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Obesity and obesity-related behaviors among rural and urban adults in the USA

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ABSTRACT

Introduction: Previous studies have reported a higher prevalence of obesity among rural Americans. However, it is not clear whether obesity-related behaviors can explain the higher level of obesity among rural adults. The purpose of this study was to examine the differences in obesity-related behaviors across rural–urban adult populations in the USA.

Methods: Data were obtained from the 1999–2006 National Health and Nutrition Examination Survey, restricted to 14 039 participants aged 20 years or more. Body mass index (BMI) was calculated using measured height and weight, and individuals with BMI≥30 kg/m^2 were categorized as obese. Physical activity recommendations were used to define participants' physical activity levels: no leisure-time physical activity, less than, meeting, and exceeding the recommended levels. Sedentary behaviors were measured by hours sitting and watching TV or videos or using a computer (outside of work). Dietary intake was assessed by one-day 24 hour dietary recall. Residence was measured at the census tract level using the Rural–Urban Commuting Area Codes. Multiple logistic regression models were used to examine urban–rural differences after adjusting for sociodemographic, health, dietary, and lifestyle factors.

Results: The prevalence of obesity was higher in rural than in urban residents (35.6% vs 30.4%, $p<0.01$), among both men (37.7% vs. 32.5%, $p<0.01$) and women (33.4% vs 28.2%, $p<0.01$). Compared to urban adults, more rural adults reported no leisure-time physical activity (38.8% vs 31.8%, $p<0.01$) and fewer rural adults met or exceeded physical activity recommendations (41.5% vs 47.2%, $p<0.01$). Rural adults had lower intake of fiber and fruits and higher intake of sweetened beverages. After adjusting for sociodemographic, health, diet, sedentary behaviors, and physical activity, the odds of being obese among rural adults were 1.19 times higher than that among urban adults (95% confidence interval: 1.06, 1.34).

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Conclusions: Higher level of obesity, physical inactivity, and poor diet among rural residents and the persistent higher risk of obesity among rural adults after adjusting for obesity-related behaviors call for more research into 'obesogenic' environments in rural America. Effective programs are needed to help rural residents reduce high risks for obesity and unhealthy lifestyles.

Key words: diet, obesity, physical activity, screen time, USA.

Introduction

Obesity has become an epidemic in the USA and throughout the world[1-3]. Obesity is associated with increased incidence of many chronic conditions, including cardiovascular disease, type 2 diabetes mellitus, dyslipidemia, osteoarthritis, and cancers[4-7]. Costs associated with obesity in the USA are estimated to exceed $147 billion per year[8]. Obesity is one of the biggest challenges facing public health in the 21st century. Physical inactivity that includes lack of leisure-time physical activity or a sedentary lifestyle, and an unhealthy diet that is high in calories, has low servings of fruits and vegetables, high servings of sugar-sweetened beverages and high servings of meat, and includes skipping breakfast, are the important modifiable behavioral risk factors for obesity[9-15].

Prevalence of obesity may differ by urban or rural residence because of differences in cultural, socioeconomic, and environmental conditions. In many developing countries, such as India[16] and China[17], urbanization and its associated lifestyle changes, such as increased sedentary behavior and a Westernized high-fat diet, are considered important risk factors for obesity. In contrast, studies from developed countries such as the USA[18-20], Canada[21,22], and Sweden[23] found a higher prevalence of obesity in rural areas. This has been attributed to a built-in environment that offers limited opportunities for physical activity[24,25], access to healthy diet[26,27], and access to medical services[28].

In the USA, where approximately 20% of the population lives in rural areas, published studies have consistently reported a higher prevalence of obesity among rural residents[18-20]. Previous studies have mainly examined the differences in sociodemographic characteristics of residents and have limited ability to explore the role of individual obesity-related behaviors such as diet and physical activity between these two populations. The objectives of the present study were to compare the differences in the obesity-related health behaviors across rural and urban populations in the USA, and further examine how these differences account for the observed disparity (if any) in the prevalence of obesity. Better understanding of rural–urban differences in obesity-related behaviors and their contribution to rural–urban differences in obesity will be beneficial to the design of evidence-based programs and policies targeting rural populations in the USA.

