A Review of Common Limitations in Rural-Related Studies in the Peer-Reviewed Literature

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Introduction

Roughly a fifth of the U.S. population lives in rural communities, according to the 2020 U.S. Census.[1] Health disparities between rural and urban communities are persistent and exist across the lifespan.[2] For example, gaps in mortality rates between rural and urban communities are sizable and have increased over time.[3-5] Similarly, rural residents continue to experience a disproportionate burden of other negative health outcomes, such as cardiovascular, respiratory, mental health, and cancer-related outcomes.[6-9] Underlying social and economic factors such as limited health care access and transportation options contribute to rural health disparities.[2] High-quality data, research, and evidence are crucial to understanding and improving health outcomes in rural communities.

Health-related data provide valuable information for promoting the health of individuals and populations.[10,11] Derived from various sources (e.g., vital records, health care claims, and surveys),[12] data commonly underpin decision-making regarding population health, health care delivery, funding eligibility and allocation, reporting, and more. Despite their importance, there are known gaps in data, data limitations, and analytic challenges when conducting rural health research. Frequently used datasets, such as the American Community Survey and mortality data from the Centers for Disease Control and Prevention (CDC), may provide national, state, and large metropolitan estimates, but estimates for smaller and rural regions are often limited.[13-15] Additional challenges such as underreporting, small sample sizes, lack of resources for collecting data, and reporting delays further undermine the quality of available

Key Takeaways

- Published rural-related studies on health that use secondary, quantitative data reported a range of limitations. Common author-reported limitations included:
  - Missing, unmeasured, or proxy variables and confounding;
  - Under/over-reporting of variables, under/over-estimating of variables, or other measurement errors; and
  - Narrow generalizability, sample characteristics or representatives, or selection bias.
- Over one-third of rural-related studies described limitations specific to definitions of rurality or geographic measures. Various measures of rurality were used across studies, with Rural-Urban Commuting Area Codes and Rural-Urban Continuum Codes among the most common.
- Approximately one in five rural-related studies identified outdated data, delayed data, or other time-related limitations. A similar proportion reported limitations concerning sample size, statistical power, or data suppression.
- The high prevalence of rural-related studies in high impact, peer-reviewed journals underscores the importance of rural analyses, despite common limitations.

data.[13,14,16] Such challenges can hinder efforts to understand rural health issues and effectively target resources and interventions in rural communities. The need for reliable and timely data received renewed attention during the COVID-19 pandemic as well.[17]

Applying definitions of "rural" creates further challenges to using health-related data in rural communities.[2,15,18] Estimates suggest there are over 30 different rural definitions used by the federal government.[19,20] A recent review similarly indicated that rural definitions and the geographic levels of analysis may not be consistent across the body of health services research.[21] Rural definitions can influence the direction of research, policy, and practice.[20,22] Discrepancies between rural definitions, for example, can impact estimates of rural population sizes and the scale of disparities observed in rural areas.[22] While challenges specific to rural definitions have increasingly been documented, a systematic assessment of the broader challenges associated with using health-related data in rural communities is lacking. Understanding the range of limitations inherent to rural health data is critical in identifying strategies to overcome them.

This study sought to quantify and characterize limitations commonly reported in rural-related studies, with a focus on studies using secondary, quantitative data. We systematically reviewed a subset of the literature published in select peer-reviewed journals between 2019-2022. Study characteristics, secondary data sources, and author-reported limitations were summarized. Findings provide a thorough description of data-related challenges, which could be used by researchers, policymakers, and health data creators to improve rural health data and inform future initiatives relying on those data, including those at the national, state, local, or tribal levels.

Methods

Study Design

Guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) process,[23] this study systematically reviewed peer-reviewed literature that considered rurality to identify commonly reported limitations. This study was reviewed by the East Tennessee State University Institutional Review Board and was determined not to be human subjects research.

