

Rural health disparities in asthma care and outcomes

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Fifty-nine million Americans (21% of the US population) live in rural areas of the United States. Compared with persons living in urban areas of the United States, rural populations have lower income, a higher rate of government versus private insurance, and decreased access to health care. Although there are reports of lower asthma prevalence in rural areas, the majority of these data have been published on international populations, with few available studies looking at American urban versus rural asthma prevalence on a national scale or comparing rural with nearby urban cohorts in the United States. A large body of literature, mainly generated from studies of rural Europe, suggests that lower prevalence might be due to beneficial effects of exposure to farm environments, but the extent to which this applies to the rural United States, where a smaller proportion of the population engages in farming, is unclear. The United States has the additional covariate of having a higher proportion of African Americans, who have a greater asthma burden than whites independent of socioeconomic status, clustered in cities. There are data indicating that rural patients have increased difficulty obtaining health care in general and limited data suggesting that they receive inferior care for asthma. Future work is needed to more clearly define asthma prevalence and morbidity among residents of the rural United States, as well as to identify interventions effective in this population. (J Allergy Clin Immunol ■■■■;■■■:■■■-■■■.)

Key words: Asthma, rural health disparities, hygiene hypothesis

What is rural? The definition of *rural* varies somewhat, even among different agencies of the US government, but in general refers to those areas not included in a central city and its surroundings. In 2000, the Census Bureau defined *urban* as those census blocks with a population density of at least 1,000 persons per square mile plus the adjacent blocks with a density of at least

Abbreviations used

ISAAC: International Study of Asthma and Allergies in Childhood
OR: Odds ratio

500 persons per square mile; furthermore, an urbanized area had to include at least 2,500 persons.^{1,2} In the 2000 Census, 59.1 million persons, or 21% of the population, lived outside such areas and were classified as rural.²

ECONOMIC AND HEALTH DISPARITIES IN THE RURAL UNITED STATES

Apparent from the above definition is that rural areas are heterogeneous in terms of their proximity to urban resources, with those areas on the fringe of a city generally enjoying better economic circumstances than those that are more isolated. Overall, however, rural areas suffer from greater poverty than urban areas: 47% of rural residents have family incomes of less than 200% of the federal poverty limit versus 27% of nonrural residents, and the median family incomes in 2001 were approximately \$32,000 for rural residents versus \$44,000 for nonrural residents.^{3,4} Rural residents are less educated than urban residents: in the 2000 Census, 23% had not completed high school versus 19% of urban residents, and only 16% had completed college versus 27% of urban residents.⁵ There are fewer minority individuals in rural areas (17% in rural areas vs 49% in urban central cities vs 23% in urban areas outside of central cities), but those minorities are greatly disadvantaged: African Americans in rural areas have household incomes 40% less than rural whites and 60% less than suburban whites.³

Overall, 17% of the nonelderly rural population lacks insurance, but when rural counties adjacent to cities are excluded, the figure increases to 24%. Of those who are insured, a higher proportion is insured under public programs like Medicaid, the State Children's Health Insurance Program, and Medicare because of increased poverty.^{3,4} Consequently, hospitals operate on thinner margins, with approximately half of rural discharges paid by Medicare versus a third of suburban discharges. In addition, there are fewer physicians available: although 21% of the overall population is rural, only 9% of physicians practice in rural areas, with particular disparity in subspecialty care availability.³ Rural residents are 10% to 20% less likely than nonrural residents to receive preventive services like well-visit examinations, mammograms, and blood pressure, lipid, and colorectal cancer screening.^{4,6}

PREVALENCE OF ASTHMA IN RURAL VERSUS URBAN POPULATIONS

Given the disadvantages rural Americans face in the broader health care system, the first question regarding the effect of

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asthma in rural communities is the following: What is the relative prevalence of asthma in rural versus urban and suburban areas? There are surprisingly few studies addressing this question, most of them international. In the International Study of Asthma and Allergies in Childhood Phase III (ISAAC III), 13.8% of 13- to 14-year-olds and 10.8% of 6- to 7-year-olds worldwide carried a diagnosis of asthma. The prevalence is somewhat higher in North America, western Europe, and Australia compared with Africa, Latin America, and Asia, although this difference has narrowed since ISAAC I. Although these data, when viewed by country and region, suggest that asthma is more prevalent in more populous and industrialized areas, the ISAAC studies generally had 1 to a few centers per country that were always located in cities, and thus it is difficult to estimate worldwide asthma prevalence in urban versus rural areas from these data.⁷