Methods

Data source

Data were obtained from the 1999–2006 continuous National Health and Nutrition Examination Survey (NHANES), an ongoing, nationally representative study conducted by the National Center for Health Statistics that includes both an interview and a follow-up physical examination. Multiple years of NHANES observations were combined to allow an adequate number of observations from rural residents. The response rate for years 1999–2006 for home interviews was 81%, and 95% of respondents interviewed at home had a follow-up examination at a mobile examination center (MEC). The study methods of NHANES are described in detail on the study website[29]. The 1999–2006 NHANES interviewed 20 294 adults who were ³20 years. For obesity prevalence estimates, data were restricted to 17 302 participants aged ³20 years, after excluding 1323 participants who were not interviewed at MEC follow-up visits, 1097 pregnant subjects, and 572 participants with missing values for weight and height measurements. For analyses addressing obesity-related behavioral factors, data were further restricted to 14 039 participants, after additional exclusions for

respondents with unreliable dietary recall (837), those requiring special equipment such as wheelchair and cane (1365), and those with missing values for main covariates (1061).

Measures

Urban and rural residence: Urban and rural residence were defined using the Rural–Urban Commuting Area (RUCA) definition developed by the University of Washington's Rural Health Research Center and the Economic Research Service at the US Department of Agriculture[30]. RUCA categories are based on the size of settlements and towns as delineated by the Census Bureau and the functional relationships between places as measured by track-level work-commuting data[30]. Urban areas were defined as RUCA codes between 1 and 3, and rural areas as RUCA codes between 4 and 10[31]. This protected Census track information was accessed through the Research Data Center at the National Center for Health Statistics.

Measure of obesity: At MEC visits, trained examiners took height and weight measurements from each subject. This information was used to calculate body mass index (BMI), by dividing weight in kilograms by height in meters squared (kg/m^2). Consistent with the definition of major health organizations, such as the US Department of Health and Human Services and the World Health Organization, obesity was defined as BMI³30 kg/m^2[32].

Sedentary behavior and physical activity: Sedentary behavior and physical activity levels (assessed from self-reported and validated questions) were categorized in two ways – total daily TV/computer screen time (<2, ≥2 to <4, ≥4 hours/day[33]) and leisure-time physical activity levels – as per the four categories for physical activity recommended by the American College of Sports Medicine: (1) no leisure-time physical activity levels; (2) less than minimum goal (<450 metabolic equivalent (MET) min/week); (3) meeting the minimum goal (450 to <750 MET min/week); (4) overachievers (>750 MET min/week)[34].

Diet: NHANES collected diet data through a one-day, 24 hour dietary recall interview. This information was used to calculate the following dietary variables to assess dietary intake and behavior: breakfast consumption ('have breakfast' vs 'skip breakfast'), sugar-sweetened beverage intake (<230, 230–680, >700 mL/day), fruit intake (0, <1, 1–2, >2 cups/day), vegetable intake (<1, 1–3, >3 cups/day), dairy product intake (<1, 1–2, 2–3, >3 cups/day), meat and bean consumption (<2, 2–4, >4 servings/day), daily total energy (continuous), and fiber intake (continuous). Breakfast skipping was defined as no energy intake before 10.30 hours.

Other control variables: Number of covariates was considered as possible confounders for the association between residence and obesity. These included sociodemographic variables such as age, sex, race/ethnicity, household's poverty status, education level, region of residence, self-reported health status, health insurance, and marital status. The racial/ethnic categories were Mexican-American, non-Hispanic Black (hereafter, Black), non-Hispanic White (hereafter, White), and other racial/ethnic groups. Economic status was divided into five categories: <100%, 100–199%, 200–399%, 400% federal poverty level or above and a proxy category for missing values.

Statistical methods

Statistical Analysis Software v9.3 (SAS Institute, Cary, NC) and SUDAAN v10 (Research Triangle Park, NC) were used to perform all statistical analyses, incorporating sample weights and adjusting for cluster and strata of the complex sample design in NHANES. The prevalence rates of obesity, and obesity-related risk factors (physical activity, sedentary behaviors, and diet) for urban and rural residents were calculated. Age-, gender- and race-specific prevalence of obesity were also calculated by residence. The χ^2 test was used to assess whether urban and rural differences were statistically significant.

