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# Geography of Adolescent Obesity in the U.S., 2007–2011

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## Abstract

**Introduction—**Obesity remains a significant threat to the current and long-term health of U.S. adolescents. The authors developed county-level estimates of adolescent obesity for the contiguous U.S., and then explored the association between 23 conceptually derived area-based correlates of adolescent obesity and ecologic obesity prevalence.

**Methods—**Multilevel small area regression methods applied to the 2007 and 2011–2012 National Survey of Children's Health produced county-level obesity prevalence estimates for children aged 10–17 years. Exploratory multivariable Bayesian regression estimated the cross-sectional association between nutrition, activity, and macrosocial characteristics of counties and states, and county-level obesity prevalence. All analyses were conducted in 2015.

**Results—**Adolescent obesity varies geographically with clusters of high prevalence in the Deep South and Southern Appalachian regions. Geographic disparities and clustering in observed data are largely explained by hypothesized area-based variables. In adjusted models, activity environment, but not nutrition environment variables were associated with county-level obesity prevalence. County violent crime was associated with higher obesity whereas recreational facility density was associated with lower obesity. Measures of the macrosocial and relational domain, including community SES, community health, and social marginalization, were the strongest correlates of county-level obesity.

**Conclusions—**County-level estimates of adolescent obesity demonstrate notable geographic disparities, which are largely explained by conceptually derived area-based contextual measures. This ecologic exploratory study highlights the importance of taking a multidimensional approach

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to understanding the social and community context in which adolescents make obesity-relevant behavioral choices.

## Introduction

Obesity remains a significant threat to the current and long-term health of U.S. adolescents. The prevalence of obesity among those aged 12–19 years exceeded 20% in 2011–2012.[1] Obesity in adolescence is associated with a higher prevalence of cardiometabolic risk factors[2]; impeded social and emotional development[3,4]; increased risk of severe obesity in adulthood[5]; comorbidities in adulthood including diabetes, hypertension, asthma, mobility limitations, and sleep apnea[6]; and lower adult educational attainment and income status.[7] Increasing autonomy during adolescence can influence the development of health behaviors that likely persist into adulthood, making this period of time particularly salient in the development and implementation of obesity prevention interventions.[8]

Growing recognition of the importance of social and environmental context in shaping individual choice and behavior has broadened the focus of obesity research and intervention beyond individual behavior alone.[9–12] Ecologic models of health behavior posit that choices made by individuals are the result of a constant interplay between intrapersonal factors and features of the social, organizational, and community environments within which they are situated.[13] It is hypothesized that the proliferation of “obesogenic” environments—where energy-dense and nutrient-poor foods are widely affordable and available, and transportation options and leisure time activities are often sedentary—has drastically altered the landscapes in which adolescents make dietary and physical activity–related choices.[14] Further, persistent socioeconomic, ethnic, racial, and geographic disparities in adolescent and adult obesity prevalence have underscored the need to better understand how environmental features may manifest differently across populations.[15–17]

Harrison et al.[18] propose a conceptual framework for understanding obesity that is adaptable to multiple stages of development from infancy through adolescence. The framework conceives of forces at multiple levels (cell, child, family, community, and culture) and across five domains (nutrition-related opportunities and resources, nutrition-related practices, activity-related opportunities and resources, activity-related practices, and personal and relational attributes).

This paper aimed to accomplish two tasks. First, small area estimates of county-level adolescent obesity for the contiguous U.S. were produced. Second, the authors tested the ecologic association between county-level adolescent obesity and multiple hypothesized obesogenic factors drawn from the “community” level of Harrison and colleagues’ multidimensional framework in order to characterize these relationships in a geographically diverse, population-based sample.

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# Methods

## Data Sample

The National Survey of Children's Health (NSCH)[19] is a nationally representative telephone-based survey assessing parent-reported physical, mental, behavioral, and environmental health status of children from birth through age 17 years. To maximize sample size for small area analysis, data were pooled from the 2007 and 2011–2012 NSCH surveys in which there was an average of 1,800 respondents aged 0–17 years in every state and the District of Columbia. The interview completion rate, one marker of non-response, was 66% in 2007, and 54% and 41% for landline and cell phone sample frames, respectively, in 2011–2012.[20] Respondents were weighted to account for non-response bias.

