

Defining Urban and Rural Areas in U.S. Epidemiologic Studies

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ABSTRACT *Among epidemiologists, there has been increasing interest in the characteristics of communities that influence health. In the United States, the rural health disparity has been a recent focus of attention and made a priority for improvement. While many standardized definitions of urban and rural exist and are used by social scientists and demographers, they are found in sources unfamiliar to health researchers and have largely not been used in public health studies. This paper briefly reviews some available definitions of urban and rural for American geographic subunits and their respective strengths and weaknesses. For example, some definitions are better suited than others for capturing access to health care services. The authors applied different definitions to breast cancer incidence rates to show how urban/rural rate ratio comparisons would vary by choice of definition and found that dichotomous definitions may fail to capture variability in very rural areas. Further study of the utility of these measures in health studies is warranted.*

KEYWORDS *Epidemiologic measurements, Epidemiologic methods, Urban health, Urban population, Review, Rural health, Rural population.*

INTRODUCTION

In addition to spatial analyses of disease occurrence, there has been increasing interest among epidemiologists in the characteristics of communities that may influence health.¹ Multi-level or hierarchical models aimed at capturing the sociocultural context in which disease occurs have appeared with increasing frequency in the epidemiologic literature,² along with criticism.³ Environmental epidemiologic studies concerned with pollution or other exposures within a rural or urban environment continue to be conducted.⁴⁻⁷ In addition, in the United States, the rural health disparity has been a recent focus of attention and made a priority for improvement,⁸ while urban health is an emerging discipline.⁹ Concomitantly with these areas of research interest and activity, it is likely that “exposure” to urban and rural living will be increasingly studied. The need to describe areas as urban or rural for research purposes is not unique to epidemiology, and as such, definitions have been developed and used by economists, demographers, and political scientists for many years. However, they are defined and discussed in sources uncommonly used by health researchers. For their convenience, we discuss

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in this brief introductory review some available definitions of urban and rural for American geographic subunits, their respective strengths and weakness in health research, and provide suggestions for further research and reading.

Vlahov and Galea make a distinction between studying urbanization versus studying urbanicity. While urbanization refers to a process causing an increase in population size and density over time, urbanicity refers to elements and characteristics of urban areas at a given point in time, and it may be these whose effect on health is of interest.¹⁰ In epidemiologic studies, “urban” and “rural,” as variables of interest, are usually included as an acknowledged or unacknowledged proxy for some known or unknown feature of communities that influence health. For example, past research in urban health has attempted to capture community exposures within three themes: 1) aspects of the physical environment; 2) aspects of the social environment, and 3) access to health and social services.¹¹ Respectively, examples include exposure to air pollution, gang violence, and availability of mammography. Conversely, rural areas are sometimes characterized as the “counterfactual” urban experience. They may be defined by exclusion as an absence of urbanism, or may be thought to have distinct exposures of their own, such as those derived from agriculture and other rural industries, or a lack of access to health care. Complexities of study are many, as rural and urban may not necessarily be a dichotomy, nor is “rural” living necessarily a homogenous American experience across Maine, Alaska, and Alabama.¹²

Other researchers may be uninterested in the context and view urban or rural influences only as a nuisance factor whose measurement is necessary because its influence needs to be adjusted away. At the outset of the study, the investigator should be guided by a clear idea of what aspects of the urban and rural context are suspected to have influence. Specification of the research question may be especially difficult in urban health due to the complexities of studying confluent interdependent factors in a field marked by interdisciplinary approaches.⁹ In addition, as a community-level characteristic, the measurement of urban or rural may require investigators to employ multilevel/hierarchical modeling methods to correct for the lack of independence of the individual outcomes (if the study is not already ecologic in nature). These methods are well-described elsewhere.¹³ Researchers will also face limitations in the choice of scale, as the size of the geographic unit under study will affect the number of definitions available. Counties have the most available measures, while population density can be applied to any size land area if its population is counted. One definition of urbanization discussed below is available at the level of Census tracts. Another factor that will limit choices of scales is the time period under study; more definitions are available for the 1990 and 2000 Censuses than in years prior. It is important also to note that definitions change over time, and comparisons of estimates of urban and rural areas over time will be affected by these changes.

