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Neighborhood commuting environment and obesity in the United States: An urban–rural stratified multilevel analysis

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ABSTRACT

Objective. Automobile dependency and longer commuting are associated with current obesity epidemic. We aimed to examine the urban–rural differential effects of neighborhood commuting environment on obesity in the US

Methods. The 1997–2005 National Health Interview Survey (NHIS) were linked to 2000 US Census data to assess the effects of neighborhood commuting environment: census tract-level automobile dependency and commuting time, on individual obesity status.

Results. Higher neighborhood automobile dependency was associated with increased obesity risk in urbanized areas (large central metro (OR 1.11[1.09, 1.12]), large fringe metro (OR 1.17[1.13, 1.22]), medium metro (OR 1.22 [1.16, 1.29]), small metro (OR 1.11[1.04, 1.19]), and micropolitan (OR 1.09[1.00, 1.19])), but not in non-core rural areas (OR 1.00[0.92, 1.08]). Longer neighborhood commuting time was associated with increased obesity risk in large central metro (OR 1.09[1.04, 1.13]), and less urbanized areas (small metro (OR 1.08[1.01, 1.16]), micropolitan (OR 1.06[1.01, 1.12]), and non-core rural areas (OR 1.08[1.01, 1.17])), but not in (large fringe metro (OR 1.05[1.00, 1.11]), and medium metro (OR 1.04[0.98, 1.10])).

Conclusion. The link between commuting environment and obesity differed across the regional urbanization levels. Urban and regional planning policies may improve current commuting environment and better support healthy behaviors and healthy community development.

Introduction

Obesity prevalence has increased substantially in all demographic groups and social strata in the last three decades in the United States (US) (Wang and Beydoun, 2007). The estimated age-adjusted obesity prevalence has increased from 14.5% in 1976–1980 to 35.7% in 2009–2010 among adults age 20 years and older in the US (Flegal et al., 1998, 2010, 2012; Kuczmarski et al., 1994). The increasing dependence of the population on automobile travel, resulting from modern urbanization, may have contributed to the US obesity epidemic (Jacobson et al., 2011).

Over the past forty years, modern urbanization has created a more differentiated land use pattern: residential, commercial and industrial areas are located in a more spatially separated form (Southworth and Owens, 1993). The modern transportation system, which is heavily oriented toward automobile commuting, has evolved to support the connections among these different land uses. More-frequent and longer motor-vehicle trips have become a necessity rather than simply a choice, in order to go to work, to shop, to access open spaces or other routine services or activities (Rodrigue, 2013). Commuting by car, and spending ever-increasing time doing so because of a jobs-housing imbalance (Sultana, 2002), has become an essential part of daily life for almost all Americans.

A growing number of studies have shown the striking link between commuting burden and obesity outcomes. A study in San Francisco indicated that urban residents with higher BMI scores reported high levels of automobile use for work/school commuting and trips to the grocery store (Pendola and Gen, 2007). Another study in Atlanta, Georgia, suggested that each additional hour spent in a car per day was associated with a 6% increase in the likelihood of obesity (Frank et al., 2004). A recent study in 12 Texas metropolitan counties reported that the commuting distance between home and workplaces was adversely associated with obesity outcomes (physical activity, BMI, and waist circumference) (Hoehner et al., 2012). A county-level ecological analysis of obesity and vehicle miles of travel in California supported the associations between obesity, motorized transportation, and commuting time (Lopez-Zetina et al., 2006). Similar ecological associations

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were also observed at the neighborhood level (census block groups) (Lathey et al., 2009). A nation-level trend analysis in the US found that increased noncommercial automobile travel was ecologically associated with increased obesity prevalence over 22 years (1985–2007) (Jacobson et al., 2011).

However, research evidence suggested that the impact of the neighborhood built environment on obesity could vary across levels of regional urbanization (Joshu et al., 2008; Wang et al., 2013). We hypothesized that neighborhood commuting environment's association with obesity may be sensitive to regional urbanization levels. Almost all previous studies linking obesity and commuting were based on local population samples from urban settings (Frank et al., 2004; Hoehner et al., 2012; Lathey et al., 2009; Lopez-Zetina et al., 2006; Pendola and Gen, 2007). The potential urban–rural differences in the association between population automobile dependency and commuting time and obesity in the US are less well understood. For example, neighborhood automobile dependency may not be associated with obesity in less urbanized areas; and the commuting time may have more impact on obesity in suburban areas. The neighborhood commuting environment may contribute to the unexplained urban–rural disparities in obesity prevalence (Befort et al., 2012). Thus, the major aim of this study is to examine the associations between neighborhood commuting environment and obesity across the levels of regional urbanization, using a large geocoded nationally representative survey, the National Health Interview Survey (NHIS) that allows geographic linkages to local neighborhood commuting environment measures: automobile dependency and commuting time.