Eligibility Criteria

Multiple criteria guided the inclusion of studies, including publication details (e.g., year), rural focus, data and study design, and inclusion of limitations. The review was limited to original research studies, set within the U.S., published in English between 2019-2022, and published in one of the following peer-reviewed journals: *American Journal of Public Health*; *Health Affairs*; *Health Services Research*; *JAMA*; or *Journal of Rural Health*. These journals were selected for their history of publications involving rural communities, focus on health, and high impact factors. Specific to rurality, studies were required to include at least one rural-related keyword in the title or abstract and a measure of, description of, or otherwise clear focus on rurality or rural communities. Additionally, given the focus on secondary data, studies needed to include quantitative data from a secondary data source, including the use of a quantifiable outcome related to health. Studies limited to secondary data collected through randomized or other clinical trials were excluded due to unique considerations involved in the collection and use of

such data, and unique limitations to these study designs. Lastly, studies needed to include an identifiable section with author-reported limitations.

Search Strategy

A comprehensive search strategy was developed with the support of a health sciences librarian. The final strategy consisted of 1) key terms indicating a rural focus in the title or abstract, 2) journals of interest, and 3) the exclusion of select article types, such as commentaries and editorials. The librarian completed the primary search in February 2023 using PubMed, with a supplemental search completed in March 2024 to incorporate an additional journal. Additional filters were applied for year and language.

Screening for Inclusion

A two-step, team-based process was used to identify studies eligible for inclusion. First, reviewers screened the titles and abstracts of returned studies using an abbreviated set of the criteria above. As a pilot, an initial sample of 20 studies was randomly selected and independently screened. Any differences were discussed as a team until a consensus was reached, including refinement of the eligibility criteria where appropriate. The remaining studies were then randomly assigned to two teams of two reviewers. Two reviewers independently screened each study and discussed until a consensus was reached. Second, reviewers screened the full text of returned studies that were not excluded during the screening of titles and abstracts using the criteria above. As a pilot, an initial sample of 20 studies was again randomly selected and independently reviewed. Any differences were discussed as a team until a consensus was reached, including refinement of the eligibility criteria where appropriate. Each remaining study was randomly assigned and independently reviewed by one of the reviewers. In instances of uncertainty, a second reviewer also screened a study to finalize a determination of inclusion or exclusion.

Data Extraction

A structured, team-based process was used to extract elements of interest from included studies. Reviewers completed data extraction using Research Electronic Data Capture (REDCap).[24,25] Two pilot reviews with a random sample of 10 studies were conducted, with data extraction completed independently by reviewers. Any differences were discussed as a team until a consensus was reached, including revisions to the overall process to increase consistency across reviewers. The remaining studies were randomly assigned to three teams of two reviewers thereafter. For each study, data extraction was completed independently by two reviewers and discussed until a consensus was reached. In instances of uncertainty, a third reviewer examined specific data elements for confirmation. Following data extraction, preliminary results were reviewed and refined as appropriate to further increase consistency across teams.

Multiple elements were extracted from each study, including study characteristics, secondary data sources, geographic focus, and limitations, as reported by the authors. Elements generally had a set of pre-determination options, including options to specify for “other” and indicate unclear or not specified when needed. Key study characteristics included: topic area and study scope (e.g., national, state, or sub-state region). Secondary data sources and geographic focus included: types of data sources (e.g., survey or claims); primary geographic focus (e.g., rural only or rural and urban); and measures of rurality and

how they were operationalized (e.g., categorical or continuous). Lastly, types of author-reported limitations within a dedicated section of a publication were collected.

Data Analysis

Descriptive statistics were used to analyze key characteristics and author-reported limitations extracted from included studies. Given that many characteristics allowed for more than one option to be selected, categories were often not mutually exclusive. Sums may, therefore, exceed 100%.