Several international studies are available, however, that compare the prevalence of asthma in urban and adjacent rural areas, with all finding lower asthma prevalence in rural areas. Solé et al⁸ analyzed ISAAC III data of 13- to 14-year-olds from 2 Brazilian centers, Caruaru and Santa Maria, and found a significantly higher rate of wheezing ever, wheezing in the past 12 months, or lifetime asthma diagnosis in the children living in urban areas compared with those living in rural areas. Yemaneberhan et al⁹ conducted a household survey in Ethiopia of 9,844 persons from the urban preindustrial city of Jimma and 3,032 persons from 3 nearby rural communities. Although the observed prevalence rates were low overall, rates differed significantly for rural and urban groups for self-reported asthma (3.6% urban and 1.3% rural) and wheeze in the prior year (3.7% urban and 1.2% rural). Keeley et al¹⁰ examined reversible airways obstruction (which they defined as a 15% decrease in peak expiratory flow with exercise correctable with salbutamol) in urban versus rural children in Zimbabwe. The rate of reversible airways obstruction by this definition was 5.8% and 3.1% in the 2 urban populations, which is statistically significantly higher than the 0.1% rate observed in the rural population. Korzyrskyj and Becker¹¹ conducted a mail survey in Manitoba, Canada, in 2002-2003 of households with 7-year-old children and found that families reported asthma in 14% of urban children compared with 8% of children from northern and 10% of children from southern rural Manitoba. It should be noted that this survey was limited by a poor response rate.

There is a paucity of studies comparing asthma prevalence in rural communities in the United States with that seen in similar populations in nearby cities. In a study of Iowa schoolchildren, Chrischilles et al¹² conducted a mail survey using ISAAC questions of parents of 3,090 children ages 6 to 14 years in 2 rural Iowa counties. They found an overall prevalence of wheeze in the past 12 months of 19.1% and a prevalence of doctor-diagnosed asthma of 12.4%. In multivariate analysis controlling for age, sex, and county, children who lived on farms versus those who lived in towns in the same counties were less likely to ever wheeze (odds ratio [OR], 0.71; 95% CI, 0.58-0.87) or to have experienced wheeze in the last 12 months (OR, 0.77; 95% CI, 0.6-0.98).

Perry et al¹³ examined asthma prevalence in 2 school districts in the Delta region of Arkansas, an impoverished, rural, and medically underserved region of the United States. The majority of students were African American (97%) and had government-issued medical insurance (73%). Of the students completing the survey, which had an 81% response rate, 268 (28%) of 964 were considered at risk for asthma based on a previous physician

diagnosis or a validated asthma algorithm diagnosis. The at-risk population was highly symptomatic, and the majority (79%) had evidence of persistent asthma, with 82% reporting activity limitations, 59% reporting frequent nocturnal symptoms, and 49% either hospitalized or treated in the emergency department for asthma in the preceding 2 years. These findings not only suggest asthma prevalence higher than national rates but also reveal significant evidence of uncontrolled asthma in this rural, impoverished, predominately African American population.

Most of the large American asthma prevalence studies (American Lung Association Trends in Asthma Morbidity and Mortality 2007, National Asthma Survey 2003, National Survey of Children's Health, Hospital Discharge Data System, National Hospital Discharge Survey, and National Health Interview Survey) with datasets that could be analyzed to address national urban versus rural asthma prevalence in the United States unfortunately have not been used to assess rural asthma burden.^{14,15} In a report by Jackson et al¹⁶ at the Rural Health Research Center at the University of Washington that analyzed Behavioral Risk Factor Surveillance System data for 2003, these investigators found a lifetime prevalence of asthma in urban American counties of 12% versus 11% for rural counties ($n = 264,648$, $P < .001$).