Methods

Study population

We used cross-sectional data from the 1997–2005 NHIS (National Center for Health Statistics (NCHS), 2010), which is collected annually via in-person household interviews of a nationally representative sample of the US civilian non-institutionalized population, with oversampling of blacks and Hispanics, in 50 states and the District of Columbia. The NHIS data include the following four basic modules: household composition, family, sample child and sample adult. The adult sample with the obesity measure (BMI) was used to examine the associations between neighborhood (census tract-level) commuting environment and obesity. The 1997–2005 NHIS used the same sampling design, annually, which means the same sampling strata and primary sampling units were visited, over this nine-year period. The shared geographic framework of the 1997–2005 NHIS data also provided a better platform to make geographic comparisons of obesity trends in residential populations over time. The final response rate for the combined 1997–2005 NHIS adult samples is 73.3%, yielding a sample size of 289,707. We excluded 354 participants without geocodable residential addresses and also 12,061 participants with missing body mass index (BMI) values or those with extreme BMI values that are biologically implausible (BMI > 70 kg/m^2 or BMI < 12 kg/m^2) (Li et al., 2009). The final study sample was 277,292, comprising 95.8% of the geocoded 1997–2005 NHIS adult participants. The average sample size per year was 30,810 with a minimum sample of 29,326 in 2003 and a maximum sample of 34,989 in 1997. The individual NHIS data were linked with the corresponding residential census tract-level variables via the 2000 census tract identifiers in the geocoded 1997–2005 NHIS.

Data and measures

Region-level urbanization measure

Regional urbanization level was based on a six-level urban–rural classification scheme for the 3141 US counties and county-equivalents developed by the National Center for Health Statistics (NCHS) in 2006 (from highly urbanized metropolitan to remote rural areas): large central metro, large fringe metro, medium metro, small metro, micropolitan, and non-core rural counties. The 2006 NCHS urban–rural classification scheme for counties had been linked with National Vital Statistics System (NVSS) mortality records and National Health Interview Survey (NHIS) data using restricted-use files and demonstrated its ability to identify health differentials across urbanization levels (National Center for Health Statistics (NCHS), 2006) (see Table 1 for detailed classification rules).

Table 1
Categories and classification rules: NCHS urban–rural classification scheme for counties, 2006.
This table was adopted from page 10 in Ingram DD, Franco SJ. NCHS urban–rural classification scheme for counties. National Center for Health Statistics. Vital Health Statistics 2(154). 2012. MSA means metropolitan statistical area.

Urbanization level	Classification rules
Metropolitan counties	
Large central metro	Counties in MSA of 1 million or more population that: 1) contain the entire population of the largest principal city of the MSA, or 2) are completely contained within the largest principal city of the MSA, or 3) contain at least 250,000 residents of any principal city in the MSA
Large fringe metro	Counties in MSA of 1 million or more population that do not qualify as large central
Medium metro	Counties in MSA of 250,000–999,999 population
Small metro	Counties in MSA of 50,000–249,999 population
Nonmetropolitan counties	
Micropolitan	Counties in micropolitan statistical area
Non-core	Counties not in micropolitan statistical area

Individual obesity outcome

A binary outcome of obesity status was defined on the basis of an NHIS participant's BMI value as either obese if BMI > = 30 kg/m^2 or not obese if BMI < 30 kg/m^2. The participants' BMI values were based on self-reported height and weight as originally reported during the interviews and calculated by dividing participants' weight in kilograms by their height in meters squared.

Individual covariates

The individual characteristics from NHIS included sex, age, race-ethnicity, educational attainment, and survey year (1997–2005). Age was categorized into 6 groups (18–24, 25–34, 35–44, 45–54, 55–64, and 65 years and older). Race-ethnicity was categorized into 6 groups (non-Hispanic white, non-Hispanic black, non-Hispanic Asian, non-Hispanic other races, Mexican Hispanic, and non-Mexican Hispanic). Educational attainment was categorized as 4 groups: less than high school, high school graduate, some college, and bachelor degree or higher. These selected individual variables all have well documented relationships with obesity in the literature (Wang and Beydoun, 2007).

