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ORIGINAL ARTICLE

A National Survey of Adult Asthma Prevalence by Urban-Rural Residence U.S. 2005

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Objectives. We analyzed national data to estimate asthma prevalence among U.S. adults by urban-rural residence and to determine the relative contributions of sociodemographic and health behavior characteristics on the probability of reporting asthma. **Methods.** We linked the 2005 Behavioral Risk Factor Surveillance System (BRFSS) to Urban Influence Codes (UICs), categorizing respondents into four urban-rural groups: metropolitan, adjacent metropolitan, micropolitan, and remote. BRFSS collects health data from all 50 states. UICs classify respondent's county as urban or rural based on population size and proximity to metropolitan areas. We calculated asthma prevalence estimates and generated odds ratios (ORs) for the probability of reporting asthma. **Results.** Overall asthma prevalence (7.9%; 95%CI = 7.73–8.08) was not statistically different ($p = 0.28$) by urban-rural residence. After adjusting for selected characteristics, adjacent metropolitan (OR = 0.96; 95%CI = 0.90–1.02) and remote (OR = 0.95; 95%CI = 0.85–1.05) residents were less likely—and micropolitan (OR = 1.04; 95%CI = 0.93–1.16) residents were more likely—to report asthma compared with metropolitan residents; but confidence intervals included null. **Conclusions.** Asthma prevalence is as high in rural as in urban areas. Certain demographic, behavioral, and health care characteristics unique to place of residence might affect asthma prevalence. Because these results substantially change our understanding of asthma prevalence in rural areas, further investigation is needed to determine geographic-related risk factors

Keywords asthma, urban population, rural population, Behavioral Risk Factor Surveillance System, urban influence codes

INTRODUCTION

As one of the most common chronic illnesses in the United States, asthma has a substantial public health impact. Over 20 million persons in the United States, including 6.2 million children, have asthma (1). Although asthma affects persons from all segments of the population, epidemiologic information continues to indicate that asthma disproportionately affects certain population subgroups more than others (e.g., children more than adults, women more than men, and blacks more than whites) (1–4). National surveillance summaries annually report wide variations in asthma prevalence between regions, states, and large metropolitan areas (3–6), but very little information is available on asthma prevalence in nonmetropolitan, suburban, and rural areas. Because known differences in asthma prevalence suggest potential differences in risk factors for disease occurrence and outcome, we posited that investigating the geographic variability of asthma onset and occurrence by urban and rural residence might lead to a better understanding of the environmental influences that contribute to the disease. Moreover, the information obtained might help reduce the overall burden of disease and eliminate its disproportionate impact, an overall goal of *Healthy People 2010* (7).

Most published findings on asthma prevalence and related risk factors come from geographically narrow studies conducted in urban areas. Results from a 2004 MEDLINE survey of asthma studies conducted between 1966 and 2004 reveal a strong emphasis on the urban population. Of the 280 references on asthma, 200 (71%) pertained to urban areas and

only 80 (29%) pertained to rural areas. Moreover, while 106 (53%) of the 200 urban studies were conducted in the United States, only 16 (20%) of the 80 rural studies were conducted in the United States (8). Given the preponderance of information on asthma prevalence from urban areas, the common belief is that asthma is more prevalent in urban than rural areas.

Studies focused on urban or rural areas suggest that among urban and rural residents, geographic variations in sociodemographic characteristics, and environmental exposures might contribute to disease prevalence and severity (9–23). Studies conducted in New York, Boston, and Chicago consistently find high asthma hospitalization rates among inner-city neighborhoods with low socioeconomic conditions and high minority populations (9, 10). Conversely, rural studies tend to compare rural farming and rural nonfarming environments and tend to have disparate results; these studies find both protective and adverse effects, depending on the timing and degree of extrinsic exposures (11–16).

Although national surveys such as the Behavioral Risk Factor Surveillance System (BRFSS) include respondents in rural areas, a national comparison of current asthma prevalence between urban and rural areas in all 50 states and the District of Columbia has not been performed (5, 6, 24). We analyzed data from BRFSS for the following reasons:

- to compare the sociodemographic and health behavior characteristics of urban-rural residents;
- to compare current asthma prevalence estimates between urban-rural areas; and
- to determine the relative contributions of place of residence sociodemographic, and health behavior characteristics on the probability of reporting current asthma.

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METHODS

The Behavioral Risk Factor Surveillance System (BRFSS) is an annual state-based system of health surveys established in 1984 by the CDC and state health departments to monitor the prevalence of health risk behaviors primarily related to chronic diseases and injuries. As the world's largest telephone survey, BRFSS uses a disproportionate, stratified sampling plan to survey the noninstitutionalized population 18 years of age and older in all 50 states, the District of Columbia, and the territories (24).