Multiple logistic regression analysis was used to evaluate the independent association between obesity and residence after adjusting for differences in population characteristics. First, crude odds ratios (OR) for obesity were calculated by residence, and then by obesity-related behaviors, including

physical activity levels, screen time, and diet, without adjusting for any covariates. Then, an adjusted model was run, which included residence, obesity-related behaviors, and all above-mentioned other control variables, to examine the independence association between residence and obesity. Since the interaction term between gender and urban–rural residence was not significant at the 0.05 level, the analysis was not stratified by gender.

Ethics approval

The study was approved by the Office of Research Compliance at the University of South Carolina (HSA5892). All information collected from participants by NHANES is kept confidential. Details of informed consent and data confidentiality can be found on the study website[29].

Results

Sociodemographic characteristics and obesity-related behaviors of the sample population are summarized in Table 1 and Table 2, respectively. In comparison to urban residents, rural residents were more likely to be older, White, and married or have a partner, and had lower self-perceived health status, household income, and educational attainment (Table 1). Rural residents were more likely to report no physical activity at all, and were also less likely to meet recommended goals for leisure-time physical activity (Table 2). Scant differences were also found for daily screen time, with a higher percentage of rural residents reporting more than 4 hours of daily screen time. In terms of diet, rural residents had higher intakes of sweetened beverages, and lower intakes of fruit and total daily dietary fiber. Rural residents were also more likely to skip breakfast (Table 2).

Approximately 31.6% of the sample population was obese. The prevalence of obesity was higher among rural than among urban adults (35.6% vs 30.4%, $p<0.01$). The prevalence of obesity was higher for rural than urban men (37.7% vs 32.5%, $p<0.01$), and also higher for rural than urban women (33.4% vs 28.2%, $p<0.01$) (Table 3). Among rural residents, the prevalence of obesity was the highest among Black adults (49.6%), and lowest among White adults (34.2%). Within each racial subgroup, rural residents had a significantly higher prevalence of obesity than urban residents (Table 3).

In crude analysis (Table 4), rural residents had 1.25 times higher odds of being obese than urban residents (95% confidence interval [CI]: 1.10, 1.41). On examining the crude association of obesity-related behavioral risk factors on obesity, it can be seen that lower levels of physical activity, excessive screen time, lower fruit consumption, higher meat and bean intake, and skipped breakfast patterns were associated with increased obesity risk. In adjusted analysis, where residence, sociodemographic variables and all obesity-related behaviors (physical activity, sedentary behavior, and diet) were simultaneously adjusted for, rural residents still had higher odds for obesity (OR 1.19, 95% CI 1.06–1.34). Among the sociodemographic variables included in the adjusted analysis, male gender, being in age group 40–59 years, and Black race/ethnicity were associated with increased odds of obesity, and never being married and having no insurance coverage were associated with reduced odds of obesity (data not shown). Among obesity-related behaviors in this model, not meeting physical activity recommendations, high screen time, low fruit consumption, high meat and bean intake, and skipping breakfast were associated with increased odds of obesity.

Discussion

This study advances previous research findings by providing a detailed description of obesity and obesity-related health behaviors (leisure-time physical activity, screen time, and dietary intake) in rural USA by using a nationally representative data set. Previous research into these topics provided limited information on obesity-related health behaviors among rural populations[18-20]. A better understanding of the modifiable determinants of obesity among high-risk populations such as rural Americans is important for the design of effective public health strategies to prevent obesity and associated comorbidities.