Neighborhood-level variables

Neighborhood commuting environment in this study was measured by two census tract-level indicators: the percentage of workers age 16 years and over who commute to work by car, van or truck; and the average commuting time of workers age 16 years and older. The first is usually referred to as neighborhood automobile dependency and the second as neighborhood commuting time. Neighborhood poverty was measured by the census tract-level percentage of individuals under the federal poverty level, which has been shown to be associated with obesity in previous studies (Black et al., 2010; Ludwig et al., 2011). It was often included as a control variable in the analysis of neighborhood context impact on obesity (Boardman et al., 2005; Rundle et al., 2007). In addition, neighborhood economic poverty measures were most robust to detect population health outcome gradients (Krieger et al., 2002). All these neighborhood-level covariates were extracted from census 2000 Summary File 3 for all 65,443 census tracts in the US. Table 2 presents the basic summary of neighborhood level variables. All three neighborhood variables keep their original continuous scales to avoid the potential bias of artificial cut-points in the analysis.

Statistical analysis

The NHIS data were collected through a complex sampling design, involving stratification, clustering and multi-stage sampling. All the data analyses in this study were weighted by using the final adult sample weights that account for differential probabilities of selection and the NHIS complex sampling design. Six multilevel logistic models, corresponding to the six levels of urbanization, were developed to assess the urban–rural differential associations between neighborhood commuting environment and obesity, while controlling the

Table 2
Summary statistics of neighborhood variables by level of regional urbanization.

Geography	N	Lower quartile	Median	Upper quartile	Mean
Neighborhood poverty (residential population under poverty (%))					
Large central metro	20,124	4.0%	8.0%	14.4%	10.3%
large fringe metro	13,743	2.2%	3.9%	6.9%	5.5%
Medium metro	12,624	3.5%	6.3%	11.4%	8.8%
Small metro	6198	4.6%	7.5%	12.1%	9.9%
Micropolitan	6804	5.4%	8.2%	11.9%	9.6%
Non-core rural	5511	6.9%	9.5%	12.9%	10.5%
Neighborhood automobile dependency (commuting to work by car (%))					
Large central metro	20,102	70.7%	87.3%	92.6%	78.0%
Large fringe metro	13,742	87.1%	91.9%	94.6%	89.3%
Medium metro	12,619	89.1%	93.1%	95.4%	90.4%
Small metro	6199	89.6%	93.3%	95.5%	90.9%
Micropolitan	6803	89.6%	92.8%	95.0%	91.2%
Non-core rural	5511	87.0%	91.3%	94.0%	89.2%
Neighborhood commuting time (minutes)					
Large central metro	20,102	22.4	26.3	30.9	27.6
Large fringe metro	13,742	23.3	26.6	30.7	27.2
Medium metro	12,619	18.5	21.2	24.6	22.0
Small metro	6199	16.5	19.5	23.4	20.3
Micropolitan	6803	16.8	20.5	24.6	21.1
Non-core rural	5511	17.7	22.1	27.1	22.7

Note: neighborhood variables in this study are not available for tracts without population or with very small populations.

effects of individual covariates, including sex, age, race-ethnicity, education and survey year, and census-tract level neighborhood poverty. Unadjusted and adjusted odds ratio (OR) and 95% confidence intervals (CI) were calculated to evaluate the association between individual obesity status and its neighborhood level commuting environment indicators: automobile dependency and commuting time. All statistical analyses were conducted in SAS callable SUDAAN version 10.0 (RTI, Research Triangle Park, North Carolina).

Results

Obesity trend across levels of county urbanization and over time

Table 3 shows the annual obesity prevalence across county urbanization levels. For the overall period, 1997–2005, obesity prevalence is the lowest in large fringe metro areas (20.2%), followed by large central metro areas (21.1%), medium metro areas (23.1%) and small metro areas (23.4%), and micropolitan areas (24.6%), and the highest in non-core rural areas (25.8%). From 1997 to 2005, obesity prevalence increased most in non-core rural areas (10.3%), followed by small metro areas (6.4%), medium metro areas (6.2%), micropolitan areas (6.1%), and large central metro areas (5.3%), and least in large fringe metro areas (4.9%).