From the available data reviewed above, asthma appears to be less prevalent in rural than in urban international areas and less convincingly so in the rural United States compared with urban areas of the United States. Rural US populations with a large proportion of minority or low-income residents seem, to the contrary, to have an exceptionally high prevalence of asthma. Furthermore, residents of the United States have a higher burden of asthma than residents of most areas of the developing world, regardless of urban or rural residence.

WHY MIGHT ASTHMA BE LESS PREVALENT IN RURAL AREAS OF THE UNITED STATES?

There are several potential explanations for an overall decreased prevalence of asthma in rural areas, including the higher beneficial exposure of rural populations to farming in general and endotoxin in particular and, in the United States, covariation of race with rural versus urban residence (see below).¹⁷⁻⁵⁴

The European farming hypothesis

Since Strachan's original article¹⁷ inversely relating household size to allergic rhinitis and eczema, a large body of evidence confirmatory of his hygiene hypothesis has emerged in studies of rural, mainly European farming communities. A number of these studies strongly support the idea that exposure to farming is one of the protective factors at work in rural populations. Riedler et al¹⁸ surveyed parents of 2,282 children aged 8 to 10 years in rural Austria and skin tested 1,137 of the children. In those rural children who lived on farms compared with rural children who did not live on farms, they found a lower prevalence of hay fever (3.1% vs 10.3%, $P = .0002$), asthma (1.1% vs 3.9%, $P = .017$), and positive skin test responses to 1 or more allergens, and ORs in a multivariate model accounting for parental education, living conditions, and diet remained significant until regular farm animal contact was added to the model. von Ehrenstein et al¹⁹ carried out a cross-sectional survey of parents of 10,163 children aged

5 to 7 years in 2 rural Bavarian districts using ISAAC questions. Comparing farmers' children with children of nonfarming rural parents, they found that the rate of hay fever and asthma decreased with additional farming exposure (no farming vs part-time farming vs full-time farming) and that the prevalence of any atopic disease similarly decreased in a dose-dependent fashion with increased farm animal contact. Ernst and Cormier²⁰ surveyed children 12 to 19 years old in school districts surrounding Quebec City, Canada, comparing 802 children from farming families with 397 nonfarming rural children and in multivariate analysis found a lower risk of current wheeze (OR, 0.70; 95% CI, 0.52-0.95), asthma (OR, 0.59; 95% CI, 0.37-0.95), and positive skin test reactivity (OR, 0.58; 95% CI, 0.46-0.75) in the children from farming families.

A few characteristics of the farm populations in these and other similar studies¹⁸⁻²² merit further comment. First, because asthma prevalence and morbidity increase with lower socioeconomic status,²³⁻²⁶ it is important that the farmers in the abovementioned studies do not represent a group with unexpectedly high socioeconomic status. Although median incomes were not given in these studies, the farm families always had lower levels of educational achievement compared with nonfarm control families, and educational level was controlled for in multivariate models. Additionally, European farmers do not appear to differ in wealth from their American counterparts; farming families on average earn approximately the median family income both in the United States and in much of western Europe.^{27,28}

Second, in the 2 studies that reported prevalence of a family history of atopy, it was significantly lower in farm children than in nonfarm children.^{19,21} This argues that in farming populations there might exist a "healthy worker effect," wherein atopic families would gravitate away from farming, preselecting for a less atopic farming population. Additionally, it might be that there is lower atopy among farming families because they have had a protective effect of farming for generations. However, this is a poorly studied issue²⁹ that clearly is not the only effect at work in farming families because nearly all of these studies accounted for family history of atopic disease in their multivariate models and still found reduced atopic disease burden in farmers' children compared with that seen in nonfarming rural control families.^{18,19,21,22} More broadly, there are no data to suggest whether a healthy worker effect might exert a net influence on urban versus rural asthma prevalence.

A large body of work has identified exposure to endotoxin as an explanatory factor as to why children from the same rural communities have a lower prevalence of atopic disease when the family is engaged in farming. Braun-Fahrlander et al³⁰ surveyed parents of children ages 6 to 13 years old in rural areas of Germany, Austria, and Switzerland and obtained blood samples and endotoxin measurements from dust from the children's bedding. Levels of endotoxin exposure were inversely correlated with hay fever, asthma, and the rate of positive blood IgE test results for specific allergens. When they exposed leukocytes from study children to LPS or staphylococcal enterotoxin B, production of TNF- α , IL-12, IFN- α , and IFN- γ was inversely related to the child's endotoxin load, indicating immune downregulation induced by environmental exposure to endotoxin.