REVIEW OF AVAILABLE MEASURES

Population Density

Population density is a measure of urbanization defined in scale by the researcher, based on a distribution of population in an area of interest. It is typically calculated as resident population of a land area as listed in a census and divided by the size of land area. Since human populations are clustered rather than distributed evenly

across a land area, population density is greatly affected by the size of its denominator, the land area. Population density has been used in recent health studies to compare breast-conserving surgery rates for breast cancer patients in the U.S. versus the U.K.¹⁴; making international comparisons may be an advantage for the use of the population density measure as geographic and administrative regional delineations are not likely to be similar across countries. A choice of cutpoints is always difficult when faced with a continuously-scaled exposure and should be guided by the research question and the goals of the study. In the U.S. it is made more difficult as there is a tremendous range of population density: Overall density is 79.6 persons per square mile but 1.1 persons per square mile in Alaska versus 9,316.4 in the District of Columbia.¹⁵

In addition, a large-sized county such as those commonly found in the American West may serve to disguise a largely urbanized population. As illustrated by Goodall,¹⁶ Laramie County in Wyoming (containing the city of Cheyenne) has a population classified as 85% urban by the 1980 U.S. Census. The largest town in Marquette County, Wisconsin, is only 1,273 in population size, and by the Census its population is 0% urban. However, the population densities of the two counties are nearly identical (25.6 versus 25.7 persons per square mile), but the differences are obscured comparing population density.¹⁶ Population density also does not take into account proximity to more urbanized areas, which may be relevant to the health outcome under study. A remote rural area and a suburban area proximal to a large city may be equivalent in population density but vastly different in terms of access to care and exposures associated with an urban environment such as air pollution.

U.S. Census Urban and Rural

Unlike relative, user-defined definitions such as population density, standardized definitions of urbanization allow comparison of geographic areas across studies, with the assumption that the definition in question is internally valid across regions (not considered in this introductory paper). The U.S. Census has a dichotomous definition of urban or rural, based on a complicated algorithm that defines areas and population as urban or rural. The urban and rural designation is applied at a finer level than Census tracts, counties and Metropolitan Areas, such that populations and areas within these units may be assigned both urban and rural components. Also, ZIP Code Tabulation Areas (ZCTAs) were recently created for the 2000 Census, and some Census measures, including percent of population urbanized (from Population and Housing Characteristics, SF1-SF3), may be applied to these units.¹⁷ The Census urban/rural definition is modified from decennial Census to Census; the most recent definition for Census 2000 defines urbanized areas by the population density of interrelated geographic units and adds a new designation of "urban clusters," which have a smaller total population than urbanized areas (2,500–49,999 versus $\geq 50,000$, respectively). For both the 1990 and the 2000 definition, rurality is defined by exclusion (all areas not urban are rural) and for certain Census data products is additionally subdivided into rural farm and rural non-farm, with farm being those households who sold at least \$1000 in agricultural products and rural non-farm all else (Table 1).^{18–20} In the 2000 Census, 79% of the U.S. population of 281,421,906 persons lived in areas designated as urban, up from 75.2% in the 1990 Census and 73.5% in the 1980 Census.^{21,22} The majority of 2000 urban residents (86.5%) lived in urban areas rather than urban clusters.²³ Data and further details on assigning urban-rural delineations and differences between the 1990 and 2000 definitions are available at

TABLE 1. United States census definitions of “urban” and “rural,” 2000 and 1990

Definition	Urban	Rural
2000 Census	<ul style="list-style-type: none"> -Territory, persons and housing units located within an urbanized area (UA) or an urban cluster (UC). UAs & UCs consist of core census block groups or blocks that have a population density of at least 1,000 persons per square mile AND -Surrounding census blocks that have an overall density of at least 500 people per square mile. UAs have a minimum total population of 50,000, while UCs may be 2,500–49,999 in population. 	<ul style="list-style-type: none"> Territory, population, and housing units located outside of UAs and UCs For sample data Census products, rural is subdivided into: <ul style="list-style-type: none"> -Farm (a residence that earned \geq\$1,000 in agricultural product sales in 1999, at least one acre in size) -Non-farm (a residence that earned less or did not earn from agricultural sales)
1990 Census	<ul style="list-style-type: none"> -Territory, persons and housing units in places of 2,500 or more persons incorporated as cities, villages, boroughs (except in Alaska and New York) and towns (except in the six New England States, New York, and Wisconsin) excluding the rural portions of “extended cities” OR -Census designated places of 2,500 or more persons, OR -Other territory, incorporated or unincorporated, included in urbanized areas. UAs comprise one or more places (“central place”) and the adjacent densely settled surrounding territory (“urban fringe”) that together have a minimum of 50,000 persons. 	<ul style="list-style-type: none"> Territory, population, and housing units not classified as urban. For sample data Census products, rural is subdivided into: <ul style="list-style-type: none"> -Farm (a residence that earned \geq\$1,000 in agricultural product sales in 1989, at least one acre in size) -Non-farm (a residence that earned less or did not earn from agricultural sales)