Table 1: Sample characteristics of US adults, by urban/rural residence, National Health and Nutrition Examination Survey 1999–2006

Characteristics	Total	Total %† (SE)	Urban %† (SE)	Rural %† (SE)	*p*-value*
Total (*n*)¶	17 302		13 788	3514	
Age (years)					<0.01
20–39	5707	38.2 (0.7)	39.7 (0.9)	33.4 (1.6)	
40–59	5476	39.2 (0.6)	38.9 (0.7)	39.9 (1.8)	
≥60	6119	22.6 (0.7)	21.4 (0.7)	26.7 (1.8)	
Sex					0.17
Female	8576	51.1 (0.4)	50.8 (0.4)	52.0 (0.8)	
Male	8726	48.9 (0.4)	49.2 (0.4)	48.0 (0.8)	
Race/ethnicity					<0.01
Hispanic	4444	12.4 (1.2)	13.8 (1.2)	7.8 (2.6)	
Non-Hispanic White	8679	71.9 (1.4)	68.3 (1.5)	84.0 (2.6)	
Non-Hispanic Black	3561	10.9 (0.9)	12.8 (1.0)	4.8 (1.2)	
Non-Hispanic other	618	4.8 (0.4)	5.2 (0.4)	3.4 (0.7)	
Self-perceived health status					<0.01
Good/fair/poor	9691	48.2 (0.8)	46.8 (0.8)	52.8 (1.6)	
Very good	4549	31.2 (0.6)	31.5 (0.7)	30.1 (1.3)	
Excellent	3049	20.6 (0.5)	21.6 (0.6)	17.1 (0.7)	
Missing	13	0.1 (0)	0 (0)	0.1 (0.1)	
Household poverty status					<0.01
<100% FPL	2815	11.9 (0.5)	10.7 (0.5)	16.1 (1.3)	
100–199% FPL	4165	19.1 (0.7)	17.0 (0.6)	26.1 (1.2)	
200–299% FPL	4593	28.7 (0.5)	29.0 (0.6)	27.6 (0.9)	
≥400% FPL	4371	33.7 (1.0)	35.9 (1.1)	26.3 (1.6)	
Missing	1358	6.6 (0.4)	7.4 (0.5)	4.0 (0.6)	
Education					<0.01
<12 years	5244	19.0 (0.6)	18.2 (0.6)	21.7 (1.1)	
12 years	4022	25.3 (0.6)	23.2 (0.7)	32.2 (0.8)	
>12 years	7421	52.3 (0.9)	55.1 (0.9)	43.2 (1.5)	
Missing	615	3.4 (0.1)	3.5 (0.2)	2.9 (0.3)	
Region					0.72
North-east	2853	17.0 (2.2)	18.0 (2.6)	13.9 (6.6)	
Midwest	3319	22.6 (3.4)	21.0 (3.0)	28.0 (10.2)	
South	6651	37.3 (2.6)	36.2 (3.1)	41.1 (7.0)	
West	4479	23 (3.3)	24.8 (3.0)	17.0 (8.0)	
Health insurance status					<0.01
Yes	13 584	81.1 (0.7)	81.2 (0.7)	80.6 (1.7)	
No	3546	18.1 (0.7)	17.7 (0.7)	19.1 (1.7)	
Missing	172	0.9 (0.1)	1.1 (0.1)	0.3 (0.1)	
Marital status					<0.01
Married or partner	10 330	62.7 (0.9)	61.5 (1.1)	66.8 (1.1)	
Separated	3826	18.2 (0.5)	17.5 (0.6)	20.7 (1.1)	
Never married	2710	16.3 (0.6)	17.6 (0.7)	11.7 (1.1)	
Missing	436	2.8 (0.8)	3.4 (1.0)	0.9 (0.7)	
Year of survey					0.36
1999–2000	4116	23.0 (1.0)	24.8 (1.6)	17.0 (7.4)	
2001–2002	4411	25.3 (1.0)	26.3 (1.2)	22.0 (3.7)	
2003–2004	4419	25.6 (1.5)	25.9 (1.5)	24.3 (6.2)	
2005–2006	4356	26.1 (1.3)	23.0 (1.8)	36.6 (6.9)	

FPL, federal poverty level; SE, standard error.
*p-values from χ^2 tests of independence.
† Weighted percentages.
¶ Unweighted sample size.