The relevance of endotoxin exposure to the prevalence of asthma in the rural United States is uncertain.²³ Compared with the European Union, American farming is much more industrialized, involving many fewer persons working much larger plots of

land. In the United States about 3 million among 305 million Americans work part-time or full-time on farms (of whom 1 million are hired laborers, who represent a poor, heavily minority, and often non-English-speaking group of workers) versus 17.9 million among 490 million European Union residents (16.1 million of whom are the landholder or family of the landholder and thus more likely to live on the land they work).³¹⁻³³ In addition, the average American farm is 431 acres (174 hectares), whereas the average European Union farm is 51 acres (20.7 hectares).^{31,33} Thus a relatively smaller portion of the rural United States enjoys the intimate contact with the land that has been shown to be associated with a reduction in atopic disease in rural European populations.

Furthermore, applying European hygiene hypothesis data to explain a somewhat lower prevalence of asthma in rural versus urban areas of the United States assumes that rural American populations have higher endotoxin exposure than urban American populations. The environment in which many urban Americans live is arguably not any more sanitary than that of the surrounding rural areas, and urban American children are exposed to situations that might be expected to increase endotoxin exposure, such as day care, crowded schools, and multifamily housing.^{23,34,35} Two groups of investigators have measured endotoxin levels in urban American environments (New York City and Boston³⁶⁻³⁸), and interestingly, both groups observed a direct and not inverse correlation between endotoxin load and wheeze (although the correlation was inverse, as expected, for eczema rate vs endotoxin exposure). Although one of these studies³⁶ points out that the urban endotoxin levels they measured are several-fold lower than the levels measured in farm homes in European studies, they note that it is problematic to directly compare determinations made by different groups using different collection procedures and assays. As yet, there are no data comparing endotoxin levels inside average (ie, mostly nonfarm) rural American households to levels inside nearby suburban and urban dwellings.

Race as a covariate in rural-urban asthma prevalence in the United States

The covariation of race with urban or rural residence in the United States might account for lower asthma prevalence in rural areas because rural areas have a higher proportion of whites than urban areas, and African Americans have a higher burden of asthma.^{3,23} Nelson et al³⁹ conducted a telephone survey in 1992-1993 of an integrated middle-class community in Michigan and found a lifetime prevalence of asthma of 12% in school-age African American children and 6% in white children despite similar income and educational levels and low poverty rates in both groups. Miller⁴⁰ examined data from the 1988 National Maternal and Infant Health Survey and its 1991 longitudinal follow-up and found that as family income increased, asthma prevalence decreased among white but not African American children. These studies suggest that demographic and not strictly regional factors might play a significant role in differences in asthma prevalence in urban and rural areas of the United States.

Other potential explanations for lower asthma prevalence in the rural United States

Additional risk factors for the onset of asthma from childhood through young adulthood have been well characterized, including

increased serum IgE levels, perennial allergen sensitization (including dust mite, cockroach, dog, and cat), presence of atopy, exposure to tobacco smoke and other air pollutants, and winter viral infections/bronchiolitis.⁴¹⁻⁴⁹ Consistent with a lower prevalence of asthma in rural areas, there are limited data indicating that the rate of cockroach sensitization is higher in urban areas.⁵⁰ Data for the rate of dust mite sensitization in urban versus rural areas is mixed.⁵⁰⁻⁵² In contrast, bronchiolitis, which is a risk factor for the development of asthma, and smoking are both more prevalent in the rural United States than in the urban United States.^{47,53} Regarding other air pollutants that exacerbate respiratory disease, including nitrogen dioxide, particulates, and other organic compounds, some sources (vehicular traffic, and industry) are more prevalent in urban areas, whereas others (combustion of organic fuels in the home) are more prevalent in rural areas, and the net effect of this issue on rural versus urban asthma is unclear.⁵⁴

The factors reviewed above offer explanations for a somewhat lower prevalence of asthma in the rural United States compared with the urban United States. The higher prevalence of African Americans in US cities and the higher burden of asthma in this community independent of socioeconomic status seem to be salient explanations for some of the differences in urban and rural asthma prevalence in the United States. Although a large group of studies has shown endotoxin to be a factor explaining decreased atopic disease in rural populations, particularly in Europe, rural US populations have much less exposure to farming than their European counterparts, and it is unclear to what extent this factor is relevant in the United States.