Source: U.S. Bureau of Census.

www.census.gov. Examples of health research using the Census include a paper by Prehn and West,²⁴ who used the 1990 Census to assign urban/rural status to block groups in a study of the geography of breast cancer risk factors.

The limitations of the 1990 Census definition for health research have been considered previously.^{25–27} Briefly, economic interdependence that may be related to health care services is not considered, and as with other dichotomous definitions, variation within the category of ‘rural’ is not captured. A modification of the 2000 Census definition is that it is not limited by counties, Census tracts or even by places (meaning named cities or towns) allowing for more flexible small-area analyses; the lack of the definition being tied to counties was also an advantage in the 1990 definition.²⁷ In 1990, only the population size of a town or city was used to define urban, without regard for the size or density of surrounding areas, likely increasing the extent to which the 2000 Census definition can capture economic integration

when compared to the 1990 definition. As with the definition below, the use of a taxonomy with such a limited scale may mean ease of use but a lack of precision in measurement, particularly in the large population contained within the category ‘urban areas.’

Metropolitan Areas and Core-Based Statistical Areas

Metropolitan Areas (MAs) refer to a dichotomous definition of urbanization created by the White House’s Office of Management and Budget (OMB). Taking economic integration into account, a MA as defined in 1990 is an area that must have a city of at least 50,000 people plus 50,000 more in surrounding areas using population counts collected in the decennial Census.²⁸ The units that define MAs are counties (except in New England, where definitions are based on towns and cities). MAs may include several counties, but if at least half of a county is considered to have metropolitan characteristics (including the extent to which people commute to the “central core”), the entire county is annexed to the MA. For the 1990 definition, rural areas are defined by exclusion: All areas not in an MA are non-MA.

For use with the 2000 Census, the MA nomenclature was replaced with a new designation, Core-Based Statistical Areas (CBSAs).²⁹ These may be either Metropolitan Statistical Areas (MeSAs) (containing urbanized areas of at least 50,000 persons), or Micropolitan Statistical Areas (MiSAs) (containing urban clusters of 10,000 to 49,999 persons) (Table 2). The size of the core determines the MeSA or MiSA designation. A MeSA may be further subdivided into Metropolitan Divisions if there is a “single core” with a population of 2.5 million or more. As with the prior designation, economic and social interdependence is recognized, as counties adjacent to MeSAs or MiSAs are annexed if a certain proportion of the population works in the county considered central to the CBSA. Also, the units comprising the areas are counties, and those counties not part of a Metropolitan and without a Micropolitan area are considered “Outside CBSAs.” MeSAs and MiSAs may be

TABLE 2. 2000 Definition of core-based statistical areas (metropolitan, micropolitan) and non-core-based statistical areas (non-CBSA), U.S. White House Office of Management and Budget

Metropolitan	Micropolitan	Non-CBSA
A CBSA associated with at least one urbanized area that has a population of at least 50,000. Comprises the central county or counties containing the core (a densely settled concentration of population), plus adjacent outlying counties having a high degree of social and economic integration with the central county as measured through commuting.	A CBSA associated with at least one urban cluster that has a population of at least 10,000 but less than 50,000. Comprises the central county or counties containing the core, plus adjacent outlying counties having a high degree of social and economic integration with the central county as measured through commuting.	Not in metropolitan or micropolitan.