Parent-reported child weight and height were used to calculate BMI for children aged 10–17 years.[21] Obesity was defined as BMI (weight [kg]/height [$m^2$]) at or above the 95th percentile for children of the same sex and age.[22,23] The post-stratification approach described below is optimized with fewer strata, and thus individual children were coarsely categorized by age (10–14 years, 15–17 years), sex, and race (white, non-white), producing eight demographic strata. These variables plus survey design weights were abstracted for analysis.

## Statistical Analysis

There are two general approaches to producing small area estimates of disease prevalence: design-based sampling and model-based estimation.[24] The NSCH uses a design-based approach drawing sufficiently large samples to permit statistically valid estimation at the state level. However, design-based approaches are expensive, and likely cost prohibitive at the scale of U.S. counties. A growing methodologic literature supports model-based estimation of population parameters for subareas from population-based surveys. To accomplish their first aim, the authors adapted a multilevel regression and post-stratification approach for the estimation of county-level obesity prevalence.[25,26] Regression model-based small area estimates have been demonstrated to provide valid county-level estimates of chronic disease outcomes derived from state-level design-based surveys.[27,28]

The data preparation and modeling approach is more completely described in Appendix A; briefly, it consisted of three steps. First, a three-level mixed effects regression model was fit to individuals in NSCH adjusting for age, race, sex, survey year, county child poverty rate, and Census region. Random county and state intercepts nested individuals within counties, which were nested within states, and random slopes for age, race, and sex were estimated at the state level. This approach produced state-specific estimates of the relationship of individual age, race, and sex with obesity, while also allowing that county obesity prevalence may vary from the state average. Second, for counties without estimates (e.g., no NSCH respondents), the authors imputed county-level random intercepts as the average of geographically contiguous county intercepts. Finally, county, age-, race-, and sex-stratified population count estimates from the 2008–2012 American Community Survey were merged with the county and state random effects, and age-, race-, and sex-specific coefficients to produce post-stratified obesity prevalence for each county. Small area uncertainty was

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estimated by summarizing 1,000 draws from distributions described by model coefficients and SEs. To assess internal validity of small area estimates, two reference standards were defined: the design-based estimates for counties with a significant number of NSCH respondents ($n$>50), and the design-based estimates at the state level. Regression model-based estimates were compared with design-based reference values.[29]

In total, 23 county- and state-level variables that conceptually map onto the five "community"-level domains in the Harrison et al.[18] framework were identified (Table 1 shows variable definitions and data sources). Harrison and colleagues' "personal and relational attributes" domain was modified to be "macrosocial and relational," reflecting the community, rather than individual-level focus of this analysis. Control variables including region, metropolitan status, and county-level population change were also included.

The associations between these candidate obesogenic factors and obesity prevalence were estimated with multilevel linear regression models, with counties nested within states. All continuous variables were standardized to make model coefficients interpretable as the change in obesity prevalence for each 1-SD change in the predictor. In settings with multiple candidate predictors, there is concern for variable collinearity and false positive associations due to multiple comparisons. Bayesian model shrinkage approaches permit estimation of multiple effects with reduced concern for variance inflation (Appendix B has details of the Bayesian model approach).[30,31]

Geographic patterns of disease can be summarized using aspatial measures of intergroup disparity including Theil's Index, Mean Log Deviation and the Index of Disparity,[32,33] and spatial measures of clustering including the global Moran's $I$ statistic for spatial autocorrelations.[34] Measures of relative health disparity in unordered groups, such as geographic units, characterize the relative gap between highest and lowest prevalence counties, with larger values indicating greater intercounty disparity (additional details in Appendix A).[32] Disparity measures were calculated on residuals from an empty model (intercept only, no covariates, indicative of crude observed disparities) and on the fully adjusted model (indicative of residual disparity above and beyond that accounted for by controlled variables). The relative change between the two estimates quantifies the proportion of the observed geographic disparity "explained" by included covariates. To estimate the overall degree of geographic clustering of high and low obesity prevalence among counties, Moran's $I$ statistics were calculated for the residuals from the empty and adjusted models. The Moran's $I$ quantifies the degree to which spatially contiguous counties have similar obesity prevalence (additional details in Appendix A). The proportional change in the Moran's $I$ of residuals from the empty (intercept only) versus the adjusted models characterizes the degree of total spatial clustering explained by controlled variables.

