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Spatial Distribution of Obesity among West Virginia 5th Grade Children: Analysis of the Socioeconomic, Physical, and Personal Environment

Sherry Roper
University of Tennessee Health Science Center

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Spatial Distribution of Obesity among West Virginia 5th Grade Children: Analysis of the Socioeconomic, Physical, and Personal Environment

Abstract

Childhood obesity defined as a body mass index (BMI) at or above the 95th percentile for children of the same age and sex, is considered an epidemic in the United States. Biology and lifestyle behaviors have been identified as important factors in the development of childhood obesity; however, researchers are beginning to place more emphasis upon the impact that continual environmental exposures have upon obesity development. Environmental risk factors associated with obesity are distributed continuously over space, yet evidence suggests that burden of risk may not be evenly dispersed across a community. West Virginia (WV), a rural Appalachian community has the tenth highest childhood obesity rate in the nation, yet little is known about the spatial distribution of the environmental risks and obesity within the state. The purposes of this study were threefold: 1) to determine which socioeconomic, physical, and personal environmental attributes contribute to a BMI equal to or greater than the 85th percentile for age, and gender; 2) to determine which socioeconomic, physical, and personal environmental attributes contribute to obesity (BMI equal to or greater than the 95th percentile for age, and gender); and 3) to assess the geographic distribution of attributes (socioeconomic, physical, and personal) in relation to BMI equal to or greater than the 85th percentile (overweight) and BMI equal to or greater than the 95th percentile (obese) among WV 5th graders.

Secondary data analyses of cross-sectional statewide data were performed to examine the proposal that obesity is the consequence of environmental exposures and that the distribution of obesity disproportionately affects some WV communities greater than others. The study sample was comprised of 12,194 fifth grade children ranging in age from 10-12 years old with a verifiable zip code for the state of WV. Study indicators used to quantify socioeconomic, physical, and personal environmental attributes were derived from various data sources. Data were gathered for the academic school years of 2007/2008 and 2008/2009. Individual data for each child subject consisting of BMI percentile and family history (diabetes and heart disease) were coded at the zip code level. Aggregate data for socioeconomic, physical, and personal environmental attributes were computed per zip code. County level data (violent crime) and school level fitness (percent of children in the fitness zone per 5th grade class) were linked back to each child by means of county to school to zip code or school to zip code. Binary logistic regression methods were employed to determine which attributes (socioeconomic, physical, and personal environment) contributed to overweight and obesity. Geographic Information System (GIS) technology was utilized to explore obesity spatial distribution and the relationship of obesity and overweight to environmental attributes at the zip code level.

Findings indicate that elements of the socioeconomic, physical, and personal environment are heterogeneous and independent, yet interact dynamically as predictors of obesity. Spatially groupings of overweight and obesity and identified risk factors were observed. Findings from this study support the need for additional research to examine the significance of spatial clusters and associated risk factors.

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**SPATIAL DISTRIBUTION OF OBESITY AMONG WEST VIRGINIA 5TH
GRADE CHILDREN: ANALYSIS OF THE SOCIOECONOMIC, PHYSICAL,
AND PERSONAL ENVIRONMENT**

A Dissertation
Presented for
The Graduate Studies Council
The University of Tennessee
Health Science Center

In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Philosophy
From The University of Tennessee

By
Sherry Roper
December 2011

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DEDICATION

This dissertation is dedicated to my husband, Gary G. Roper, for his unconditional love, words of encouragement, and never wavering support throughout this challenging endeavor. Your endless reassurance has enabled me to endure and your love continues to inspire me to do great things. In addition, to my children Chelsea, Katelyn, and Shane, you bring great joy to my life and are a continued source of inspiration.

Proverbs 3: 5-6 "Trust in the LORD with all your heart and lean not on your own understanding; in all your ways acknowledge Him, and He will make your paths straight."

"To God be the glory."

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ABSTRACT

Childhood obesity defined as a body mass index (BMI) at or above the 95th percentile for children of the same age and sex, is considered an epidemic in the United States. Biology and lifestyle behaviors have been identified as important factors in the development of childhood obesity; however, researchers are beginning to place more emphasis upon the impact that continual environmental exposures have upon obesity development. Environmental risk factors associated with obesity are distributed continuously over space, yet evidence suggests that burden of risk may not be evenly dispersed across a community. West Virginia (WV), a rural Appalachian community has the tenth highest childhood obesity rate in the nation, yet little is known about the spatial distribution of the environmental risks and obesity within the state. The purposes of this study were threefold: 1) to determine which socioeconomic, physical, and personal environmental attributes contribute to a BMI equal to or greater than the 85th percentile for age, and gender; 2) to determine which socioeconomic, physical, and personal environmental attributes contribute to obesity (BMI equal to or greater than the 95th percentile for age, and gender); and 3) to assess the geographic distribution of attributes (socioeconomic, physical, and personal) in relation to BMI equal to or greater than the 85th percentile (overweight) and BMI equal to or greater than the 95th percentile (obese) among WV 5th graders.

Secondary data analyses of cross-sectional statewide data were performed to examine the proposal that obesity is the consequence of environmental exposures and that the distribution of obesity disproportionally affects some WV communities greater than others. The study sample was comprised of 12,194 fifth grade children ranging in age from 10-12 years old with a verifiable zip code for the state of WV. Study indicators used to quantify socioeconomic, physical, and personal environmental attributes were derived from various data sources. Data were gathered for the academic school years of 2007/2008 and 2008/2009. Individual data for each child subject consisting of BMI percentile and family history (diabetes and heart disease) were coded at the zip code level. Aggregate data for socioeconomic, physical, and personal environmental attributes were computed per zip code. County level data (violent crime) and school level fitness (percent of children in the fitness zone per 5th grade class) were linked back to each child by means of county to school to zip code or school to zip code. Binary logistic regression methods were employed to determine which attributes (socioeconomic, physical, and personal environment) contributed to overweight and obesity. Geographic Information System (GIS) technology was utilized to explore obesity spatial distribution and the relationship of obesity and overweight to environmental attributes at the zip code level.

Findings indicate that elements of the socioeconomic, physical, and personal environment are heterogeneous and independent, yet interact dynamically as predictors of obesity. Spatially groupings of overweight and obesity and identified risk factors were observed. Findings from this study support the need for additional research to examine the significance of spatial clusters and associated risk factors.

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LIST OF ABBREVIATIONS

ACS	American Community Survey
BMI	Body Mass Index
BRFSS	Behavioral Risk Factor Surveillance System
CARDIAC	Coronary Artery Risk Detection in Appalachian Communities
CDC	Centers for Disease Control
CVD	Cardiovascular Disease
DHHR	Department of Health and Human Resources
DXA	Dual Energy X-Ray Absorptiometry
ESRI	Environmental Systems Research Institute
FBI	Federal Bureau of Investigations
FIPSSTCO	Fipscode for the State and County
GIS	Geographic Information System
H-L	Hosmer-Lemeshow
IOTF	International Obesity Task Force
IRB	Institutional Review Board
LSES	Low Socioeconomic Status
NAICS	North American Industry Classification System
NCHS	National Center for Health Statistics
NHANES	National Health and Nutrition Examination Survey
NHES	National Health and Examination Survey
NIBRS	National Incident Based Reporting System
NIH	National Institutes of Health
SES	Socioeconomic Status
SSI	Supplemental Security Income
US	United States
WHO	World Health Organization
WV	West Virginia
WVEIS	West Virginia Education Information System
ZCTA	ZIP Code Tabulation Area

CHAPTER 1. INTRODUCTION

OVERVIEW

Childhood obesity, defined as a body mass index (BMI) at or above the 95th percentile for children of the same age and sex, is considered an epidemic in the United States (Centers for Disease Control and Prevention [CDC], 2011a). In the last 30 years the prevalence of childhood obesity (children aged 6 to 11) has increased from 6.5% in 1980 to 19.6% in 2008 (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010; Ogden & Flegal, 2010; Wilkinson & Marmot, 2003). This increase in prevalence has been so severe that some perceive that the obesity epidemic threatens to reverse the steady increase in life expectancy observed over the last decade (Olshansky et al., 2005; Whitlock, Williams, Gold, Smith, & Shipman, 2005). Biology and lifestyle behaviors have been identified as important factors in the development of childhood obesity; however, researchers are beginning to place more emphasis upon the impact that continual environmental exposures such as low socioeconomic status, low levels of education, and lack of access to healthy food sources have upon obesity development. Environmental risk factors associated with obesity are distributed continuously over space, yet evidence suggests that the burden of risk may not be evenly dispersed across a community. Additionally, the obesity epidemic appears to disproportionately affect some communities greater than others. Analysis of spatial distribution may help provide answers to fundamental childhood obesity questions related to environmental risks. Such methods may provide a means to identify geographical obesity patterns and offer the ability to filter information to identify obesity related events.

Spatial analysis techniques have been utilized to examine how environmental attributes may influence weight (Cutts, Darby, Boone, & Brewis, 2009; Davies-Cole, Kidane, Lum, & Richardson, 2003; Michimi & Wimberly, 2010), as well as in the identification of obesity related events of hypertension, diabetes, and cardiovascular disease (Davies-Cole et al., 2003). Epidemiological studies have employed spatial techniques to examine disease clusters associated with outbreaks and to assist in the quantification of risk factors associated with environmental determinants of disease (Siaway, Davies-Cole, & Kidane, 2007). Yet, few spatial studies have been performed at the micro level regarding childhood obesity.

While it is well documented that the physical environment is associated with obesity development (Galvez, Pearl, & Yen, 2010; Papas et al., 2007), there is a paucity of information on the effect of cumulative environmental factors on overweight and obese children. The literature supports the linkage between individual environmental risk factors including the built, home, and socioeconomic environment; however, it is unclear whether such environmental risks produce an environment prone to obesity development. The phenomenon of an obesogenic environment is not well understood. Yet, researchers contend that behaviors are a reflection of one's environment and that the more obesogenic the environment the stronger the influence towards developing obesity (Kirk, Penney, & McHugh, 2010; Papas et al., 2007).

Community socioeconomic status (SES) such as poverty, is a fundamental factor perceived to influence child weight (Drewnowski & Specter, 2004). Socioeconomically individuals who are less educated and/or make less money have higher obesity rates (Trust for America's Health, 2011). Economically the poorest states: West Virginia (WV), Mississippi, and Tennessee have the heaviest children (Trust for America's Health, 2011).

Ethnic minorities, low socioeconomic status families, and children in southern states have higher rates of obesity than the rest of the population (Cochran, 2008). Geographically, a higher percentage of rural children are obese compared to urban children (Trust for America's Health, 2009).

Over the last 15 years, the adult obesity rate in WV has increased more than 80% (Trust for America's Health, 2011); whereas, the current combined obesity and overweight rate among adults in WV is 68.1%. West Virginia ranks tenth in the nation for childhood obesity and third for adult obesity. The obesity rate for children and adolescents (ages 10 to 17 years) is 18.9% (Trust for America's Health, 2011).

For the purpose of this study, associations between attributes of the socioeconomic, physical, and personal environment, overweight, and obesity were examined statistically using binary logistic regression techniques. Geographic Information System (GIS) technology was utilized to explore obesity spatial distribution and burden of risk at the zip code level.

PURPOSE OF STUDY

West Virginia, a rural Appalachian community, has the third highest adult and tenth highest childhood obesity rates (32.2% and 18.9%, respectively) in the nation (Trust for America's Health, 2011); therefore, WV serves as an ideal environment to examine childhood obesity. The study design supports the hypothesis that overweight and obesity are the consequence of environmental exposures and that the distribution of overweight and obesity disproportionately affects some WV communities more than others. Therefore, the purposes of this study were threefold: 1) to determine which socioeconomics, physical, and personal environment attributes contribute to a BMI equal to or greater than the 85th percentile for age, and gender; 2) to determine which socioeconomics, physical, and personal environment attributes contribute to obesity (BMI equal to or greater than the 95th percentile for age, and gender); and 3) to assess the geographic distribution of attributes (socioeconomic, physical, and personal) in relation to BMI equal to or greater than the 85th percentile (overweight) among WV 5th graders and BMI equal to or greater than the 95th percentile (obese) among WV 5th graders.

Aim One

To determine which socioeconomic, physical, and personal environment attributes contribute to overweight (BMI equal to or greater than the 85th percentile for age and gender) in WV 5th graders. Hypotheses:

- 1.a. Socioeconomic attributes (lower level of education, lower household income, and higher level of violent crime in the county) will be associated with a BMI equal to or greater than the 85th percentile (overweight).
- 1.b. BMI equal to or greater than the 85th percentile (overweight) will be inversely associated with physical attributes of the number of grocery stores, fruit and vegetable markets, and the number of recreational facilities.
- 1.c. BMI equal to or greater than the 85th percentile (overweight) will be positively associated with physical attributes of the number of fast food restaurants and convenience stores.
- 1.d. BMI equal to or greater than the 85th percentile (overweight) will be positively associated with personal attributes of a family history of cardiovascular disease and diabetes.
- 1.e. BMI equal to or greater than the 85th percentile (overweight) will be inversely associated with the personal attribute of child aerobic fitness at the school level.

