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FINDINGS BRIEF

RURAL & MINORITY Health Research Center

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Development of a Childhood Obesogenic Environment Index

- This report describes how several county-level environment variables were utilized to construct the Childhood Obesogenic Environment Index which consists of 10 variables related to physical activity and healthy eating.
- Noncore counties scored significantly higher (worse) on the childhood obesogenic environment index compared to counties classified as metropolitan or micropolitan.
- The South region scored significantly higher on the childhood obesogenic environment index compared to the Northeast, Midwest, and West regions of the United States(U.S.)
- This report demonstrates how sorting counties by characteristics of the environment can identify areas in need of additional interventions or policies to reduce physical inactivity and poor diet and increase access to healthy foods and recreational opportunities.

BACKGROUND

Childhood obesity has become a major threat to public health in the U.S. and other developed countries.[1,2] Among children, overweight and obesity are assessed using age, gender, height, and weight and are expressed as percentiles.[3] Children and adolescents are considered overweight if they score at the 85th percentile to less than the 95th percentile for their age and gender; they are considered obese if they score at or above the 95th percentile. Within the last three decades, child obesity rates rose considerably with 18.5% of children aged 2 to 19 classified as obese and 32% classified as overweight or obese.[4] Further, obesity is more prevalent in children residing in rural areas with a 26% greater chance of being obese compared to children residing in urban areas.[5]

The environment is a key factor contributing to unhealthy diets and physical inactivity.[6,7] While the effect of specific environmental features can be nuanced (e.g., supermarkets can contain both healthy and unhealthy products), having access to healthy foods, such as proximity to supermarkets and farmers' markets, and availability of unhealthy options, such as proximity to fast food restaurants and convenience stores, can influence diet and weight status.[8,9] Moreover, access to recreation facilities, such as parks and playgrounds, other neighborhood factors such as walkability and safety, and ability to utilize active transportation to work or school are associated with increased physical activity.[10,11]

In recognition of the influence of environmental factors on obesity-related health behaviors, researchers and practitioners have placed increased focus on what has been termed the "obesogenic environment."[7,12,13] In this study, obesogenic environments are defined as the sum of physical elements within communities that promote sedentarism, restrict physical activity, and encourage unhealthy eating practices among children. Despite substantial research into environmental influences on childhood obesity, no prior studies have sought to develop a comprehensive

community obesogenic environment index for children that can be applied on a large geographic scale. Given these considerations, the purposes of this study were to:

1) Describe the development of a childhood obesogenic environment index
2) Examine differences in obesogenic environment index values by rurality and region across the United States

METHODS FOR INDEX CREATION

Development of the child obesogenic environment index consisted of a series of stages involving a review of extant literature, expert feedback, and statistical analyses. Initially, we conducted a search to locate review articles that summarized associations between the environment and its impact on nutrition, physical activity, and overweight/obesity levels in youth. Ultimately, a final list of 24 variables was agreed upon for distribution to additional experts and possible inclusion within the childhood obesogenic environment index.

During the next major project phase, input was solicited from 12 experts within the fields of nutrition, physical activity, and environmental influences on obesity. These experts reviewed the list of 24 variables that were identified throughout the literature review process. Specifically, they were asked to rate the importance of each variable (1=low importance, 7=high importance), provide input on potential data sources that had been identified for each variable, and offer any additional comments about the variables, data sources, or other aspects of the index development process. Experts were also able to suggest additional variables and data sources not included within the original list (five new variables were recommended).

Expert feedback was evaluated by the project team, and consensus was obtained regarding the variables to include in the index. Specifically, mean ratings and standard deviations were calculated for each variable, and all comments submitted by the expert reviewers were compiled and analyzed. Extensive discussion of expert reviewer feedback among the project team resulted in a refined list of 10 variables to be included in the childhood obesogenic environment index (see Table 1).

Table 1: Variables in the Childhood Obesogenic Environment Index
Grocery stores and superstores*
Farmers markets*
Fast food restaurants
Full-service restaurants
Convenience stores
Births at baby-friendly facilities*
Exercise opportunities*
School proximity*
Walkability*
Violent crime
* Variable was reverse scored such that higher values for all variables indicate a more obesogenic environment

Data for each variable for all counties in the United States were collected from several different publicly-available sources (see Appendix). For each variable, the values for all counties were ranked

and a percentile was assigned to each county that could range from 0 to 100 (0=least obesogenic, 100=most/worst obesogenic).