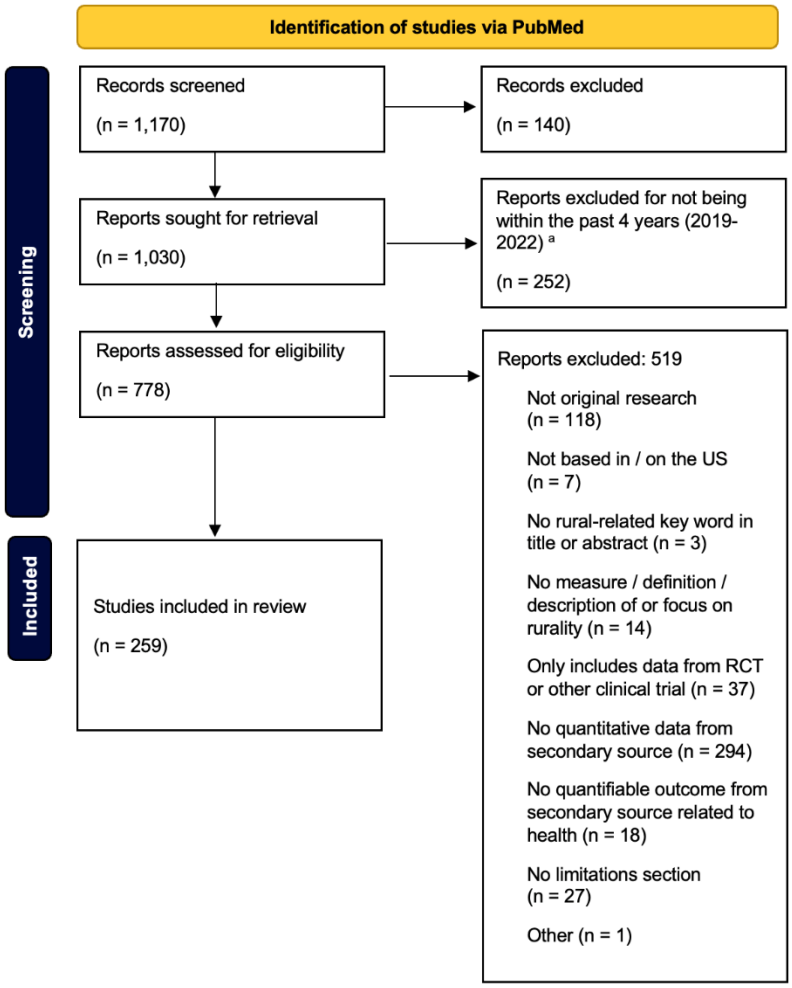
Limitations

This study has limitations that should be considered when interpreting its findings. Although this study provides a rigorous description of study limitations, it only considered limitations as reported by the authors of included studies within an identifiable section of a publication (e.g., one or more paragraphs in the methods or discussion section). Additionally, it only included studies that used quantitative, secondary data and were published in a selection of peer-reviewed journals. While all included studies considered both health and rurality, rural health was not always a primary focus. Similarly, identified limitations did not always have a rural lens; therefore, findings may not reflect the full scope of limitations inherent to rural health research. Given the focus on characterizing limitations as reported by authors, the methodological quality of included studies was also not examined. Additionally, this study only included studies that were published between 2019-2022. The COVID-19 pandemic emerged during this time period, which may have impacted publication trends. Also, this time period overlaps with the 2020 U.S. Census. This could have various implications for studies using Census data as these data underpin many rural definitions, and studies using 2010 U.S. Census data may have had a higher likelihood of reporting outdated data. Lastly, while screening and data collection procedures were completed by a team of trained reviewers and incorporated double review at multiple points, it is possible that relevant information was erroneously omitted, collected, or classified.

Results

The search strategy yielded 1,170 records for potential inclusion. After screening for eligibility, 259 full-text articles were included in the review (Figure 1).[26] Across the target journals, 166 included articles were published in the *Journal of Rural Health*, 38 in *Health Affairs*, 30 in *Health Services Research*, 15 in the *American Journal of Public Health*, and 10 in *JAMA*. They similarly spanned the publication years of interest (2019-2022), with most published in 2019 (n=64) and 2022 (n=93).

Figure 1. PRISMA Diagram for Included Studies



RCT= Randomized controlled trial

[a] The primary search strategy included a broader timeframe; however, this review was ultimately limited to studies published during 2019-2022, providing a current representation of limitations commonly reported in published studies.