Aim Two

To determine which socioeconomic, physical, and personal environment attributes contribute to obesity (BMI equal to or greater than the 95th percentile for age and gender) in WV 5th graders. Hypotheses:

- 2.a. Socioeconomic attributes (lower level of education, lower household income, and higher level of violent crime in the county) will be associated with a BMI equal to or greater than the 95th percentile (obese).
- 2.b. BMI equal to or greater than the 95th percentile (obese) will be inversely associated with physical attributes of the number of grocery stores, fruit and vegetable markets and the number of recreational facilities.
- 2.c. BMI equal to or greater than the 95th percentile (obese) will be positively associated with physical attributes of the number of fast food restaurants and convenience stores.
- 2.d. BMI equal to or greater than the 95th percentile (obese) will be positively associated with personal attributes of a family history of cardiovascular disease and diabetes.
- 2.e. BMI equal to or greater than the 95th percentile (obese) will be inversely associated with the personal attribute of child aerobic fitness at the school level.

Aim Three

To assess the geographic distribution of attributes (socioeconomic, physical, and personal) in relation to BMI equal to or greater than the 85th percentile and obesity BMI equal to or greater than the 95th percentile among WV 5th graders. Hypotheses:

- 3.a. BMI equal to or greater than the 85th percentile will be disproportionately distributed across the state of WV.
- 3.b. BMI equal to or greater than the 95th percentile will be disproportionately distributed across the state of WV.
- 3.c. Socioeconomic attributes (lower level of education, lower household income, and higher level of violent crime) will be disproportionately distributed across the state of WV.
- 3.d. Physical attributes (the number of grocery stores, fruit, and vegetable markets, the number of recreational facilities, and fast food restaurants and convenience stores) will be disproportionately distributed across the state of WV.
- 3.e. Personal attributes (family history of cardiovascular disease and diabetes, and child aerobic fitness) will be disproportionately distributed across the state of WV.
- 3.f. Overweight will be spatially patterned in association with the distribution of socioeconomic, physical, and personal environmental attributes.
- 3.g. Obesity will be spatially patterned in association with the distribution of socioeconomic, physical, and personal environmental attributes.

SIGNIFICANCE OF STUDY

Over the last 5 years, WV has consistently ranked among the top tenth most obese states in the nation for both adults and children. Additionally, WV residents experience among the highest rates of chronic conditions associated with obesity including diabetes and hypertension (Trust for America's Health, 2009, 2011). Obese children are more likely to become obese adults (Biro & Wien, 2010; Centers for Disease Control and Prevention [CDC], 2011a; Serdula et al., 1993) and are at increased risk of morbidity, mortality (Flegal, Carroll, Ogden, & Curtin, 2010; Flegal, Graubard, Williamson, & Gail, 2005; Fontaine, Redden, Wang, Westfall, & Allison, 2003; Franks, Hanson, & Knowler, 2010), disability, premature death due to cardiovascular disease (Freedman, Dietz, Srinivasan, & Berenson, 1999; Freedman et al., 2005; Mokdad et al., 2001; Must et al., 1999; Must & Strauss, 1999), and increased insulin resistance and type 2 diabetes in adulthood (Whitlock et al., 2005). Nationally, medical expenditures associated with obesity constituted approximately \$147 billion in 2008 (Finkelstein, Trogon, Cohen, & Dietz, 2009). Expenditures associated with overweight and obesity in WV were estimated to be \$668 million in 2008. If current trends continue, expenditures are estimated to be between \$1,556 – 3,212 million by 2018 (Thorpe, 2009).

Researchers contend that an obesogenic environment is a major explanation for the increased incidence of overweight and obesity (Boehmer, Lovegreen, Haire-Joshu, & Brownson, 2006; Giskes, Van Lenthe, Avendano-Pabon, & Brug, 2011; Michimi & Wimberly, 2010); however, what constitutes an environment that promotes obesity is not well understood. Additionally, the obesity epidemic appears to disproportionately affect some communities greater than others (Cochran, 2008) yet, few studies have examined childhood overweight and obesity among Appalachian children from an obesogenic environmental perspective.

Spatial analysis methods may help provide answers to fundamental questions related to childhood obesity and environmental risk, furthering understanding of the obesogenic environment phenomenon. Such findings could aid in predicting overweight and obesity in children. Developing a spatial understanding may help provide more information about the obesity epidemic within the state of WV in order to help shape local obesity-prevention interventions.

CONCEPTUAL MODEL

Childhood obesity is perceived to be the result of an increased risk derived from the cumulative impact of socioeconomic (education, income, socioeconomic status, and crime); physical (fast food establishments, convenience stores, supermarkets, recreational facilities, and fruit and vegetable markets); and personal (family history of heart disease, diabetes, and child aerobic fitness) environmental attributes that stimulate an obesogenic environment. Environmental attributes are perceived to be disproportionality distributed across the state of WV, but spatially clustered resulting in an increased burden of risk for overweight and/or obesity development.

The conceptual framework supports the proposed hypothesis that overweight and obesity are the consequence of the cumulative impact of environmental factors that are disproportionately distributed across the state. The cumulative impact of such factors is perceived to create an environment supportive of obesity development with an end consequence of overweight and/or obesity among WV children. In turn, overweight and obesity disproportionately affects some WV communities greater than others, resulting in a cycle of unequal distribution and risk. See **Figure 1-1**.

MAJOR CONCEPTS AND DEFINITIONS

Theoretical and operational definitions for the major concepts presented within the conceptual model included socioeconomic (income, education, LSES, and violent crime); physical (supermarket, convenience stores, fitness and recreational facilities, fruit and vegetable markets, and fast food establishments); and personal (family history of heart disease, family history of diabetes, and child aerobic fitness).

Figure 1-1. Conceptual Framework of Environmental Attributes Perceived to Stimulate an Obesogenic Environment.

ENVIRONMENTAL ATTRIBUTES

Environment attributes were defined as the socioeconomic, physical, and personal attributes, which cumulatively shape one's environment and health risks. Attributes included: education, income, socioeconomic status, violent crime, fast food establishments, convenience stores, supermarket and other grocery establishments, fruit/vegetable markets, fitness/recreational sports centers, family history of heart disease and/or diabetes, and child fitness.

Socioeconomic Environment

The socioeconomic environment was defined according to attributes of education (total population 25+ years with at least a high school diploma), median household income, low socioeconomic status, and number of violent crimes in the community. Data were defined at the zip code, school, and county level.

Education. The number of high school graduates age 25+ years included people whose highest degree was a high school diploma or its equivalent, people who attended college or professional school, and persons who received a college, university, or professional degree. Persons completing the 12th grade but not receiving a diploma were not considered high school graduates and were excluded from the tabulation (U.S. Census Bureau [Data file], 2010).

Household income. Household income was the sum of money income including wage or salary income; net self-employment income; interest, dividends, or net rental or royalty income or income from estates and trusts; Social Security or Railroad Retirement income; Supplemental Security Income (SSI); public assistance or welfare payments; retirement, survivor, or disability pensions; and all other income, received by all household members 15 years of age and older (U.S. Census Bureau [Data file], 2011). All household members included unrelated household members such as household members not related to the householder, people living alone, and other nonfamily household members (U.S. Census Bureau [Data file], 2011).

Low socioeconomic status. Low Socioeconomic Status (LSES) was defined according to aggregate data based on free and reduced lunch eligibility per child's 5th grade class of attendance. According to 2007 and 2008 criteria, families with an income at or below 130 percent of the poverty level were eligible for free meals and children from families between 130 percent and 185 percent of the poverty level were eligible for reduced-price meals (West Virginia Department of Education [Data file], 2011).

Violent crime. Crime was defined as the aggregate total of crime data at the county level: rape, sexual assault, robbery, assault, burglary, motor vehicle theft, and theft for 52 of the 55 WV counties. Putman and Wood counties were excluded from the analysis due to lack of complete data.

Physical Environment

Physical environmental attributes were examined and coded at zip code level. The physical environment was defined according to the physical attributes of food services (fast food, convenience store, supermarket and other grocery, fruit and vegetable markets and fitness/recreational sports centers). The North American Industry Classification System (NAICS) was utilized to define and classify food services (U.S. Census Bureau [Data file], 2007):

- Fast food establishments (NAICS code 722211)
- Convenience store establishments (NAICS code 445120)
- Supermarket and other grocery establishments (NAICS code 445110)
- Fruit and vegetable markets (NAICS code 445230)
- Fitness and recreational sports centers (NAICS code 713940)

Personal Environment

For the purpose of this study, the personal environment of interest was that of the child's at the zip code and school level. Personal environment was defined according to family history of diabetes, heart disease, and child aerobic fitness. Attributes of interest are described below.

Aerobic fitness. Child fitness was categorized as 1) "in the healthy fitness zone" (student met or exceeded fitness target) or 2) "needs improvement" (student failed to meet fitness target) (Cureton & Plowman, 2008). Fitness categorizations are criterion-referenced health standards defined according to the minimal level of performance on each test item that is consistent with acceptable good health and adequate function. Good health being defined as minimal disease risk and adequate functions as the ability to carry out activities of daily living (Welk & Meredith, 2008). Five fitness types, i.e., aerobic capacity, abdominal strength, upper body strength, flexibility, and trunk strength are measured in the assessment of child fitness (Welk & Meredith, 2008). Fitness types are categorized as aerobic capacity or musculoskeletal fitness (abdominal strength, upper body strength, flexibility, and trunk strength performance). Children are then classified as "in the healthy fitness zone" or "needs improvement" for each of the two categories: aerobic capacity and musculoskeletal fitness. For the purpose of this study, only aerobic fitness was examined per percentage of 5th graders in the "healthy fitness zone" at the school level.

Family history. For the purpose of this study, parental self-reported data were obtained from the CARDIAC project's disease surveillance and intervention program. Family history was based on parental self-report of current or past occurrence of heart disease and/or diabetes.

Disproportionate Distribution

Disproportionate distribution was defined as an unequal spatial dispersion of occurrences across a community, county or state. For the purpose of this study, data were examined at the zip code, school, and/or county level.

Cumulative Impact

Cumulative impact was defined as the totality of influence (positive or negative) socioeconomic, physical, and personal environmental factors imposes on overweight and obesity development. Cumulative impact was perceived to increase a child's probability of overweight and/or obesity.

Burden of Risk

Burden of risk was defined as the encumbrance produced by the cumulative impact of environmental factors of socioeconomic, physical, and personal attributes that place the individual at greater odds for the development of BMI at or greater than the 85th percentile (overweight) or BMI at or greater than the 95th percentile (obese). Therefore, for the purpose of this study, the burden of risk was defined according to the socioeconomic, physical, and personal attributes significantly associated (statistically and spatially) with increased odds of overweight or obesity.

Obesogenic Environment

According to the literature, an obesogenic environment is the totality of influences that the environments have on promoting obesity (Kirk et al., 2010; Papas et al., 2007). Therefore, for the purpose of this study the obesogenic environment was defined according to the sum of socioeconomic, physical, and personal attributes significantly associated (statistically and spatially) with increased odds of overweight or obesity.

Overweight-Obesity in Children

Overweight was defined as a BMI $\geq$ 85th percentile for age and gender, while obesity was defined as a BMI $\geq$ 95th percentile for age and gender (Barlow & Expert Committee, 2007). BMI was computed by weight in kilograms divided by height in meters squared and plotted on a growth chart. Percentile cut points developed by the NHANES was utilized for the classification of overweight ($\geq$ 85th percentile) and obese ($\geq$ 95th percentile) (Centers for Disease Control and Prevention [CDC], 2000). Data from the NHANES (conducted in three cycles 1970s, 1980s, and 1990s) has been utilized in previous studies and by various organizations to derive a statistical definition of overweight and obesity. Although BMI does not directly measure body fatness,

measurements taken using the BMI method have been found to correlate with the dual energy x-ray absorptiometry (DXA) and underwater weighting (Flegal, 1993). Both methods; the DXA and underwater weighing, provide direct measures of body fatness, but are time consuming and expensive. Therefore, BMI offers a valid, rapid and inexpensive method to measuring obesity in children (Centers for Disease Control and Prevention, 2000).

ASSUMPTIONS

The following assumptions were made for this study:

- Data in the original studies were collected in an accurate manner and in congruency with the original research question/aims.
- An excess risk of obesity in children is associated with environmental attributes.
- Children progressed to the next grade level and were included only once in the sample.
- Children accurately reported zip code of residence.

POTENTIAL LIMITATIONS

A secondary data analysis was utilized and was suitable to address proposed research questions. Although the secondary data analysis design has both strengths and limitations the plan did allow the investigation of previously unanalyzed combinations of variables and provided access to a large sample (Burns & Groves, 2001; Rew, Koniak-Griffin, Lewis, Miles, & O'Sullivan, 2000). Study limitations are presented below:

- Data were obtained for other purposes; therefore, this researcher had limited control over the data collection process (Burns & Groves, 2001; Mainous & Hueston, 1997; Nicoll & Beyea, 1999).
- BMI was considered to be a crude measurement of obesity limiting the ability to evaluate fat mass.
- A lack of a unified definition of an obesogenic environment.
- Trans-boundary spillover due to activities in one community influencing activities in other communities (Amarasinghe, D'Souza, Brown, & Borisova, 2006).
- ZIP Codes were administrative entities of the U.S. Postal Service. As such, boundaries were implied and may not necessarily follow clearly identifiable physical features.
- A lack of crime data for three WV counties.