As indicated in Table 1, variables that were considered positive aspects of the environment - grocery stores/superstores, farmers markets, births at baby-friendly hospitals, exercise opportunities, school proximity, and walkability – were reverse scored such that a lower score for these variables indicated a healthy environment. Variables that were considered negative aspects of the environment – fast food restaurants, full-service restaurants, convenience stores, and violent crime – were scored as is, such that a higher score for these variables indicated an unhealthy environment. For each county, a total obesogenic environment index score was generated by calculating the average percentile for all 10 variables. Minimal missing data were excluded such that if a variable(s) was not available for a county, the total score was generated taking the mean of all available variables.

Each county was classified by rurality and by region. Urban Influence Codes (UIC), retrieved from the USDA, were utilized to determine rurality classification for all counties in the U.S. Of the original twelve UIC categories, we divided counties into three groups: metropolitan, micropolitan and noncore. Additionally, nonmetropolitan counties collectively include micropolitan and noncore counties. Census regions, defined and retrieved from the U.S. Census Bureau, were utilized to identify four U.S. regions: Northeast, Midwest, South, and West.

Technical Notes

All analyses were performed at the county level. Counties were characterized based on level of rurality using Urban Influence Codes (UIC) developed by the U.S. Department of Agriculture Economic Research Service: metropolitan (UICs 1,2), micropolitan (UICs 3,5,8), and noncore (UICs 4,6,7,9-12). Nonmetropolitan counties included both micropolitan and noncore areas.