DISPARITIES IN HEALTH CARE FOR RURAL ASTHMATIC PATIENTS

As discussed earlier in the review, rural Americans have decreased ability to access care for asthma because of both economic disparities (lower income and higher rates of uninsured, underinsured, and government-insured residents) and supply disparities (lower rates of preventive screening, suggesting difficulty accessing primary care, and lower relative supply of both primary care and specialist physicians in rural areas).^{3,4,6} Furthermore, rural residents who might otherwise be eligible for care must have the means to travel to the location of care. There is evidence that, compared with urban residents, rural Americans travel greater distances to obtain care,⁵⁵ and greater distance to care is a risk for poor health outcomes and increased morbidity and mortality,⁵⁶⁻⁵⁸ including for asthma.⁵⁹

There are limited direct data, both international and from the United States, indicating that those with asthma who live in rural areas receive inferior care for their asthma. Tong and Drake⁶⁰ used hospital discharge and mortality data to show a higher rate of asthma-related hospitalization and a higher case fatality rate for rural versus urban residents of New South Wales, Australia, in the 1980s and early 1990s, but this study did not attempt to control for confounding variables. Lum et al⁶¹ reviewed charts of 3,072 patients from 42 Canadian primary care practices and divided patients by urban or rural residence. The rural patients were more likely to be male, nonsmokers, and younger, but they made more emergency department visits (38% of charts vs 17%, $P < .001$) and received more specialist referrals, suggesting increased difficulty accessing primary care. Consistent with this is a retrospective claims review study by Smith et al⁶² of 1,474 urban children with Medicaid insurance in Hartford, Connecticut,

showing that children with more asthma-related primary care visits in the preceding 12 months had fewer asthma-related emergency department visits (particularly if they had also filled an inhaled corticosteroid prescription), whereas those with more asthma-related emergency department visits had a lower rate of primary care visits for any reason. Withy and Davis⁶³ analyzed emergency department insurance claims data for 7,064 Hawaiians by urban or rural residence and found that although urban and rural children had no difference in time to outpatient follow-up after an emergency department visit (suggesting equal access), rural adults were less likely than urban adults to have either a follow-up office or emergency department visit for asthma in the month after an emergency department visit.

Finally, for this review, we analyzed county-level data for yearly asthma hospitalization rate from a Tennessee Department of Health report on asthma in Tennessee⁶⁴ based on whether each county was an urban central county, a noncentral county within a Standard Metropolitan Statistical Area, or a rural county, as defined by the most recent Office of Management and Budget listing.⁶⁵ In the state report, data for all asthma-related discharges in Tennessee from 2004-2006 were obtained from the Hospital Discharge Data System database and were presented by the patient's county of residence and not the location of the hospital. When reorganized by urban or rural residence, these data show that in Tennessee, the total number of asthma-related hospitalizations per 100,000 persons per year is 133 in urban central counties, 120 in noncentral counties within the Standard Metropolitan Statistical Areas, and 160 in rural counties. We combined these county data with US Census data for county populations and poverty rates (Fig 1),⁶⁶ demonstrating that rural counties in Tennessee have a higher burden of poverty and that there is an association between poverty and asthma morbidity, as measured based on asthma hospitalizations. Whether these data indicate inferior ability to access timely and appropriate outpatient asthma care or a higher prevalence of covariates associated with worsened asthma is not known. Given the lower socioeconomic status of rural US populations compared with urban and suburban populations³⁻⁵ and previous work showing worsened asthma morbidity with lower socioeconomic status,²³⁻²⁶ differential urban-rural asthma morbidity is likely partly socioeconomic, independent of region of residence. In summary, although rural US populations have many socioeconomic disadvantages and are geographically isolated from health care, there are as yet only limited data, generally showing worsened asthma outcomes compared with urban residents, and further study in this area is needed.