CHAPTER 2. LITERATURE REVIEW

INTRODUCTION

Chapter 2 presents the major findings within the literature relevant to the concepts proposed in the conceptual framework of the study. The first section of the review presents a brief discussion regarding the surrogate terms utilized within the literature to describe the concepts obesity and childhood. A historical overview of the concept obesity follows and transitions into a discussion regarding the childhood obesity epidemic. The second section provides an overview of anthropometric techniques utilized to measure the concept obesity, controversies associated with utilization in children and obesity classifications. The third section examines the social and economic attributes of education, income, and violent crime; the physical attributes (convenience stores, supermarkets and other grocery, fast food facilities, recreational and fitness centers), and personal environment (family history of diabetes and/or heart disease and childhood aerobic fitness). The final section examines the geographical distribution of childhood obesity universally and within the state of WV and the utilization of spatial analyses techniques to describe environmental risk factors on obesity development in children.

SURROGATE TERMS

According to Rodgers (1989), surrogate terms can be used interchangeably to express the same concept. Fatness, stout, obeseness, adiposis, and plumpness were used interchangeably throughout the literature to describe obesity. Obesity, overweight and "at risk of overweight" were the most commonly utilized terms. The terms "obese" and "overweight" are often used interchangeably, but rather ambiguously (Mullen & Shield, 2004). In addition, the term childhood was also examined revealing a variety of surrogate terms utilized in the literature: youth, preadolescents, child, and children. To ensure a thorough examination of the literature the concept of childhood obesity was examined using known surrogates.

HISTORICAL OVERVIEW OF OBESITY

Obesity dates back to the stone age and has been described since the time of Galen and the Roman Empire (Bray, 1990; Papavramidou, Papavramidis, & Christopoulou-Aletra, 2004). Galen was among the first to utilize scientific methods to describe obesity: pachis (fat), efsarkos (chubby), and polysarkos (obese) (Papavramidou et al., 2004). Even though Galen's views regarding the physiology and pathology of obesity have been proven wrong his observations regarding the association of obesity to diet, exercise, and the environment are still observed today (Papavramidou et al., 2004). It was not until the era of Hippocrates that obesity was first recognized as a medical

disorder. Hippocrates identified obesity as a risk to health and noted the value of dietary restriction, and increasing exercise (Bray, 1990; Haslam, 2007).

Scholarly discussions regarding the concept first began to appear in the late 16th century; however, it was not until the end of 18th century and throughout the 19th that published identification of familial factors of obesity began to emerge (Bray, 1990). The discoveries of fat cells in the 19th century lead to the identification of specific types of obesity and standards for measuring body weight. Beginning in the 20th century obesity began to be analyzed more intensely by physicians as a medical disorder (Hamin, 1999; Moffat, 2010; Stearns, 1999) and in the last 25 years obesity has drawn attention on a global scale.

CHILDHOOD OBESITY EPIDEMIC

In the past 30 years the rate of childhood obesity has more than tripled (Ogden et al., 2010; Ogden, Flegal, Carroll, & Johnson, 2002). From 1980 to 2008 the rate increased from 6.5% to 19.6% among children aged 6 to 11 years and from 5.0% to 18.1 in children ages 12-18 years of age (Centers for Disease Control and Prevention [CDC], 2011a; Flegal et al., 2010; Ogden et al., 2010). According to findings from the National Survey of Children's Health (NSCH), a survey of parents in each state, obesity rates for children ages 10–17 ranged from a low of 9.6 percent in the state of Oregon to a high of 21.9 percent in Tennessee (Centers for Disease Control and Prevention [CDC], 2011b). Eight states had childhood obesity rates over 20 percent: Arkansas, Georgia, Illinois, Kentucky, Louisiana, Mississippi, Tennessee, and Texas (Centers for Disease Control and Prevention [CDC], 2011b) .

ANTHROPOMETRY

Anthropometry is the non-invasive method of assessing size, shape, and body composition. Body weight and stature are utilized to estimate body size, whereas, ratios of body weight to height are used to represent body proportion. Historically, overweight and obesity anthropometry measurement techniques have included circumference or girth measurements, waist-to-hip ratio, skin fold thickness, bioelectrical impedance, and body mass index (BMI) to name a few (Claessens, Beunen, & Malina, 2008; Lasker, 1994).

Body Mass Index (BMI)

BMI correlates well with body fat in adults (Bertakis & Azari, 2005; Freedman et al., 2005) and children (Dietz & Robinson, 1998; Freedman, Khan, Serdula, Ogden, & Dietz, 2006; Maynard et al., 2001; Velasquez-Mieyer, Neira, Nieto, & Cowan, 2007) and is considered a safe, simple, inexpensive method to express relative weight to height to characterize childhood obesity (Freedman et al., 2005; Himes & Dietz, 1994; Krebs et al.,

2007; National Research Council, 2005). The technique has been widely utilized to characterize childhood weight in epidemiological studies (Borecki et al., 1998). Although BMI does not directly measure body fatness, measurements taken using the BMI method have been found to correlate with the dual energy x-ray absorptiometry (DXA) and underwater weighing (Rothman, 2008). Both methods; the DXA and underwater weighing, provide direct measures of body fatness but are time consuming and expensive (Rothman, 2008). BMI offers a valid, rapid and inexpensive method to measuring obesity in children (Zuguo et al., 2002).

BMI Classification

Earlier studies (1959 to 1983) of obesity relied on Metropolitan Life Insurance tables of weight-for-height as the reference for overweight (Flegal, Carroll, Kuczmarski, & Johnson, 1998). More recently, the scientific community has relied on data collected from a series of National Health Examination cross-sectional surveys (NHES): the National Center for Health Statistics (NCHS) conducted by the Centers for Disease Control and Prevention (CDC) and the National Health and Nutrition Examination Survey (NHANES).

Data from the NHES (spanning the years 1960 to 1970) and NHANES (1970s, 1980s, and early 1990s) has been utilized by various organizations to derive a statistical definition of overweight and obesity. For example, the World Health Organization (WHO) utilized NHANES II data to recommend a 3 "grade" classification system of overweight using body mass index (BMI) cutoff points of 25, 30, and 40 (Kuczmarski & Flegal, 2000; World Health Organization [WHO], 2000). In 1998, the National Institutes of Health (NIH) expert panel on obesity released a report of definitions for overweight and obesity that were similar to those introduced by the WHO. The panel categorized normal weight as a BMI of 18.5 – 24.9; overweight as a BMI of 25 – 29.9; and obesity as a BMI in adults greater than 30. BMI cutoff points of 25 and 30 are used collectively to define overweight and obesity in adults (Björntorp, 1998; Kuczmarski, Carroll, Flegal, & Troiano, 1997; Kuczmarski et al., 2000); however, no standard BMI definition of overweight and obesity for children existed (Cole, 2002; Cole, Bellizzi, Flegal, & Dietz, 2000).

For children, the use of BMI is problematic due to maturation changes in the distribution and amount of body fat in children (Dietz & Robinson, 1998); thus, BMI percentiles are used to estimate overweight and obesity in children up to the age of 18 years (Barlow & Dietz, 1998; Barlow & Expert Committee, 2007). BMI percentiles are derived from the plotting of child age and BMI on age and gender specific growth charts. Age is plotted on the horizontal axis and BMI on the vertical, a single point where the two meet is drawn and the curved lines indicate selected percentiles that designate rank of the child's measurement (Dietz & Robinson, 1998; Roberts & Dallal, 2001).

Based on percentiles, the CDC and NHANES previously classified children as "at risk of overweight" if the BMI-for-age and- gender ranges from the 85th to less than the

95th percentile and "overweight" if the BMI-for-age-and gender specific greater than or equal to the 95th (Barlow & Dietz, 1998; Barlow & Expert Committee, 2007; Kuczmarski et al., 1997; Kuczmarski & Flegal, 2000; Kuczmarski et al., 2000). Much of the literature however fails to make reference to children as "at risk of overweight" but rather classifies all children above the 85th percentile as overweight or obese (Moffat, 2010).

In an effort to internationally standardize the classification of weight in children the International Obesity Task Force (IOTF) created an age sex specific table of percentile cutoffs for overweight and obese to match those of the 25 and 30 BMI cutoffs used for adults (Cole et al., 2000; Dietz & Robinson, 1998). However, the 85th and 95th percentiles proposed by the CDC and NHANES are more commonly referenced within the literature (Moffat, 2010).

In 2010, the American Medical Association introduced changes in BMI terminology; whereas, a BMI for age and gender equal to or greater than the 85th percentile now constitutes overweight and the 95th percentile obese (Ogden & Flegal, 2010). The terminology change was most notably due to the need to convey the seriousness of the 95th cutoff value (previously referred to as overweight) and to denote the increased risk for negative health outcomes in the future (U.S. Department of Health and Human Services [DHHS], 2010) including cardiovascular disease (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007) and insulin resistance and type 2 diabetes (Fagot-Campagna, 2000; Fagot-Campagna et al., 2000; Whitlock et al., 2005).

A great deal of empirical evidence exists supporting the specificity of BMI percentile cut-offs for the diagnosis of childhood obesity (Barlow & Dietz, 1998; Barlow & Expert Committee, 2007; Cole, 2002; Cole et al., 2000; Flegal, 1993; Reilly, Dorosty, & Emmett, 2000; Reilly et al., 2003; Reilly, Wilson, Summerbell, & Wilson, 2002). Thus, BMI percentile cut-offs are unlikely to diagnose a non-obese child as obese; however, due to only moderate sensitivity these percentile cut-points may lead to under diagnoses (Reilly et al., 2000; Reilly et al., 2002).

A substantially consistent body of evidence exists that children with BMI percentiles in the 85th or 95th range are at greater risk of morbidity than their peers (Bertakis & Azari, 2005; Hickman et al., 1998; Reilly et al., 2003). Such findings confirm the relevance and validity of cut off points and associated definitions in the diagnosis of obesity and obesity related outcomes (Barlow & Dietz, 1998; Cole, 2002; Cole et al., 2000; Reilly, 2002; Reilly et al., 2000; Reilly et al., 2002).

In conclusion, BMI assessment offers a valid, inexpensive, noninvasive, and easy to use method for identifying obesity in children. Thus, BMI is an appropriate surrogate measurement of fatness in children. Therefore, for the purpose this study overweight was defined as BMI percentile greater than or equal to the 85th; whereas, obesity was defined as a BMI equal to or greater than the 95th percentile for age and gender.

ATTRIBUTES

Evidence suggests that the environment in which a person resides influences behaviors associated with obesity development (low physical activity and food choices) and that income demarcates the type of environment in which one lives. Thus, education, income, crime, and food availability are intertwined; and therefore, must be taken into consideration when examining socioeconomics as a contributing factor in the development of childhood obesity.

SOCIOECONOMICS

The role that socioeconomic factors play in obesity development is multifaceted (Wang & Zhang, 2006). In the US, a high socioeconomic status appears to be a protective factor against the development of overweight. Such findings correspond with previous studies (Wang & Zhang, 2006) which identified a significant association between low socioeconomic status and risk of obesity; however, the socioeconomic influence appears to vary across ethnic groups (Roberts & Dallal, 2001; Wang & Zhang, 2006; Zhang & Wang, 2004). Economically the poorest states; West Virginia, Mississippi, and Kentucky, have the heaviest children with 22.4% of 10-to-17-year-olds living below the poverty line being overweight or obese (Trust for America's Health, 2009). US findings are similar to observations among 6-year old Germany children in which a strong dose-response relationship between social class and obesity was identified (Lamerz et al., 2005).

Education

In a study of 9 to 10 year old black and white girls, the effect of race, household income, and parental education on obesity was examined. Findings revealed that of the three variables, higher education was consistently associated with lower percentage of dietary fat and higher levels of vitamin C, calcium, and potassium (Crawford et al., 1995). Evidence suggests that population groups with the highest poverty rates and the least education have the highest obesity rates (Drewnowski & Specter, 2004). Education attainment was often used as an alternative measure for socioeconomic status. Researchers contend that less education is a predictor of health disparities (Metzler, 2007).

Economics

According to the literature, obesity appears to disproportionately affect those with limited economic resources. A substantial number of studies demonstrate the association between childhood obesity, low household income, and food insecurity (Casey, Szeto, Lensing, Bogle, & Weber, 2001; Crooks, 1999, 2000; Wang & Lobstein, 2006). Eighty-one percent of economically poor counties in the Appalachian region of Kentucky, Tennessee, and West Virginia have the highest rates of childhood obesity (Centers for

Disease Control and Prevention [CDC], 2011a). When combined with poverty obesity has a greater impact upon quality life years. Obese adults (18-years or older) for example can expect to live 47 quality-adjusted life-years; whereas obese adults living under the poverty line can expect to live 43 quality-adjusted life-years. Even when adjustments were made for life style behaviors such as smoking and alcohol use, the risk of mortality in obese adults was greater in groups with incomes at the lowest threshold (Lantz et al., 1998; Muennig, Sohler, & Mahato, 2007).