Characteristics of Included Studies

Characteristics of the included studies are presented in Table 1. Studies addressed multiple topics, with the most common being the health care workforce or availability (n=78, 30.1%), mental or behavioral health (including substance use disorder) (n=49, 18.9%), and social determinants of health (n=36, 13.9%). Most studies were national in scope (n=187, 72.2%) and considered rural and urban communities (n=233, 90.0%).

Table 1. Characteristics of Included Studies

Study Characteristic	Count of Studies [a] N (%)
Main Topic [b]	
Health care workforce or availability	78 (30.1)
Mental or behavioral health (including substance use)	49 (18.9)
Social determinants of health	36 (13.9)
Cancer	33 (12.7)
Reproductive or maternal health	23 (8.9)
Health care financing	23 (8.9)
COVID-19	16 (6.2)
Health care quality	15 (5.8)
Emergency, trauma care, or injury	14 (5.4)
Telehealth or Health Information Technology	14 (5.4)
Chronic conditions or diseases	13 (5.0)
Health promotion, education, or behaviors	13 (5.0)
Infectious diseases	13 (5.0)
All cause, premature, or other mortality	11 (4.2)
Medicaid expansion	7 (2.7)
Oral health	5 (1.9)
End of life and related care	5 (1.9)
Other	25 (9.7)
Geographic Focus [c]	
Rural and urban	233 (90.0)
Rural only	26 (10.0)
Scope	
National	187 (72.2)
Single state	46 (17.8)
Subset of states	20 (7.7)
Sub-state region	6 (2.3)

[a] Some categories for study characteristics were not mutually exclusive. Totals may not sum to 100% or 259.
[b] A maximum of three main topics were identified per included study.
[c] These categories were designed to include similar terminology. For example, studies with a focus on non-metropolitan communities only would have been captured as rural only.

Table 2. Data Sources and Measures of Rurality Used in Included Studies

Study Characteristic	Count of Studies [a] N (%)
Secondary Data Source	
Administrative or medical records	137 (52.9)
Survey	129 (49.8)
Claims	42 (16.2)
Surveillance or disease registry	38 (14.7)
Vital records	22 (8.5)
Other	95 (36.7)
Measure of Rurality	
RUCA	62 (23.9)
RUCC	58 (22.4)
OMB-based definition	37 (14.3)
National Center for Health Statistics (NCHS) rural-urban classification scheme	34 (13.1)
Distance or time to provider/facility	31 (12.0)
Urban Influence Codes (UICs)	18 (6.9)
Federal Office of Rural Health Policy (FORHP) rural areas	13 (5.0)
Other U.S. Census-based definition [b]	12 (4.6)
Other	33 (12.7)
Unclear, unsure, or not specified [c]	18 (6.9)

RUCA = Rural-Urban Commuting Area Codes, RUCC = Rural-Urban Continuum Codes, OMB = U.S. Office of Management and Budget
[a] Some categories for data characteristics were not mutually exclusive. Totals may not sum to 100% or 259.
[b] This category was designed to exclude specific measures or definitions that may rely on U.S. Census data (e.g., RUCA Codes). Examples of U.S. Census-based definitions that could have been captured under this category include urbanized areas and urban clusters.
[c] This category includes studies with at least one measure of rurality that could not be identified.

Types of secondary data sources and measures of rurality used in included studies are presented in Table 2. Studies used various types of secondary data sources, with many studies using more than one source. Approximately half of the studies incorporated secondary data derived from administrative or medical records (n=137, 52.9%) or surveys (n=129, 49.8%, e.g., American Community Survey, American Hospital Association Annual Survey, or Behavioral Risk Factor Surveillance System). Additionally, over one-third of studies (n=95, 36.7%) incorporated secondary data derived from sources categorized as other. Examples of other sources included County Health Rankings & Roadmaps, Area Health Resources Files, and KFF. Like secondary data sources, studies used various measures of rurality, most of which were categorical measures. The most common measures included Rural-Urban Commuting Area (RUCA) Codes (n=62, 23.9%), Rural-Urban Continuum Codes (RUCC) (n=58, 22.4%), and any U.S. Office of Management and Budget (OMB)-based definition (n=37, 14.3%). Approximately 13% of studies used measures categorized

as other. Examples of other measures included population density, Critical Access Hospital designation, and self-reported measures.

