Deavers & Brown, 1985). Tilly (1974) attributes this dependence to state-making, urbanization, industrialization, and commercialization. Much of the literature on class relations (e.g., Stinchcombe, 1961), including peasant studies (e.g., Wolf, 1969), can also be considered here. While conceptually distinct, many of these issues relate, at least indirectly, to Durkheim's (1964) theorizing on rural, suggesting that demographic characteristics could be used in some instances to approximate political economic classifications.

Socio-cultural theories frame rural in terms of formal

[1]We are particularly grateful for the feedback of an anonymous reviewer who outlined and summarized the theories discussed in this section.

and informal social and cultural networks (e.g., Schafft, 2000) and interactive community fields (e.g., Kaufman, 1959; Wilkinson, 1972). Schafft and Brown (2000) note that "embedded intra-community relations, including individual and group-level social ties, cultural practices, and political behavior, reinforce the affiliative networks within a given locality" (p. 204). Strong ties among members within a community promote social cohesion, while ties (albeit weaker) with wider networks (e.g., ties between rural communities and neighboring cities) ensure sufficiency of resources and prevent isolation (Schafft, 2000). Although these networks are socially defined, spatial influences are clearly evident. With respect to interactional communities, Kaufman (1959) explains that "at the cultural level, integration is effected through the widely shared values and objectives pertaining to the community field and, at the ecological level, through a 'functional relation' of services" (p. 12). Discussions of social norms (e.g., reciprocity and civic engagement) as they relate to social capital (e.g., Putnam, 1993) also contribute to social-cultural conceptualizations of rural.

The issues discussed in the remainder of this article relate most directly to place-based theories of rural, particularly the demographic and spatially based theories of rural. However, we would be remiss not to mention social constructivist approaches to conceptualizing rural. In particular, Halfacree (1993, 2006) emphasizes the importance of considering non-tangible indicators of space such as cognitive structures and social representations. Place identity construction, specifically the notion of urban and rural identities (Bell, 1992; Creed & Ching, 1997), falls under this approach. Bell (1992) observes that, although "the difference between country life and city life may only ever be true in the mind" (p. 66), perceived differences have real social consequences.

Operational definitions. To conduct quantitative research, one's theoretical perspective of rural must be translated into operational terms. A reasonable first step in searching for an appropriate operational definition is to examine the definitions that are currently in use. Most well-established and commonly used definitions have been developed by one of four federal agencies/centers. The U.S. Department of Agriculture, Economic Research Service (ERS) has developed the Rural-Urban Continuum Codes (RUCCs, also referred to as the Beale Codes; ERS, 2013a), Urban Influence Codes (UICs; ERS, 2013b), and Rural-Urban Commuting Areas (RUCAs; ERS, 2013c), developed jointly with the Washington, Wyoming, Alaska, Montana, and Idaho Rural Health Research Center (WWAMI RHRC, n.d.-a). The U.S. Office of Management and Budget (OMB) has defined Core Based Statistical Areas (CBSAs), which include Metropolitan and Micropolitan Statistical Areas (OMB, 2010). In addition, the U.S. Census Bureau (2013a) has created an Urban and Rural Classification. Finally, NCES has developed the Urban-Centric Locale Codes (NCES, n.d.-b), a revised version of the previously used Metro-Centric Locale Codes (or simply, the Locale Codes; NCES, n.d.-c). Detailed descriptions and comparisons of the definitions' strengths and weaknesses are provided by Arnold, Biscoe, Farmer, Robertson, and Shapley (2007); Coburn et al. (2007); Hart (2012); and Hart et al. (2005).

Given the prominence and usage of these ways of classifying geographies, we strongly encourage researchers to consider the definitions seriously. At the same time, we recognize that the definitions have limitations and may not be appropriate for all study contexts. As an alternative, a number of researchers have created their own rural definition by modifying or combining one or more of the existing definitions. For instance, Isserman (2005) introduced a Rural-Urban Density Typology that combines elements of the U.S. Census Bureau and OMB definitions—including county population density, percentage of county population in urban/rural areas, and presence/absence of urban areas of 10,000+ or 50,000+—to acknowledge the presence of "mixture" counties that contain both rural and urban areas. As another example, Waldorf (2006) proposed the Index of Relative Rurality, a continuous measure of rural comprised of population size and density, extent of urban area, and remoteness. A primary advantage of the index is that it avoids the need to impose arbitrary thresholds such as 10,000+ and 50,000+.

