

# A Spatial Analysis of Obesogenic Environments for Children

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## ABSTRACT

*In this study, we use spatial analysis techniques to explore environmental and social predictors of obesity in children. We constructed a merged database, incorporating clinical data from an electronic medical record system, the Regenstrief Medical Record System (RMRS) and societal & environmental data from a geographical information system, the Social Assets and Vulnerabilities Indicators (SAVI) Project. We used the RMRS to identify cohorts of children that were normal weight, overweight, or obese. The RMRS records were geocoded and merged into the SAVI database. Using the merged databases, we analyzed the relationships between markers of socioeconomic status and obesity outcomes in children. Our preliminary analyses show that markers of low socioeconomic status at the census tract level correlate with both overweight and obese outcomes in our study population. Utilization of geographic information systems (GIS) for the study of health epidemiology is discussed.*

## ABBREVIATIONS

BMI – Body mass index; GIS – geographic information system; RMRS – Regenstrief Medical Record System; SAVI – Social Assets and Vulnerabilities Indicators Project;

## BACKGROUND

*Burden Of Disease.* In the past two decades, the prevalence of obesity has risen so dramatically worldwide that many investigators have suggested the onset of a global obesity epidemic.<sup>1</sup> According to the classification scheme devised by the World Health Organization, 54% of U.S. adults are overweight [a body mass index (BMI)  $\geq 25$  kg/m<sup>2</sup>] and 22% are obese (BMI  $\geq 30$  kg/m<sup>2</sup>).<sup>2</sup> The prevalence of overweight in U.S. children is estimated between 22 and 30%, representing a doubling since 1980.<sup>3,4</sup>

Concern about the increasing prevalence of obesity centers on its link to increased adult health risks that translate into increased medical care and disability costs. In the U.S., the total cost attributable to obesity exceeded \$100 billion in 2000, or approximately 8% of the national health care budget<sup>5</sup> with \$52 billion in direct medical costs resulting

from diseases associated with obesity.<sup>6-8</sup> Although the immediate health implications of obesity in childhood have not been examined extensively, obese children are likely to become obese adults, particularly if obesity is present during adolescence.<sup>9, 10</sup> Adverse social and psychological effects of childhood obesity have been demonstrated.<sup>11, 12</sup> Overweight during adolescence has been shown to have deleterious effects on high school performance, educational attainment, psychosocial functioning, and socioeconomic attainment.<sup>8</sup>

Overweight is associated with various cardiovascular disease risk factors even among children as young as 7 years of age.<sup>13</sup> Longitudinal data has shown that the occurrence of overweight, hypertension, and dyslipidemia was associated with these same risk factors in childhood. A growing body of epidemiological evidence supports the theory that obesity related disease begins at a young age, and that risk factors for disease persist or track with advancing age, growth, and development.<sup>14</sup>

Because obesity is highly prevalent in both children and adults, its onset is insidious, and the expression of primary risk factors for obesity-related disease burden occurs at young ages, there is a clear rationale to presume health promotion and the primary prevention of obesity in childhood should reduce the adult incidence of cardiovascular disease.<sup>15-18</sup> Moreover, overwhelming difficulty has been encountered when intervening to assist adults to lose weight and this further highlights the need for primary obesity prevention in childhood.

*Environmental Approaches To The Prevention Of Obesity*  
To date, educational efforts, behavioral interventions, and pharmacologics have demonstrated only limited success in managing and preventing obesity.<sup>19</sup> Though there are clear genetic predispositions toward obesity, it is unlikely that addressing genetic factors alone will be enough to successfully prevent or manage an obesity epidemic.<sup>20</sup> Environmental factors that promote increased caloric intake and decreased energy expenditure are believed to underlie much of the present obesity trend.<sup>21-23</sup> The current U.S. environment is characterized by an essentially

unlimited supply of convenient, inexpensive, palatable, energy-dense foods coupled with a lifestyle requiring negligible amounts of physical activity for subsistence. Such an environment is conducive to the development of obesity because the human body inadequately defends itself against the accumulation of excess visceral fat when caloric intake is excessive.

We need systems-based environmental prevention efforts, in addition to programs or therapeutics aimed at individuals, to address the environmental pressures for overeating and sedentary behavior that pervade the U.S. A report by the World Health Organization recently has acknowledged that environmental strategies for controlling obesity are important and yet remain relatively under-explored.<sup>24</sup> The prevention of obesity requires a blending of medical expertise and insight into an array of community & environmental factors. We describe here a unique convergence of technologies and research efforts that will deepen our understanding of the environmental context of childhood obesity and enable more precise targeting of systems-based environmental prevention efforts.