Children living in low-income neighborhoods have limited access to physical activity facilities (Gordon-Larsen, Nelson, Page, & Popkin, 2006). Poverty and food insecurity are associated with lower food expenditures, low fruit and vegetable consumption (Roos, Johansson, Kasmel, Klumbiené, & Prättälä, 2000), and lower-quality diets (Drewnowski & Specter, 2004). Investigators examining social determinants of health have proposed that poverty is a “fundamental” cause of disease (Metzler, 2007; Wilkinson & Marmot, 2003).

Crime

Within the literature, associations between obesity and neighborhood crime are limited. The association is most commonly examined according to the effect of crime on physical activity most notably the relationship between physical activity and crime perception of parents (Carver, Timperio, & Crawford, 2008). Parents who perceive their community to be unsafe may be less likely to permit their children to play outside (Nestle & Jacobson, 2000). In fact, parental concern about crime is among the leading reasons why parents keep their children indoors (Gordon-Larsen, McMurray, & Popkin, 2000; Molnar, Gortmaker, Bull, & Buka, 2004). Indoor sedentary behavior; computer gaming and television viewing, is perceived to contribute to low physical activity and has been positively associated with community crime and sex offender rates (Brown, Perez, Mirchandani, Hoelscher, & Kelder, 2008). Such findings support similar studies in which perceived safety was positively associated with parental reports of child participation in physical activity (Molnar et al., 2004). Girls who perceived their neighborhood to be safe were more likely to participate in outdoor physical activity as compared to girls reporting unsafe perceptions (Gomez, Johnson, Selva, & Sallis, 2004). Sallis and Glanz (2006) contend that access to safe places affects activity behavior, which may influence obesity development. However, the effect that crime has on physical activity is not clearly delineated within the literature. Several studies report no association between safety perception and physical activity (Adkins, Sherwood, Story, & Davis, 2004; Sallis, Taylor, Dowda, Freedson, & Pate, 2002).

Poverty within one given community may influence personal crime rates of nearby locations (Wilson & Kelling, 1982). Relationships associated with spatial interaction are due to movement of people from one given location to another. For example, the “journey to crime” theory argues that criminal activity is the result of accessibility between the crime event and the criminal’s home location (Sampson, 1985).

In conclusion, crime is viewed as a contributing factor for obesity development in childhood. A commonality noted within the literature was that parents perceive children to be less vulnerable to crime indoors and that indoor sedentary behaviors appears to contribute to the epidemic of childhood obesity (Carver et al., 2008; Weira, Etelsonb, & Brandb, 2006).

OBESOGENIC ENVIRONMENT

People who lived when food was sporadically available benefited from genes that predisposed them to obesity since these genes provided a protective advantage during times of famine (Bonner, 2003) ; however, according to Friedman, these genes in a modern day environment result in significant health consequences, such as obesity, diabetes, and heart disease (Bonner, 2003). Baranowski (1996) contends that the modern obesogenic environment places individuals with ancestral energy conserving genes at the greatest risk for overweight and obesity. According to the literature, an obesogenic environment is the totality of the surroundings, opportunities, or conditions (Bray, 1990) that promote an imbalance between energy intake and energy expenditure (Baranowski, 1996). Energy balance is based on one of the two ‘Laws of Obesity’: intake must be in excess of expenditure (Trayhurn, 2005). Personal behavior and biology are perceived to have a direct influence on energy intake and expenditure; whereas, the environment is perceived to influence personal behavior. Children today are being raised in environments non-conductive of physical activity (Frank & Engelke, 2001) in which the food industry promotes convenient, inexpensive, and low-nutrient food (Brownell & Horgen, 2004; Nestle & Jacobson, 2000).

PHYSICAL ENVIRONMENT

Research findings indicate that obesity is in part the result of influential interactions of the community environment, diet, and physical activity (Papas et al., 2007; Sallis & Glanz, 2006). An association between elements of the physical (recreational activities, mixed land use, green space and safety for pedestrian and bicyclists) and obesity (Cervero & Duncan, 2003; Ellaway, Macintyre, & Bonnefoy, 2005; Li, Fisher, Brownson, & Bosworth, 2005) have been identified. Changes in the community environment including greater dependence on convenience store style foods and fast food combined with a lack of access to fruits and vegetables are perceived to contribute to obesity in childhood (Sallis & Glanz, 2006). However, Sallis and Glanz (2006) suggest that no conclusive evidence exists that aspects of the physical environment promote obesity in children.

Food Deserts

Within the literature food store, availability has been linked with negative outcomes such as obesity (Beaulac, Kristjansson, & Cummins, 2009; Blanchard &

Lyson, 2006; Moore, 2003). Poorer areas tend to have limited access to fruit and vegetable markets, natural food stores (Beaulac et al., 2009) and fewer chain supermarkets (Powell, Slater, Mirtcheva, Bao, & Chaloupka, 2007). Blanchard and Lyson (2003) contend that the establishment of “supercenter” grocery stores produce “food deserts” for the rural population creating physical and economic barriers to healthy food.

Fruit and Vegetable Markets

According to Trust for America’s Health (2011), only 18.2% of WV students and 18.6% of WV adults regularly consume the recommended daily allowance of fruits and vegetables; ranking WV the 16th state for the lowest fruit and vegetable consumption in school children and 4th for adults. Fruit and vegetable consumption is associated with the presence of supermarkets and supermarkets are more likely to be located in wealthier neighborhoods (Morland, Wing, & Diez, 2002). Families who have easy access to affordable, fruits and vegetables report higher levels of fruit and vegetable consumption (Sallis & Glanz, 2006). However, regardless of availability per calorie intake, low-density, high-nutrient food such as fruits and vegetables cost more; therefore, economically the purchase of low-nutrient foods is a feasible alternative for low-income families (Drewnowski & Specter, 2004).

Fast Food Establishments

In the late 1970s, fast food meals accounted for 2% of total energy intake in children, whereas by the 1990s, fast food meals contributed to 10% of overall energy intake (American Heart Association, 2011). Generating approximately \$120 billion in sales, the fast food restaurant business is one of the largest segments of the food industry in the U.S. (Hoover Inc., 2010).

The number of and proximity to fast-food restaurants have been associated with significant increases in the risk of obesity in children (Currie, Vigna, Moretti, & Pathania, 2010; Kipke et al., 2007; Kwate, Yau, Loh, & Williams, 2009; Li, Hamer, Cardinal, Bosworth, & Johnson-Shelton, 2009; Powell et al., 2007). For children, having a fast food restaurant within 0.10 miles of school increases the probability of obesity by 5.2% (Currie et al., 2010). Proximity to fast food was found to be greater among less educated women and African-American adult females; with predominantly black neighborhoods having 2.4 fast food restaurants per square mile compared to 1.5 restaurants in predominantly white neighborhood (Kwate et al., 2009). The findings support an earlier study (Block, Scribner, & DeSalvo, 2004) documenting a geographic correlation between exposure of black and low-income neighborhoods to fast food restaurants. Powell et al. (2007) found that fast food restaurants are more concentrated in poor neighborhoods nationwide. Caution is warranted however as “no cause-and-effect” data on fast food and overweight/obesity in children currently exists (Mullen & Shield, 2004).

Convenience Stores

The number of convenience stores (Galvez et al., 2009; Powell et al., 2007) has been associated with a higher BMI and lower levels of fruit and vegetable consumption (Timperio, Ball, Roberts, Andrianopoulous, & Crawford, 2009) in children. However, the literature is sparse.

Recreational Facilities

The relationship between obesity, levels of physical activity, and access to recreational facilities has been well researched (Gordon-Larsen et al., 2000; Gordon-Larsen et al., 2006; Trost et al., 1997; Tucker et al., 2009). Tucker et al. (2009) found that recreational opportunities and physical activity were positively associated; thus as recreational opportunities increased physical activity increased. Physical activity is most notably connected to obesity development; thus, obesity is often examined in context with access to recreational facilities. (2006)Gordon-Larsen et al. (2006) found that availability of physical activity facilities was associated with overweight patterns and that the inequality in availability contributed to decreased activity and an increase in overweight. Children living in low-income neighborhoods have limited access to physical activity facilities (Gordon-Larsen et al., 2006).

CONCLUSION

In conclusion, an obesogenic physical environment is associated with limited availability of and access to fresh produce and healthy foods. People living in resource poor communities demonstrate the greatest risk for obesity development. The number and proximity to food sources including grocery stores, fruit and vegetable markets, fast food establishments, and convenience stores appear to influence (negatively and positively) obesity development.

PERSONAL ENVIRONMENT

States with adult obesity rates exceeding 25% doubled in the past year from four to eight - Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, and West Virginia (Trust for America's Health, 2009) . West Virginia is the third most obese state in the nation with an adult obesity rate exceeding 30% (Trust for America's Health, 2011). As a result, many WV children are living in households in which obesity is a common occurrence. Among children, heredity and maturation influence fitness (Armstrong & Welsman, 2000; Pangrazi & Corbin, 1990). A child with a hereditary predisposition for fitness may be less active but yet score better on fitness assessments than younger physically active children who lack the hereditary predisposition (Armstrong & Welsman, 2000; Pangrazi & Corbin, 1990).

Family History

Understanding the dynamics of the family in relation to obesity related behaviors including; history of cardiovascular disease and/or diabetes, may provide clues to childhood obesity risk factors. Children with parents with early heart disease are at an increased risk for obesity (Slyper, 1998). Children who are overweight, have a family member with type 2 diabetes, and are over 10 years of age are at increased risk for developing type 2 diabetes during childhood, adolescence, or adulthood. Type 2 diabetes observed in youth is perceived to be a “first consequence” of the obesity epidemic in children (Fagot-Campagna, 2000; National Diabetes Education Program, 2008).

Fitness

Physical fitness and physical activity are not one in the same. Physical fitness is a characteristic or attribute defined according to the ability to carry out work (Claessens et al., 2008). Although fitness encompasses many dimensions, the most referenced relate to aerobic capacity (fitness) and musculoskeletal fitness (Armstrong & Welsman, 2000).

Associations between body mass index and aerobic fitness in children have been noted within the literature with the majority of studies focusing on cardiovascular risk factors. Variations in cardiovascular risk factors are most notably due to the degree of body fatness (Boreham et al., 2001; Hubert, Feinleib, McNamara, & Castelli, 1993). Individuals classified with low fitness and high BMI demonstrated the greatest degree of cardiovascular disease (CVD) risk factors including: higher blood lipids and glucose (Eisenmann, Welk, Ihmels, & Dollman, 2007). However, the literature reliably demonstrates that fatness is a major confounding variable when examining the relationship between fitness and metabolic and/or cardiovascular risk factors (Armstrong & Van Mechelen, 2008; Armstrong & Welsman, 2001; Bergstrom, Hernall, & Persson, 1997; Fripp et al., 1985; Hansen, Hyldebrandt, Frober, & Nielsen, 1990; Sallis, Patterson, Buono, & Nadder, 1988).

The methodology for measuring fitness components in children could influence fitness outcomes and falsely elevate or diminish a child's fitness level. Measurement normalization of exercise performance data is a process utilized to accommodate for physiological functional differences in children as a result of body size (related to growth and maturation). The method assists in controlling body size as a confounder; therefore, the aim is to remove body size as an influence thus formulating a size-free variable. A variety of scaling methods have been derived to assist in the formulation of a size-free variable. Scaling methods utilized include ratio scaling (per body mass ratios thus size dependent); linear regression scaling and allometric scaling (allows for size adjusted ratios and the examination of different growth rates as part of the growth process). Longitudinal scaling methods include ontogenetic allometry which allows for the examination of different growth rates as part of the individual growth process and multilevel modeling (Armstrong & Van Mechelen, 2008; Armstrong, Welsman, & Kirby, 1998; Bar-Or & Rowland, 2004; Nevill, 1997; Nevill & Holder, 1994; Nevill, Rowland, Goff, Martel, & Ferrone, 2004).

Maximal VO_2 is considered to be the single best indicator of aerobic fitness (Armstrong & Van Mechelen, 2008). VO_2 is based upon the ability to measure the volume of expired air per unit time and the fractions of oxygen and carbon dioxide in expired air. Barometric pressure, gas temperature and water vapor pressures of the gases are required for the measurement. The calculation/formula is based upon volume of expired air per minute and fraction of oxygen and carbon dioxide work (Armstrong & Van Mechelen, 2008). Some researchers advocate that “peak” VO_2 rather than maximal VO_2 is more appropriate term for utilization in children due to the small percentage of children and adolescents who fail to demonstrate the VO_2 plateau (Banquet, Van Praagh, & Berthoin, 2003; Bar-Or & Rowland, 2004; Cooper, Weiler-Ravell, Whipp, & Wasserman, 1984; Rowland, 2005).

Due to various issues such as equipment cost; complexity of test administration; and time; direct peak VO_2 testing is not always practical. As a result, numerous field tests of aerobic fitness are now utilized and have been found to produce reliable and valid results in comparison to lab testing work (Armstrong & Van Mechelen, 2008). The three main aerobic fitness tests discussed in the literature include distance run, timed run and endurance shuttle run. Running tests require maximal effort and are appropriate methods of measuring aerobic fitness in children. Other field tests that produce maximal effort discussed in the literature include jumping tests and sprinting tests. Although less prominently discussed anaerobic fitness has been associated with health and function in children (Armstrong & Welsman, 2001) and should also be considered when examining child fitness.