Primary considerations. In creating a new definition or choosing among well-established definitions, researchers must ultimately bear in mind their theoretical perspective of rural. Different definitions of rural use different operational indicators; the most relevant indicators are those that match the researcher's theoretical perspective. For example, the U.S. Census Bureau (2013a) uses a definition of urban and rural that is based primarily on population size and density. This definition clearly links to demographic-based theories of rural. A moderately strong relationship has been identified between population density and human capital investment (Garces-Voisenat, 2011), suggesting that in education research population density might be important for explaining job growth for teachers or other school officials. The OMB and RUCA classification systems additionally take commuting patterns into account (OMB, 2010; WWAMI RHRC, n.d.-b) and thus relate to spatially based theories of rural. Commuting patterns might be particularly relevant to education researchers who want to understand the impact of access to big-city resources, such as art museums or institutions of higher education, on child outcomes. Similarly, the Urban-Centric Locale Codes stem from spatial conceptualizations of rural, as they rely on geographic information systems (GIS) technology to classify locations (NCES, n.d.-d). Researchers might use this definition to study the impact of geographic remoteness on schools' reliance on distance technology.

Consistent with the guidelines of Hart et al. (2005), the indicators described above are quantifiable and relatively objective. However, as noted by Coladarci (2007), some researchers question the meaningfulness of such "traditional constructs of demography" and argue for "more important notions of 'local commitments' and 'meaning-making'" (p. 2). In particular, none of the aforementioned definitions directly captures the tenets of the political-economic, socio-cultural, and social constructivist theories. If researchers deem demographic and spatial characteristics to be insufficient proxies for operationalizing rural under these alternative theories, then other indicators should be explored. In doing so, however, researchers must be willing and able to provide convincing evidence that the potentially subjective indicators do in fact measure what they are purported to measure.

Related to choosing a rural indicator(s) is determining the geographic unit to which the indicator(s) should be applied. This consideration is important because the geographic unit represents the experimental unit—the smallest unit to which the "treatment" is independently applied (Milliken & Johnson, 2009)—for the rural/urban predictor. As discussed in the "Analyzing Rural Data" section, inferences about rural exist at the level of the experimental unit (e.g., the county), which is not always the same as the lowest-level sampling unit (i.e., the lowest-level unit for which data are being collected, for example, the student).

Common geographic units include schools, school districts, ZIP code areas, census tracts, and counties. Obviously, researchers should choose a geographic unit that matches their target sampling unit. For example, the *school*-level definitions provided by the Metro- and Urban-Centric Locale Codes might be particularly useful for comparing an intervention's efficacy in rural versus urban *schools*. On the other hand, *county*-level definitions provided by the RUCCs and UICs would be more appropriate for evaluating rural and urban *county* health and wellness initiatives. County-level definitions may also be advantageous in the context of multi-year longitudinal studies, as counties tend to be more stable over time compared to other geographical units (Hart et al., 2005). When the ideal geographic unit is not immediately apparent, researchers may benefit from choosing the geographic unit that has the most variation on the outcome variable. For instance, suppose "professional development opportunities" is the outcome variable. If most of the variability in professional development opportunities exists between school districts as opposed to within school districts, then school-district-level predictors will generally account for more variability in professional development opportunities than, say, school-level predictors. Hence, in this context, rural definitions applied at the school-district level are likely preferred over rural definitions applied at the school level.

The choice of geographic unit strongly influences conclusions about rural phenomena, a consequence that has been defined in the literature as the modifiable areal unit problem (MAUP). Waller and Gotway (2004) describe MAUP as the "geographic manifestation of the ecological fallacy in which conclusions based on data aggregated to a particular set of districts may change if one aggregates the same underlying data to a different set of districts" (p. 104). MAUP involves both a scale/aggregation problem and a grouping/zoning problem. The scale/aggregation problem relates to the fact that statistical results will vary as a function of the level of aggregation applied. As Arnold et al. (2007) note, greater aggregation generally results in a greater loss of information—e.g., many counties classified as metropolitan contain significant rural spaces and vice versa (Isserman, 2005). The grouping/zoning problem relates to the fact that statistical results will vary depending on how groups are formed, given a particular level of aggregation. For example, census tract boundaries often change across census years, resulting in different groupings across census years (Hart et al., 2005). While there is no definitive solution to MAUP, researchers should be aware of the implications of choosing a particular geographic unit, and shape their inferences about rural phenomena accordingly.

Supplemental considerations. Sometimes logistical concerns make a theoretically ideal rural operationalization practically infeasible. One such concern is financial constraints. Consider a definition that is applied to counties. The power to detect a rural effect is primarily influenced by the number of counties sampled. Sampling counties is likely to be much more expensive than sampling schools, which tend to exist in greater numbers and in narrower geographical regions. Researchers may not have the time and resources to sample at the county level. Likewise, choosing one of the broader definitions of rural (e.g., the U.S. Census Bureau's definition) will result in more places qualifying as in-need based on policy or program eligibility requirements, but programs may be limited in their funding (Coburn et al., 2007).