## METHODS

*Data Collection and Manipulation:* The Regenstrief Medical Records System (RMRS) is an electronic version of the paper medical chart, which has been in existence since 1974. It has now captured and stored 200 million temporal observations for over 1.5 million patients. Because RMRS data are both archived and retrievable, investigators may use these data to perform retrospective and prospective research. We queried the Regenstrief Medical Record System to identify all children between the ages of 4 and 18 years seen at the Wishard Medical Center in Indianapolis, IN, the calendar year 2000 ( $n = 21,719$ ). We examined a random sample of children drawn from this cohort and found no significant differences in the distributions of gender and age when compared to the general population. We identified a subset of children that had a simultaneous height and weight measured ( $n = 2,554$ ). We calculated body mass index (BMI) and classified children as “normal” [ $BMI < 25 \text{ kg/m}^2$ ,  $n = 1,521$ ], “overweight” [ $BMI \geq 25 \text{ kg/m}^2$ ,  $n = 470$ ], or “obese” [ $BMI \geq 30 \text{ kg/m}^2$ ,  $n = 505$ ]. 58 children were excluded from the analysis because race information was not recorded in their medical record. We also extracted demographic information and insurance status for all children meeting these case definition criteria.

The Social Assets and Vulnerabilities Indicators (SAVI) Project is one of the most sophisticated and extensive systems of its kind (<http://www.savi.org>). SAVI contains more than 20 gigabytes of environmental and social data covering a broad array of regional resources and attributes in a nine county region surrounding Indianapolis.

Examples of SAVI data include school performance measures, US Census results, health surveillance, crime surveillance, and social services utilization. SAVI is maintained by the Polis Center, a multidisciplinary research center dedicated to addressing the challenges of community development in Indiana. We worked with systems analysts from the Polis Center to transfer data obtained from the RMRS into the SAVI project, and subsequently perform spatial analysis. In order to transfer RMRS data into the SAVI Project, programmers converted patient address data into numeric coordinates in a process called “geocoding.” Only children residing in Marion County, Indiana, were included in this analysis because the SAVI database has a richer collection of data regarding this geographic region.

For preliminary spatial analysis, we used GIS tools (ArcView 8.1, ESRI, Redlands, CA 2001) to stratify geocoded data into layers, isolate spatial relationships, and develop mappings of data. The mappings of data were subsequently translated into data tables and subjected to exploratory statistical analysis. The tables contain environmental and social factors, and the relative position of these factors to the residences of obese children. By conducting exploratory analyses on the data tables, we are attempting to build a model of environmental and social factors that are predictive of childhood obesity.

*Model Design:* We have designed a preliminary conceptual model of environmental and social factors represented in SAVI that may predict childhood obesity (Figure 1). These factors exert influence in four broad spheres: family, diet, activity, and barriers. We are defining strategies to operationalize each factor for incorporation into the model. For example, we are examining whether public play-space may be a protective environmental factor against childhood obesity by enabling increased physical activity. One strategy for operationalizing play-space involves determining the geographic density of public play-space resources within regions such as census tracts. Another strategy for operationalizing playspace would be to measure the shortest distance from a child’s home to each of the kinds of public play-spaces and use geographic proximity as a proxy for access to play-space. In this paper, the results of analyses performed on proximity to public playspace are briefly reported.

*Data Analysis:* We evaluated individual model variables for significance as well as overall model performance. Patient demographics such as race, age, and gender, as well as GIS environmental variables were subjected to univariate analyses to measure association with overweight and obesity. In terms of GIS variables we compared the relationship between proximity to the nearest public playspace (meters) with body mass index. We measured

the shortest distance between the child's home address and any of four types of public playspace: Young Men's Christian Associations (YMCA), city parks, city trails, and after school program with physical education curricular components. In future work on the model, we will look at other component variables, such as socioeconomic status markers, and all variables displaying an observed significance level < 0.05 in univariate analysis will be incorporated into a logistic regression model.

## RESULTS

1. *General descriptive measures.* Our study population (n = 2496) reflects the racial profile of the Wishard Medical Center, an urban county hospital that serves a population that has high representations of black patients, as well as those insured through federal assistance programs such as Medicaid.