Table 2: Obesity-related behaviors among US adults by residence, National Health and Nutrition Examination Survey 1999–2006 (*n*=14 039)

	All %† (SE)	Urban %† (SE)	Rural %† (SE)
Leisure-time physical activity*			
No physical activity	33.5 (0.8)	31.8 (0.7)	38.8 (1.8)
<Minimum goal (<450 MET min/week)	20.7 (0.5)	21 (0.5)	19.9 (1.1)
Meeting goal (450–750 MET min /week)	9.3 (0.3)	9.8 (0.3)	7.8 (0.5)
Overachievers (>750 MET min/week)	36.5 (0.8)	37.4 (0.9)	33.5 (1.9)
Screen time (h)**			
<2	28.4 (0.6)	28.5 (0.7)	28 (1.3)
2–4	44.1 (0.6)	44.3 (0.6)	43.2 (1.5)
>4	27.6 (0.5)	27.2 (0.7)	28.9 (0.9)
Total energy (kcal/day)	2236 (11.7)	2239.9 (12.7)	2223.5 (26.1)
Total fiber (g/day)*	15.7 (0.2)	16.1 (0.2)	14.8 (0.3)
Sweetened beverage (mL/day)**			
0–230	22.1 (0.6)	23.4 (0.7)	17.8 (1.1)
230–680	29.8 (0.6)	31 (0.6)	25.8 (1.1)
≥710	48.1 (0.9)	45.5 (0.9)	56.4 (1.5)
Vegetable intake (cups/day)			
<1	33.9 (0.6)	33.2 (0.6)	36 (1.4)
1–3	49.9 (0.6)	50.3 (0.7)	48.3 (1.2)
>3	16.3 (0.4)	16.5 (0.5)	15.7 (0.6)
Fruit intake** (cups/day)			
0	26.5 (0.7)	24.9 (0.7)	31.9 (1.2)
0–1	37.2 (0.5)	36.5 (0.4)	39.5 (1.3)
1–2	19.2 (0.5)	20.1 (0.4)	16.5 (1.1)
>2	17 (0.6)	18.5 (0.7)	12.1 (0.9)
Dairy intake (cups/day)			
<1	43.9 (0.6)	43.6 (0.7)	44.7 (1.4)
1–2	26.8 (0.4)	26.8 (0.4)	26.8 (1.2)
2–3	14.3 (0.4)	14.6 (0.4)	13.3 (1.0)
>3	15 (0.5)	14.9 (0.6)	15.1 (1.0)
Meat and bean intake (servings/day)			
<2	13.4 (0.4)	13.6 (0.5)	12.1 (0.8)
2–4	21.7 (0.4)	21.2 (0.5)	23.2 (0.8)
>4	64.9 (0.6)	65.1 (0.7)	64.2 (1.2)
Breakfast intake**			
Breakfast skipped	14.3 (0.5)	11.4 (0.8)	15.2 (0.6)
Have breakfast	85.7 (0.5)	88.6 (0.8)	84.8 (0.6)

SE, standard error.
*p<0.01; **p<0.001 (p-values from χ^2 tests of independence).
†Weighted percentages.

Table 3: Proportion of US adults who were obese by residence, age, gender, and race 1999–2006 (*n*=17 302)

Characteristic	All % (SE)	Urban %† (SE_	Rural %† (SE)
Overall	31.6 (0.7)	30.4 (0.8)	35.6 (1.0)***
Sex			
Female	29.4 (0.8)	28.2 (0.9)	33.4 (1.5)**
Male	33.7 (0.8)	32.5 (1.0)	37.7 (1.2)**
Age (years)			
20–39	27.0 (0.8)	25.4 (0.9)	33.2 (1.5)***
40–59	35.8 (1.1)	34.7 (1.2)	39.4 (1.7)**
≥60	32.1 (0.7)	31.7 (0.9)	33.0 (1.3)
Race/ethnicity			
Hispanic	31.6 (1.06)	30.4 (1.04)	38.6 (4.01)*
Non-Hispanic White	30.7 (0.75)	29.4 (0.92)	34.2 (0.95)**
Non-Hispanic Black	41.9 (0.96)	41.1 (0.90)	49.6 (3.16)*
Non-Hispanic other	21.5 (2.50)	17.1 (2.31)	44.0 (6.90)*

SE, standard error.
*p<0.05, **p<0.01, ***p<0.001 (p-values from χ^2 tests of independence).
† Weighted percentages were presented.