Another concern is the availability of data. Coburn et al. (2007) offer a health policy example in which they note that provider claims are based on ZIP codes. Without additional information, rural definitions applied to counties cannot be used to address questions about provider claims, because counties and ZIP codes are not directly comparable. ZIP codes were created by the U.S. Postal Service as mail delivery areas and are not bound to counties or even states ("Can ZIP codes cross," 2011) and can change monthly ("How many changes are made," 2011). Although ZIP codes may be loosely aggregated with GIS techniques into approximate counties (DuScheid, 2011), this practice introduces additional error as it does not always provide an exact match. In the context of a secondary data analysis, researchers are limited to the data at hand. If the dataset does not provide NCES school IDs or census tract or county codes (either the American National Standards Institute [ANSI] codes or the older Federal Information Processing Series [FIPS] codes; U.S. Census Bureau, 2013b), then the corresponding definition codes cannot be merged with the dataset.

Finally, a dataset may include all the necessary identification and coding information, but whether it is appropriate to make comparisons based on higher-level geographic units depends on the sampling design of the original study. For instance, although the restricted-license ECLS-K dataset provides information on higher-level units, the study's website states that "the ECLS-K sample was not designed to support state-level (or city- or county-level) estimates, as the sample is not necessarily representative of children in particular states (or cities or counties)" (NCES, n.d.-e).

To conclude this section, we stress the hierarchy of theoretical and practical considerations. Ultimately, theory should be the driving force in selecting an operational definition of rural. Practical considerations, while important, should serve more as an evaluation of the feasibility of the chosen rural definition, and potentially as an indication of the need for additional or alternative study resources.

Analyzing Rural Data

Once a rural definition is chosen, the next step is to determine an appropriate analytic strategy. The analysis plan follows directly from the sampling design, which in large part depends on the geographic unit to which the rural definition is applied. In education and rural research, simple random samples are generally impractical and inefficient. Instead, researchers often use complex sampling procedures that involve clustering (also referred to as nesting). Clustering is a sampling method in which the units being sampled contain multiple related observation units (Kish, 1965). For instance, rather than directly sampling students, it may be more convenient to randomly sample schools and then observe a selection of students within each school. Whereas clustering is often more time and cost efficient than simple random sampling (Kish, 1965), a disadvantage of clustering is that the assumption of independent observations, implicit to most basic statistical models and tests, is violated.

Consider the following scenario. Suppose a researcher is interested in comparing the body mass index (BMI) of rural and urban children, where the terms rural and urban are defined at the school level. The researcher randomly selects 10 rural schools and 10 urban schools, and within each school, measures the BMI of 10 randomly selected children. The sampling design involves two levels where level 1 units (the lowest-level sampling units; = 200 children) are nested within level 2 units (the experimental units for the rural/urban predictor; = 20 schools). At first glance, it might seem that an independent samples t-test comparing the average BMI of the 100 children in rural schools to the average BMI of the 100 children in urban schools is sufficient for testing the "rural" effect on BMI. However, the assumption of independent error terms is violated. Children who go to the same school will tend to be more similar than children who go to different schools, so in actuality, there are 10 independent observations per group instead of 100. Only considering data at the lowest level of sampling is referred to as disaggregation (Snijders & Bosker, 2012). In the simplest case, when predictor variables are assigned at a higher level of sampling, disaggregation increases the chance of a Type I error (e.g., finding urban and rural differences when there are no differences). In contrast, when nesting is present (and ignored) but predictor variables are measured at the lowest level of sampling, disaggregation increases the chance of a Type II error (e.g., failing to find urban and rural differences when there are in fact differences).

An alternative is to aggregate the lower-level data to the higher level. This approach would involve computing the average BMI for each school and then performing an independent samples t-test to compare the average BMI of the 10 rural schools to the average BMI of the 10 urban schools. Like disaggregation, aggregation has its disadvantages. Aggregation throws away within-cluster (i.e., within-school) variability, which prevents researchers from fully understanding all of the variability in the outcome. For instance, research has shown that the prevalence of obesity among children is greater for low-income families (Ogden, Lamb, Carroll, & Flegal, 2010), suggesting that socioeconomic status (SES) is an important predictor to include in any analysis of BMI. In the case of an aggregated analysis of BMI, the only means for including SES as a predictor would be to aggregate family-level SES to the school level and then regress average BMI on average SES and rural status. Importantly, family-level SES and school-level SES are distinct predictors with potentially distinct effects on BMI. The effect of school-level SES on BMI may be weaker, stronger, or even in the opposite direction[2] of the effect of family-level SES. Drawing inferences about lower-level relationships based on higher-level relationships is referred to as an ecological fallacy (Snijders & Bosker, 2012). In an attempt to avoid such a fallacy a researcher might perform two separate regressions, one at the child level and one at the school level. This approach is not ideal. First, all else being equal, the estimators of the regression

[2]For instance, we might find this case if a county initiative aggressively targeted low SES schools for healthy lunch programs.

coefficients will be less statistically efficient (resulting in greater standard errors) when the analyses are conducted separately. Second, separate analyses preclude the possibility of cross-level interactions (e.g., the interaction between child-level SES and school-level rural status). This limitation is serious. Rural education research is complex, and examining interactions is one way to acknowledge the complexity (Howley et al., 2005).