Obesity and neighborhood commuting

Higher automobile dependency measured at the neighborhood level was consistently associated with increased obesity risk in metropolitan statistical areas, from large central metro, large fringe metro, medium metro, to small metro (model I–IV adjusted ORs, Table 4). A 10% greater rate of neighborhood automobile dependency was associated with an increased odds of being obese by 11% in large central metro, by 17% in large fringe metro, by 22% in medium metro, and 11% in small metro areas respectively. But no significant associations between neighborhood automobile dependency and obesity were observed in non-metropolitan rural areas (model V–VI adjusted ORs, Table 4).

Neighborhood commuting time was observed to be positively associated with obesity in large central metro and less-urbanized small metro, micropolitan and non-core rural areas (model I, IV–VI, Table 4). A 10 minute increase in neighborhood commuting time was associated with an increase in odds of being obese by 9% in large central metro, by 8% in small metro, by 6% in micropolitan, and 8% in non-core rural areas. But no significant associations between neighborhood commuting time and obesity were observed in the large fringe metro and medium metro areas (model II–III adjusted ORs, Table 4).

Discussion

Our study found that the complex links between neighborhood commuting environment and the obesity epidemic in the US differed widely across the levels of regional urbanization, while adjusting for significant individual level demographic and socioeconomic factors and neighborhood poverty that were associated with obesity. Obesity is the result of accumulative imbalance of energy expense (physical activity) and food intake. The neighborhood commuting environment could directly affect residents' physical activity and food intake. More frequent vehicle-based trips and longer commuting times could result in lower physical activity levels and increased fast food access and less frequent home cooking. At the same time, these possible impacts could be significantly modified by the other regional and local built environment components which usually were quite different across levels of urbanization. Our study used a national representative population sample and our findings supported the hypothesis that the impact of neighborhood automobile dependency and commuting time on obesity might depend on specific urban–rural geographic contexts.

Neighborhood automobile dependency and obesity

Urban neighborhood automobile dependency was consistently and strongly associated with obesity in metropolitan statistical areas (large central metro, large fringe metro and medium metro, small metro areas). This finding is consistent with most previous urban studies

Table 3
NHIS sample sizes and obesity prevalence by level of regional urbanization.

Geography	US	Large central metro	Large fringe metro	Medium metro	Small metro	Micropolitan	Non-core counties
N	277,292	86,970	59,884	57,454	26,855	29,595	16,534
Year							
1997–2005	22.2(0.1)	21.1(0.2)	20.2(0.2)	23.1(0.3)	23.4(0.5)	24.6(0.4)	25.8(0.5)
1997	19.0(0.3)	18.3(0.5)	17.6(0.5)	19.3(0.6)	19.5(0.9)	21.4(0.9)	22.0(0.8)
1998	20.0(0.3)	19.6(0.5)	17.9(0.5)	20.7(0.6)	21.5(0.9)	20.4(0.8)	23.4(1.1)
1999	21.1(0.3)	20.0(0.5)	19.4(0.6)	21.7(0.6)	22.4(0.9)	23.2(0.9)	24.0(1.4)
2000	21.3(0.3)	20.5(0.5)	19.9(0.6)	21.2(0.6)	22.2(0.9)	24.1(1.0)	24.3(1.2)
2001	22.5(0.3)	20.8(0.5)	19.8(0.5)	24.5(0.7)	23.7(1.0)	25.3(1.0)	25.8(1.3)
2002	23.5(0.3)	22.7(0.6)	21.1(0.6)	24.4(0.7)	24.8(1.3)	26.4(1.1)	26.1(1.4)
2003	23.2(0.3)	21.6(0.5)	20.7(0.6)	25.2(0.8)	25.5(1.1)	24.8(1.0)	27.2(1.1)
2004	24.0(0.3)	22.2(0.6)	22.5(0.6)	24.9(0.6)	24.5(1.0)	28.0(1.0)	27.1(1.4)
2005	24.9(0.3)	23.6(0.6)	22.5(0.7)	25.5(0.7)	25.9(1.0)	27.5(1.1)	32.3(1.2)

Note: prevalence in terms of percentage and its standard error in the parentheses; NHIS sample size for the combined years 1997–2005.

Table 4
The unadjusted and adjusted odds ratios (ORs) associated with 10 units increase in neighborhood variables.