We used Urban Influence Codes (UICs) from the U.S. Department of Agriculture to categorize respondents with current asthma as urban-rural residents. These codes initially group the 3,141 U.S. counties into three basic groups based on the official metropolitan residence definitions announced by the Office of Management and Budget (OMB) in June 2003. These groups include metropolitan areas with an urban core of at least 50,000 people, micropolitan areas with an urban core of 10,000 to 50,000 people, and noncore areas with an urban core of less than 10,000 people. UICs further classify these three OMB groups into a total of 12 separate codes based on the population size of the largest city within each county and proximity to metropolitan or micropolitan areas. These codes define nonmetropolitan counties as adjacent to metropolitan counties if they abut a metropolitan area and have at least 2% of employed persons commuting to work in the core metropolitan area. UIC codes 1–2 correspond to metropolitan areas with “large” areas of at least 1 million residents and “small” areas with fewer than 1 million residents; UIC codes 3–7 correspond to micropolitan counties adjacent to metropolitan areas; UIC code 8 corresponds to micropolitan counties not adjacent to metropolitan areas; and UIC codes 9–12 correspond to noncore areas not adjacent to metropolitan areas (25).

All BRFSS survey respondents were asked the following questions: (1) “Have you ever been told by a doctor, nurse, or other health professional that you had asthma?” (2) “Do you still have asthma?” If respondents answered yes to both questions, we identified them with current asthma. We determined each respondent's county of residence by his or her response to “What county do you live in?” (26).

Using respondents' reported county of residence, we merged the 2005 BRFSS with UICs using the Federal Information Processing Standard (FIPS) county codes obtained from the 2005 BRFSS nonpublic use file (written request, July 2007) (24–26). To increase subgroup sample size and to increase statistical power, we grouped the 12 UIC categories into four urban-rural residence categories: one metropolitan category (UICs 1–2) and three nonmetropolitan categories (adjacent metropolitan [UICs 3–7], micropolitan [UIC 8], and remote [UICs 9–12]) (25). We analyzed these urban-rural residence categories from most urban to most rural, with the metropolitan category considered most urban and the remote category considered most rural. We excluded from further analysis respondents with missing county information.

In addition to the UIC stratifications, we analyzed several measures from the 2005 BRFSS core questionnaire to describe the population characteristics of each urban-rural residence category and to adjust for potential confounding from

three main variable groups: demographics (age, sex, race, and ethnicity, level of education, level of income, and state residence); modifiable behaviors (body mass index [BMI] and smoking status); and health care variables (health insurance coverage, “could not see a doctor because of cost,” and “has a health care provider”). To determine a respondent's race and ethnicity, all respondents were asked: (1) “Are you Hispanic or Latino?” and (2) “Which one or more of the following would you say is your race: white, black or African American, Asian, Native Hawaiian or Other Pacific Islander, American Indian or Alaska Native, other?” If respondents selected more than one answer, they were asked which one best represented them. Based on the respondent's selection, we classified respondents as white only, non-Hispanic; black only, non-Hispanic; other, non-Hispanic; or Hispanic. We classified a respondent with BMI less than 18.5 kg/m² as underweight, 18.5 kg/m² to 24.9 kg/m² as normal weight, 25.0 kg/m² to 29.9 kg/m² as overweight, and a BMI of 30 kg/m² or more as obese. We classified smoking status into three groups: current cigarette smokers (respondents who have smoked at least 100 cigarettes in their entire life, and currently smoke); former cigarette smokers (respondents who have smoked 100 cigarettes in their entire life, but who no longer smoke); and never cigarette smokers (respondents who have not smoked at least 100 cigarettes in their entire life) (26). We selected these measures based on a literature review of population-based studies and on information available from BRFSS (9, 10, 17, 27, 28).

We analyzed all measures as categorical variables. For three variables (race and ethnicity, level of income, and BMI), the response was missing (i.e., coded as “do not know,” “not sure,” refused, or missing) for more than 200 respondents (0.7%) with current asthma and for more than 3,000 respondents (0.9%) in the entire survey. To retain these respondents in further analyses, we created an indicator for missing by including an unknown category for each of these three variables. For the other variables, the number for whom the response was missing was 200 respondents (0.7%) with current asthma or less and 3,000 respondents (0.9%) or less in the entire survey. Since the number for the other variables was small ($\leq 0.7\%$ with current asthma and $\leq 0.9\%$ in the entire survey), we did not include an unknown category for these variables; and we excluded these respondents from further analyses.

For examining bivariate associations, we used chi-square tests to evaluate any differences in demographic, modifiable behaviors, health care, and self-reported asthma by urban-rural residence. We also used the chi-square test to evaluate differences in self-reported asthma by sex and by urban-rural residence. We used univariate logistic regression to identify selected characteristics as significant effectors for reporting current asthma and multivariate backward logistic regression of correlates to determine the effects on self-reporting current asthma by urban-rural residence. All analyses were weighted to adjust for variability in respondents' probability of selection, disproportionate selection of subgroups (compared with the state's population distribution), and item non-response (24). To account for the complex sample design, we conducted all analyses using SAS-callable SUDAAN to calculate 95% confidence intervals and *p* values (29, 30). We

TABLE 1.—Characteristics of US adults by urban-rural residence—2005 Behavioral Risk Factor Surveillance System.