All analysis was carried out in 2015 using R, version 3.1 and maps were prepared in ArcGIS, version 10.1. Small area estimation required access to county identifiers, which are not part of the public use data files from NSCH. Restricted-access NSCH files that included respondent county code were analyzed through the Research Data Center of the Centers for Disease Control and Prevention. The study was reviewed by the Emory University IRB.

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## Results

There were 42,390 and 39,381 respondents aged 10–17 years with non-missing BMI from the 3,109 eligible counties in NSCH surveys from 2007 and 2011–2012, respectively. The survey design-based estimate of adolescent obesity in the target counties was 16.4% in 2007 and 15.7% in 2011–2012, with lower prevalence in older adolescents, girls, and whites (Table 2). Model-estimated county-level obesity prevalence is mapped in Figure 1. Adolescent obesity was greatest in the Deep South and Central Appalachia, the San Joaquin Valley in California, as well as in pockets in the four corners region, Oklahoma, and the Northern Plains. Modeled obesity prevalence uncertainty is mapped in Appendix Figure 1, where higher SEs are clustered along the Mississippi River valley, Gulf Coast, and Upper Peninsula of Michigan. In counties with ≥50 NSCH respondents, the Spearman correlation coefficient for design-based reference values versus model-based prevalence was $r=0.95$ ($p<0.001$). Model-estimated county prevalence averaged to the state level correlated with state-level design-based reference values ($r=0.93$, $p<0.001$).

The distributions of county- and state-level variables are summarized in Table 1. In adjusted models (Table 3), none of the nine variables measuring the “nutrition-related opportunities and resources” or “nutrition-related practices” domains were significantly associated with county-level obesity. In the activity-related domains, violent crime rates were positively associated with obesity prevalence, whereas natural amenity index and the proportion of adults walking to work were inversely associated with obesity prevalence. Five of six variables in the “macrosocial and relational” domain were significant. The two indicators of community SES, poverty rate and persistent county poverty, were associated with higher obesity prevalence, but the food insecurity measure was inversely correlated with obesity. The Gini index of income inequality was not significant, but the other indicator of social marginalization, black–white segregation index, was associated with higher obesity prevalence. Finally, as an indicator of community health and disease, the prevalence of adults with Type 2 diabetes was positively associated with adolescent obesity prevalence.

The Moran’s $I$ statistic for global spatial autocorrelation of the residuals from the empty (intercept-only) model was 0.47 ($p<0.001$) suggesting a moderate degree of spatial clustering of obesity prevalence. By contrast, the Moran’s $I$ for the residuals from the adjusted model was 0.05 ($p<0.001$), suggesting that very little spatial clustering remains above and beyond that explained by predictor variables. The Index of Disparity was 37.8 in the empty (intercept-only) model, and 25.8 in the adjusted model, representing a 32% reduction. The reduction in relative disparity after adjustment for covariates was 44% and 47% using Mean Log Deviation and Theil’s Index respectively (Appendix Table 1). Thus, from one third to one half of the total geographic disparity in county obesity prevalence was explained by included variables.

## Discussion

There are substantial geographic disparities and geographic clustering of adolescent obesity prevalence among counties in the contiguous U.S. Building on an existing conceptual framework for the determinants of childhood obesity at various stages of child development,

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the authors used an exploratory modeling process to contrast candidate obesogenic correlates of county-level adolescent obesity prevalence. Together, these correlates explained one third to one half of the geographic disparity and nearly all geographic clustering. The strongest predictors of county-level adolescent obesity prevalence include community health status, proxied as the percentage of adults with prevalent Type 2 diabetes, and measures of community SES (child poverty rate) and social marginalization (segregation index). Variables from the activity-related opportunities, resources, and practices domains were also significantly associated with county-level adolescent obesity. By contrast, no variables from the nutrition opportunities, resources, or practices domains were significant predictors of county-level adolescent obesity.