Aggregation and disaggregation leave much to be desired. An alternative approach to handling clustering is multilevel modeling (MLM),[3] also referred to as linear mixed modeling, hierarchical linear modeling (not to be confused with hierarchical multiple regression), and random coefficients modeling (Raudenbush & Bryk, 2002). MLM avoids the limitations of aggregation and disaggregation by partitioning variance in the outcome into its multiple sources and then modeling these sources simultaneously. It is useful (albeit an oversimplification) to conceptualize MLMs simply as regression models with more than one error term. As an example, the unconditional (i.e., no predictor) model for the two-level BMI scenario can be expressed in equation form as

$$\text{Level 1: } y_{ij} = \beta_{oj} + e_{ij} \quad (1)$$
$$\text{Level 2: } \beta_{oj} = y_{oo} + u_{oj} \quad (2)$$

which can be simplified by replacing the β_{0j} placeholder in Equation 1 with Equation 2:

$$\text{Combined: } y_{ij} = \gamma_{oo} + u_{oj} + e_{ij} \cdot \quad (3)$$

[3]Another option for handling clustered data is to calculate empirical standard errors that adjust for the complex sampling design (e.g., Wolter, 2007).

In Equation 3, y_{ij} represents the BMI of the i^{th} child who attends the j^{th} school, γ_{00} is the grand mean, u_{oj} is the difference between the j^{th} school's mean and the grand mean, and e_{ij} is the difference between the i^{th} child's BMI and the j^{th} school's mean. The only difference between a traditional regression model and Equation 3 is the presence of the additional school-level error term (u_{oj}). Figure 1 provides a small illustration of each of the terms in Equation 3 based on hypothetical data for two schools (j=1,2), each with two children (i=1,2). We see that the mean BMI for School 1 ($y_{.1}$=25) is lower than the grand mean (γ_{00}=26), so u_{01} is negative. In contrast, Child 1 from School 1 has a higher BMI (y_{11}=25.54) than the mean BMI for his or her school, so e_{11} is positive. If we did not include the school-level error terms, the residual would instead represent the distance between the child's BMI and the grand mean, which would result in correlated error terms due to the fact that children from the same school tend to have more similar BMIs than children from different schools (in our hypothetical example).

Earlier we noted that MLM serves to partition variance in the outcome into its between- and within-level sources. The proportion of variability that exists at the higher level can be estimated via an intraclass correlation coefficient (ICC)

$$ICC = \frac{\sigma_B^2}{\sigma_W^2 + \sigma_B^2} \quad (4)$$

where σ_B^2 is the between-level (e.g., between-school) variance in the outcome, and σ_W^2 is the within-level (e.g., within-school or between-child) variance in the outcome. The larger the ICC, the greater the proportion of variability

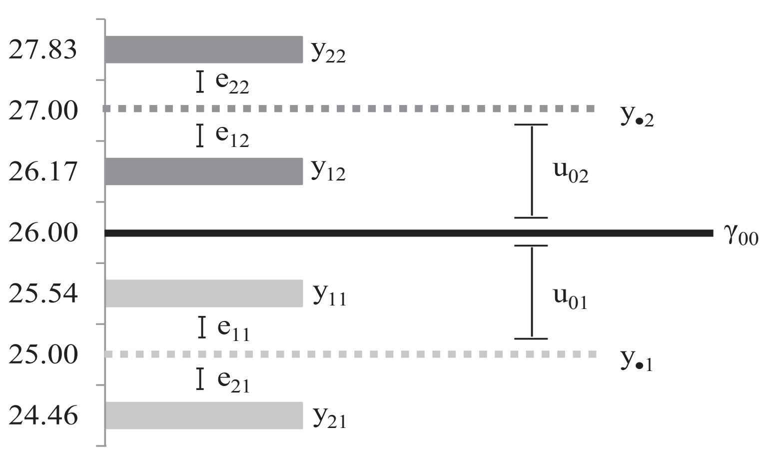

Figure 1. An illustration of the regression terms presented in Equation 3.

that exists at the higher level. By calculating the proportion of variability in the outcome that exists at each level we can determine which types of predictors will be most helpful in explaining the outcome. If very little variability in BMI exists at the school level then a rural definition applied at the school level will probably not tell us much about BMI.

We conclude this discussion of MLM with a demonstration to illustrate the consequences of ignoring clustering and omitting important covariates. Our review of the quantitative articles published in JRRE between 2009 and 2013 revealed only one study (Stockard, 2011) that used MLM.[4] This finding by no means indicates that the studies that did not use MLM should have used MLM (MLM is only applicable under certain conditions), but it suggests that a demonstration might be worthwhile. The interested reader should see Durham and Smith (2006), Reeves and Bylund (2005), and Roscigno and Crowley (2001) for additional examples of MLM in rural education research. Readers who are new to MLM and interested in learning more about the topic should see one of the many comprehensive textbooks on MLM methods (e.g., Raudenbush & Bryk, 2002; Singer & Willett, 2003; Snijders & Bosker, 2012).