Unweighted number	Unweighted number n = 341,932	Overall n = 341,932 (%)(SE)	Metropolitan n = 228,984 (%)(SE)	Adjacent Metropolitan n = 61,394 (%)(SE)	Micropolitan n = 28,442 (%)(SE)	Remote n = 23,112 (%)(SE)	p value for chi-square*
Age, in years							<0.01
18–24	17,236	13.0 (0.16)	13.0 (0.19)	13.1 (0.37)	13.4 (0.59)	12.7 (0.68)	
25–34	44,596	17.9 (0.14)	18.4 (0.17)	15.8 (0.29)	16.2 (0.45)	15.7 (0.58)	
35–44	60,881	19.8 (0.14)	20.3 (0.16)	17.9 (0.29)	17.8 (0.45)	17.5 (0.62)	
45–54	72,314	19.0 (0.13)	19.0 (0.15)	18.8 (0.28)	19.1 (0.42)	19.4 (0.49)	
≥ 55	146,905	30.2 (0.14)	29.3 (0.17)	34.3 (0.33)	33.4 (0.51)	34.7 (0.59)	
Sex							0.33
Male	130,923	48.5 (0.18)	48.6 (0.21)	48.1 (0.39)	48.0 (0.60)	49.4 (0.72)	
Female	211,009	51.5 (0.18)	51.5 (0.21)	51.9 (0.39)	52.0 (0.60)	50.6 (0.72)	
Race and ethnicity							<0.01
White only, non-Hispanic	273,203	70.1 (0.18)	67.3 (0.21)	82.3 (0.32)	80.0 (0.54)	82.0 (0.81)	
Black only, non-Hispanic	25,722	9.5 (0.10)	10.3 (0.12)	6.7 (0.18)	5.5 (0.27)	5.0 (0.33)	
Other, non-Hispanic	19,590	6.3 (0.10)	6.6 (0.12)	4.4 (0.18)	6.2 (0.30)	4.4 (0.27)	
Hispanic	20,368	13.3 (0.16)	14.9 (0.19)	5.8 (0.24)	7.5 (0.42)	7.5 (0.66)	
Unknown	3,049	0.8 (0.03)	0.8 (0.03)	0.8 (0.06)	0.8 (0.10)	1.2 (0.46)	
Level of education							<0.01
Did not graduate high school	35,248	12.0 (0.14)	11.4 (0.16)	13.8 (0.27)	13.6 (0.46)	16.6 (0.64)	
Graduated high school	105,513	29.9 (0.16)	28.0 (0.19)	39.2 (0.38)	35.2 (0.58)	37.4 (0.67)	
Attended college or technical school	90,204	26.3 (0.15)	26.3 (0.18)	26.0 (0.34)	26.8 (0.53)	26.3 (0.67)	
Graduated college or technical school	110,239	31.6 (0.15)	34.0 (0.18)	20.8 (0.28)	24.2 (0.47)	19.4 (0.49)	
Unknown	728	0.3 (0.03)	0.3 (0.03)	0.2 (0.03)	0.1 (0.03)	0.3 (0.09)	
Level of income							<0.01
Less than \$25,000	89,255	23.9 (0.16)	22.7 (0.19)	28.6 (0.35)	28.3 (0.57)	31.3 (0.67)	
\$25,000 to less than \$50,000	91,199	25.2 (0.15)	24.1 (0.17)	29.8 (0.34)	28.6 (0.53)	29.7 (0.61)	
\$50,000 or more	115,724	37.8 (0.17)	40.3 (0.20)	27.7 (0.34)	29.5 (0.52)	23.7 (0.64)	
Unknown	45,754	13.1 (0.12)	12.9 (0.14)	13.9 (0.27)	13.6 (0.41)	15.3 (0.55)	

*Based on a chi-square test with the null hypothesis that the proportion of adults in each characteristic category is the same for each Urban Influence Code category.

used PROC CROSSTAB to calculate chi-square tests and PROC RLOGIST to calculate crude and adjusted odds ratios for current asthma. For all analyses, an alpha (α) = 0.05 was considered significant (30).