**Table 1. Distribution of BMI by Race and Sex**

	Black (%)	White (%)	Other (%)
<b>Male</b>			
Normal	391 (69)	242 (66)	46 (65)
Overweight	85 (15)	69 (18)	16 (23)
Obese	93 (16)	64 (17)	9 (13)
<b>Female</b>			
Normal	495 (55)	306 (61)	41 (56)
Overweight	184 (20)	100 (20)	16 (22)
Obese	227 (25)	96 (19)	16 (22)

Overall, the proportions of children falling into normal, overweight, and obese categories based on BMI are similar across the race categories. The females tended to be more overweight / obese when compared to males.

**Table 2. Summary Statistics on Age by BMI**

	Normal	Overweight	Obese
<b>Age</b>			
Mean	14.51	14.84	15.20
Std. Dev.	1.99	2.04	1.94
n	1521	470	505

In general, with increasing age, the proportion of children falling into the overweight and obese categories increased.

2. *Map development.* A mapping is shown for the obese patients in the study group in Figure 2. Each patient is represented by a blue dot, and four types of public playspace are depicted: YMCA programs are shown as yellow squares, city parks as dark green colored space, city trails as light green colored space, and after school program with physical education curricular components as black triangles.

3. *Proximity data analysis.* There were no statistically significant differences between normal, overweight, and obese children in terms of their straight-line proximity to public playspace (Table 3.)

**Table 3. Proximity to Playspace by BMI**

Obesity	Mean distance (meters)	Std Dev (m)	n
Noted	567	450	505
Not noted	571	478	1991

In further analysis of a larger sampling of the pediatric patient population from which our study cohort was assembled, there are racial discrepancies in terms of proximity to the kinds of public playspace assessed. When looking at children who have ICD-9 coding for asthma in addition to the children for whom BMI data was available, Hispanic children were noted to live the farthest from public playspace.

**Table 4. Proximity to Playspace by Race**

Race	N	Mean rank distance
Black	3269	2433
White	1555	2619
Hispanic	175	2701

Kruskal-Wallis Test Statistic	Chi square	20.981
	D. freedom	2
	Signif.	<.0001

## DISCUSSION

We are designing a multivariate model of environmental predictors of childhood obesity and will refine the model through iterative statistical analyses. We will evaluate the capability of the final model to predict normal, overweight, and obese outcomes. The value of this study lies in how its results can further understanding of obesogenic environments and how useful it is at a practical level. This study's mappings will enable researchers, community leaders, health care providers, and policy makers to better understand community and population determinants of obesity. The study may lead to more effective resource allocation and interventions by providers. In turn, this should lead to children and their families having increased access to health care and health promotional initiatives effective against obesity. Maps created by the study could also be used as educational materials, promoting public participation in community health projects.