Source: U.S. Federal Register, December 27, 2000: Standards for Defining Metropolitan and Micropolitan Statistical Areas.

combined, if they are geographically contiguous, and if so are called Combined Statistical Areas. As with the last definition, a town and city based definition for New England is available (New England City and Town Areas) although the CBSA can also be applied.³⁰ The statistical areas are planned to be updated annually to correspond with population change; the most recent update at the time of this writing was December 2004 (released in February 2005, corresponding to Census estimates for 2002 and 2003), with prior updates in December 2003 and June 2003.^{31,32}

The vast majority of the U.S. population lives inside CBSAs. In the April 1 2000 Census estimate, 82.6 and 10.5% of the population were in Metropolitan and Micropolitan CBSAs, respectively, while 6.9% were outside CBSAs. States in the West North Central region (Iowa, Kansas, Minnesota, Missouri, Nebraska, North and South Dakota) had the largest proportion of population (18.3%) outside CBSAs, while the Pacific region (California, Oregon and Washington) had the smallest (1.7%).³³ The largest Metropolitan CBSA by population size was New York-Northern New Jersey-Long Island NY area (population 18,323,002), while the smallest was Carson City, NV (population 52,457).^{34,35} The proportion of population in Metropolitan areas increased to 83% in using the July 2003 population estimate.²³ OMB data for CBSAs are available at the U.S. Census website. Recent public health research has used the 2003 OMB taxonomy to study geographic patterns in unintentional deaths from drug poisoning, and showed differences by area.³⁶ Also, researchers at the Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System (BRFSS) have recently linked survey data with at least 500 respondents with metropolitan and micropolitan areas in a project called SMART: Selected Metropolitan/Micropolitan Area Risk Trends.³⁷

As with the U.S. Census taxonomy the use of a standardized definition enhances comparability of studies. Critiques of the 1990 MA nomenclature include potential underestimation of the population living in rural areas due to the annexation of mostly rural counties that border a metropolitan area.^{25,27} Conversely, if a city of 49,999 exists in an otherwise sparsely populated area, it would be classified as non-Metropolitan using the MA system under the 1990 definition, but would be called a Micropolitan Area under the 2000 definition. While the OMB definitions capture economic integration that may be important in capturing socioeconomic status and access to care, neither the 1990 or the 2000 definition characterize diversity in areas that are non-Metropolitan/Outside CBSAs. In addition, in the 2000 classification, there may be a tendency of researchers to combine Metropolitan and Micropolitan residents since both comprise CBSAs, when Micropolitan Areas may have rural characteristics of interest; further review of the new taxonomy may be found in a paper by Slifkin.³⁸ If rural areas are specifically of interest, for example when studying the rural health disparity, the following two measures are related to the OMB definition, but expand the scale at the rural end. Issues and practices around rural definitions have also been the focus of a recent review by Hart.³⁹

Urban Influence Codes (UICs) and Rural–Urban Continuum Codes (RUCCs)

Previously called the Parker–Ghelfi Urbanicity Codes, UICs are a 12-level county classification system developed by researchers in the Economic Research Service of the United States Department of Agriculture in order to better describe character-

istics of rural areas.^{40,41} The unit comprising UICs are counties, and their definition is tied to the OMB designation of CBSAs. In the codes released in June 2003 that correspond to the 2000 Census, counties are first defined as being in a Metropolitan area, a Micropolitan area or outside Metropolitan and Micropolitan areas (called here “Non-core”). Non-core counties are further subdivided based on adjacency and the presence of a town of at least 2,500 in size (an “own town”), with the assumption derived from “central place theorem” that adjacency confers an economic integration compared to non-adjacency (Table 3).⁴² 1993 codes are also available, based on the 1990 U.S. Census data for population and commuting characteristics.^{43,44} In both versions, adjacency is defined as physical adjacency but also by percent of population commuting—at least 2% of the population must commute to the Metropolitan or Micropolitan Area.

Rural-Urban Continuum Codes (RUCCs) (previously called the Beale codes) are a nine-level scale similar to UICs, as they are also at the county level but with a different treatment of non-core areas. Also designed by the Economic Research Service, the scale takes into account adjacency to a larger economy but does not consider the large or small size of the adjacent area in their definition for non-core areas. Rather, they count the entire urban population (as defined in the Census) within the county, rather than the city or town of largest size. Like UICs, the codes are issued decennially based on Census counts, and a prior definition for the 1990 Census issued in 1993 is available, as well as definitions for the 1970 and 1980 Censuses. Unlike the UICs, the 2003 RUCCs corresponding to the 2000 Census do not incorporate the new ‘micropolitan’ category into the scale (Table 4).⁴⁵