RESULTS

In 2005, BRFSS collected records on 349,901 respondents from the 50 states and the District of Columbia; of these, 7,969 (2.3%) respondents were excluded from our analysis for not having county information. Among the remaining 341,932 respondents, the bivariate analyses for demographic measures by urban-rural residence showed significant differences in distribution frequencies for age, race, and ethnicity, level of education, and level of income (Table 1). As compared with adults in the metropolitan areas, a higher percentage (over 33%) of adults in the nonmetropolitan areas (adjacent metropolitan, micropolitan, and remote areas) was 55 years of age or older. Compared with the metropolitan areas, each of the nonmetropolitan areas also had higher proportions (80% or greater) for white-only, non-Hispanic adults, and lower proportions for black-only, non-Hispanic, and Hispanic adults. For each of the four urban-rural categories, comparing proportions of adults in the lowest level of education category (did not graduate high school), and in the lowest level of annual household income category (less than \$25,000), the highest proportions were in the remote area.

Among the 341,932 survey respondents with information on county of residence, current asthma was identified in 29,249 respondents. We stratified the 29,249 respondents with current asthma by urban-rural residence: 19,653 (67%) of respondents lived in metropolitan counties and 9,596 (33%) of respondents lived in nonmetropolitan counties. Among those with current asthma, 5,344 (18%) lived in counties adjacent to metropolitan areas, 2,386 (8%) lived

in micropolitan counties, and 1,866 (6%) lived in remote counties not adjacent to metropolitan areas (Table 2).

Weighted Prevalence

In 2005, 7.9% of the civilian noninstitutionalized population 18 years of age and older in all 50 states and the District of Columbia reported current asthma. Among the four categories of urban-rural residence, current asthma prevalence was highest in micropolitan areas (8.6%) and lowest in metropolitan areas (7.8%); however, these prevalences were not statistically different ($p = 0.28$) (Figure 1). Although current asthma prevalence was higher among women than men in each of the four urban-rural categories, the prevalences among women were not statistically different for each of the four urban-rural categories; but the prevalences among men were statistically different ($p = 0.01$) with the highest prevalence (7.5%) among men in micropolitan areas (Figure 2).

The bivariate analyses for demographic, modifiable behaviors and for health care measures showed significant differences in the distribution frequencies for all characteristics except having a health care provider (Table 2). When compared with adults in the metropolitan area, the remote area had higher percentages for the following categories: 55 years of age or older, white only, non-Hispanic, did not graduate high school, income less than \$25,000, current and former smoking status, no health insurance coverage, could not see a doctor because of cost, and lower percentage than the metropolitan area for normal weight.

Univariate and Multivariate Analyses

In univariate analysis, survey respondents in all three nonmetropolitan areas (adjacent metropolitan, micropolitan, and remote) were more likely to self-report current asthma compared with metropolitan residents (OR: 1.03,

TABLE 2.—Characteristics of US adults with current asthma, by urban-rural residence—2005 Behavioral Risk Factor Surveillance System.