Drawing on our hypothetical example, we simulated BMI data for 200 children from a total of 20 schools (10 "rural" and 10 "urban"). To use MLM, the data must be in stacked (also referred to as person-period or long) format—that is, each row should correspond to the lowest-level unit (i.e., the child, in our example). The datafile and model syntax (both SAS and SPSS syntax) are available from the first author upon request.

As a first step we calculated the ICC by analyzing the unconditional two-level model (Model 1) corresponding to Equation 3. Table 1 provides partial results. Approximately (2.77/[2.01 + 2.77]) * 100% = 58% of the variability in BMI is at the between-school level. This bodes well for our school-level rural predictor.

As an example of disaggregation, we evaluated the effect of rural status on BMI using a single-level model that ignored the existence of school-level variance (Model 2). Based on 198 degrees of freedom, we would determine that rural status has a significant effect on BMI ($p < .001$). Of course, this conclusion is untrustworthy because the model's assumption of independent error terms is violated. Next we evaluated Model 3, a multilevel model that accounted for the nesting of children within schools. Table 1 shows that the estimated beta coefficient representing the effect of school rural status is the same for Models 2 and 3 (note that this result may not hold perfectly in more complex data situations). However, for Model 3, the test of the rural effect is only based on 18 degrees of freedom resulting in a larger standard error. In examining the estimated variance components for Model 3, it is not a coincidence that the within-level variance is the exact same as the within-level variance estimated for Model 1, but the between-level variance is reduced (again, this result may not hold perfectly in more complex data situations). Rural status is the same for all children within a particular school so it cannot explain within-school variance.

Table 1

Single-Level and Multilevel Model Estimates for Simulated BMI Data

	$\hat{\sigma}_W^2$	$\hat{\sigma}_B^2$	$\hat{\gamma}_{01}$	SE	df[a]	p
Model 1	2.01	2.77	—	—	—	—
Model 2	3.20	—	2.42	0.25	198	< .001
Model 3	2.01	1.31	2.42	0.55	18	< .001
Model 4	0.90	0.90	0.24	1.06	16.98	.827

Note. [a]Denominator degrees of freedom were estimated using a Satterthwaite approximation. $\hat{\sigma}_W^2$ = within-cluster variance (residual variance). $\hat{\sigma}_B^2$ = between-cluster variance. $\hat{\gamma}_{01}$ = effect of rural on BMI. Model 1 = unconditional two-level model. Model 2 = single-level model with rural predictor. Model 3 = two-level model with rural predictor. Model 4 = Model 3 + child-level and school-level SES predictors.

A key consideration when analyzing rural data is whether covariates should be included in the model. As Coladarci (2007) emphasizes, "without adequate controls in place, the obtained [rural/urban] differences may be either unwittingly exaggerated or understated (although exaggeration is more likely)" (p. 4). Earlier in this section we mentioned the relationship between SES and BMI. Table 1 indicates that, upon controlling for child- and school-level SES (Model 4), we would conclude that school rural status is not a significant predictor of BMI ($p = .827$). What appeared to be a rural phenomenon based on Models 2 and 3 was actually explained by SES.

Our discussion and examples of MLM focused on only one possible source of dependency among observations, dependency due to nesting or clustering of lower-level units within higher-level units. Dependency can occur for a multitude of other reasons. Particularly relevant to rural education research is the possibility of geographic, or spatial, dependency (see Kučerová & Kučera, 2012, for a

[4]Irvin, Farmer, Leung, Thompson, and Hutchins (2010) discuss MLM but do not actually employ the method.

discussion of "the geographical aspects of education," p. 3). Goodchild (1992) defines spatial dependence as "the propensity for nearby locations to influence each other and to possess similar attributes" (p. 33). For instance, it certainly seems plausible that counties in the Northeastern region of the United States are more similar to one another than to counties in the Southeastern region of the United States. A number of methods have been developed for analyzing spatially dependent data (see, for example, the two-level spatial model described by Verbitsky-Savitz & Raudenbush, 2009). In fact, an entire branch of statistics is devoted to the study and analysis of spatial dependency. While an in-depth discussion of spatial methods exceeds the scope of this article, interested readers should seek out additional information (e.g., Cressie, 1993; Gelfand, Diggle, Fuentes, & Guttorp, 2010).

The purpose of this section was to remind readers about some of the critical issues that arise when analyzing rural education data. Although educational outcomes are most often measured at the level of individual children, teachers, principals, etc., rural definitions are most often applied at higher levels such as census tracts or counties. Dependency among observations must be taken into account when considering the effect of rural on the outcome. In addition, alternative explanations of rural findings should be evaluated through the inclusion of covariates.

Communicating Rural Findings

A study is not complete until results have been disseminated. Providing transparent and detailed accounts should be a goal of all researchers, but it is perhaps even more critical for rural education researchers given that many theoretical perspectives and operational definitions of rural exist. Using the nondescript label of rural is to commit a nominal fallacy; rural alone does not actually explain what is being measured.