Table 4: Residence and obesity-related behaviors as risk factors for obesity among US adults, National Health and Nutrition Examination Survey 1999–2006 (*n*=14 039)

Characteristic	Crude odds ratios†	Adjusted odds ratios¶
Residence		
Rural vs urban	1.25 (1.10, 1.41)	1.19 (1.06, 1.34)
Leisure-time physical activity		
No activity	1.26 (1.08, 1.47)	1.10 (0.93 1.30)
<Minimum goal (<450 MET min/week)	1.18 (1.01, 1.38)	1.12 (0.95, 1.33)
Meeting goal (450–750 MET min/week)	1.00	1.00
Overachievers (>750 MET min/week)	0.76 (0.65, 0.89)	0.83 (0.70, 0.97)
Excessive screening time (h/day)		
<2	1.00	1.00
2–4	1.34 (1.21, 1.49)	1.32 (1.17, 1.48)
>4	1.86 (1.63, 2.13)	1.70 (1.48, 1.94)
Whole grain intake (serves/day)		
0	1.02 (0.91, 1.13)	1.02 (0.91, 1.15)
≥1	1.00	1.00
Sweetened beverages (mL/day)		
0–230	1.00	1.00
230–680	0.81 (0.72, 0.92)	0.80 (0.70, 0.91)
≥710	0.91 (0.80, 1.03)	0.90 (0.80, 1.02)
Vegetable intake (cups/day)		
<1	1.05 (0.89, 1.25)	1.01 (0.84, 1.20)
1–3	1.04 (0.90, 1.20)	1.01 (0.87, 1.18)
>3	1.00	1.00
Fruit intake (cups/day)		
0	1.42 (1.24, 1.65)	1.40 (1.19, 1.66)
0–1	1.33 (1.19, 1.49)	1.27 (1.14, 1.43)
1–2	1.09 (0.90, 1.32)	1.04 (0.85, 1.26)
>2	1.00	1.00
Dairy intake (cups/day)		
<1	1.00	1.00
1–2	0.88 (0.79, 0.99)	0.93 (0.82, 1.04)
2–3	0.97 (0.85, 1.12)	1.03 (0.90, 1.17)
>3	0.93 (0.78, 1.10)	0.99 (0.83, 1.17)
Meat and bean intake (cups/day)		
<2	1.00	1.00
2–4	1.10 (0.92, 1.31)	1.08 (0.89, 1.32)
>4	1.34 (1.15, 1.56)	1.35 (1.15, 1.58)
Breakfast skip pattern		
Breakfast skipped	1.16 (1.04, 1.28)	1.20 (1.07, 1.34)
Have breakfast	1.00	1.00

†The model only includes only one variable of interest except diet model where all diet variables were included altogether.
¶ In addition to adjusting all variables shown in the table, this model was also adjusted for age, gender, race/ethnicity, household income level, reference person's education, region, survey year, marriage, insurance coverage, total energy intake and total fiber intake.

This research confirms findings from previous epidemiological studies that adults living in rural areas across the USA have a higher prevalence of obesity than urban residents do. In addition, findings from this study also indicate that rural residents are more likely to be physically inactive and have unhealthy diets in many aspects when compared to urban residents. To promote and maintain good health, the American College of Sports Medicine recommends at least 150 minutes per week of moderate exercise or 60 minutes per week of vigorous exercise (or a combination of moderate and vigorous activity[34]). The results from this study indicate that in comparison to their urban counterparts, higher proportions of rural residents do not meet recommended levels of leisure-time physical activity. Along with being physically active, having a healthy and balanced diet is an important lifestyle behavior that can help an individual manage healthy body weight. The results from this study suggest rural residents have a higher intake of

sweetened beverages, a lower intake of fruits, and a lower intake of daily dietary fiber, and were more likely to skip breakfast. All these dietary behaviors have been well documented in the literature as 'pro-obesogenic'[10,12-15].