Unweighted number	Unweighted number n = 29,249	Overall n = 29,249 (%)(SE)	Metropolitan n = 19,653 (%)(SE)	Nonmetropolitan			p value for Chi-Square*
				Adjacent metropolitan n = 5,344 (%)(SE)	Micropolitan n = 2,386 (%)(SE)	Remote n = 1,866 (%)(SE)	
Age, in years							<0.01
18–24	1,781	15.1 (0.54)	15.0 (0.61)	14.4 (1.27)	20.2 (2.98)	14.6 (2.48)	
25–34	3,941	17.6 (0.45)	18.2 (0.53)	15.2 (0.94)	15.5 (1.62)	14.1 (1.56)	
35–44	5,157	18.9 (0.43)	19.2 (0.50)	17.6 (0.90)	18.0 (1.58)	17.2 (1.52)	
45–54	6,221	18.6 (0.44)	18.8 (0.52)	18.6 (0.91)	16.4 (1.27)	17.4 (1.30)	
≥ 55	12,149	29.8 (0.47)	28.9 (0.55)	34.2 (1.11)	29.9 (1.77)	36.7 (2.02)	
Sex							0.02
Male	7,697	34.6 (0.59)	34.0 (0.68)	35.3 (1.30)	42.1 (2.56)	37.9 (2.30)	
Female	21,552	65.4 (0.59)	66.0 (0.68)	64.7 (1.30)	57.9 (2.56)	62.1 (2.30)	
Race and ethnicity							<0.01
White only, non-Hispanic	22,962	71.9 (0.58)	69.8 (0.69)	81.4 (1.09)	77.4 (2.51)	82.4 (1.79)	
Black only, non-Hispanic	2,445	10.6 (0.37)	11.7 (0.45)	6.7 (0.56)	6.2 (0.98)	4.2 (0.93)	
Other, non-Hispanic	2,063	6.8 (0.32)	6.8 (0.38)	5.5 (0.53)	9.1 (1.60)	7.7 (1.09)	
Hispanic	1,502	9.7 (0.47)	10.8 (0.56)	5.3 (0.89)	6.6 (2.20)	4.6 (1.23)	
Unknown	277	1.0 (0.11)	0.9 (0.13)	1.1 (0.22)	0.7 (0.26)	1.1 (0.40)	
Level of education							<0.01
Did not graduate high school	4,047	13.5 (0.41)	12.5 (0.48)	16.3 (0.88)	17.7 (1.77)	23.1 (1.90)	
Graduated high school	8,740	29.3 (0.52)	27.2 (0.59)	38.1 (1.26)	37.2 (2.48)	36.4 (2.17)	
Attended college or technical school	8,161	28.1 (0.52)	28.5 (0.61)	26.6 (1.11)	25.8 (2.05)	27.1 (2.18)	
Graduated college or technical school	8,240	29.1 (0.52)	31.8 (0.62)	19.0 (1.01)	19.3 (1.55)	13.4 (1.08)	
Unknown	61						
Level of income							<0.01
Less than \$25,000	10,275	30.4 (0.53)	28.1 (0.61)	37.8 (1.20)	43.2 (2.49)	43.1 (2.21)	
\$25,000 to less than \$50,000	7,209	24.5 (0.49)	23.8 (0.57)	27.8 (1.15)	25.5 (1.95)	26.3 (2.15)	
\$50,000 or more	7,976	32.2 (0.54)	35.3 (0.64)	21.0 (1.05)	19.9 (1.54)	15.6 (1.54)	
Unknown	3,789	12.9 (0.39)	12.9 (0.46)	13.4 (0.99)	11.3 (1.33)	15.1 (1.49)	
Body mass index, kg/m ²							<0.01
Less than 18.5 (underweight)	513	1.7 (0.14)	1.8 (0.17)	1.1 (0.20)	2.8 (0.68)	2.3 (0.61)	
18.5–24.9 (normal weight)	8,237	29.3 (0.54)	30.1 (0.63)	25.6 (1.10)	29.8 (2.59)	24.5 (1.72)	
25.0–29.9 (overweight)	8,868	30.9 (0.53)	30.6 (0.61)	32.3 (1.19)	28.8 (2.01)	33.8 (2.28)	
30.0 or more (obese)	10,130	33.5 (0.54)	32.9 (0.63)	37.0 (1.26)	34.7 (2.13)	33.5 (2.07)	
Unknown	1,501	4.6 (0.24)	4.7 (0.28)	3.9 (0.43)	4.0 (0.66)	5.9 (1.15)	
Smoking status							<0.01
Current	6,818	23.8 (0.49)	22.4 (0.55)	27.7 (1.17)	35.2 (2.71)	28.5 (1.97)	
Former	9,017	26.4 (0.48)	26.1 (0.56)	28.2 (1.08)	24.7 (1.70)	29.0 (1.86)	
Never	13,318	49.8 (0.58)	51.5 (0.67)	44.1 (1.28)	40.1 (2.18)	42.5 (2.31)	
Unknown	96						
Health insurance coverage							<0.01
Yes	25,759	86.5 (0.42)	87.5 (0.49)	84.2 (0.95)	79.9 (2.17)	79.4 (1.97)	
No	3,428	13.5 (0.42)	12.5 (0.49)	15.8 (0.95)	20.1 (2.17)	20.6 (1.97)	
Unknown	62						
Could not see doctor because of cost							<0.01
Yes	5,531	20.1 (0.48)	19 (0.55)	24.4 (1.12)	24.6 (2.51)	27.8 (1.96)	
No	23,648	79.9 (0.48)	81 (0.55)	75.6 (1.12)	75.4 (2.51)	72.2 (1.96)	
Unknown	70						
Has a health care provider							0.37
Yes	26,314	86.7 (0.45)	86.7 (0.53)	87.6 (0.90)	83.0 (2.45)	86.8 (1.48)	
No	2,886	13.3 (0.45)	13.3 (0.53)	12.4 (0.90)	17.0 (2.45)	13.2 (1.48)	
Unknown	49						

*Based on a Chi-square test with the null hypothesis that the proportion of adults in each characteristic category is the same for each Urban Influence Code category.

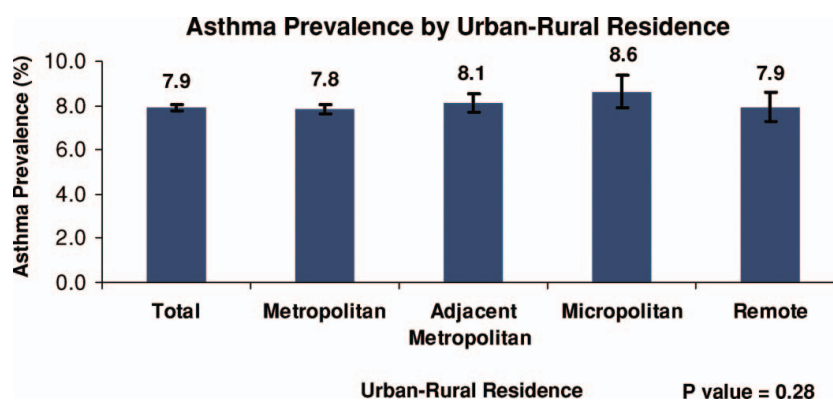


FIGURE 1.—Among the four categories of urban-rural residence, current asthma prevalence was highest in micropolitan areas (8.6%) and lowest in metropolitan areas (7.8%); however, these prevalences were not statistically different ($p = 0.28$).