Existing studies have taken varied approaches to conceptualizing and measuring obesogenic environments, including the examination of socioeconomic environments, local food environments, and physical and built environments.[35–39] Assessing measures similar to those included in the “macrosocial and relational” domain explored in this study, Rossen and Talih[40] demonstrated that racial and ethnic disparities in adolescent obesity prevalence were significantly attenuated after accounting for fundamental neighborhood-level socioeconomic and demographic features, including indices of segregation and income inequality. However, the pathways through which such “fundamental causes” influence obesity are not fully understood. Disparities in adolescent obesity have been attributed to a higher exposure among disadvantaged populations to obesogenic environments, such as limited access to healthy foods and resources for physical activity.[41–44] Yet, this study indicates that factors like persistent poverty and segregation remain significant even after accounting for features of the nutrition and activity environments. The results also point to an inverse association between ecologic child food insecurity rates and obesity prevalence. This is in contrast to some findings that at the individual level, food insecurity has been associated with higher obesity risk.[45,46] The findings of ecologic correlations point to possible sources of contextual influence on obesity prevalence, but require further examination of mediating pathways and multilevel mechanisms through which area-based disadvantage could influence obesity.

Research on the associations among the local food environment, the physical and built environment, and obesity has produced mixed results. A recent systematic review of the literature on local food environments identified predominantly null associations, yet highlighted trends toward inverse associations between supermarket availability and obesity, and positive associations between fast food availability and obesity.[36] It is possible that mixed results for the importance of food environment reflect measurement error in that most studies rely on administrative lists of food stores as proxies for food accessibility without explicit attention to food quality or cost, each of which could affect nutrition independent of proximity.[47] As is the case with the current study, more-consistent results have been found for the physical and built environment correlates of obesity prevalence, including inverse associations between adolescent obesity and the presence of recreation centers, parks and playgrounds, and sidewalks and walking paths.[38,39,48,49] This study also provides further evidence in support of the emerging relationship between area-based crime rates and adolescent physical activity and obesity prevalence.[49,50] Overall, these findings are

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consistent with existing evidence on activity environments compared to nutrition environments.

This study helps to advance understanding of environmental correlates of, and disparities in, adolescent obesity prevalence in several ways. First, the geographic patterns of obesity prevalence among adolescents track closely with geography of adult obesity,[51] suggesting common local variation in correlates of obesity in different life stages, and highlighting the public health importance of addressing obesity in a life course framework.[52] Much of the extant literature has used localized samples, which occasionally provide richer local measurement, but have limited generalizability.[36,38] The national scope of the adolescent obesity epidemic necessitates the identification of more widely applicable factors that may be intervened upon to facilitate population level change. In this ecologic study, characterizing obesity at the county level allowed for explicit acknowledgement of important within-state variations in both predictors and obesity prevalence.

This study also contributes to the growing body of literature recognizing the complexity of environmental influences on obesity. The number of studies simultaneously examining multiple domains of the obesogenic environments, including the food, built, social, and economic environments of adolescents, remains limited.[37,49,53–55] The wide array of measures from multiple diverse domains included in this study explained most of the spatial clustering and one third to one half of the geographic disparity in obesity, underscoring the importance of comprehensive approaches to exploring environmental correlates of obesity.

## Limitations

This study design was descriptive and exploratory, and thus limited in several ways. First, the findings are dependent on both the validity of parent-reported height and weight in the NSCH, and on the assumptions of small area estimation methods. Although parent-reported height and weight may be systematically biased for younger children, estimates of BMI for children aged 10 years older are more reliable.[56,57] There is also evidence for geographic variation in the accuracy of self-reported height and weight among adults,[58] although it is unclear whether this is true for parent-reported values of children. However, the broad geographic patterns observed are consistent with those obtained from other data sources for adolescents[59] and adults.[60]

This study design is ecologic, and reported obesity prevalence is marginal (e.g., not race-, sex- or age-specific). The marginal nature of the prevalence estimates limits the opportunity to comment on race, gender, or age differences in the importance of area-based factors, but the small area estimation techniques required aggregation across demographic strata to produce valid county-level estimates. The ecologic design also limited examination of behavioral mediators between environment and obesity. However, both the ecologic design and marginal prevalence lend themselves to the goal of characterizing the population burden of adolescent obesity in places, and characterizing places with higher or lower obesity prevalence.