TABLE 3. 2003 Urban influence codes, economic research service, U.S. Department of Agriculture

Code	Description	Number of counties	Percentage (%) of U.S. population*
Metropolitan			
1	In large metro area of 1+ million residents	413	53.0%
2	In small metro area of less than 1 million residents	676	29.6%
Non-metropolitan			
3	Micropolitan adjacent to large metro	92	1.8%
4	Non-core adjacent to large metro	123	0.8%
5	Micropolitan adjacent to small metro	301	5.2%
6	Non-core adjacent to small metro with own town	358	2.8%
7	Non-core adjacent to small metro no own town	185	0.7%
8	Micropolitan not adjacent to a metro area	282	3.2%
9	Non-core adjacent to micro with own town	201	1.1%
10	Non-core adjacent to micro with no own town	198	0.5%
11	Non-core not adjacent to metro or micro with own town	138	0.8%
12	Non-core not adjacent to metro or micro with no own town	174	0.4%
Total		3,141	100.0%

*Using 2000 U.S. Census population estimate of 281,421,906.

Source: U.S. Department of Agriculture, Economic Research Service.

Further description of codes and code data for counties for both the 1993 and the 2003 versions can be downloaded from the Economic Research Service's website, www.ers.usda.gov. UICs may be more useful than RUCCs for research related to access to health care as the largest community within the population is more likely to reflect available health services than the total urban population in all cities and towns "...due to the structure of health care systems which involve threshold levels of institution size and complexity of the medical community based on the population of the largest city in a service area."²⁵ Although both UICs and RUCCs are presented as a numeric continuum, the scale is truly ordinal and must be treated as such in the analysis; there is no equal "distance" between levels. UICs were used recently to show that the residents in rural, non-adjacent areas visited their health provider less often than residents of other areas. The authors concluded that a non-dichotomous definition may reveal hidden variation.⁴⁶ Hawley used both RUCCs and UICs to describe the variation in colon cancer incidence and mortality rates in Texas and concluded that finer delineations on the rural end of the scales revealed heterogeneity in rates with respect to African-Americans.⁴⁷ Similarly, we found much lower rates of mammography-detected breast cancer in North Carolina (NC) in the most rural areas using the UIC taxonomy; these differences would have been attenuated had we used a dichotomous measure.⁴⁸ Researchers have also grouped the scales. In a study of adolescent pregnancy rates, Bennett et al.⁴⁹ used three (metropolitan,

TABLE 4. 2003 Rural–urban continuum codes, Economic Research Service, U.S. Department of Agriculture

Code	Description	Number of counties	Percentage (%) of U.S. population*
Metropolitan			
1	Counties in metro areas of 1 million population or more	413	53.0%
2	Counties in metro areas of 250,000 to 1 million population	325	19.7%
3	Counties in metro areas of fewer than 250,000 population	351	9.9%
Non-core			
4	Urban population of 20,000 or more -Adjacent to a metro area	218	5.1%
5	Urban population of 20,000 or more -Not adjacent to a metro area	105	2.0%
6	Urban population of 2,500 to 19,999 -Adjacent to a metro area	609	5.4%
7	Urban population of 2,500 to 19,999 -Not adjacent to a metro area	450	3.0%
8	Completely rural or less than 2,500 urban population -Adjacent to a metro area	235	0.9%
9	Completely rural or less than 2,500 urban population -Not adjacent to a metro area	435	1.0%
	Total	3,141	100.0%

*Using 2000 U.S. Census population estimate of 281,421,906.

Source: U.S. Department of Agriculture, Economic Research Service.

urbanized non-metropolitan, and rural non-adjacent) and compared the two extremes. Researchers may want to experiment and compare their results using the two scales, and group categories if results are similar. The lack of a micropolitan designation in the RUCC may prove a disadvantage if these areas or adjacency to them are of interest. A disadvantage for both taxonomies relates to scale in that that county units may be still too large a size to capture heterogeneity within pockets of a county that may be of interest. The measure described in the following is available a finer delineation of geography, Census tracts.