Appropriate communication of rural findings starts with the literature review. In describing previous rural studies, it is important to note how researchers defined (or did not define) rural. For example, in reviewing the findings of Farmer et al. (2006), Irvin, Farmer, Leung, Thompson, and Hutchins (2010) condition their discussion based on the operational definition that was used: "African American youth attending schools identified as *Rural Low Income* by the Rural Education Achievement Program are four times less likely to meet Adequate Yearly Progress" (p. 2). The goal is to appropriately situate the present study within the broader rural research context rather than limit the discussion to studies that use a similar definition. In fact, the presence of different operational definitions adds richness to the field. Operational definitions are merely proxies for theoretical definitions of rural, so determining whether a particular finding holds across different operational definitions is noteworthy (e.g., by exploring alternative ways of combining the Beale Codes and observing no significant impact on the results, Jordan, Kostandini, and Mykerezi [2012] were able to have more confidence in the robustness of their results).

As with any method section, researchers should provide readers with enough detail to replicate the study. Limiting the description to generic terms such as "rural" and "urban" does not facilitate replication. At a minimum, it is necessary to specify the indicators used in defining rural and the unit to which the definition was applied. Along with this description, researchers should provide a strong rationale for why they chose the definition. A nice example of such a rationale is given by Jordan et al. (2012):

> Beale Codes were used here because they were designed specifically to examine the continuum between urban and rural areas. They were developed for the analysis of trends in non-metro areas that are related to the population density and metropolitan influence. Beale Codes allow a more detailed analysis of the survey data than the more common urban-suburban-rural classification systems (p. 4).

Not only does this explanation inform the reader, it forces the researchers to carefully consider whether the definition is indeed appropriate given their theoretical perspective and the context of their study.

Appropriate communication concludes with a discussion section that is framed by the researcher's theoretical perspective of rural but couched in terms of the operational definition that was applied. Again, operational definitions are merely proxies, so researchers should avoid making unjustified generalizations. Hannum, Irvin, Banks, and Farmer (2009) provide a great example of limiting their conclusions to the population from which they sampled. They emphasized that "the results are generalizable to rural schools meeting the definitions in the REAP program. The results may or may not be the same in urban, suburban, or rural schools other than those identified in the REAP definition" (p. 13). As recognized by Hannum and colleagues, it is important to limit generalizations to the geographic unit to which the definition was applied. For example, if the rural definition was applied at the county level then the effect of rural should be discussed at the county level. A higher-level predictor cannot explain lower-level variation in the outcome. That is, a county-level rural predictor cannot explain why individuals within counties perform differently on the outcome of interest; rather, it can only explain why counties perform differently on the outcome of interest. Likewise, it is more revealing and precise to relate findings to the observable indicators used to operationally define rural (e.g., "remoteness alone did not compromise access to technology" [Howley, Wood, & Hough, 2011, p. 6]) rather than use the elusive terms "urban" and "rural." This practice is critical for public policy and the development of educational programs that rely on tangible indicators.

As we demonstrate in the next section, different operational definitions of rural can lead to very different results. This consequence does not mean that certain definitions are inherently wrong, but it does mean that choosing a definition requires careful thought, and the interpretation and discussion of results should be intimately tied to the chosen definition.

An Illustration

In this section we provide an empirical example using the ECLS-K to demonstrate the impact of the rural definition on parameter estimates and substantive interpretations. The ECLS-K is a longitudinal study that followed a nationally representative sample of children from kindergarten entry (1998-1999 school year) through eighth grade. The restricted-use license provides access to the census tract and county FIPS codes for each participating child's school, which allowed us to merge existing rural definition codes with the dataset.

It is important to stress that this example is provided solely for demonstration purposes. The results from our analyses should not be interpreted in any real manner. We did not apply sampling weights or adjust for additional layers of design complexity (e.g., stratification, additional levels of clustering) as is normally required when analyzing data from the ECLS-K. Our goal is simply to highlight differences that may result when choosing among different modeling approaches and different rural definitions.