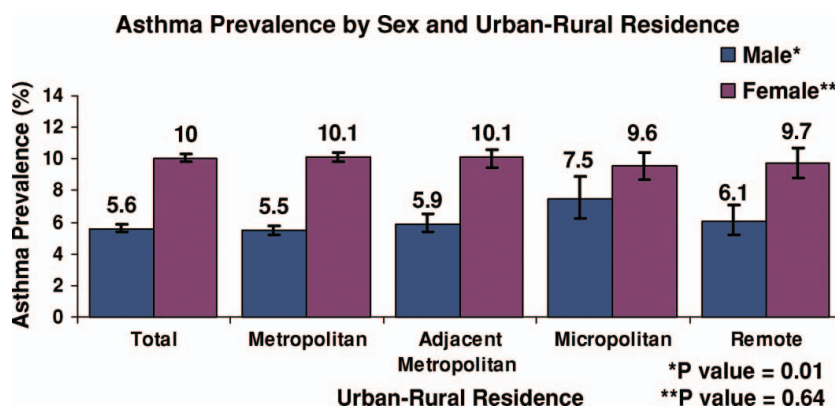


FIGURE 2.—Although current asthma prevalence was higher among women than men in each of the four urban-rural categories, the prevalences among women were not statistically different for each of the four urban-rural categories; but the prevalences among men were statistically different ($p = 0.01$) with the highest prevalence (7.5%) among men in micropolitan areas.

95% confidence interval [CI]: 0.97–1.09; OR: 1.10, 95% CI: 0.99–1.22; and OR: 1.01, 95% CI: 0.92–1.11, respectively); but confidence intervals included null (Table 3). Crude and adjusted odds ratios were determined for all demographic, modifiable behaviors, and health care measures included in the multivariate logistic model (Table 3). Risk factors significantly associated with reporting current asthma included age, sex, race and ethnicity, level of education, level of income, state residence, BMI, smoking status, health insurance coverage, could not see a doctor because of cost, and having a health care provider. After controlling for these risk factors in multivariate analysis, adjacent metropolitan (OR = 0.96; 95%CI = 0.90–1.02) and remote (OR = 0.95; 95%CI = 0.85–1.05) residents were less likely—and micropolitan (OR = 1.04; 95%CI = 0.93–1.16) residents were more likely—to self-report current asthma compared with metropolitan residents; but confidence intervals included null. Females were significantly more likely to report current asthma compared with males (OR: 1.81, 95% CI: 1.71–1.92); adults with annual household incomes less than \$25,000 were significantly more likely to report current asthma compared with adults who had annual household incomes of \$50,000 or more (OR: 1.52, 95% CI: 1.41–1.63); overweight and obese respondents were significantly more likely to report current asthma than those of normal weight (OR: 1.25, 95% CI: 1.18–1.34; OR: 1.98, 95% CI: 1.86–2.11); and respondents who could not see a doctor because of cost were more likely to report current asthma (OR: 1.72, 95% CI: 1.60–1.85). Respondents who did not have a health care provider were less likely to report current asthma (OR: 0.60, 95% CI: 0.55–0.66).

DISCUSSION

In this analysis of self-reported current asthma among adult respondents in a national BRFSS survey, we found similar asthma prevalence in urban and rural areas. After adjusting for sociodemographic and behavior characteristics, among residents in all four urban-rural groups we found no significant difference in the probability of reporting current asthma. This finding substantially challenges the common belief that asthma is more prevalent in urban than in rural areas.

Although urban residence has become a well-recognized risk factor for asthma prevalence and morbidity, more studies

have been conducted in urban than in rural areas (8). Urban correlates found in inner-city studies for asthma prevalence and morbidity include low levels of education and income, lack of health care coverage, poorly maintained housing, and cockroach and rodent infestations (9, 31). Although similar sociodemographic, health care, and environmental characteristics are found in rural areas, very few studies have been conducted to determine asthma prevalence in them (32).

In contrast to other chronic diseases, asthma is a complex inflammatory disease involving multiple pathophysiologic processes that place of residence might influence. Although the definitive causes of asthma remain undetermined, investigations identifying its etiologic pathways suggest that interactions of genetic factors with certain exposures might contribute to disease onset and recurrence (27, 28, 33–35). However, because genetic influences on disease evolve slowly, the observed similarities in disease prevalence between urban and rural residents are more likely related to environmental exposures than to genetic changes. While environmental exposure categories such as allergens, irritants, and infections are ubiquitous, specific exposures within these categories might be unique to certain areas, such as environmental exposures to traffic exhaust in urban environments and to organic dust in rural environments, and might contribute to asthma onset and recurrence (36–42).