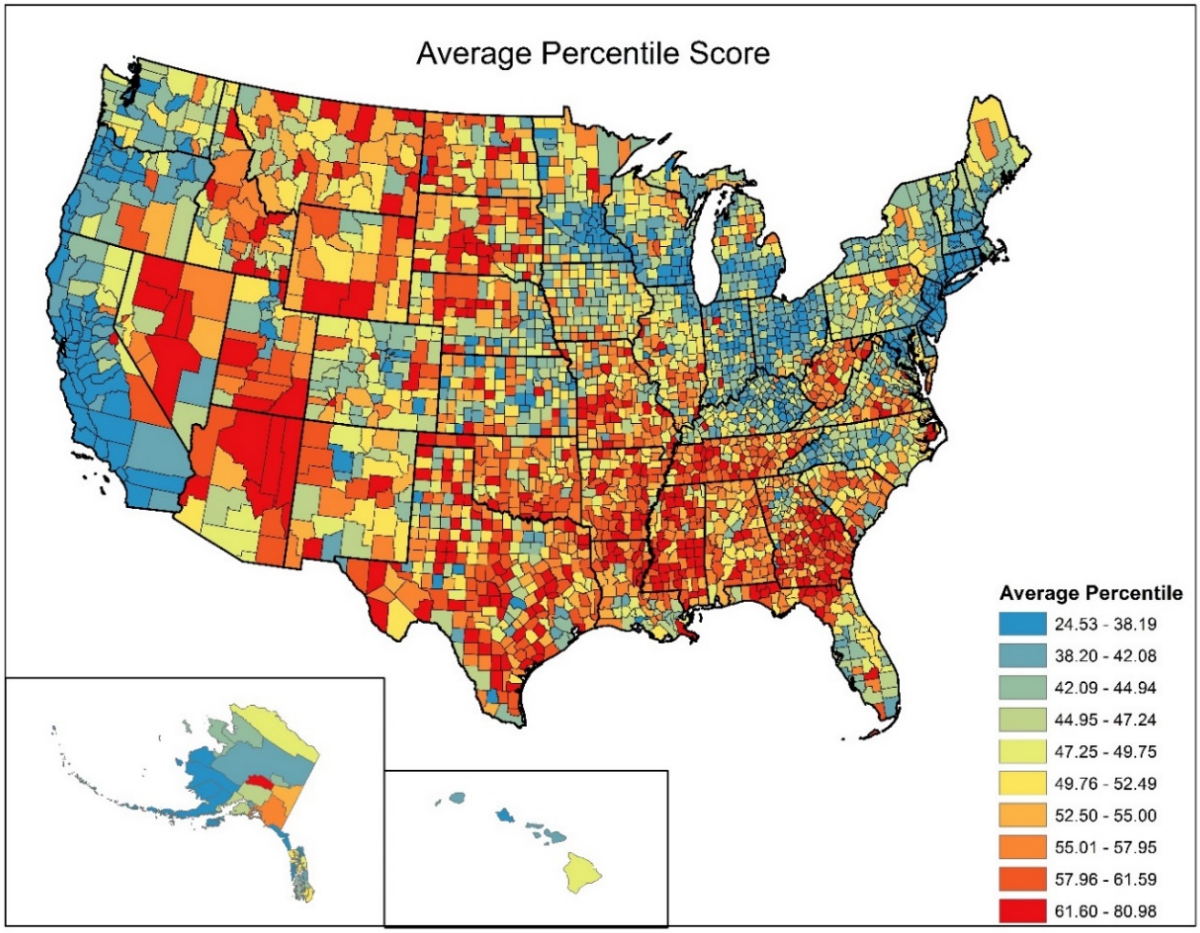
RESULTS

All counties within the United States were included in the present analyses (N=3,142). The average Childhood Obesogenic Environment Index percentile ranged from 24.53-80.98 (Mean [M]=50.02, Standard Deviation [SD]=9.01) with lower scores indicating a less obesogenic or healthier environment and higher scores indicating a more obesogenic or less healthy environment). A total of 1,599 counties fell below the 50th percentile, and 1,543 counties fell at or above the 50th percentile.

Childhood Obesogenic Environment Index: United States

A map was generated to display the Childhood Obesogenic Environment Index by county across the United States (see Figure 1). There were fewer obesogenic counties in the Northeast, Midwest, and West; whereas, the South contained a greater number of obesogenic counties. It is important to note that this map provides a spatial depiction of the obesogenic environment but is not a representation of the population or the prevalence of youth obesity.

Figure 1: Childhood Obesogenic Environment Index by County



Note: a larger percentile indicates a more obesogenic environment

Childhood Obesogenic Environment Index: Rurality

When examined by county rurality (see Table 2), there were significant differences between metropolitan, micropolitan, and noncore counties across the United States for obesogenic environment index scores ($p<.0001$). Specifically, metropolitan counties had significantly lower (better) obesogenic environment index scores ($M=46.5$, $SD=8.4$) compared to micropolitan ($M=50.3$, $SD=8.1$) and noncore ($M=52.9$, $SD=8.8$) counties. Similarly, micropolitan areas had significantly lower (better) index scores compared to noncore areas.

Table 2: Childhood Obesogenic Environment Index by County Rurality	
	Average Percentile (SD)
Metropolitan Counties	46.5 (8.4)
Nonmetropolitan Counties	52.1 (8.7)
Micropolitan Counties	50.3 (8.1)
Noncore Counties	52.9 (8.8)
Notes: A larger percentile indicates a more obesogenic environment. ANOVA used to assess differences between means.	

Childhood Obesogenic Environment Index: Region

When examined by U.S. region (see Table 3), there were significant differences between the Northeast, Midwest, South, and West regions of the United States ($p<.0001$). The Northeast region ($M=43.2$, $SD=6.9$) had a significantly lower (better) average index value compared to the Midwest ($M=48.1$, $SD=8.5$), South ($M=53.0$, $SD=8.3$), and West ($M=48.4$, $SD=9.8$) regions. The Midwest region showed a significantly higher (worse) average index score compared to the Northeast region and a significantly lower (better) index score compared to the South region but no significant difference compared to the West region. Counties in the South region had significantly higher (worse) index scores compared to all other regions.

Table 3: Childhood Obesogenic Environment Index by Region	
	Average Percentile (SD)
Northeast	43.2 (6.9)
Midwest	48.1 (8.5)
South	53.0 (8.3)
West	48.4 (9.8)
Notes: A larger percentile indicates a more obesogenic environment. ANOVA used to assess differences between means.	

Childhood Obesogenic Environment Index by Rurality and Region

As shown in Table 4, analyses were also conducted incorporating both county rurality and U.S. region. Overall, the Northeast region of the United States had the lowest (best) childhood obesogenic environment index for all of metropolitan, micropolitan, and noncore counties. In contrast, the South had the highest (worst) index values across metropolitan, micropolitan, and noncore counties. There were significant differences between regions and county type across the United States ($p<.0001$). Looking at rurality differences within each region, important differences

were observed. There were significant differences between all categories of rurality in the Northeast (p<.0001), Midwest (p<.0001), and West (p<.0001). In the South, there were also significant differences based on rurality (p=<.0001), but comparing categories, metropolitan counties had better environments while micropolitan and noncore areas were not significantly different.