Author-Reported Limitations

Types of identified author-reported limitations are presented in Table 3, with examples of commonly reported limitations in Table 4. Most studies identified missing, unmeasured, or proxy variables or confounding as a limitation (n=218, 84.2%). Additional commonly cited limitations focused on under/over-reporting of variables, under/over-estimating of variables, or other measurement errors (n=156, 60.2%) and generalizability, sample characteristics or representativeness, or selection bias (n=144, 55.6%). Notably, nearly 40% of studies specifically cited definitions of rurality or geographic measures as a limitation. Although identified in some studies, less commonly reported limitations included those concerning missing data (n=21, 8.1%) and data modeling or other statistical limitations (n=21, 8.1%).

Table 3. Author-Reported Limitations in Included Studies

Limitation Type	Count of Studies [a] N (%)
Missing, unmeasured, or proxy variables or confounding	218 (84.2)
Underreporting or underestimating, overreporting or overestimating, or other measurement errors	156 (60.2)
Generalizability, sample characteristics or representativeness, or selection bias	144 (55.6)
Definitions of rurality or geographic measures	101 (39.0)
Study design	97 (37.5)
Outdated data, delayed data, or other time-related limitations	54 (20.8)
Self-reported data limitations, including associated biases	53 (20.5)
Small sample size, data suppression, or limited statistical power	49 (18.9)
Missing data	21 (8.1)
Data modeling or other statistical limitations	21 (8.1)
Other type of limitation	9 (3.5)

[a] Categories for limitations were not mutually exclusive. Totals may not sum to 100% or 259.

Table 4. Examples of Common Author-Reported Limitations

Limitation Type	Example(s)
Missing, unmeasured, or proxy variables or confounding	• Cultural, behavioral, or other individual-level characteristics that may be relevant, but not available in the data source(s) • Unmeasured interventions or other changes that cannot be accounted for through the data source(s)
Underreporting or underestimating, overreporting or overestimating, or other measurement error	• Rates of health outcomes (e.g., COVID-19 prevalence rate) estimated based on testing or reporting, which may result in underestimation • Measurement of health outcomes based on data availability and quality, which may lead to the use of extreme outcomes (e.g., mortality)
Generalizability, sample characteristics or representativeness, or selection bias	• Data from a single hospital, health system, payer, state, or region may not be generalizable to the U.S. rural population
Definitions of rurality or geographic measures	• Assumptions based on available location information, even though the location of a health care provider or facility may not be the same as that of a patient • Dichotomizing or categorizing measures of rurality, which overlooks heterogeneity across the rural-urban continuum • Measures of rurality change over time
Study design	• Study designs are cross-sectional or descriptive in nature, leading to an inability to determine causality • Ecological fallacy, with conclusions drawn about individuals using aggregate data (e.g., county-level data)
Outdated data, delayed data, or other time-related limitations	• Challenges with timely availability of data, leading to analyses based on data that may not represent current trends • Data are limited to a single year
Self-reported data and associated biases or limitations	• Social desirability bias • Recall bias
Small sample size, data suppression, or limited statistical power	• Small numbers for subpopulations • Sample size limits the ability to detect differences or creates instability in estimates

Discussion

Health-related data inform policy and programming activities at the national, state, local, and tribal levels. While many of the challenges with data available for use in rural communities are generally understood, they have yet to be rigorously assessed in rural health research. This study reviewed published studies that considered rurality to describe the current state of limitations as reported in the peer-reviewed literature. Findings document a range of limitations inherent to studies using secondary data. They could inform strategies to overcome common challenges and advance the feasibility and quality of rural health research.