Recent publications on environmental exposures have drawn attention to the hygiene hypothesis, which proposes that exogenous exposures encountered at an early age can influence immunoregulation to favor processes that protect against atopic disease (33). Researchers often cite this theory in support of the belief that asthma is less prevalent in rural than in urban areas. While this inference might be true for some children predisposed to atopic asthma when the exposure type, timing, and dose are appropriate, the information on sustained benefit for children is limited. Moreover, studies of farmers have shown a higher prevalence of nonatopic than atopic asthma and a positive association between endotoxin levels and nonatopic asthma. In a study of Norwegian farmers, nonatopic asthma accounted for more than three-quarters of all current asthma and was more often found in livestock farmers, and especially in pig farmers (16, 42). Given the high proportion of nonatopic asthma among farmers, the current

TABLE 3.—Crude and adjusted odds ratios for current asthma among US adults—2005 Behavioral Risk Factor Surveillance System.

Unweighted number = 335,668	Crude odds ratio (95% CI*)		Adjusted odds ratio (95% CI*)		p value for Wald F†
Urban-rural residence					0.32
Metropolitan	1.00		1.00		
Adjacent metropolitan	1.03	(0.97, 1.09)	0.96	(0.90, 1.02)	
Micropolitan	1.10	(0.99, 1.22)	1.04	(0.93, 1.16)	
Remote	1.01	(0.92, 1.11)	0.95	(0.85, 1.05)	
Age, in years					<0.01
18–24	1.00		1.00		
25–34	0.82	(0.74, 0.91)	0.75	(0.67, 0.83)	
35–44	0.81	(0.73, 0.89)	0.68	(0.61, 0.75)	
45–54	0.83	(0.75, 0.92)	0.64	(0.58, 0.71)	
≥ 55	0.84	(0.77, 0.92)	0.59	(0.53, 0.65)	
Sex					<0.01
Male	1.00		1.00		
Female	1.87	(1.77, 1.97)	1.81	(1.71, 1.92)	
Race and ethnicity					<0.01
White only, non-Hispanic	1.00		1.00		
Black only, non-Hispanic	1.09	(1.00, 1.18)	0.94	(0.86, 1.03)	
Other, non-Hispanic	1.08	(0.97, 1.20)	1.09	(0.98, 1.23)	
Hispanic	0.67	(0.60, 0.75)	0.62	(0.54, 0.70)	
Unknown	1.14	(0.91, 1.43)	1.18	(0.92, 1.52)	
Level of education					<0.01
Did not graduate high school	1.23	(1.14, 1.34)	1.09	(0.99, 1.20)	
Graduated high school	1.07	(1.01, 1.13)	0.88	(0.82, 0.94)	
Attended college or technical school	1.18	(1.11, 1.26)	0.97	(0.91, 1.04)	
Graduated college or technical school	1.00		1.00		
Level of income					<0.01
Less than \$25,000	1.53	(1.44, 1.63)	1.52	(1.41, 1.63)	
\$25,000 to less than \$50,000	1.15	(1.08, 1.23)	1.13	(1.06, 1.21)	
\$50,000 or more	1.00		1.00		
Unknown	1.14	(1.06, 1.24)	1.18	(1.08, 1.28)	
Body mass index, kg/m ²					<0.01
Less than 18.5 (underweight)	1.22	(1.03, 1.45)	1.10	(0.92, 1.31)	
18.5–24.9 (normal weight)	1.00		1.00		
25.0–29.9 (overweight)	1.06	(1.00, 1.13)	1.25	(1.18, 1.34)	
30.0 or more (obese)	1.81	(1.71, 1.93)	1.98	(1.86, 2.11)	
Unknown	1.30	(1.15, 1.47)	1.35	(1.20, 1.52)	
Smoking status					<0.01
Current	1.22	(1.15, 1.28)	1.31	(1.23, 1.40)	
Former	1.30	(1.23, 1.38)	1.27	(1.20, 1.35)	
Never	1.00		1.00		
Health insurance coverage					<0.01
Yes	0.80	(0.75, 0.86)	0.73	(0.67, 0.79)	
No	1.00		1.00		
Could not see doctor because of cost					<0.01
Yes	1.70	(1.60, 1.81)	1.72	(1.60, 1.85)	
No	1.00		1.00		
Has a health care provider					<0.01
Yes	1.00		1.00		
No	0.58	(0.53, 0.63)	0.60	(0.55, 0.66)	

*Confidence Interval.