Rural–Urban Commuting Area Codes

When Census tracts are known, a finer level of measurement of urbanization is possible that incorporates the density of population, urbanization and daily commuting, the Rural-Urban Commuting Area (RUCA) codes, available for Census tracts. Developed by researchers at the USDA in collaboration with Health Resources Service Administration Office of Rural Health Policy and WWAMI Rural Health Research Center, RUCA codes are similar to the UICs and RUCCs in that they are based on the OMB nomenclature for metropolitan and micropolitan but further divide by the type of community to which commuting primarily “flows.”⁵⁰ Codes are available for the 1990 and 2000 U.S. Census estimates and may be downloaded at the www.ers.usda.gov website. Commuting codes are useful in health studies because the communities to which persons flow (for employment) may also be places where they receive health care. There are 10 primary and 30 secondary codes; the whole numbers (primary) refer to the primary commuting destination, the secondary codes refer to secondary flow (Table 5). Codes 2, 5, and 8 are codes for ‘high commuting’ areas (primary flow to a core, 30% or more share) while codes 3, 6, and 9 are ‘low commuting’ areas (primary flow to a core, but less than 30% share); codes 1, 4 and 7 have the single largest flow within themselves. The decimal place number refers to the size and destination of the second largest share of commuting flow. The codes are especially useful within non-core areas that may have some pockets of urbanization otherwise lost in the non-core designation. In addition, the codes can identify ‘bedroom’ communities as well as areas potentially urbanizing within non-core areas.⁴⁹

The numerous levels of RUCAs are unwieldy to work with, especially in multivariate models where they use up degrees of freedom, but are constructed to provide maximum flexibility for later combination. A recent paper used RUCA groupings defined by the authors to describe quality of life among urban, suburban, and rural veterans.⁵¹ Six examples of aggregation of the scale into four categories or fewer are available from rural health researchers at the University of Washington, along with recommendations for their use in health research.⁵² Their website contains further information and practical advice on use of the codes. In addition, the same researchers have constructed a ZIP code approximator of the codes for those persons whose census tract is not known. This may be helpful in situations in which an address may not be able to be assigned a Census tract due to missing street address information. The ZIP code approximator considers the RUCAs and the population distribution across all the Census tracts contained within a particular ZIP code and uses an algorithm to assign a RUCA code that best represents the population in that ZIP code. If more than 66.6% of the population is in one RUCA code, that code is assigned for the ZIP code. Further details of methodology and assignment statistics may be found at the website of this research group; approximators for the 1990 and 2000 Census are now available.⁵³

TABLE 5. Rural–urban commuting area codes for 2000 U.S. census tracts

-
- 1 Metropolitan area core: primary flow within an urbanized area (UA)
 - 1.0 No additional code
 - 1.1 Secondary flow 30 to 50% to a larger UA
 - 2 Metropolitan area high commuting: primary flow 30% or more to a UA
 - 2.0 No additional code
 - 2.1 Secondary flow 30 to 50% to a larger UA
 - 3 Metropolitan area low commuting: primary flow 5 to 30% to a UA
 - 3.0 No additional code
 - 4 Micropolitan area core: primary flow within an Urban Cluster of 10,000 to 49,999 (large UC)
 - 4.0 No additional code
 - 4.1 Secondary flow 30 to 50% to a UA
 - 4.2 Secondary flow 10 to 30% to a UA
 - 5 Micropolitan high commuting: primary flow 30% or more to a large UC
 - 5.0 No additional code
 - 5.1 Secondary flow 30 to 50% to a UA
 - 5.2 Secondary flow 10 to 30% to a UA
 - 6 Micropolitan low commuting: primary flow 10 to 30% to a large UC
 - 6.0 No additional code
 - 6.1 Secondary flow 10 to 30% to a UA
 - 7 Small town core: primary flow within an Urban Cluster of 2,500 to 9,999 (small UC)
 - 7.0 No additional code
 - 7.1 Secondary flow 30 to 50% to a UA
 - 7.2 Secondary flow 30 to 50% to a large UC
 - 7.3 Secondary flow 10 to 30% to a UA
 - 7.4 Secondary flow 10 to 30% to a large UC
 - 8 Small town high commuting: primary flow 30% or more to a small UC
 - 8.0 No additional code
 - 8.1 Secondary flow 30 to 50% to a UA
 - 8.2 Secondary flow 30 to 50% to a large UC
 - 8.3 Secondary flow 10 to 30% to a UA
 - 8.4 Secondary flow 10 to 30% to a large UC
 - 9 Small town low commuting: primary flow 10 to 30% to a small UC
 - 9.0 No additional code
 - 9.1 Secondary flow 10 to 30% to a UA
 - 9.2 Secondary flow 10 to 30% to a large UC
 - 10 Rural areas: primary flow to a tract outside a UA or UC
 - 10.0 No additional code
 - 10.1 Secondary flow 30 to 50% to a UA
 - 10.2 Secondary flow 30 to 50% to a large UC
 - 10.3 Secondary flow 30 to 50% to a small UC
 - 10.4 Secondary flow 10 to 30% to a UA
 - 10.5 Secondary flow 10 to 30% to a large UC
 - 10.6 Secondary flow 10 to 30% to a small UC
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Source: Economic Research Service, United States Department of Agriculture.