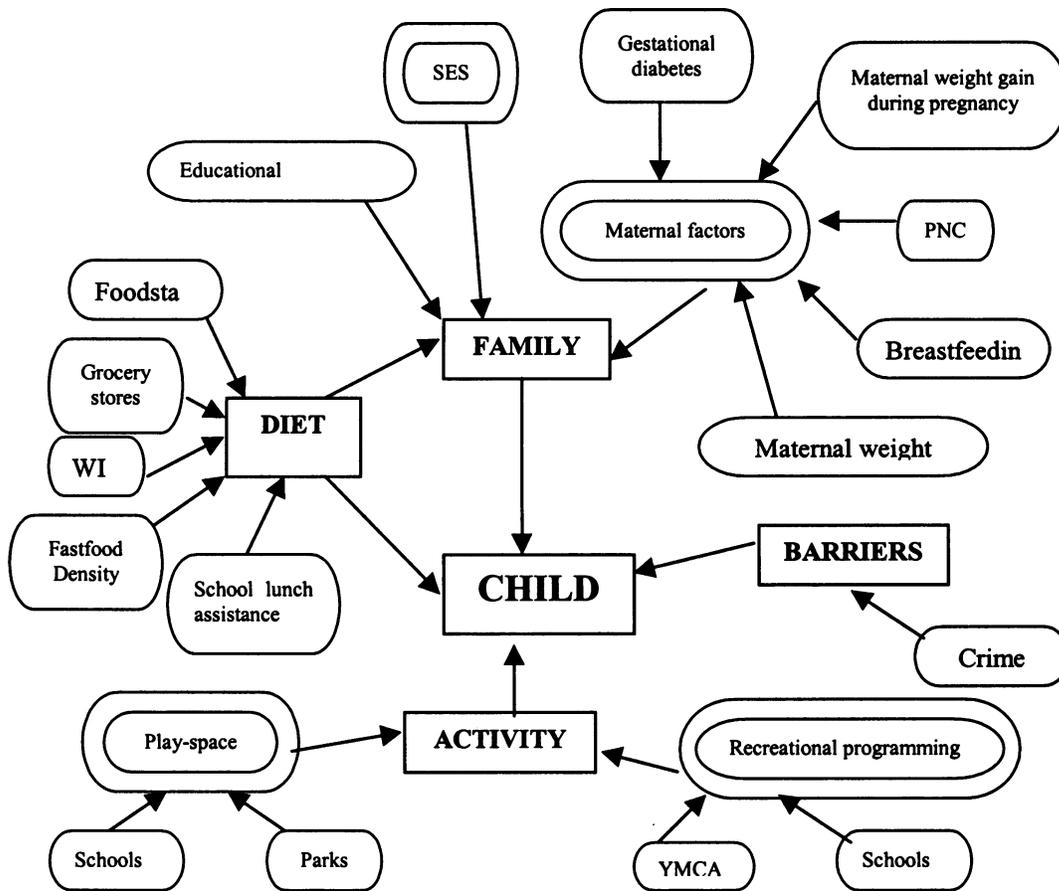
*Study Challenges:* The application of geographical information systems to improving health care quality is an

under-studied field and advancing methodology in this arena presents a study challenge. Data in the geographic information systems is typically collected for purposes of urban planning not directly relevant for health assessment. We will grapple with questions concerning data accuracy & generalizability, as well as the feasibility of using GIS for health surveillance.

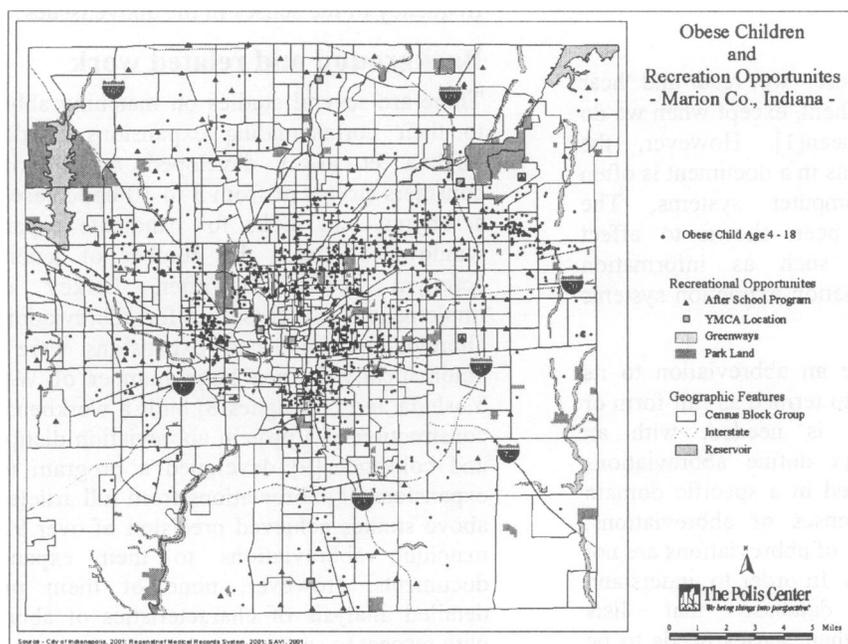
The pediatric data in the RMRS reflects a population in which African Americans, Latinos, and patients receiving Medicaid are over-represented. This selection bias, however, may work to our advantage given that several U.S. minority populations are disproportionately affected by obesity, particularly African Americans, Hispanics and Native American women.<sup>25</sup> Identifying environmental changes that either reinforce healthy eating and exercise or reduce the barriers to healthy lifestyles may diminish disparities related to obesity, as barriers may be more prevalent in ethnic minority groups or disadvantaged communities.

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**Figure 1. Conceptual Model of Environmental and Social Factors Predicting Childhood Obesity**



**Figure 2. Mapping of Obese Children and Recreational Opportunities**