Model	I	II	III	IV	V	VI
Urban–rural	Large central metro	Large fringe metro	Medium metro	Small metro	Micropolitan	Non-core rural
Neighborhood automobile dependency (commuting to work by car, van, or truck (%))						
Unadjusted	1.07(1.06,1.09)	1.17(1.12,1.21)	1.17(1.10,1.23)	1.14(1.06,1.23)	1.16(1.08,1.25)	1.00(0.94,1.08)
Adjusted	1.11(1.09,1.12)	1.17(1.13,1.22)	1.22(1.16,1.29)	1.11(1.04,1.19)	1.09(1.00,1.19)	1.00(0.92,1.08)
Neighborhood commuting time (minutes)						
Unadjusted	1.24(1.19,1.30)	1.06(1.01,1.12)	1.10(1.02,1.17)	1.17(1.09,1.25)	1.13(1.07,1.20)	1.15(1.08,1.23)
Adjusted	1.09(1.04,1.13)	1.05(1.00,1.11)	1.04(0.98,1.10)	1.08(1.01,1.16)	1.06(1.01,1.12)	1.08(1.01,1.17)

Note: ORs are rescaled to 10 units increase in neighborhood covariates. OR greater than 1.0 means a higher likelihood of being obese, and OR less than 1.0 means a lower likelihood of being obese; the 95% confidence intervals (CIs) are presented here for all ORs. Unadjusted ORs were based on the models with only two neighborhood commuting variables. Adjusted ORs are from the models adjusting the effects of individual level covariates, including sex, age, race-ethnicity and education, as well as survey year and neighborhood level poverty rate.

relating commuting by car to obesity outcomes (Jacobson et al., 2011; Lopez-Zetina et al., 2006; Pendola and Gen, 2007). However, neighborhood automobile dependency did not demonstrate the expected association with obesity in non-metropolitan rural areas. This is contrary to what was observed in urban areas in previous studies (Lopez-Zetina et al., 2006; Pendola and Gen, 2007). Compared to more metropolitan urban neighborhoods, non-metropolitan rural areas lack public transportation and people have to depend more on automobiles to commute and access necessary nearby resources (Table 2). The missing link between automobile dependency and obesity in rural areas may be related to other confounders not included in this analysis, such as physical activity, since non-metropolitan rural populations are more likely to have more labor-oriented occupations than those in metropolitan urban areas (Pearson and Lewis, 1998).

Neighborhood commuting time and obesity

Commuting in an urban environment is more time-consuming and urban neighborhoods, especially in large metropolitan areas, have significantly longer commuting time than less urbanized areas (medium and small metro areas) and non-metropolitan rural areas (Table 2). However, neighborhood commuting time, was significantly associated with obesity in large central metro and less urbanized areas in small metro, micropolitan and non-core rural counties, but not in large fringe metro and medium metro areas. This result was largely in accordance with the findings of several studies on commuting time and obesity outcomes in urban settings (Frank et al., 2004; Hoehner et al., 2012; Lathey et al., 2009; Lopez-Zetina et al., 2006). There are at least three possible reasons associated with this unexpected result in large fringe metro (suburban areas) and medium metro areas. First, the differences in population characteristics among the neighborhoods with different commuting environments may play a role in our finding in this study. Those who choose to live in large fringe metro (suburban) and medium metro neighborhoods with longer commuting time may be mentally and physically fit and are willing to commute longer for better employment opportunities. This is quite possible, since in larger metropolitan and medium metro areas, individual socioiodemographic characteristics are more important predictors of commuting behaviors than urban sprawl status and population density (Sultana and Weber, 2007). The substantial reduction in the strength of the link between neighborhood commuting time after controlling individual characteristics also confirmed this (unadjusted vs adjusted ORs, Table 4). A recent study in Sweden also suggests that long duration car commuters are a relatively homogeneous and distinctive group, being male, well-paid and working overtime on jobs associated with high psychological demands and a high level of control (Hansson et al., 2011). Second, the difference in the population sample under study and study design is another possible reason. Hoehner et al used a convenience sample of a clinic population from 12 large Texas metropolitan counties to examine the link between commuting time (commuting distance) and obesity status (Hoehner et al., 2012); Frank et al selected the study population from the 13-county Atlanta metropolitan region using a computer-aided telephone interview which excluded those households without phones (Frank et al., 2004). Lathey et al. and Lopez-Zetina et al's studies only examined the ecological relationship between obesity prevalence and commuting time in large urban counties (Lathey et al., 2009; Lopez-Zetina et al., 2006). All these studies obtained most of their samples from the large central metro counties. Therefore, differences in results with previous studies could be due to differences in population sampling and ecological study design. Finally, the association between commuting time and obesity may vary by locations. The relationships between commuting time and obesity in those local urban studies may not be applicable at the national level (Frank et al., 2004; Hoehner et al., 2012; Lathey et al., 2009; Lopez-Zetina et al., 2006). In the less urbanized small metro and micropolitan areas and non-core rural areas, people living in the neighborhoods with longer commuting time may have to commute longer in terms of time and distance to find employment opportunities far from home locations, compared to those in the neighborhoods with shorter commuting time. Thus, the associations between obesity and neighborhood commuting time is significant in less urbanized and non-core rural areas but not in large fringe metro (suburban) and medium metropolitan areas