APPLICATION OF SCALES TO PUBLIC HEALTH DATA

Misclassification of exposure to urban or rural areas may be a greater threat to an ecologic study's validity when urbanization is more strongly associated with the outcome. For example, when we calculated age-adjusted invasive breast cancer

TABLE 6. Variation in “urban” and “rural” rates and rate ratios of age-adjusted breast cancer incidence per 100,000 women, white women, North Carolina, 1995–1999, by choice of county definition

Classification of county	Stage-specific rate	“Urban” rate	“Rural” rate	Rate ratio	Comparison
Population density* quintiles	Invasive	127.6	101.0	1.26	Most dense (≥ 194) vs. least (< 51)
	In situ	26.0	14.5	1.79	
Percent urban by U.S. Census, 1990	Invasive	132.3	105.8	1.25	$\geq 50\%$ urban vs. $< 50\%$ urban
	In situ	27.7	17.9	1.55	
Metropolitan/ non-metropolitan, 1990	Invasive	122.7	109.8	1.12	Metropolitan vs. non-Metropolitan
	In situ	24.5	17.5	1.40	
Urban influence codes, 1993 (grouped)	Invasive	122.7	104.0	1.18	UICs 1-2 (Metropolitan) vs. 7-9
	In situ	24.5	15.3	1.60	
Rural–Urban continuum codes, 1993 (grouped)	Invasive	122.7	98.9	1.24	RUCCs 0-3 (Metropolitan) vs. 8-9
	In situ	24.5	13.6	1.80	

*Mid-year, 1997, expressed in persons per square mile.

incidence rates among white women in NC for 1995–1999 using available measures for counties, urban/rural rate ratios did not vary appreciably by choice of scale (range: 1.12–1.35) (Table 6). For in situ breast cancers (detected through mammography and related to the availability of health care services), we initially observed a stronger relationship between very rural areas and lower screening-detected incidence compared to invasive breast cancers. In that instance, the choice of scale resulted in a wider range of rate ratios (1.40–1.80). Those definitions that used one category for rural (MSA, U.S. Census) obscured the lowest rates in the most rural areas compared to grouped RUCCs, grouped UICs and quintiles of population density. It is important to examine data across various definitions to look for hidden heterogeneity; more expanded scales may reveal health disparities in more rural areas.

CONCLUSIONS

Urbanization and characteristics of communities are increasingly considered in epidemiologic research. The goal of this brief review was to familiarize health researchers to the availability of various definitions for measuring urbanization in American geographic subunits. The use of the definitions presented above would enhance comparability of “exposure” to urban and rural contexts across studies and integrate existing rural health and geographic expertise into epidemiologic methods. Taxonomies in addition to those described above are available; see Hewitt’s²⁶ work for additional county-based definitions. Researchers at the University of Washington Rural Health Research Center also describe additional, less commonly-used typologies that may be of interest to readers.⁵⁴ In our data example, we found that dichotomous definitions masked hidden heterogeneity in very rural areas when we considered an outcome that was related to health care access. Further study of the performance of taxonomies in health research is warranted, as the utility of the scales may vary across U.S. regions and by research question. The U.S. has become increasingly populous and urban (from 39.6% urban in the 1900 U.S. Census to 79% in 2000—keeping in mind changing

definitions),^{10,22} so minimizing misclassification at the urban end of the scale may be more important in the future. However, a rural health disparity still persists and should remain a research priority, along with better methods to capture community characteristics associated with health outcomes across all community types.

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