Table 4: Childhood Obesogenic Environment Index by County Rurality and U.S. Region

	Northeast	Midwest	South	West
Metropolitan Counties	40.5	43.7	50.1	43.0
Nonmetropolitan Counties	47.1	49.8	55.1	50.9
Micropolitan Counties	45.1	47.0	54.8	48.9
Noncore Counties	49.4	51.1	55.2	51.8

Notes: A larger percentile rank indicates a more obesogenic environment. ANOVAs were used to assess differences between rurality category means within each region.

Childhood Obesogenic Environment Index: Variables by Rurality

Each of the 10 variables comprising the obesogenic environment index were examined by county rurality (see Table 5). Grocery stores/superstores and farmer's markets were less prevalent per population in metropolitan compared to noncore or micropolitan counties. Additionally, fast food restaurants are more prevalent per population in metropolitan counties. Full-service restaurants and convenience stores were more prevalent per population in noncore counties compared to metropolitan and micropolitan counties. The percentage of births in baby-friendly facilities (measured at the state-level) was greatest in metropolitan counties and least in noncore counties. Exercise opportunities, school proximity, and walkability were best among metropolitan counties and worst in noncore counties. Violent crime was most prevalent in metropolitan counties and least prevalent in noncore counties.

Table 5: Childhood Obesogenic Environment Index Variable Percentiles by County Rurality

	Metropolitan	Non-metro	Micropolitan	Noncore	Non-metro Better or Worse than Metro
Grocery stores/superstores[a]	62.6	42.6	54.7	36.8	Better
Farmers markets[a]	54.3	47.4	47.0	47.7	Better
Fast food restaurants	56.8	46.0	56.7	40.9	Better
Full-service restaurants	45.6	52.6	50.1	53.8	Worse
Convenience stores	36.0	58.2	50.2	62.1	Worse
Births at baby friendly facilities[a]	46.3	52.2	48.1	54.1	Worse
Exercise opportunities[a]	38.6	56.7	48.0	60.9	Worse
School proximity[a]	28.4	62.7	48.1	69.8	Worse
Walkability[a]	39.8	56.0	46.2	60.8	Worse
Violent crime	56.9	45.7	54.3	41.4	Better
Average percentile	**46.5**	**52.1**	**50.3**	**52.9**	Worse

Note: a larger percentile indicates a more obesogenic environment

[a]Variable was reverse scored such that higher values indicate unhealthier environments for all variables

Childhood Obesogenic Environment Index: Variables by Region

Each of the 10 variables comprising the index were also examined by region of the U.S. (see Table 6). Grocery stores/supercenters and farmers markets were less prevalent in the South. Fast food restaurants and full-service restaurants were more available in the Northeast, and convenience stores were most prevalent in the South. The percentage of births at baby-friendly facilities was highest in the Northeast. Exercise opportunities, school proximity, and walkability were best in the Northeast. Violent crime was most prevalent in the South.

Table 6: Average Childhood Obesogenic Environment Index Variable Percentile Rank by U.S. Region

	Northeast	Midwest	South	West
Grocery stores/superstores[a]	42.8	45.7	56.9	41.8
Farmers markets[a]	39.1	43.5	58.1	45.5
Fast food restaurants	61.3	45.4	51.1	52.0
Full-service restaurants	67.5	57.2	38.1	62.2
Convenience stores	35.2	48.1	57.8	37.0
Births at baby friendly facilities[a]	45.5	53.5	49.4	45.7
Exercise opportunities[a]	38.6	47.7	56.6	40.0
School proximity[a]	25.5	52.6	45.6	69.7
Walkability[a]	31.8	46.3	59.4	37.7
Violent crime	45.6	39.8	57.2	52.5
Average percentile	**43.2**	**48.1**	**53.0**	**48.4**

Note: a larger percentile indicates a more obesogenic environment

[a]Variable was reverse scored such that higher values indicate unhealthier environments for all variables

CONCLUSION

Noncore counties had higher (worse) average childhood obesogenic environment index scores compared to their metropolitan or micropolitan counterparts. By region, the South had the highest (worst) observed obesogenic environment index scores followed by the West, Midwest, and Northeast regions. Southern noncore counties had the greatest obesogenic environment burden; whereas, Northeast metropolitan counties had the lowest burden.