Among children, heredity predisposition and maturation have more influence on fitness than does physical activity (Armstrong & Van Mechelen, 2008; Pangrazi & Corbin, 1990). For example, a child who is older with a hereditary predisposition for fitness may be less active, yet score better on fitness assessments than younger physically active children who lack the hereditary predisposition (Armstrong & Welsman, 2000; Pangrazi & Corbin, 1990). As children become adults, maturation and age become less important factors (Armstrong & Van Mechelen, 2008; Bar-Or & Rowland, 2004; Baxter-Jones, Eisenmann, & Sherar, 2005). The relationship between children’s aerobic fitness and fatness are unclear.

Findings regarding the relationship between fitness and obesity are inconclusive. A review by Marrow & Freedson (1994) examining the relationship between physical activity and aerobic fitness concluded that a small to moderate relationship between activity and fitness in children and youth existed. Observation studies have more commonly identified a relationship between activity, fitness, and fatness. In a sample of 8 to 10 year old children, low fitness level and increased fatness were associated with decreased physical activity (Rowlands, Eston, & Ingledew, 1999). Researchers suggested; however, that the degree of fatness may moderate fitness and physical activity findings due to an increase in heart rate threshold in response to degree of child fatness (Rowlands et al., 1999).

GEOGRAPHICAL DISTRIBUTION OF OBESITY

Socioeconomic factors, as well as obesity are closely associated with geographic disparities. South-central regions of the US have the highest prevalence (18%) of childhood obesity and the Mountain region the lowest prevalence (11.4%) (Singh, Kogan, & Van Dyck, 2008). Children living in West Virginia, Kentucky, Texas, Tennessee, and North Carolina are at twice the odds of being obese than children living in the Mountain regions of the US (Singh et al., 2008). Therefore, geographic disparity must be taken into consideration when examining obesity. Behavioral Risk Factor Surveillance System data identified obesity prevalence rates being lowest (below 20 percent of population) in Colorado, Hawaii, Vermont, and Connecticut but highest in Louisiana, Mississippi, and West Virginia with a prevalence of 30% or higher (Centers for Disease Control and Prevention [CDC], 2011b). Geographically, 16.5% of rural kids qualify as obese as compared with 14.4% of urban kids (Trust for America's Health, 2009).

WEST VIRGINIA

According to Trust for America's Health (2011), WV ranks tenth in the nation for childhood obesity and third for adult obesity. Over the past decade, the rate of obesity has increased in virtually all WV counties, with the highest prevalence found in the southern and western regions of the state (West Virginia Health Statistic Center [HSC], 2002). As stated previously, low socioeconomic status families and children in southern Appalachian states appear to have higher rates of obesity than the rest of the population (Cochran, 2008). West Virginia is the only state that lies wholly within Appalachia and is both rural and economically disadvantaged (Bureau of Economic Analysis, 2007). For the last three years, WV has consistently ranked as the 6th (2007 and 2008) or 7th (2009) poorest state in the US (U.S. Census Bureau [Data file], 2010). The state has been described as having poor accessibility with a large degree of urban mountainous sprawl resulting in a heavy reliance on automotive transportation (Amarasinghe et al., 2006).

A spatial analysis of the potential impact of obesogenic factors on obesity development in WV adults found that a 1% increase in poverty would raise the county prevalence of obesity by 0.13% and a one-minute increase in transportation/ commute time to work increased the incidence of obesity by 0.3% (Amarasinghe et al., 2006). Additional findings revealed a reduction in obesity rates by 3% for each unit increase in the number of food stores per thousand population and a 0.2% decrease in obesity rates for each 1% increase in the percentage of the population completing a college education (Amarasinghe et al., 2006). To date, researchers have not examined the potential impact of these obesogenic factors to obesity risk in children.

The sum effect of these environmental pressures on promoting obesity and related consequences in the community are evident: In the United States (U.S.), WV ranks number one in terms of diabetes, number three for hypertension, and number four for total medical costs for obesity related health care treatment (Trust for America's Health, 2009). West Virginia 5th grade children were identified to have elevated total

cholesterol, elevated systolic blood pressures, and elevated systolic blood pressures as compared to non-overweight (Demerath et al., 2003). Such findings are similar to other communities with high childhood obesity rates. Throughout WV, there are counties in which children are expected to die at a younger age than their parents (Ezzati, Friedman, Kulkarni, & Murray, 2008). Life expectancy among men and women within rural counties of WV dropped between 1983 and 1999 with the most significant decline occurring in southern WV counties of Lincoln, Logan, and especially McDowell counties (Ezzati et al., 2008). In McDowell County, life expectancy has fallen to third-world levels (Finn, Higgins, & Lilly, 2011). The average age of death among WV residents declined by 6 months between the years of 1996 to 2006 to slightly more than 72 years; however, in Wyoming and McDowell counties the average age of death decreased by four years in one decade to 67 years of age (Ezzati et al., 2008; Finn et al., 2011; West Virginians for Affordable Health Care [WVAHC], 2008). Findings indicate that WV youth are disproportionately at greater risk for obesity and obesity related consequences because of an obesogenic environment.

GEOTECHNIQUES

Geo-techniques such as spatial analysis using geographic information systems (GIS), are emerging as powerful tools in the investigation of disease determinants. GIS is a computer database that stores geographic data (Aronoff, 1989). Through spatial analysis techniques, researchers can examine the distribution of and relationships between GIS geographic data and health events.

GIS spatial analysis of health/disease is a phenomenon that first emerged in the 1980s but did not take hold until the 1990s. However, the diffusion of GIS into the mainstream of health and/or disease research has been slow and is described as being in the early expansion stage of research applicability (Albert, Gesler, & Whittie, 1995).

Within health and/or disease literature, GIS usage is very diverse (Sallis & Glanz, 2006). The most cited usage was among medical geographers and epidemiologists examining temporal and spatial patterns of environmental health hazards and infectious diseases (Cromley & McLafferty, 2002). From a public health perspective, GIS has played a pivotal role in disease prevention and health promotion. Yet, few studies have utilized GIS in the examination of childhood obesity at the zip code level; especially, the socioeconomic environment of childhood obesity. There are virtually no childhood obesity studies geocoded at the zip code level for an entire state.

Geomapping demands data that contains a geographical identifier such as state, county, census tract, or zip code which impacts the type of relationships and inferences that can be made in a study (Albert et al., 1995; Cromley & McLafferty, 2002). The prevalence of obesity is most often portrayed at the county or state level, which is not necessarily representative of a community and could potentially conceal patterns of obesity occurrence.

To utilize GIS methods, the geographical scale must be carefully defined and associated data geocoded. How scale is defined can critically impact the types of inferences that can be made (Albert et al., 1995; Cromley & McLafferty, 2002; Drewnowski, Rehm, & Solet, 2007). Albert, Gesler, and Levergood (2005) point out that spatial patterns and /or variable associations may vary significantly at different scales of analysis; therefore, investigations of disease and health should be carried out at different geographical levels. Additionally, spatial boundaries may have no inherent meaning in the real world; therefore, may result in the formation of artificial relationships (Fotheringham, Densham, & Curtis, 1995). Replication of study findings at different scale levels could help identify and define clusters of disease (Albert et al., 1995; Cromley & McLafferty, 2002).

Data at the ZIP code scale can be problematic for spatial analysis (Drewnowski et al., 2007). Population counts per ZIP code area can vary and be too small to provide area-based prevalence estimates (Drewnowski et al., 2007), especially in rural communities. Zip code boundaries are also arbitrary in regards to what defines a community in the traditional sense. However, zip code areas do “provide a geographical frame of reference to which other data layers are tied” (Cromley & McLafferty, 2002, p. 68); thus, allows data to be examined at a neighborhood or community level vs. a county or state.

Identifiers and scales pose unique statistical challenges. For example, according to Tobler’s first law of geography, everything is related to everything else (Miller, 2004); thus, correlated. The closer communities are proximally, the stronger the spatial dependency and the stronger the similarities in community characteristics (Miller, 2004). Spatial dependency leads to the statistical problem of spatial autocorrelation and violates the statistical assumption of independence among observations. However, despite the statistical challenges, spatial analysis techniques provide a valid means to visualize spatial patterns.

CONCLUSION

The childhood obesity epidemic appears to disproportionately affect some communities greater than others. The development of childhood overweight and/or obesity is multifactorial resulting from a complex interaction of many factors. Contributing factors identified include: genetics, behavior, environment, and socio-economic; as well as socio-demographic influences. When combined, such factors are perceived to create an environment conducive for obesity development – an obesogenic environment. The literature supports the linkage between the individual environmental risks factors of the socioeconomic, physical, and personal environment. However, there is a paucity of information on the effect of cumulative environmental factors on overweight and obesity in children, and whether the spatial distribution of these factors is associated with childhood obesity within communities. Additionally, demographic statistics regarding the distribution of childhood obesity demonstrates that the epidemic appears to disproportionately affect some communities greater than others.

CHAPTER 3. PREDICTORS OF OVERWEIGHT AND OBESITY AMONG WV 5TH GRADE CHILDREN

INTRODUCTION

Childhood obesity, defined as a body mass index (BMI) at or above the 95th percentile for children of the same age and sex, is considered an epidemic in the United States (Centers for Disease Control and Prevention [CDC], 2011b). In the last 30 years, the prevalence of childhood obesity (children aged 6 to 11) has increased from 6.5% in 1980, to 19.6% in 2008 (Ogden et al., 2010). Biology and lifestyle behaviors have been identified as important factors in the development of childhood obesity; however, researchers are beginning to place more emphasis upon the impact that continual environmental exposures have upon obesity development. Environmental risk factors associated with obesity are distributed continuously over space; yet, evidence suggests that the burden of risk may not be evenly dispersed across a community. Additionally, the obesity epidemic appears to disproportionately affect some communities greater than others. Examination of spatial distribution may help provide answers to fundamental childhood obesity questions related to environmental risks. Such methods may provide a means to identify geographical obesity patterns and offer the ability to filter information to identify obesity related events.

While it is well documented that the physical environment is associated with obesity development (Galvez et al., 2010; Papas et al., 2007), there is a paucity of information on the effect of cumulative environmental factors on overweight and obese children. The literature supports the linkages between individual environmental risk factors including the built, home, and socioeconomic environment. Obesity has been associated with limited community physical resources such as recreational activities, mixed land use, green space, and safety for pedestrians and bicyclists (Cervero & Duncan, 2003; Ellaway et al., 2005; Li et al., 2005). Access to food sources including grocery stores and fruit and vegetable markets, appear to reduce the risk of obesity, while higher numbers of fast food establishments and convenience stores are linked to obesity development (Beaulac et al., 2009; Blanchard & Lyson, 2006; Currie et al., 2010; Kipke et al., 2007; Kwate et al., 2009; Li et al., 2009; Moore, 2003; Powell et al., 2007).

Community socioeconomic factors including poverty and educational level (Drewnowski & Specter, 2004), is a fundamental factor perceived to influence child weight. Socioeconomically individuals who are less educated and/or make less money have higher obesity rates (Trust for America's Health, 2011). Economically, the poorest states: West Virginia, Mississippi, and Tennessee have the heaviest children (Trust for America's Health, 2011).

While crime rates tend to be higher in low socioeconomic communities, studies examining the relationship between neighborhood community crime rates and obesity development have yielded equivocal results (Burdette & Whitaker, 2004). Community crime and sex offender rates have been positively associated with indoor sedentary

behavior (Brown et al., 2008); as has gender, with girls participating in less physical activity in areas perceived to have higher rates of crime (Gomez et al., 2004). Whether crime, particularly violent crime, contributes to obesity development through greater psychological stress, overeating, or more indoor, sedentary activity remains unclear.

West Virginia, a rural Appalachia community has the 3rd highest adult and 10th highest youth obesity rates (32.2% and 18.9% respectively) in the nation (Trust for America's Health, 2011). The study design proposed that childhood overweight and obesity are the consequence of exposure to environmental attributes. The purposes of this study of WV 5th graders were threefold: 1) To determine which socioeconomics, physical, and personal environment attributes contribute to overweight (BMI equal to or greater than the 85th percentile for age and gender) and 2) to determine which socioeconomics, physical, and personal environment attributes contribute to overweight (BMI equal to or greater than the 5th percentile for age and gender).

PROCEDURES AND METHODS

A secondary data analysis of cross-sectional statewide representative data was performed to examine the proposal that overweight and obesity are the consequence of exposure to environmental attributes. Data compiled were gathered from various secondary data sources for the academic school years of 2007/2008 and 2008/2009.

The study sample consisted of 5th grade children participating in The Coronary Artery Risk Detection in Appalachian Communities (CARDIAC) (Coronary Artery Risk Detection In Appalachian Communities [CARDIAC], 2010) project during the academic school years of 2007/2008 and 2008/2009. The CARDIAC project, initiated in 1998, is a disease surveillance and intervention program designed to combat the high prevalence of heart disease and diabetes in WV. All 5th grade students enrolled in WV public schools were eligible to participate in the CARDIAC project.