Finally, it is likely that area-based factors for units other than counties (e.g., neighborhoods, cities) affect obesity prevalence, although it has been argued that counties represent the

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smallest analytic unit with useful policy implications.[61,62] Variable selection was limited by conceptual linkage with the Harrison et al.[18] framework, and availability at the county or state scale; missing variables could result in biased estimates or residual unexplained geographic disparities.

## Conclusions

Nationwide small area estimates of adolescent obesity prevalence demonstrated substantial geographic variation and patterning. The domain most strongly associated with county-level obesity prevalence was the "macrosocial and relational" domain, including community SES, community health, and social marginalization. By applying a multidimensional conceptual model of the determinants of childhood obesity, no ecologic correlation between nutrition-related factors and obesity prevalence was identified, but there were some associations between activity-related factors and obesity prevalence, including county-level crime rates, recreational facility density, and prevalence of adults walking to work. These results highlight the importance of multidimensional thinking in developing public health responses to the obesity epidemic. Although individual behaviors are likely intervening variables, the social and community context in which adolescents are exposed to norms and develop behaviors may need additional etiologic and interventional focus to meaningfully reduce geographic disparities in obesity prevalence.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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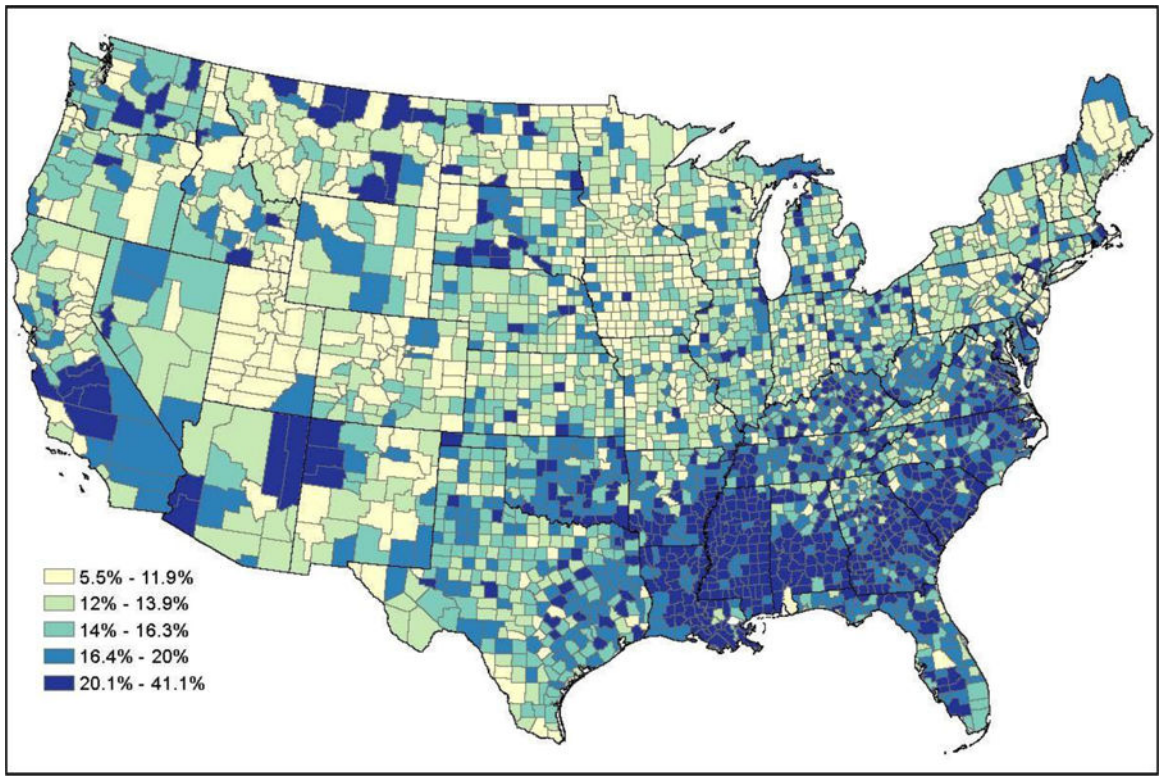


**Figure 1.**
Model-estimated obesity prevalence for children 10–17 years old in U.S. counties, National Survey of Children's Health 2007 and 2011–2012.