Method

Using data from the spring third grade wave, we compared students' science scores across urban and rural locations as defined by the school-level Metro-Centric Locale Codes[5] (drawn from the 1999-2000 Private School Universe Survey [PSS] and 2000-2001 Common Core of Data [CCD]; NCES, 2003), census-tract-level RUCAs (Version 2.0, based on data from the 2000 U.S. Census; WWAMI RHRC, n.d.-b), and 2003 county-level OMB designations (based on the 2000 OMB Standards; OMB, 2000). As a whole, these definitions map on most directly to the demographic- and spatially-based theories of rural. All three definitions are derived directly or indirectly from population size and density, and relation to a CBSA. The Metro-Centric Locale Codes additionally distinguish among types of incorporated places (e.g., central city vs. town) and census-designated places. The OMB and RUCA definitions additionally take commuting patterns into account. The RUCA definition goes further by distinguishing areas based on their primary and secondary flows.[6] In their full form, the Metro-Centric Locale Codes and RUCAs provide a much finer-grained measure of rurality than the OMB classification. However, for practical reasons, researchers often combine the codes into considerably fewer categories. Consequently, differences among definitions become less pronounced. For this illustration we used a two-category classification scheme (urban vs. rural) that was obtained from the Rural and Low-Income School Program for the Metro-Centric Locale Codes (codes 1-5 were designated as urban; all other codes were designated as rural; U.S. Department of Education, Office of Communications and Outreach, 2012), the WWAMI RHRC website for the RUCAs (codes 1.0, 1.1, 2.0,2.1, 3.0, 4.1, 5.1, 7.1, 8.1, and 10.1 were designated as urban; n.d.-c), and based on common practice by many federal programs for the OMB classification (metropolitan counties were designated as urban; Coburn et al., 2007). Note that the two-category classification scheme for the RUCAs is an approximation of the two-category classification scheme for the OMB definition, but at the census tract level (WWAMI RHRC, n.d.-c).

Analyses were performed in M*plus* Version 6.1 (Muthén & Muthén, 1998-2010). Syntax is available from the first author upon request. We first analyzed a set of single-level models that ignored the dependency among observations. We then estimated a set of multilevel models that accounted for the nesting of children within geographic units (where the geographic unit varied by definition). Finally, we estimated the same multilevel models but additionally controlled for child- and location-level SES. Analyses were limited to cases with complete data on all the variables of interest, which resulted in an effective sample size of 12,270 children, 2,440 schools, 2,240 census tracts, and 290 counties.[7]

Results

Approximately 14% of sample schools were classified as rural based on the Metro-Centric Locale Codes, 11% of sample census tracts were classified as rural based on the RUCAs, and 19% of sample counties were classified as rural based on the OMB definition. Although there was

[5]The ECLS-K dataset does not include the newer Urban-Centric Locale Codes.

[6]See the respective sources for a more complete description of each definition's codes.

[7]Sample size numbers have been rounded to the nearest 10 per Institute of Education Sciences' restricted-use data reporting guidelines.

considerable overlap among definitions, cross-classification did occur. Four percent of rural schools were located in urban census tracts, and 3% of urban schools were located in rural census tracts. In addition, 4% of rural schools were located in urban counties, and 5% of urban schools were located in rural census tracts. Finally, 2% of rural census tracts were located in urban counties, and 4% of urban census tracts were located in rural counties. The estimated ICCs indicated that 33% of the variance in science scores existed at the school level or higher, 32% existed at the census tract level or higher, and 15% existed at the county level or higher.

Table 2 provides the model-estimated means and mean differences in third grade science scores across rural definitions. The results corresponding to the first set of analyses are listed under "Single-Level, SES Omitted." There was a significant mean difference in science scores between urban and rural counties based on the OMB classification (B = -0.07, SE = 0.02, $p < .001$) such that urban counties tended to outperform rural counties. There was no significant difference in science scores between urban and rural schools based on the Metro-Centric Locale Codes (B = 0.02, SE = 0.02, $p = .308$) or between urban and rural census tracts based on the RUCAs (B = -0.03, SE = 0.02, $p = .150$). The results under "Multilevel, SES Omitted" correspond to the second set of analyses. Urban counties significantly outperformed rural counties based on the OMB classification (B = -0.13, SE = 0.06, $p = .031$). In contrast, rural schools significantly outperformed urban schools based on the Metro-Centric Locale Codes (B = 0.10, SE = 0.03, $p = .003$). There was no significant difference between urban and rural census tracts based on the RUCAs (B = 0.05, SE = 0.04, $p = .185$). The results under "Multilevel, SES as Covariate" correspond to the final set of analyses. Upon controlling for child- and location-level SES, all three definitions indicated that rural locations significantly outperformed urban locations (B = 0.20, SE = 0.02, $p < .001$ for the Metro-Centric Locale model; B = 0.19, SE = 0.03, $p < .001$ for the RUCA model; and B = 0.12, SE = 0.04, $p = .004$ for the OMB model).

Discussion

As evidenced by our demonstration, the statistical model (single-level vs. multilevel model), rural definition (the indicators used to define rural, the geographic unit to

Table 2

Estimated Means and Mean Differences in 3rd Grade Science Scores for "Rural" and "Non-Rural" Locations