Active consent of a parent or guardian and child assent was required for CARDIAC project participation. Parents were provided a consent packet, which described the purpose of the screening, screening procedures, reporting procedures, and protocol elements associated with participating in the screening project. The study protocol was approved by the West Virginia University Institutional Review Board for the Protection of Human Subjects and written permission was obtained from the county school superintendents (Coronary Artery Risk Detection In Appalachian Children project [CARDIAC], 2010). The current study was approved by the Institutional Review Board of the University of Tennessee. The study sample was drawn from 53 of the 55 counties in WV and consisted of 12,194 fifth grade children enrolled in WV public schools during the 2007/2008 and 2008/2009 academic school years.

OPERATIONALIZATION OF SECONDARY DATA VARIABLES

Study indicators used to quantify socioeconomic, physical, and personal environmental attributes were derived from various data sources including the CARDIAC project; WV Board of Education; US Census Bureau,; and WV State Police Crime in WV website. Geolytics compiled US Census Bureau data, a data resource management company experienced in US Census Bureau data retrieval (GeoLytics, 2010). Prior to performing the secondary data analysis, permission was obtained from the Institutional Review Board (IRB) for the University of Tennessee.

Socioeconomic Environment

The socioeconomic environment was defined according to attributes of education (aggregate total of population 25+ with high school diploma or higher), median household income, aggregate student population classified as low socioeconomic status and aggregate total of violent crime in the county. Socioeconomic data were derived from various secondary data sources including U.S. Census Bureau, WV Board of Education, and WV State Police.

Physical Environment

The physical environment included the attributes consisting of the aggregate total of: fast food, convenience store, supermarket, and grocery establishments; fruit and vegetable markets; and fitness and recreational sports centers. The North American Industry Classification System (NAICS) was utilized to define and classify food services and recreational facilities at the zip code and county for 53 of the 55 WV counties: 722211 limited-service restaurants; 445120, convenience stores; 445110, supermarkets; 445230, fruit and vegetable markets; and 713940, fitness recreation and sports (U.S. Census Bureau [Data file], 2007).

Personal Environment

Attributes of the personal environment included a positive or negative family history of diabetes and heart disease and child fitness status (in the healthy fitness zone or needs improvement). Family history was parental self-reported data; whereas, child fitness was aggregate 5th grade data at the school level.

Secondary Data Sources

Study indicators used to quantify socioeconomic, physical, and personal environmental attributes were derived from various data sources including the CARDIAC project; WV Board of Education; the United States (U.S.) Census Bureau; and WV State

Police. US Census Bureau data at the zip code and county level was compiled by Geolytics a data resource management company experienced in US Census Bureau data retrieval. Secondary data sources are described below.

CARDIAC project: BMI and family history. The Coronary Artery Risk Detection in Appalachian Communities project (CARDIAC) is a disease surveillance and intervention program, designed to combat the high prevalence of heart disease and diabetes in WV. The program has been implemented in all WV public schools. Since 1998, team members of the CARDIAC project have screened more than 46,078 fifth graders for cardiovascular disease (Coronary Artery Risk Detection In Appalachian Children project [CARDIAC], 2010). For the purpose of this study, data from a sample of 12,194 fifth grade children for academic school years 2007/2008 and 2008/2009 were examined.

WV Board of Education: Fitnessgram and low socioeconomic status. Fitnessgram was implemented in WV schools in the spring of 2006 in response to WV state fitness level reporting requirements. Each school is responsible for reporting data by grade level and class. Students enrolled in grades four through eight are tested annually. The fitness evaluation protocol was approved by the WV Board of Education and mandated by WV House Bill 2816 in 2005, serving as a replacement to the President's Physical Fitness Challenge (West Virginia Department of Education [Data file], 2011). Socioeconomic status was based on free and reduced lunch percentage eligibility rate for the academic school years 2007 and 2008 as reported by the WV Department of Education.

U.S. Census Bureau: Education and median household income. The U.S. Census Bureau is funded by the U.S. government and is widely utilized by researchers as a source for demographic data such as education and income. For the purpose of this study, data obtained through Geolytics consisted of WV business patterns and WV demographics at the zip code and county level.

U.S. Census Bureau: WV business patterns. Physical data of interest was sorted and retrieved according to the North American Industry Classification System (NAICS). NAICS is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy (U.S. Census Bureau [Data file], 2007).

WV State Police: Crime. WV crime data were available through the WV Crime Statistics report (2008 & 2009) and accessible by county and/or district. All crime incidents identified within the state are chronicled. WV crime data is certified by the National Incident Based Reporting Systems (NIBRS) and crime data is submitted to the Federal Bureau of Investigations (FBI) (West Virginia State Police [Data file], 2008, 2009).

STUDY MEASURES

Socioeconomic, physical, and personal environmental attributes were derived from various data sources including the CARDIAC project; WV Board of Education; the United States (U.S.) Census Bureau; and the WV State Police. United States Census Bureau data at the zip code and county level was compiled by Geolytics, a data resource management company experienced in U.S. Census Bureau data retrieval.

Socioeconomic Environment

Median household income and education data were obtained from the U.S. Census Bureau one-year estimates derived from the American Community Survey (ACS). U.S. Census Data were compiled by Geolytics and obtained at the zip code and county level for the years 2007 and 2008. Low socioeconomic status data were gathered from the WV Department of Education data website for the academic years 2007/2008 and 2008/2009 school year. Violent crime data were gathered from the WV State Police data website (Crime in WV) for the years of 2007 & 2008. Socioeconomic indicators of number of persons 25+ years completing high school, median household income was examined at the zip code level. Aggregate 5th grade student population classified as Low socioeconomic status (LSES) was examined by 5th grade class. Violent crime was examined at the county level.

Education. Data were available as aggregate total for total population 25+ years and total population of high school graduates age 25+ years. Data estimates were derived from the census long form in which approximately one in every six households received this sample questionnaire. The data estimates are subject to sampling variability levels.

Household income. Household income was recorded as the sum of money income including wage or salary income; net self-employment income; interest, dividends, or net rental or royalty income or income from estates and trusts; Social Security or Railroad Retirement income; Supplemental Security Income (SSI); public assistance or welfare payments; retirement, survivor, or disability pensions; and all other income, received by all household members 15 years of age and older. All household members included unrelated household members such as household members not related to the householder, people living alone, and other nonfamily household members (U.S. Census Bureau [Data file], 2010) .

Both direct survey-based estimates and regression predictions from administrative records, population estimates, and decennial census data are utilized to create estimates of income. Bayesian techniques are employed to create estimates of income for different geographic levels (U.S. Census Bureau [Data file], 2010). For this study, median household income at the zip code level was used as the measure of household income.

Low socioeconomic status (LSES). Defined as the aggregate total of students eligible for free or reduced lunch as based on the National School Lunch Program

standards. Children from families with incomes at or below 130% of the poverty level were eligible for free meals; whereas children from families between 130% and 185% of the poverty level were eligible for reduced-price meals (West Virginia Department of Education [Data file], 2011). Eligibility was determined by school district and criteria established by the Child Nutrition Act and National School Lunch Act. The application process for availability varies with most children submitting an application containing information regarding household income and size information or proof of participation in a federally subsidized Medicaid program (West Virginia Department of Education [Data file], 2011). School level data for the 2007/2008 and 2008/2009 school years were used in the analysis.

Violent crime. WV crime data were available through the National Incident Based Reporting System (NIBRS). An "incident" was defined as an offense committed by the same offender, or group of offenders acting in concert, at the same time and place (West Virginia State Police [Data file], 2008, 2009). Crimes were categorized by means of a standardized procedure in which survey questionnaire data were entered into a computer system by the investigating officer. The computer program utilized a hierarchy approach to classify the crime event as a: rape, sexual assault, robbery, assault, burglary, motor vehicle theft, and theft. For each offense known to police incident, victim, property, offender and arrest information was gathered and entered by the investigating officer (West Virginia State Police [Data file], 2008, 2009). All crime incidents identified within the state were chronicled. Incident data were available per county, per agency, per category and per offense.

Aggregate crime data (rate per 100) rape, sexual assault, robbery, assault, burglary, motor vehicle theft, and theft, were collected from the WV State Police website for the years 2007-2008 at the county level. Crime data were available for 52 of the 55 WV counties.

Physical Environment

The physical environment was defined according to attributes of convenience stores, supermarkets and other grocery, fast food, and recreational/fitness centers supplied by Geolytics. Physical data of interest was sorted and retrieved according to the 6 digit North American Industry Classification System (NAICS) code: 722211 limited-service restaurants; 722110 full service restaurants; 445120, convenience stores; 445110, supermarkets; 445230, fruit and vegetable markets; and 713940, fitness recreation and sports (U.S. Census Bureau [Data file], 2007). An aggregate total of NAICS data at the zip code and county level for each 6-digit level was derived. NAICS data at the zip code level for the year 2008 were used for binary logistic regression.

Fast food. Data at the six level classification system 722211 (Limited-Service Restaurants) was utilized to calculate the aggregate number of fast food restaurants by zip code. Limited-service restaurants were defined as food services (except snack and nonalcoholic beverage bars) where patrons generally 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 selling alcoholic beverages (U.S. Census Bureau [Data file], 2010). NAICS fast food aggregate data were obtained for the year 2008 at the zip code and county level.

Convenience stores. Convenience stores were defined according to the 6 level classification code 445120 (Convenience Stores) as an industry comprising establishments engaged in retailing a limited line of goods generally including milk, bread, soda, and snacks (U.S. Census Bureau [Data file], 2010). An aggregate total of NAICS convenience store data for the year 2008 was derived at the zip code level.

Supermarkets and other grocery. Defined at the 6 digit level 445110 as an establishment known as supermarkets and grocery stores (excluding convenience) engaged primarily in retailing a general line of food and delicatessen-type establishments primarily engaged in retailing a general line of food (U.S. Census Bureau [Data file], 2010). An aggregate total of NAICS supermarkets and other grocery data for the year 2008 were derived at the zip code level.

Fruit and vegetable markets. The fruit and vegetable market classified at the 445230 level comprised establishments primarily engaged in retailing fresh fruits and vegetables (Trust for America's Health, 2009). An aggregate total of NAICS fruit and vegetable markets for the year 2008 were derived at the zip code level.

Fitness and recreational sports centers. The six level classification 713940 (Fitness and Recreational Sports Centers) was utilized to calculate the aggregate number of fitness and recreational sports center by zip code. Fitness and recreational sports centers were defined as an establishment engaged primarily in featuring exercise and other active physical fitness conditioning or recreational sports activities, such as swimming, skating, or racquet sports (U.S. Census Bureau [Data file], 2010). An aggregate total of NAICS fitness and recreational sports center data at the zip code level for the year 2008 was derived for logistic regression analysis.

Personal Environment

Personal environment variables of interest included family history of diabetes, family history of heart disease, and child fitness. Family history data were derived from the CARDIAC Project and examined at the zip code, school, and county level. Child fitness was examined at the school and county level.

Family history. As part of the CARDIAC project, parents completed a comprehensive risk screening which included family history of heart disease and diabetes. The presence or absence of heart disease and diabetes was reported as yes, no or do not know.

Child fitness. Child fitness data were derived from WV FITNESSGRAM. FITNESSGRAM® is a comprehensive fitness assessment and reporting program for youth developed by the Cooper Institute (Welk & Meredith, 2008). The comprehensive assessment included physical fitness tests to assess aerobic capacity, muscular strength, muscular endurance, and flexibility. To determine child's overall physical fitness scores are assigned to a Healthy Fitness Zone® (Welk & Meredith, 2008).

Healthy Fitness Zone® standards are age and gender criterion-referenced standards representing required fitness levels for good health. Based on performance, students are categorized as being in the healthy fitness zone or needing improvement (Welk & Meredith, 2008). The FITNESSGRAM and Health Fitness Zone® standards have established validity and reliability in multi-ethnic groups of children (Welk & Meredith, 2008).

Physical education teachers were trained to administer and report grade level FITNESSGRAM® data through the West Virginia Education Information System (WVEIS) Tenth Month Report. The grade level report included the number of students tested and the number of students performing in the “healthy zone” for each category (aerobic and musculoskeletal) as defined by the FITNESSGRAM® (West Virginia Department of Education [Data file], 2011). For the purpose of this study, only 5th grade level aerobic fitness data were examined.

Body Mass Index (BMI)

Anthropometric measurement of height and weight were obtained as part of the CARDIAC project. The child height (cm) and weight (kg) was measured using the *SECA 840 Personal Digital Scale*. Children removed any foot wear or headgear that might alter the height measurements. Children's height was measured to the nearest centimeter while standing with feet together and head level. The digital scale was calibrated before each child was weighed. Children removed shoes, socks, and any heavy outerwear prior to stepping on the scale. The weight was recorded in pounds to the nearest one tenths of a pound as displayed. Trained health professionals and health professional students collected height and weight data. Training was provided by the CARDIAC staff and local school nurses trained to collect anthropometric measurements (Coronary Artery Risk Detection In Appalachian Children project [CARDIAC], 2010). The equation $\text{weight (kg)}/\text{height(cm)}^2 * 10,000$ was utilized to calculate BMI.