CONCLUSIONS

There are 59.1 million persons living in rural areas of the United States. Although their experiences are heterogeneous, overall rural US populations face increased poverty and inferior health care for reasons related to insurance status and to poor access because of increased travel distance and lack of providers, particularly specialists. There are international data showing lower rates of asthma in rural areas, with limited confirmatory data regarding the rate of asthma in rural compared with urban areas of the United States. The available data suggest that asthma prevalence in the rural United States is greater than that seen worldwide and not as significantly different from that seen in urban areas as in other countries. The hypothesis of lower asthma prevalence in rural areas is consistent with a large body of work

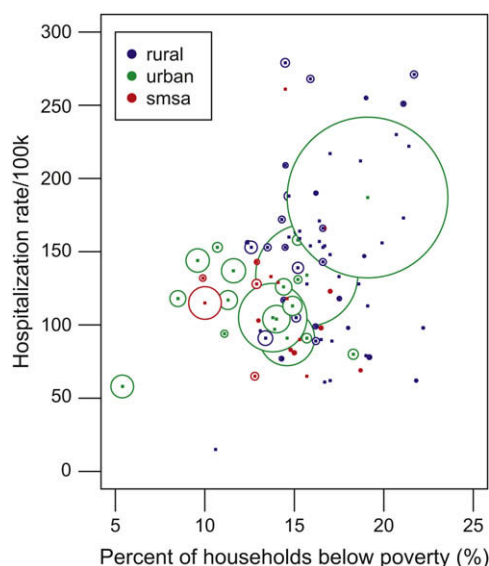


FIG 1. Yearly asthma hospitalization rate and poverty level by county in Tennessee. This bubble plot shows asthma hospitalization rates for residents of each county obtained from a Tennessee Department of Health asthma report⁶⁴ plotted against the percentage of county residents below the federal poverty level.⁶⁵ Each bubble (circle with a central dot) represents one of the 95 counties in Tennessee, and the size of the circle represents county population (the largest green circle is Shelby County [Memphis], the second largest is Davidson County [Nashville], and so forth).⁶⁶ The green circles are urban central counties within Standard Metropolitan Statistical Areas (by current Office of Management and Budget definition⁶⁵). The red circles are noncentral counties within the Standard Metropolitan Statistical Areas. The blue circles are rural counties. The plot shows that rural counties in Tennessee face higher burdens both of poverty and asthma hospitalization.

mainly conducted in Europe identifying farming in general, and endotoxin exposure in particular, as protective against the development of asthma, but the extent to which this paradigm applies to rural US populations is unclear. An additional factor in the United States that does not apply to European populations is that African Americans are more likely to live in urban than in rural areas of the United States and have higher rates of asthma, even after controlling for covariates such as socioeconomic status, place of residence, and income level. Thus higher asthma prevalence in the urban United States might be confounded by the disproportionate distribution of African Americans in urban areas.

The suggestion that asthma prevalence might be lower in rural regions of the United States is not tantamount to stating that asthma is not an important public health concern in rural communities. Rural patients with asthma face difficult challenges, including limited access to general medical care and poor access to specialized and urgent medical services, and there are limited data that they might in fact have a higher burden of asthma hospitalizations than others. Large-scale interventions to reduce morbidity and mortality among rural patients with asthma in the United States have not been designed or implemented, despite rural Americans representing one of the most highly disadvantaged populations in the United States.

FUTURE DIRECTIONS

The rural experience with asthma in the United States is insufficiently studied, and there are several areas that would

benefit from further work. First, there are currently no peer-reviewed studies analyzing national asthma prevalence data sets to develop good estimates of nationwide rural versus urban asthma prevalence, morbidity, and mortality, including accounting for the racial and socioeconomic covariates present in the United States. Second, there are no studies comparing endotoxin levels in urban and rural homes in the United States to assess the relevance of this issue to differences in American urban versus rural asthma prevalence. Finally, if rural Americans with asthma indeed represent a group with disproportionate asthma morbidity, there are few data to suggest which potential interventions (expanding government insurance programs on which rural Americans disproportionately rely, expanding transportation services for rural Americans, increasing incentives for primary and particularly specialist physicians to serve rural areas, and providing telemedicine services to rural Americans) would be most effective.

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