When compared to their urban counterparts, rural populations have a higher representation of less-educated and low-income residents. Earlier studies have documented associations between obesity and low socioeconomic status[35,36]. Multiple mechanisms have been suggested, including the relationship of low education levels, low income, and other markers of low socioeconomic status to lower levels of recreational physical activity, unhealthy diet, and certain psychosocial behaviors leading to increased risk for obesity[37]. Thus, lower socioeconomic status may partly explain the higher prevalence of obesogenic behaviors among rural residents[37].

This study has several noteworthy strengths. First, previous studies on rural–urban obesity disparities provided either none[18] or limited information[19,20] for the differences in obesity-related behaviors among these two populations. Patterson et al[19] included physical activity (inactive vs active) and Befort et al[20] considered physical activity (inactive vs active) and dietary variables (daily energy intake, and percent kilocalories from fat) in their analyses. However, their measurements on obesity-related behaviors were not as comprehensive as in this study, thus explaining none or little significant differences in the rural–urban context. Second, the use of measured height and weight in this study helps to avoid misclassification of the outcome when compared to the use of self-reported height and weight in many previous studies. To the authors' knowledge, with the exception of one recent study[20], all previous studies on rural–urban obesity disparities have used self-reported height and weight to calculate BMI and classify obesity status, which may underestimate obesity prevalence[38]. Third, this study used ZIP code-approximated RUCA codes to have a precise definition of rural residence, which is more precise than the definition of rurality based on county of residence used in the previous studies[18-20], as the large geographical area of counties often obscures intracounty differences[30].

This study is limited by its reliance on self-reported leisure-time physical activity as the quantitative measure of physical activity. Work-related activity, household activity, and transportation-related physical activity were not considered, which could be relevant considering the differences in the working environment of urban and rural residents. However, the agriculture, forestry, and fishing sectors constitute only about 6% of employment in high-density rural areas and about 12% of employment in low-density rural areas in the USA[39]. Thus, it is unlikely that the working environment in rural areas is conducive to a more physically active lifestyle. In the adjusted analysis, even after including all the sociodemographic factors, obesity-related behaviors and other covariates, rural residence is still associated with higher odds of obesity than urban residence. This could suggest either other unmeasured factors are at work, or possible measurement errors in the study's covariates. Future studies may consider including variables such as stress levels[40], sleep time[40], social support[41], and access to primary care services, factors that are known to affect an individual's weight and overall health through different mechanisms and can be important when considering socioeconomic differences in urban–rural populations.

Obesity is an ever-increasing problem in the USA and across the globe. The association between obesity and rural residence in industrialized countries such as the USA is evident and robust. A study using more recent data (2005–2008) reported that obesity prevalence is as high as 40% in rural areas in the USA[20]. Thus, it is important to understand that obesity reduction is much more challenging in rural areas, where both cultural and environmental factors contribute to a higher prevalence. Emphasis must be given to developing evidence-based programs that can be successful in diverse rural environments, which can range from the forests of New England to the deserts of Nevada. Strategies keyed to an urban environment, such as convenient access to public transportation or increases in the availability of paved sidewalks[42], are irrelevant in rural USA. Examples of obesity interventions that have been effective in rural areas are a community-based health promotion program that relied on community group discussions, educational presentations,

health fairs and screenings[43], and continued medical education for rural physicians to integrate physical activity and diet counseling in their clinical practice[44].

The built environment in rural USA plays a role in promoting unhealthy behaviors conducive to obesity. For example, rural residents have limited access to healthy food choices[45,46], and the limited recreational resources such as parks and exercise facilities is an impediment to physical activity[47,48]. Additional research is needed to identify low-cost, sustainable changes that can improve built environments in rural areas. Techniques that empower rural communities to increase the availability of quality food markets and recreational resources need to be identified and disseminated.

Conclusions

The national epidemic of obesity is particularly acute in rural USA and demands prompt public health action. The disparities in rural versus urban health issues including obesity are complex and based on sociodemographic, environmental, and lifestyle differences. Future research, community-based interventions and structural changes are needed to get rural populations moving towards a healthier future.

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