BMI percentiles derived from CARDIAC project data were assigned to cut points of overweight defined as a BMI $\geq 85^{\text{th}}$ percentile for age and gender and obesity defined as a BMI $\geq 95^{\text{th}}$ percentile for age and gender (Barlow & Dietz, 1998; Dietz & Bellizzi, 1999). All weight percentile cut points: overweight (BMI $\geq 85^{\text{th}}$), obese (BMI $\geq 95^{\text{th}}$ percentile), were based on age and gender-specific growth charts recommended by the CDC (Centers for Disease Control and Prevention [CDC], 2000).

Percentile measurements taken using the BMI method have produced reliable estimates of body fat with results correlating with body fat percentage, skin fold test, and is only weakly associated with height (Himes & Dietz, 1994). BMI correlates well with body fat in adults (Bertakis & Azari, 2005) and children (Velasquez-Mieyer et al., 2007) and is recommended as the preferred methods for determining obesity. Data from the CARDIAC (2010) project was available by both BMI and BMI percentiles. Data of interest was obtained for the academic years 2007/2008 and 2008/2009 at the zip code level.

STATISTICAL ANALYSIS PLAN

De-identified data for this secondary data analysis were stored on separate Microsoft Excel spreadsheets and then merged by zip code onto one spreadsheet. SPSS Statistical Software Package (Version 17) was used for statistical analyses. Descriptive statistics were used to portray demographic characteristics for 5th grade child participants. Frequency distributions were obtained for categorical data such as race and gender, while means and standard deviations were reported for continuous variables. Logistic regression analysis was performed to explore the relationship of socioeconomic, physical, and personal attributes to overweight (BMI $\geq$ 85th percentile) and obesity (BMI $\geq$ 95th percentile). The significance level was set at 0.05 for the final regression model.

Aim One

To determine which socioeconomic, physical, and personal environment attributes contribute to overweight (BMI equal to or greater than the 85th percentile for age and gender) in WV 5th graders. Hypotheses:

- 1.a. Socioeconomic attributes (lower level of education, lower household income, and higher level of violent crime in the county) will be associated with a BMI equal to or greater than the 85th percentile (overweight).
- 1.b. BMI equal to or greater than the 85th percentile (overweight) will be inversely associated with physical attributes of the number of grocery stores, fruit and vegetable markets, and the number of recreational facilities.
- 1.c. BMI equal to or greater than the 85th percentile (overweight) will be positively associated with physical attributes of the number of fast food restaurants and convenience stores.
- 1.d. BMI equal to or greater than the 85th percentile (overweight) will be positively associated with personal attributes of a family history of cardiovascular disease and diabetes.
- 1.e. BMI equal to or greater than the 85th percentile (overweight) will be inversely associated with the personal attribute of child aerobic fitness at the school level.

Aim Two

To determine which socioeconomic, physical, and personal environment attributes contribute to obesity (BMI equal to or greater than the 95th percentile for age and gender) in WV 5th graders. Hypotheses:

- 2.a. Socioeconomic attributes (lower level of education, lower household income, and higher level of violent crime in the county) will be associated with a BMI equal to or greater than the 95th percentile (obese).
- 2.b. BMI equal to or greater than the 95th percentile (obese) will be inversely associated with physical attributes of the number of grocery stores, fruit and vegetable markets, and the number of recreational facilities.
- 2.c. BMI equal to or greater than the 95th percentile (obese) will be positively associated with physical attributes of the number of fast food restaurants and convenience stores.
- 2.d. BMI equal to or greater than the 95th percentile (obese) will be positively associated with personal attributes of a family history of cardiovascular disease and diabetes.
- 2.e. BMI equal to or greater than the 95th percentile (obese) will be inversely associated with the personal attribute of child aerobic fitness at the school level.

For both aim one and aim two, binary logistic regression methods were employed to determine which attributes (socioeconomics, physical, and personal environment) contributed to overweight (BMI equal to or greater than the 85th percentile for age, and gender) and obesity (BMI equal to or greater than the 95th percentile for age, and gender). For analysis purposes, the dependent variable BMI percentile was categorized as discrete variables (0, 1); whereas, a BMI less than the 85th percentile (84.99) = 0 and a BMI greater than or equal the 85th percentile = 1. A second BMI category was categorized as BMI less the 95th percentile (94.99) = 0 and a BMI equal to or greater than the 95th percentile = 1. A variety of regression models were constructed: 1) unadjusted odds ratios (ORs) to determine which independent variables in the model were most predictive and 2) a Forward LR analysis to examine which term combination significantly affected the dependent variables of overweight and obesity. Univariate variables within each environmental attribute category found to be significant at the $p < .10$ were retained and included in the multivariate analysis (Forward LR). Variables that were significant ($p < .10$) in the Forward LR analysis of socioeconomic, physical, and personal attribute categories were retained and analyzed using multivariate techniques; therefore, the final analysis included all significant socioeconomic, physical, and personal variables identified in the Forward LR analysis. Variables at the $p < .05$ were considered significant in the final model. See **Figure 3-1**.

To test the statistical significance of each coefficient (β) in the model, a Wald test was performed. A Wald test calculates a Z statistic. The Z value is squared, yielding a Wald statistic with a chi-square distribution. Wald significant values less than 0.10 were Retained during model testing; values less than 0.05 were considered significant in the

Figure 3-1. Analysis Plan: Progression of Model Exploration

final analysis. The Exp (β) value was used to measure the corresponding influence between one unit change in the IV and odds of overweight and / or obesity occurrence. Direction of influence of Exp (β) was interrupted as values exceeding one increased odds of overweight or obesity occurrence and values less than one decreased odds (Menard, 2001; Peng, Lee, & Ingersoll, 2002; Peng, Manz, & Keck, 2001).

Standardized residuals for outliers (ZResid) and residuals were examined; whereas cases exceeding 2.58 (outliers at the 0.01 level) were removed. The H-L goodness-of-fit test statistic was examined to evaluate the overall fit of the model. A $p > 0.05$ indicated insignificance suggesting that the model was fit to the data well. *Nagelkerke's R* was examined to evaluate the strength of the relationship between the DV and IV. The *Nagelkerke's R* is the most reported R-squared estimate and is reflective of the relationship between the predictors and the prediction (Peng, et al., 2001 & 2002). The overall significance of each model was tested using the Model Chi square, as well as the Wald statistic.

To validate the accuracy of the final model a training sample was derived using the R^2 . Through examination of the classification tables and variable in the equations, output the training model was compared to the binary logistic regression forward LR model. Criteria to support the classification accuracy of the model was an accuracy rate of the holdout sample that was no more than 10% lower than the accuracy rate for the training sample.

FINDINGS

The sample consisted of 12, 194 WV students who were enrolled in 5th grade during the 2007/2008 or 2008/2009 academic year. Approximately 30% of all WV 5th graders are represented in the study sample. Forty-eight percent of the subjects had a BMI $\geq$ 85th percentile of which 3483 were considered obese (BMI $\geq$ 95th percentile). Similar to statewide racial demographics, the majority of subjects were white. Study demographic characteristics are presented in **Table 3-1**.

AIM ONE

Aim one: To determine which socioeconomics, physical, and personal environment attributes contributed to overweight (BMI equal to or greater to the 85th percentile for age, and gender) in WV 5th graders a univariate analysis followed by forward regression modeling was undertaken. To validate the accuracy of the final model for generalizability of the findings, a training sample was derived using the R^2 . Through examination of the classification tables and variables in the equations output, the training model was compared to the binary logistic regression model. An accuracy rate of the holdout sample no more than 10% lower than the accuracy rate for the training sample was utilized to support the classification accuracy of the model.

Table 3-1. Study Demographics (N=12,194)

Characteristics	Mean (SD)	N (%)
Age (yrs)	10.99 (.467)	
Female (%)		6557 (54)
Male (%)		5637 (46)
Race (%)		
Black		325 (.03)
White		11,011 (.90)
Asian		48 (.004)
Hispanic		94 (.008)
Bi-Racial		316 (.02)
Other		44 (.003)
Unidentified		3546 (.03)
BMI $\geq$ equal to 85 th percentile		5851 (48)
BMI $\geq$ equal to 95 th percentile		3483 (29)

SOCIOECONOMIC ENVIRONMENTAL PREDICTORS

Univariate analysis was undertaken to examine the relationship of each socio-economic factor (income, education, LSES, and violent crime) to BMI equal to or greater than the 85th percentile. Socioeconomic variables that were significantly associated ($p \leq 0.10$) with a BMI equal to or greater than the 85th percentile, were then entered for Forward (LR) Stepwise regression. Socioeconomic variables that were significant were then included in the final model of socioeconomic, physical, and personal environment.

Univariate Analysis of Socioeconomic Environmental Predictors

Significant variables of the univariate analysis of socioeconomic predictors of overweight (BMI $\geq$ 85th percentile) included education, household income, socioeconomic status, and violent crime ($p < 0.10$). The odds of a child being overweight increased significantly ($p < 0.05$) in association with socioeconomic variables of lower levels of education, median household income and socioeconomic status. For each unit increase in percentage of the population age 25 years or older with a high school education or greater, the odds of a child being overweight decreased by 56%. Each \$10,000 dollar increase in income decreased the odds of overweight by 11%. For each percentage increase in child classified as low socioeconomic status defined as receiving free or reduced lunch; the odds of being overweight increased by 135%. Crime increases the odds of being overweight by 14.6%. See **Table 3-2**. The significant variables ($p \leq 0.10$) of education, income, socioeconomic status, and crime were then entered for Forward (LR) Stepwise regression analysis.

Table 3-2. Univariate Analysis: Socioeconomic Environmental Predictors of BMI Equal to or Greater than the 85th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	95% C.I. for EXP(B)	
			Lower	Upper
Education	.000	.434	.298	.633
Household Income	.000	.884	.841	.930
Socioeconomic Status	.006	2.350	1.865	2.961
Violent Crime	.076	1.146	.986	1.333

Forward (LR) Stepwise Analysis of Socioeconomic Environmental Predictors

The socioeconomic variables of education and socioeconomic status ($p < 0.05$) were the most significant of the Forward Stepwise LR analysis and was included in the final model of socioeconomic, physical, and personal environment. Among the variables of significance, each unit increase in education decreased overweight by 48.3%; whereas, overweight increased by 102.8% for each unit increase in low socioeconomic classification. See **Table 3-3**.

PHYSICAL ENVIRONMENTAL PREDICTORS

Univariate logistic regression was done to examine the association between the physical factors of supermarket, convenience stores, fitness and recreational facilities, fruit and vegetable markets, and fast food establishments with overweight ($BMI \geq 85^{\text{th}}$ percentile). Physical variables that were significantly associated ($p \leq 0.10$) with a BMI greater than the 85th percentile, were then entered for Forward (LR) Stepwise regression. Physical variables that were significant were then included in the final model of socioeconomic, physical, and personal environment.

Univariate Analysis of Physical Environmental Predictors

The odds of having a BMI equal to or greater than the 85th percentile were associated with lower numbers of supermarket, convenience stores, fitness and recreational facilities, fruit and vegetable markets, and fast food. The number of grocery stores, convenience stores, fitness and recreational facilities, fruit and vegetable markets, and fast food restaurants were inversely associated with a child being overweight. For a one facility, increase in the number of grocery stores the odds of being overweight decreased by 1.9%. An increase of one fruit and vegetable market was associated with a decrease in overweight by 11.8%. An increase of one recreational facility decreased overweight by 2.9%.; whereas, an increase of 1 convenience store decreased the odds of being overweight by 3.4%. A 1 facility increase in fast food restaurants decreased the odds of overweight by 0.4%. See **Table 3-4**.

Table 3-3. Forward (LR) Stepwise Analysis: Adjusted Model of Socioeconomic Environmental Predictors of BMI Equal to or Greater than the 85th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	<u>95% C.I. for EXP(B)</u>	
			Lower	Upper
Education	.002	.517	.343	1.459
Socioeconomic Status	.000	2.028	1.574	2.613

Table 3-4. Univariate Analysis: Physical Environmental Predictors of BMI Equal to or Greater than the 85th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	<u>95% C.I. for EXP(B)</u>	
			Lower	Upper
Supermarkets and Other Grocery	.002	.981	.969	.993
Fruit and Vegetable Markets	.018	.882	.794	.979
Fitness and Recreational Centers	.032	.971	.946	.997
Convenience Store Establishments	.001	.966	.949	.986
Fast Food Establishments	.019	.996	.993	.999

Forward (LR) Stepwise Analysis of Physical Environmental Predictors

The physical variable of convenience stores was the most significant variable ($p < .005$) of the Forward Stepwise LR analysis (see **Table 3-5**). Therefore, number of convenience stores was included in the final model of socioeconomic, physical, and personal environment.