†Wald F tests the null hypothesis that the regression coefficients for a characteristic are equal to zero, conditioned on all the other characteristics being in the model.

‡Excludes respondents with missing county information for Urban-Rural residence, and excludes respondents with missing responses for level of education, smoking status, health insurance coverage, could not see a doctor because of cost, and has a health care provider, where ≤ 0.7% with current asthma and ≤ 0.9% in the entire survey were missing responses.

hygiene hypothesis should not infer that adults in rural areas have a lower asthma prevalence.

Together with considering environmental exposures specific to residence, the geographic variations in sociodemographic and health care characteristics should be considered when explaining similar asthma prevalence between urban and rural areas. As compared with the metropolitan category, respondents in the nonmetropolitan categories—especially in the remote category—had a higher proportion of adults with the following characteristics: age 55 years or older, did not graduate high school, annual household income less than \$25,000, no health insurance coverage, and could not see a doctor because of cost. These demographic characteristics are similar to the nonmetropolitan population characteristics prepared by the United States Department of Agriculture (USDA) using U.S. Census Bureau 2005 population esti-

mates (32). Previous studies have also shown that in general and in contrast to their urban counterparts, adults in rural areas tend toward older age, lower income, less education, less wellness, and less health insurance coverage (32, 43). Because the socioeconomic and health care characteristics of low income, low education level, and no health care coverage are similar to the “high-risk” urban poor population in inner-city neighborhoods, these findings suggest that in both locations similar population issues might play an important role in the asthma burden.

Additionally, the increased probability of reporting current asthma among overweight and obese adults is consistent with previous studies. Similar to current asthma prevalence, the current obesity prevalence is higher among women and minority groups (44). Using state-level data from BRFSS and the National Health and Nutrition Examination Survey

(NHANES) in 2005, CDC reported that 23.9% of U.S. adults were obese (45). In our analysis of U.S. adults with current asthma, we found that 33.5% were obese—a substantially higher percentage than the general adult population estimate. In this analysis, the highest proportions of persons with current asthma who were either overweight or obese with BMI ≥ 25 kg/m² were in the adjacent metropolitan (69.3%) and remote (67.3%) areas. Understanding the distribution of modifiable risk factors (e.g., obesity) by urban-rural residence will enable public health officials to develop site-specific initiatives to reduce disease occurrence.

Although this is the first published study to our knowledge that uses BRFSS linked to UICs to compare current asthma prevalence across the United States by urban-rural categories, a Canadian study using Statistics Canada's 2000/01 Canadian Community Health Survey linked to codes similar to UICs (i.e., modified Beale Codes) showed no significant difference in asthma prevalence across urban-rural regions except for a significantly lower prevalence of asthma in the most urban major metropolitan region (46).

Limitations

The findings in this analysis are subject to potential limitations. An important methodology issue is the use of county-level data. County-level data is the smallest geographical unit currently available for national comparisons, but counties are not homogeneous regarding urban and rural classifications. To account for county-level variability, we used the UICs to classify counties on an urban-rural continuum based on the population size of the largest city, urbanization, and access to larger communities. This limited the potential for misclassification of a predominantly rural county as urban, which could occur if substantial differences in population density are present within a county (25).

Three potential sampling frame errors might have occurred due to nonresponse, noncoverage, and self-reported measurement while conducting the survey. The median response rate for BRFSS' telephone survey was low (51.1%); however, current asthma prevalence estimates in this study are similar to estimates in other studies from other national surveys such as the National Health Interview Survey, a face-to-face survey with a higher response rate (69.0%) (24, 47). Noncoverage might occur because BRFSS does not survey institutionalized adults, the military, or residents without telephone landlines. While estimates of total population characteristics are likely unbiased, our subpopulation estimates for current asthma in rural areas might be biased due to a lack of telephone lines in remote areas, potentially underestimating asthma prevalence in this group (24). Furthermore, the validity of self-reported survey measurements might be less accurate than those based on physical measurements. Nevertheless, a 1993 review of asthma questionnaires reported a sensitivity of 68% (range: 48%–100%) and specificity of 94% (range: 78%–100%) when self-reported asthma was compared with a clinical diagnosis of asthma (48). We used BRFSS-weighted adjustments to minimize the impact of these potential survey errors.

CONCLUSIONS

In this analysis of asthma prevalence by place of residence, we determined that current asthma prevalence is as high in

rural as in urban areas. Certain demographic, behavioral, and health care characteristics unique to place of residence might affect asthma prevalence. Because these results substantially change our understanding of asthma prevalence in rural areas, only further investigation will lead to better understanding of geographic-related risk factors. Methodological challenges uncovered in this analysis suggest the need for standardized methods for defining and sampling rural areas to improve asthma prevalence and management comparisons between studies. This would also allow routine analysis of national surveys by urban-rural residence and would facilitate asthma surveillance in micropolitan and remote areas.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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