Found in over half of included studies, the most common author-reported limitations were: missing variables, proxy variables, or confounding; under/over-reporting, under/over-estimating of key variables

(e.g., outcome measures), or other measurement errors; and narrow generalizability, sample characteristics/representativeness, or selection bias. Although not exclusive to rural health research, these limitations can have nuanced implications when studying rural populations. Challenges stemming from variables not available within an existing dataset, for example, may undermine the ability to account for contextual factors (e.g., behavioral, cultural, or environmental) that may be particularly impactful in rural communities. Similarly, given the variation within and across rural communities, challenges stemming from the sampling methods originally used to collect data, for example, may reduce the applicability of findings to specific rural populations. Notably, the overall frequency at which these limitations were identified in included studies may, in part, reflect the focus on secondary data, whereby researchers must work within the constraints of existing datasets. Importantly, the prevalence of published studies from high-impact, peer-reviewed journals included in this review underscores the importance of rural analyses, despite common limitations.

Multiple measures of rurality were used across included studies. Consistent with a recent review focused on health services research,[21] RUCA was the most common measure of rurality, but no single measure was used in a majority of studies. Various challenges associated with the use of measures or definitions of rurality, including measures quantified in this review, have been described.[21,22,27-30] Examples include under/over-estimating the population in rural areas, geographic level of the data (e.g., county versus census tract), and stability over time. Despite recognition of such challenges, less than half of included studies described limitations specific to definitions of rurality or geographic measures more broadly, at least within a limitations section. Given that incomplete descriptions of such limitations could undermine appropriate interpretation of study findings, these potential gaps may highlight opportunities to strengthen the execution and reporting of rural health research.

Considerations for Rural Health Research

- **Consider specifying each measure of rurality used and any associated limitations.** Some studies lacked clarity on one or more measures of rurality used. Building on prior work,[18,20-22,30,31] researchers could not only clearly specify each measure of rurality used, but also why it was selected and how it was operationalized when feasible. Additionally, consideration could be given to describing limitations (and strengths) associated with the use of a specific measure.
- **Consider providing a thorough description of any secondary data sources used.** Studies incorporated a variety of secondary data sources. This inclusion underscores the range of potential data sources that can be leveraged for rural health research. To promote an understanding of potential limitations (and strengths) as well as potential use by future researchers with similar interests, researchers could clearly document each secondary data source used, including explicitly reporting the use of secondary data.
- **Consider comprehensively documenting limitations, including any rural-specific limitations, when appropriate.** Some full-text articles were excluded for not having an identifiable section on limitations. Across included studies, limitations sections also did not always include limitations that explicitly considered rurality. Researchers could comprehensively report data-related limitations inherent to their studies and, when appropriate, could expand any descriptions of limitations to include specific considerations for rural populations.

Policy Opportunities for Improving Rural Health Data and Analyses

Multiple opportunities to improve rural health data and health-related data more broadly have been discussed.[15-17,29,30,32,33] Some of these opportunities are longstanding yet remain relevant. Guided by the findings of this study and echoing prior literature where applicable, we highlight policy opportunities aimed at improving the quality and use of rural health data.

- Assessing the quality of commonly used datasets for rural analyses, including identification of major limitations (and strengths). Where feasible, identifying strategies to address those limitations and improve data quality (e.g., inclusion of appropriate measure[s] of rurality).
- Identifying strategies to improve the utility of and timely access to commonly used datasets for rural analyses, including publicly available and restricted datasets. For example, this could include strategies to reduce costs for accessing restricted datasets with geographic indicators or allowing approved access to restricted datasets to be transferred or shared when appropriate.
- Providing adequate funding and other resources to strengthen sampling and representativeness of rural populations (including rural sub-populations) in commonly used datasets, such as the American Community Survey and the Behavioral Risk Factor Surveillance System.
- Encouraging data owners, particularly those at the federal and state levels, to include measures of rurality and geographic indicators more broadly in publicly available and other commonly used datasets when feasible. The inclusion of measures of rurality with multiple levels and at different geographic levels could be particularly beneficial for rural analyses that combine datasets that may only be available at select geographic levels (e.g., county or zip code).
- Encouraging data owners to provide clear data documentation for data users that highlights the availability of any geographic indicators.
- Encouraging data owners, possibly in collaboration with rural health researchers, to develop guidance for data users aimed at promoting the exploration of differences in health-related outcomes by geography.
- Assessing the quality of rural analyses when using available evidence for decision-making, including identifying the implications of any limitations (and strengths) of the underlying data.

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