This study identified several key environmental variables that may play a significant role in childhood obesity. A number of these variables may prove problematic in the rural environment particularly as existing literature shows that rural populations are at an increased risk for childhood obesity.[14] In some rural areas, agricultural work may facilitate healthy eating and physical activity among children and farming families, but in most cases, additional environmental improvement efforts will be useful. Indeed, documented resource limitations in rural areas such as access to healthful foods and opportunities for physical activity may contribute to geographic disparities in childhood obesity.[15] These barriers to healthy living, however, may be overcome through a number of different public health policies and initiatives.

Aspects of the physical environment could be modified to promote physical activity and increase access to exercise opportunities. For example, public health, planning, and other government agencies could improve walkability and pedestrian and bicycle safety through improvements to infrastructure (e.g., traffic calming measures, sidewalks).[16,17] Rural schools may adopt programming such as Safe Routes to School which increases safety surrounding schools to encourage active travel to/from school.[18] Further, physical activity-related policies such as shared use agreements that increase accessibility of school recreation facilities and playgrounds to the public could be a viable method to increase access to exercise opportunities.[19]

Features of the physical environment can also be modified to increase the availability of healthy food options. For example, policy makers could work to improve the food environment through food outlet zoning. Unhealthy food outlets – fast food restaurants, convenience stores, etc. – may cluster around schools[20,21] and negatively influence student diets.[22] Such efforts could reduce the prevalence of food swamps which have been linked to higher obesity rates.[23] Additionally, rural public health agencies could work to improve childhood obesity rates through partnerships with fellow public agencies, schools, and local grocery stores and restaurants.[14,24] For example, public health agencies could sponsor farmers markets to promote healthful and affordable food options. Moreover, fostering relationships between farms and schools and local businesses could bring healthier food choices into schools and restaurants.[24,25] These efforts to increase access to healthy food options could contribute to reducing the number of food deserts in rural areas.

The foundation of our obesogenic environment index was variables that represent resource availability. It is important to note that counties that have fewer total resources to promote healthy eating and physical activity (e.g., lower access to grocery stores, poorer walkability) do not necessarily have higher childhood obesity prevalence or vice versa. Other key area-level drivers of childhood obesity including socioeconomic status, lack of health insurance, and proportion of racial/ethnic minorities may interact with an area's physical environment to determine obesity outcomes. Additional research is needed to explore the additive and multiplicative interaction between the obesogenic environment and other area-level sociodemographic factors that predict childhood obesity.

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APPENDIX: DEFINITIONS OF VARIABLES INCLUDED IN CHILDHOOD OBESOGENIC ENVIRONMENT INDEX

Variable	Measure	Source	Year	Description
Grocery stores and supercenters	Number of grocery stores/supermarkets and supercenters/warehouse club stores in the county per 1,000 county residents	United States Department of Agriculture (Stores: U.S. Census Bureau, County Business Patterns Population: U.S. Census Bureau, Population Estimates)	2014	"Grocery stores include establishments generally known as supermarkets and smaller grocery stores primarily engaged in retailing a general line of food, such as canned and frozen foods; fresh fruits and vegetables; and fresh and prepared meats, fish, and poultry." [1] "Warehouse clubs and supercenters are primarily engaged in retailing a general line of groceries in combination with general lines of new merchandise, such as apparel, furniture, and appliances." [1] This variable was created by combining the number of grocery store/supermarkets per 1,000 residents with the number of supercenters/club warehouses per 1,000 residents in each county.
Farmers markets	Number of farmers markets in the county per 1,000 county residents	United States Department of Agriculture (Farmers Markets: Agricultural Marketing Service, Marketing Services Division Population: U.S. Census Bureau, Population Estimates)	2016	"A farmer's market is a retail outlet in which two or more vendors sell agricultural products directly to customers through a common marketing channel. At least 51 percent of retail sales are direct to consumers." [1]
Fast food restaurants	Number of fast food restaurants in the county per 1,000 county residents	United States Department of Agriculture (Restaurants: U.S. Census Bureau, County Business Patterns Population: U.S. Census Bureau, Population Estimates)	2014	"Fast food/limited-service restaurants include establishments primarily engaged in providing food services (except snack and nonalcoholic beverage bars) where patrons generally order or select items and pay before eating. Food and drink may be consumed on premises, taken out, or delivered to the customer's location. Some establishments in this industry may provide these food services in combination with alcoholic beverage sales."[1]
Full-service restaurants	Number of full-service restaurants in the county per 1,000 county residents	United States Department of Agriculture (Restaurants: U.S. Census Bureau, County Business Patterns Population: U.S. Census Bureau, Population Estimates)	2014	"Full-service restaurants include establishments primarily engaged in providing food services to patrons who order and are served while seated (i.e., waiter/waitress service) and pay after eating. These establishments may provide this type of food service to patrons in combination with selling alcoholic beverages, providing takeout services, or presenting live nontheatrical entertainment." [1]