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**Table 1**

Definition and Distribution of Ecologic Measures of Obesogenic Environments

| Ecological correlates of childhood obesity | | Selected variables | Data source (year of measure) | Unit of geography | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|---|---|
| **Domain** | **Sub-domain** | | | | | | | |
| **Nutrition-related opportunities and resources** | | | | | | | | |
| | *Healthcare system structure* | Pediatricians and primary care providers per 10,000 pop | U.S. DHHS and HRSA Area Health Resources File (2010) | County | 3.04 | 2.2 | 0 | 30.76 |
| | | Hospitals per 10,000 pop | U.S. DHHS and HRSA Area Health Resources File (2010) | County | 0.58 | 0.91 | 0 | 9.61 |
| | | Uninsured children (%) | U.S. Census Bureau, Small Area Health Insurance Estimates (2009) | County | 8% | 5% | 2% | 36% |
| | *Breastfeeding practices* | Infants ever breastfed (%) | CDC Breastfeeding Report Card (2009) | State | 71% | 9% | 47% | 90% |
| | | State-mandated employer lactation support (1/0) | CDC Breastfeeding Report Card (2009) | State | 26% | | | |
| | *Accessibility/proximity of food outlets* | Low access to food store (%)[a] | USDA Food Environment Atlas (2010) | County | 6% | 4% | 0% | 36% |
| | | Grocery stores per 1,000 pop | USDA Food Environment Atlas (2010) | County | 0.29 | 0.22 | 0 | 3.23 |
| **Nutrition-related practices** | | | | | | | | |
| | *Community food restriction/bans* | Soda price (ratio of local price to national price) | USDA Food Environment Atlas (2010) | County | 1.04 | 0.06 | 0.93 | 1.32 |
| | *Peer food choices* | Adults with low fruit and vegetable intake (%)[b] | CDC Behavioral Risk Factor Surveillance System (2011) | State | 32% | 4% | 23% | 42% |
| **Activity-related opportunity and resources** | | | | | | | | |
| | *Crime rates* | Violent crime rate per 10,000 pop | FBI Uniform Crime Reporting Program Data: County-level Detailed Arrest and Offense Data (2009) | County | 4.59 | 3.03 | 0 | 48.89 |
| | *Access to recreation facilities* | Natural amenity index[c] | USDA Economic Research Service (1999) | County | 3.49 | 1.04 | 1 | 7 |
| | | Recreation and fitness facility per 1,000 pop | USDA Food Environment Atlas, derived from U.S. Census Bureau, County Business Patterns (2007) | County | 0.09 | 0.09 | 0 | 1.49 |
| | *School activity requirements* | State mandated school activity policy (1/0)[d] | Shape of the Nation Report (2012) | State | 80% | | | |
| **Activity-related practices** | | | | | | | | |
| | *Local employment practice* | Adults walking to work (%) | American Community Survey (2006–2010) | County | 3% | 3% | 0% | 34% |