Modern urbanization has dramatically changed not only neighborhood commuting patterns but also other aspects of built environment contexts in a mixed way across the levels of regional urbanization. Inner city neighborhoods tend to be characterized by high population density, better-connected streets, mixed land use, and high job concentrations (Rodrigue, 2013; Wang et al., 2013; World Resources Institute, 1996). However, the benefits of their built environments could be offset by their adverse social characteristics (Cutts et al., 2009), the concentration of low income populations, and high crime rates (World Resources Institute, 1996). On the other hand, suburban neighborhoods tend to be characterized by low population density, poorly-connected streets, single-mode land use, and high automobile-commuting for spatially separated land uses (Rodrigue, 2013). However, the disadvantages of these built environmental features could be overcome by social characteristics, such as populations with high income and educational attainment. A spatial mismatch of built and social environments across the levels of urbanization may leave fewer places favoring active living. Our stratified analysis, by levels of county urbanization, suggests that greater automobile-commuting in urban neighborhoods in metropolitan areas and increased commuting time in large central metro areas, less urbanized small metropolitan and non-metropolitan rural areas significantly increase population obesity risk.

Our results also confirmed the significant urban–rural disparities in obesity prevalence (Befort et al., 2012) and showed its changes over time. The highest obesity prevalence is in non-core rural areas and its fastest increase was most likely associated with other neighborhood built environmental factors not included in this study, such as lack of access to recreational facilities, safety, food access, and rural isolation (Befort et al., 2012; Boehmer et al., 2006; Bove and Olson, 2006), rather than neighborhood poverty and automobile dependency. This suggests that more in-depth investigations on rural obesity and its rapid increase would be beneficial.

Strengths and limitations

One strength of this study is that it combined 9-year nationally-representative samples to allow each stratified analysis by level of urbanization to have sufficient sample size. Additionally, the geocoded individual NHIS was linked to local residential neighborhood (census tract), thus making the examination of neighborhood environment effects on individual health outcome feasible. There were several limitations for this study. First, the obesity outcome is based on self-reported data. The comparison of objectively-measured and self-reported weight and height shows that men tend to overestimate their height and women tend to underestimate their weight, and thus obesity prevalence is usually underestimated (Kuczmarski et al., 2001; Merrill and Richardson, 2009; Wen and Kowaleski-Jones, 2012). This may cause some bias in our findings. Second, this cross-sectional study does not permit causal inference on the examined relationships between commuting burden and obesity. Also individual commuting measures were not available for this survey, thus further study is needed based on a longitudinal nationally-representative sample with both individual level obesity and commuting measures.

Conclusions

This study used a nationally representative sample to empirically demonstrate that neighborhood automobile dependency and commuting time are associated with differential effects on adult obesity outcomes across levels of regional urbanization. The urban–rural differential association of neighborhood automobile dependency and commuting time on obesity found in this study as well as evidence from other studies can inform modifications in urban and regional planning policies and practices intended to improve the current commuting environment across levels of urbanization and better support local population healthy behaviors and developing healthy communities for successful obesity prevention.

Contributors

Xingyou Zhang and James B. Holt conceived the study and wrote the final version of the paper. Xingyou Zhang conducted statistical data analysis. Hua Lu, Stephen Onufrak, Jiawen Yang, Steven P. French, and Daniel Sui contributed to model results' interpretation and participated in the draft revision. All authors have read and approved the final manuscript.

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Competing interest

There are no competing interests for publications.

Disclaimer

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