	Single-Level, SES Omitted			Multilevel, SES Omitted			Multilevel, SES as Covariate		
	B	SE	*p*	B	SE	*p*	B	SE	*p*
Metro-Centric Locale Codes									
Mean Urban Science Score	-0.33	0.01	< .001	-0.40	0.02	< .001	-0.38	0.01	< .001
Mean Rural Science Score	-0.31	0.02	< .001	-0.30	0.03	< .001	-0.18	0.02	< .001
Mean Difference	0.02	0.02	.308	0.10	0.03	.003	0.20	0.02	< .001
RUCAs									
Mean Urban Science Score	-0.32	0.01	< .001	-0.40	0.02	< .001	-0.37	0.01	< .001
Mean Rural Science Score	-0.35	0.02	< .001	-0.34	0.03	< .001	-0.19	0.02	< .001
Mean Difference	-0.03	0.02	.150	0.05	0.04	.185	0.19	0.03	< .001
OMB Classification									
Mean Urban Science Score	-0.31	0.01	< .001	-0.26	0.03	< .001	-0.33	0.02	< .001
Mean Rural Science Score	-0.38	0.02	< .001	-0.38	0.05	< .001	-0.21	0.04	< .001
Mean Difference	-0.07	0.02	< .001	-0.13	0.06	.031	0.12	0.04	.004

Note. B = unstandardized estimate of mean or mean difference. The third set of analyses controlled for child-level and location-level (school-level, census tract-level, or county-level) SES, where SES was grand-mean centered.

which the definition was applied, and the way in which the codes were combined),[8] and exclusion/inclusion of covariates greatly impacts parameter estimates and substantive conclusions. If this study was real and we had used a single-level or multilevel model based on the OMB definition without consideration of SES, we would have concluded that urban locations tend to have higher science test scores than rural locations. If we had instead used a single-level model without consideration of SES based on the Metro-Centric Locale Codes, or a single-level or multilevel model without consideration of SES based on the RUCAs, we would have concluded that urban and rural locations tend to perform equally well. Finally, if we had used a multilevel model without consideration of SES based on the Metro-Centric Locale Codes, or if we had taken into account SES and used a multilevel model based on any one of the rural definitions, we would have concluded that rural locations tend to have higher science test scores than urban locations.

Rather than try to provide a substantive interpretation of these results, we use this exercise instead to comment on the appropriateness of the various definitions and analytic decisions given the context of our demonstration. With respect to operationally defining rural, the Metro-Centric Locale and RUCA definitions are preferred over the OMB definition, as the OMB definition was not designed to make inferences about rural areas (OMB, 2013). In addition, the OMB definition is applied at the county level, and counties tend to be much more heterogeneous than schools and census tracts. Choosing between the Metro-Centric Locale and RUCA definitions is less clear and would require careful theoretical consideration by subject-matter researchers. Of course, a different definition altogether may be more appropriate given an alternative theoretical perspective. With respect to the various modeling approaches, the multilevel models are more appropriate than the single-level models because they account for similarities among children who are nested within the same geographic location. Likewise, including relevant covariates is preferred over examining the rural effect in isolation, as covariates help to disentangle seemingly rural differences from differences that are actually explained by other variables such as SES.

Conclusion

Due to the many theoretical perspectives and operational definitions of rural, rural researchers must shoulder extra responsibility to ensure that their work is maximally informative and easily replicable. To this end, we noted throughout our discussion that researchers should familiarize themselves with the most common definitions available today, and choose (or develop) a definition that, above all else, reflects their theoretical perspective. Supplemental considerations, such as the feasibility of a definition given the structure of the data and the intended analyses, are also important. Since rural research typically involves clustered data (e.g., children within classrooms, schools within counties), we described multilevel modeling as a potentially useful means for analyzing rural data. We also encouraged the use of covariates to account for additional variance in the model and rule out alternative explanations to rural phenomena. Finally, we reminded researchers to fully communicate the rural nature of their study, from their theoretical perspective and choice of an operational definition to situating their research findings within the context of other rural definitions. This approach provides the necessary detail to spur replication and encourage inclusion in meta-analytic work.

Researchers also need to be cognizant of how modeling decisions and the choice of an operational definition of rural affect research outcomes and policy decisions. Using the ECLS-K dataset, we demonstrated the extent to which parameter estimates and substantive interpretations can differ across statistical models, rural definitions, and exclusion/inclusion of covariates. Inappropriate selection, analysis, and/or communication of the rural definition may result in misinformed conclusions about rural phenomena, which in turn may result in misinformed policy and program eligibility decisions.

It is our hope that this article has provided researchers, both new and seasoned, with firm guidance in several critical aspects of rural research. We believe that more consistent and informed consideration of the presented guidelines will enhance and clarify the quantitative literature on rural education. We strongly encourage qualitative and mixed-methods researchers to continue our conversation on rural in order to provide a more complete set of guidelines. In addition, we encourage conversations such as those of Howley et al. (2005) that extend beyond a particular method. A blending, or at least a comparison, of perspectives is desired. Finally, we certainly acknowledge that rural education research is complex and each study is unique. There is no simple solution to the issues presented in this article. Informed and deliberate decision-making should always trump strict adherence to guidelines.

[8]Our comparison of the three rural definitions is confounded in the sense that we do not know whether the observed differences are due to differences in the indicators used to define rural, the geographic unit to which the definition was applied, or the way in which the codes were combined. Rather than using existing definitions, researchers could create new definitions that are more comparable by fully crossing the levels of these three factors.

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