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| Ecological correlates of childhood obesity | | Selected variables | Data source (year of measure) | Unit of geography | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|---|---|
| **Domain** | **Sub-domain** | | | | | | | |
| | *Leisure time activity and media usage* | Adolescents use electronics >1 hr/day (%) | National Survey of Children's Health (2011–2012) | State | 34% | 4% | 25% | 44% |
| **Macrosocial and relational** | | | | | | | | |
| | *Community SES* | Poverty rate (%) | USDA Food Environment Atlas, derived from U.S. Census (2010) | County | 17% | 6% | 3% | 50% |
| | | Persistent child poverty (1/0)[e] | USDA Food Environment Atlas, derived from U.S. Census (2010) | County | 23% | | | |
| | *Food insecurity* | Child food insecurity rate[f] | Map the Meal Gap 2011- Feeding America (2009) | County | 0.26 | 0.06 | 0.07 | 0.52 |
| | *Social marginalization* | Gini index of income inequality | American Community Survey (2006–2010) | County | 0.43 | 0.04 | 0.21 | 0.64 |
| | | Black-white racial segregation (H Index) | U.S. Census Bureau (2010) | County | 0.06 | 0.08 | 0 | 0.66 |
| | *Community health/disease* | Adult diabetes prevalence (%) | USDA Food Environment Atlas, derived from CDC Behavioral Risk Factor Surveillance System (2009) | County | 10% | 2% | 3% | 20% |
| **Place-based characteristics** | | | | | | | | |
| | | Population loss (1/0)[g] | USDA Food Environment Atlas, derived from U.S. Census (2010) | County | 19% | | | |
| | | Metropolitan area (1/0) | USDA Food Environment Atlas, derived from U.S. Census (2010) | County | 37% | | | |
| | *Census region* | Northeast | U.S. Census Bureau (2010) | State | 7% | | | |
| | | Midwest | | | 34% | | | |
| | | South | | | 46% | | | |
| | | West | | | 13% | | | |

[a] Low food access is living >1 mile from supermarket in metropolitan area or >10 miles in rural area; our measure is the average of: % children with low access; % population with both low access and low income; and % of population with low access and no vehicle for each county.

[b] % of adults who report eating less than 1 serving daily of fruit and vegetables.

[c] The Natural Amenity Index is created by USDA Economic Research Service and ranges from 1 to 7, with higher values indicating higher amenities. It captures climate, topography, and water area that reflect environmental qualities most people prefer.

[d] State mandated physical activity indicates whether states have two or more of the following: physical education mandated in middle school or in high school; or weekly physical activity mandated in middle school or high school.

[e] Counties where the poverty rate of related children under age 18 was 20% or more over the last 30 years, as measured by 1980, 1990, and 2000 decennial censuses and the 2007–2011 American Community Survey 5-year estimates; where 1=persistent poverty and 0=otherwise

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[f] County level child food insecurity prevalence was estimated by Gunderson et al. for Feeding America (Gundersen CE. Waxman E, Engelhard, Brown J. Map the Meal Gap 2011: A Report on County Level Food Insecurity and Food Cost in the United States in 2009. Feeding America, 2011).

[g] Counties where the number of residents declined both between 1980 and 1990 and between 1990 and 2000, where 1=population-loss county, 0=otherwise.

HRSA, Health Resources and Services Administration; CDC, Centers for Disease Control and Prevention; USDA, U.S. Department of Agriculture; FBI, Federal Bureau of Investigation

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**Table 2**

Obesity Prevalence in National Survey of Children's Health (NSCH)

| Eligible children, 10–17 years old | NSCH 2007 | | | NSCH 2011–2012 | | |
|---|---|---|---|---|---|---|
| | N | % Obese | SE | N | % Obese | SE |
| Total | 42,390 | 16.4 | 0.49 | 39,381 | 15.7 | 0.42 |
| 10–14 years old | 23,894 | 18.3 | 0.65 | 23,091 | 18.0 | 0.57 |
| 15–17 years old | 18,496 | 13.3 | 0.72 | 16,290 | 12.1 | 0.61 |
| Male | 22,098 | 19.2 | 0.7 | 18,838 | 18.4 | 0.61 |
| Female | 20,292 | 13.5 | 0.68 | 20,543 | 12.9 | 0.58 |
| White | 30,374 | 14.0 | 0.55 | 27,482 | 13.6 | 0.46 |
| Non-white | 12,016 | 21.3 | 0.98 | 11,899 | 19.9 | 0.86 |