Variable	Measure	Source	Year	Description
Convenience stores	Number of convenience stores in the county per 1,000 county residents	United States Department of Agriculture (Stores: U.S. Census Bureau, County Business Patterns Population: U.S. Census Bureau, Population Estimates)	2014	"Establishments known as convenience stores or food marts (defined by North American Industry Classification System (NAICS) codes 445120 and 447110) are primarily engaged in retailing a limited line of goods that generally includes milk, bread, soda, and snacks." [1]
Births at baby-friendly facilities	Percent births at baby-friendly facilities at the state level	Centers for Disease Control and Prevention (Breastfeeding Report Card, Division of Nutrition, Physical Activity, and Obesity, National Center for Chronic Disease Prevention and Health Promotion)	2016	This state-level variable is defined as the percentage of births that occur at Baby-Friendly Hospitals and Birth Centers as designated by Baby-Friendly USA (https://www.babyfriendlyusa.org).[2]
Exercise opportunities	Percentage of individuals in a county who live close to a location for physical activity	County Health Rankings (2010 US Census Bureau Population data 2016 SIC codes 2016 parks Business Analyst Delorme map data, ESRI US Census Tigerline Files)	2018	"Access to Exercise Opportunities measures the percentage of individuals in a county who live reasonably close to a location for physical activity. Locations for physical activity are defined as parks or recreational facilities. Parks include local, state, and national parks. Recreational facilities include YMCAs as well as businesses identified by the following Standard Industry Classification (SIC) codes and include a wide variety of facilities including gyms, community centers, dance studios and pools. Individuals who reside in a census block within a half mile of a park; or in urban census blocks: reside within one mile of a recreational facility; or in rural census blocks: reside within three miles of a recreational facility are considered to have adequate access for opportunities for physical activity."[3]
School proximity	Percentage of the county covered by school buffers	National Center for Education Statistics	2016-2017	The geographic data for all public schools in the United States in 2016-2017 were downloaded as a shapefile from the National Center for Education Statistics website.[4] Within ArcGIS Pro, a half-mile buffer was created around each school location and then the square mileage covered by the school buffers was aggregated to the county level using the Dissolve tool. The total area covered by these school buffers was divided by the total area of the county to obtain the percent of the county that was within close proximity of a school. The selected distance of 0.5 miles was based on the literature which demonstrated that children who live within close proximity of a school are more likely to actively commute to school as well as have access to active amenities.

Variable	Measure	Source	Year	Description
Walkability	National Walkability Index	EPA Smart Growth Smart Location Mapping Database	2010-2012	"The National Walkability Index is a nationwide geographic data resource that ranks block groups according to their relative walkability. The national dataset includes walkability scores for all block groups as well as the underlying attributes that are used to rank the block groups. The Walkability Index dataset characterizes every Census 2010 block group in the U.S. based on its relative walkability. Walkability depends upon characteristics of the built environment that influence the likelihood of walking being used as a mode of travel. The Walkability Index is based on the EPA's previous data product, the Smart Location Database (SLD). Block group data from the SLD was the only input into the Walkability Index and consisted of four variables from the SLD weighted in a formula to create the new Walkability Index. This dataset shares the SLD's block group boundary definitions from Census 2010."[5] We extracted the index from the publicly available EPA dataset.[5] The data were available at the block level. Since census blocks are nested within counties, we created county-level scores by finding the population-weighted walkability score of all block groups within each county.
Violent crime	Number of violent crimes reported per 100,000 population	County Health Rankings (Uniform Crime Reporting, Federal Bureau of Investigation)	2012-2014	"Violent Crime is the number of violent crimes reported per 100,000 population. Violent crimes are defined as offenses that involve face-to-face confrontation between the victim and the perpetrator, including homicide, rape, robbery, and aggravated assault."[6]

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4. National Center for Education Statistics, Education Demographic and Geographic Estimates, School Locations and Geoassignments: https://nces.ed.gov/programs/edge/Geographic/SchoolLocations
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