*Note:* N=3,109 target counties in lower 48 states and District of Columbia

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**Table 3**

Exploratory Model Results for Selected Ecologic Obesogenic Factors and Adolescent Obesity Prevalence in U.S. Counties

| **Harrison, et al. Ecological correlates of childhood obesity** | | **Selected variables** | **Adjusted Bayesian model** | | |
|---|---|---|---|---|---|
| **Domain** | **Sub-domain** | | **β** | **95% CI** | |
| | | (Intercept) | **15.82** | **14.77** | **16.82** |
| **Nutrition-related opportunities and resources** | | | | | |
| | *Healthcare system structure* | Pediatricians and primary care providers density[a] | −0.05 | −0.21 | 0.11 |
| | | Hospitals density[a] | −0.05 | −0.21 | 0.11 |
| | | Uninsured children (%)[a] | 0.02 | −0.20 | 0.24 |
| | *Breastfeeding practices* | Infants ever breastfed (%)[a] | 0.04 | −0.74 | 0.87 |
| | | State-mandated employer lactation support (binary)[b] | −0.29 | −1.21 | 0.59 |
| | *Accessibility/proximity of food outlets* | Low access to food store (%)[a] | 0.12 | −0.03 | 0.26 |
| | | Grocery store density[a] | −0.14 | −0.30 | 0.01 |
| **Nutrition-related practices** | | | | | |
| | *Community food restriction/bans* | Soda price (ratio of local price to national price)[a] | 0.15 | −0.10 | 0.39 |
| | *Peer food choices* | Adults with low fruit and vegetable intake (%)[a] | 0.25 | −0.43 | 0.99 |
| **Activity-related opportunity and resources** | | | | | |
| | *Crime rates* | Violent crime rate[a] | **0.28** | **0.12** | **0.45** |
| | *Access to recreation facilities* | Natural amenity index[a] | **−0.39** | **−0.59** | **−0.19** |
| | | Recreation and fitness facility density[a] | 0.00 | −0.13 | 0.14 |
| | *School activity requirements* | State mandated school activity policy (binary)[b] | −0.03 | −0.91 | 0.90 |
| **Activity-related practices** | | | | | |
| | *Local employment practice* | Adults walking to work (%)[a] | **−0.22** | **−0.38** | **−0.05** |
| | *Leisure time activity and media usage* | Adolescents use electronics >1 hr/day (%)[a] | 0.14 | −0.46 | 0.80 |
| **Macrosocial and relational** | | | | | |
| | *Community SES* | Poverty rate (%)[a] | **1.44** | **1.19** | **1.70** |
| | | Persistent child poverty (binary)[b] | **0.46** | **0.07** | **0.87** |

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| Harrison, et al. Ecological correlates of childhood obesity | | Selected variables | Adjusted Bayesian model | | |
|---|---|---|---|---|---|
| **Domain** | **Sub-domain** | | **β** | **95% CI** | |
| | *Food insecurity* | Child food insecurity rate[a] | **−0.60** | **−0.84** | **−0.38** |
| | *Social marginalization* | Gini index of income inequality[a] | −0.10 | −0.26 | 0.06 |
| | | Black-white racial segregation[a] | **0.96** | **0.80** | **1.12** |
| | *Community health/disease* | Adult diabetes prevalence (%)[a] | **1.14** | **0.93** | **1.35** |
| **Place-based characteristics** | | | | | |
| | | Population loss (binary)[b] | **−0.37** | **−0.74** | **−0.01** |
| | | Metropolitan area (binary)[b] | 0.20 | −0.12 | 0.53 |
| | | Northeast | ref | | |
| | | Midwest | −0.10 | −1.01 | 0.78 |
| | | South | 0.45 | −0.48 | 1.54 |
| | | West | 0.16 | −0.79 | 1.11 |
| Variance components[c] | | sigma – state | 1.86 | 1.46 | 2.37 |
| | | sigma – residual | 3.58 | 3.50 | 3.67 |
| | | ICC | 0.34 | 0.29 | 0.39 |
| | | AIC/DIC | | 16812 | |

*Notes:* Boldface indicates statistical significance ($p<0.05$)

N=3,109 counties nested within 48 states and District of Columbia

[a] β-coefficients represent the change in county obesity prevalence per 1-SD change in the predictor.

[b] β-coefficients represent the change in county obesity prevalence for having versus not having the binary indicator.

[c] Variance components and fit statistics from the empty model (intercept only): sigma (state): 3.27; sigma(residual): 4.06; ICC: 0.45 (95% CI 0.40,0.49); AIC: 17705.

ICC, Intra-cluster Correlation Coefficient; AIC, Akaike Information Criterion; DIC, Deviance Information Criterion_