PERSONAL ENVIRONMENTAL PREDICTORS

Three personal environmental variables (family history of diabetes, family history of heart disease, and child aerobic fitness per fifth grade class) were examined as predictors of overweight ($\text{BMI} \geq 85^{\text{th}}$ percentile) in 5th grade children residing in WV. Univariate analysis was undertaken to examine the relationship of each personal environmental factor (family history of heart disease, family history of heart disease, and aerobic fitness) to BMI equal to or greater than the 85th percentile. Personal environmental variables that were significantly associated ($p \leq 0.10$) with a BMI equal to or greater than the 85th percentile, were then entered for Forward (LR) Stepwise regression. Socioeconomic variables that were significant were then included in the final model of socioeconomic, physical, and personal environment.

Univariate Analysis of Personal Environmental Predictors

A family history of diabetes or heart disease was associated with a greater likelihood of the child being overweight ($\text{BMI} \geq 85^{\text{th}}$ percentile). Higher fitness was associated with lower odds of having a BMI above the 85th percentile. For each increase of 1 child with a family history of heart disease, the odds of overweight increased by 21%; while an increase of 1 child with a family history of diabetes increased the odds by 36%. Aerobic fitness was inversely associated with overweight with a 38% decrease in odds for each unit increase in fitness. See **Table 3-6**. Univariate variables retained for the block analysis included family history of diabetes and heart disease, as well as aerobic fitness.

Table 3-5. Forward (LR) Stepwise Analysis: Adjusted Model of Physical Environmental Predictors of BMI Equal to or Greater than the 85th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	95% C.I. for EXP(B)	
			Lower	Upper
Convenient Store	.001	.966	.946	.986

Table 3-6. Univariate Analysis: Personal Environmental Predictors of BMI Equal to or Greater than the 85th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	95% C.I. for EXP(B)	
			Lower	Upper
Family History of Heart Disease	.000	1.213	1.121	1.314
Family History of Diabetes	.000	1.364	1.268	1.466
Aerobic Fitness: 5 th Grade Class	.000	.619	.491	.781

Forward (LR) Stepwise Analysis of Personal Environmental Predictors

According to the Forward (LR) Stepwise analysis, a family history of heart disease increased the odds of overweight by 12.9%, while a family history of diabetes increased the odds by 31.7%. Aerobic fitness was inversely associated with a BMI greater than the 85th percentile with a 39.6 % decrease in obesity for each unit increase in aerobic fitness. See **Table 3-7**. All three personal environmental factors were retained for the final model.

FINAL MODEL

A logistic regression analysis was conducted to predict overweight using socioeconomic status; family history of heart disease and diabetes; convenience stores; and aerobic fitness factors as predictors. A test of the full model against a constant only model was statistically significant, indicating that the predictors as a set reliably distinguished between overweight and non-overweight (chi square = 94.730, $p < 0.000$ with $df = 5$). The Hosmer-Lemeshow (H-L) inferential goodness-of-fit test yielded a χ^2 (8) of 6.384 and was insignificant ($p > 0.05$) with a p value of 0.604, suggesting that the model was fit to the data well.

Nagelkerke's R^2 of 0.015 indicated a weak relationship between prediction and the multivariate grouping. Prediction success overall was 54.5% (65.8% for non-overweight and 43.2 % for overweight) which exceeded the constant prediction success of 52. The Wald criterion demonstrated that socioeconomic status; family history of heart disease; family history of diabetes; child aerobic fitness; and the number of convenience stores made a significant contribution to predicting ($p < 0.05$) BMI equal to or equal to the 85th percentile.

A percentage increase in 5th grade children classified as low socioeconomic status increased the child's odds of overweight by 72%; whereas, an increase in family history of heart disease or diabetes increased a child's odds of overweight by 12 and 30% respectively. An increase in the percentage of children classified as aerobic fit decreased the odds of overweight by 26%, while each 1 facility increase in the number of convenience stores decreased the odds of overweight by 4%. See **Table 3-8**.

Table 3-7. Forward (LR) Stepwise Analysis: Adjusted Model of Personal Environmental Predictors of BMI Equal to or Greater than the 85th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	<u>95% C.I. for EXP(B)</u>	
			Lower	Upper
Heart Disease	.010	1.129	1.030	1.237
Diabetes	.000	1.317	1.208	1.433
Aerobic Fitness	.000	.604	.473	.773

Table 3-8. Final Model: Forward (LR) Stepwise Analysis of Environmental Predictors of BMI Equal to or Greater than the 85th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	<u>95% C.I. for EXP(B)</u>	
			Lower	Upper
Socioeconomic Status	.000	720	1.296	2.282
Family History of Heart Disease	.014	124	1.024	1.231
Family History of Diabetes	.000	399	1.202	1.426
Aerobic Fitness	.024	744	.575	.961
Convenience Stores	.002	963	.941	.986

The Forward LR Stepwise binary logistic regression of the training model resulted in the same number of steps as the full sample model: socioeconomic status; family history of heart disease; family history of diabetes; child aerobic fitness; and the number of convenience stores. The accuracy for the validation sample was larger (55.1) than the classification accuracy for the training sample (54.2), implying a better fit than obtained for the training sample. Thus, the validation analysis supported the generalizability of the final model findings to the population represented by the study sample.

AIM TWO

Aim two: To determine which socioeconomics, physical, and personal environment attributes contribute to obesity (BMI equal to or greater to the 95th percentile for age, and gender) in WV 5th graders univariate analysis, followed by forward regression modeling were undertaken. To validate the accuracy of the final model for generalizability of the findings, a training sample was derived using the R². Through examination of the classification tables and variables in the equations output, the training model was compared to the binary logistic regression model. An accuracy rate of the holdout sample no more than 10% lower than the accuracy rate for the training sample was utilized to support the classification accuracy of the model. Findings from the validation sample were used to evaluate the generalizability of the final model to the population represented by the study sample.

SOCIOECONOMIC ENVIRONMENTAL PREDICTORS

Four socioeconomic variables (income, education, LSES, and violent crime) were examined as predictors of obesity (BMI $\geq$ 95th percentile) in 5th grade children residing in WV. Univariate analysis was undertaken to examine the relationship of each socioeconomic variable to BMI equal to or greater than the 95th percentile. Socioeconomic variables that were significantly associated ($p \leq 0.10$) with a BMI greater than the 95th percentile, were then entered for Forward (LR) Stepwise regression. Significant variables were then included in the final model of socioeconomic, physical, and personal environment.

Univariate Analysis of Socioeconomic Environmental Predictors

The odds of a child being obese increased significantly ($p < 0.05$) in association with education, median household income, and socioeconomic status. For each unit increase in percentage of the population age 25 years or older with a high school diploma or greater, the odds of a child being obese decreased by 78.5%. Each \$10,000 dollar increase in income decreased the odds of obese by 17.8%. For each percentage increase in children classified as low socioeconomic status defined as being eligible to receive free or reduced lunch; the odds of being obese increased by 260%. Crime increased the odds

of being obese by 20 % for each unit increase in county crime rate per 100 persons. See **Table 3-9**.

Forward (LR) Stepwise Analysis of Socioeconomic Environmental Predictors

The socioeconomic variables of socioeconomic status, education, and crime ($p < 0.10$) were the most significant variables of the Forward Stepwise LR analysis and were included in the final model of socioeconomic, physical, and personal environment. For each unit increase in the percentage of 5th grade children classified as low socioeconomic status, obesity increased by 182%; whereas, each percentage unit increase in high school education among the population aged 25+ years, the odds of obesity decreased by 63.9%. For each unit increase in the rate of county crime per 100 persons, the odds of a child being obese increased by 22.7%. See **Table 3-10**. All three socioeconomic variables were included in the final Forward (LR) Stepwise Analysis.

PHYSICAL ENVIRONMENTAL PREDICTORS

Univariate logistic regression was done to examine the association between the physical factors of supermarket, convenience stores, fitness and recreational facilities, fruit and vegetable markets and fast food with BMI equal to or greater than the 95th percentile. Physical variables that were significantly associated ($p \leq 0.10$) with a BMI equal to or greater than the 95th percentile, were then entered for Forward (LR) Stepwise.

Univariate Analysis of Physical Environmental Predictors

The odds of having a BMI equal to or greater than the 95th percentile were inversely associated with the number of supermarkets, convenience stores, fitness and recreational facilities, fruit and vegetable markets, and fast food establishments. For a one facility increase in number of grocery stores, the odds of a child being obese decreased by 1.6%. An increase of one fruit and vegetable market was associated with a decreased odd of being overweight of 16.4%; while an increase of one recreation facility decreased the odd of being overweight by 3.8%. An increase in one convenience store decreased the odds of being overweight by 3% percent, while for a one facility increase in the number of fast food restaurants the odds of obesity decreased by 0.4%. See **Table 3-11**.

Forward (LR) Stepwise Analysis of Physical Environmental Predictors

The physical variable of fruit and vegetable markets was the most significant variable ($p < .10$) of the Forward (LR) Stepwise analysis and was included in the final Model. See **Table 3-12**.

Table 3-9. Univariate Analysis: Socioeconomic Environmental Predictors of BMI Equal to or Greater than the 95th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	95% C.I. for EXP(B)	
			Lower	Upper
Education	.000	.215	.144	.321
Household Income	.000	.822	.776	.871
Socioeconomic Status	.000	3.602	2.784	4.660
Violent Crime	.026	1.206	1.022	1.424

Table 3-10. Forward (LR) Stepwise Analysis: Adjusted Model of Socioeconomic Environmental Predictors of BMI Equal to or Greater than the 95th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	95% C.I. for EXP(B)	
			Lower	Upper
Socioeconomic Status	.010	2.821	2.125	3.744
Education	.000	.369	.236	.576
Violent Crime	.020	1.227	1.032	1.459

Table 3-11. Univariate Analysis: Physical Environmental Predictors of BMI Equal to or Greater than the 95th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	95% C.I. for EXP(B)	
			Lower	Upper
Supermarkets and Other Grocery	.019	.984	.970	.997
Fruit and Vegetable Markets	.003	.836	.743	.942
Fitness and Recreational Centers	.010	.962	.934	.991
Convenience Store Establishments	.012	.970	.948	.993
Fast Food Establishments	.016	.996	.992	.999

Table 3-12. Forward (LR) Stepwise Analysis: Adjusted Model of Physical Predictors of BMI Equal to or Greater than the 95th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	95% C.I. for EXP(B)	
			Lower	Upper
Fruit and Vegetable Markets	.003	.836	.743	.942

PERSONAL ENVIRONMENTAL PREDICTORS

Three personal environmental variables were examined as predictors of BMI greater than the 95th percentile in 5th grade children residing in WV. Univariate analysis was undertaken to examine the relationship of each personal environmental factor (family history of heart disease, family history of diabetes, and aerobic fitness) to BMI equal to or greater than the 95th percentile. Personal environmental variables that were significantly associated ($p \leq 0.10$) with a BMI equal to or greater than the 95th percentile, were then entered for Forward (LR) Stepwise regression. Personal environmental variables that were significant were then included in the final model of socioeconomic, physical, and personal environment.

Univariate Analysis of Personal Environmental Predictors

A family history of diabetes or heart disease was associated with a greater likelihood of the child being obese ($BMI \geq 95^{\text{th}}$ percentile). Higher aerobic fitness was associated with lower odds of having a BMI above the 95th percentile. For each increase of 1 child reporting a family history of diabetes, the odds for obesity increased by 41.1%, while an increases in 1 child reporting a family history of heart disease increased the odds of obesity by 24.6%. Aerobic fitness was inversely associated with obesity with a 50.3% decrease in odds for each unit increase in fitness. See **Table 3-13**. Univariate variables retained for the Forward (LR) analysis included family history of diabetes and heart disease, as well as aerobic fitness.

Forward (LR) Stepwise Analysis of Personal Environmental Predictors

The odds for obesity increased for each unit increase in family history of heart disease and diabetes (15.7%, and 35.4%). For each unit increase in the percentage of 5th grade, children classified as aerobic fit (“healthy zone”), the odds of obesity decreased by 50.6%. See **Table 3-14**. All three predictors were included in the final Forward Stepwise Analysis.

Table 3-13. Univariate Analysis: Personal Environment Predictors of BMI Greater than the 95th Percentile in 5th Grade Children

Predictor	p	Odds Ratio	95% C.I. for EXP (B)	
			Lower	Upper
Heart Disease	.000	1.246	1.143	1.358
Diabetes	.000	1.411	1.302	1.529
Aerobic Fitness	.000	.497	.385	.640

Table 3-14. Forward Stepwise Analysis: Adjusted Model of Personal Environmental Predictors of BMI Equal to or Greater than the 95th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	95% C.I. for EXP (B)	
			Lower	Upper
Heart Disease	.004	1.157	1.047	1.279
Diabetes	.000	1.354	1.232	1.489
Aerobic Fitness	.000	.494	.378	.645

FINAL MODEL

The Forward LR Stepwise binary logistic regression of the training sample failed to result in the same number of steps as the full sample model. The Forward LR Stepwise binary logistic model was rerun excluding the suspect variables of aerobic fitness and fresh fruit and vegetable markets. Education, socioeconomic status, crime, family history of heart disease and diabetes were included in the final analysis. The modified model resulted in the same variables selected in the forward logistic regression of the training sample: education, socioeconomic status, family history of heart disease, family history of diabetes, and crime. The accuracy for the validation sample was larger (72.1) than the classification accuracy for the training sample (71.5), implying a better fit than obtained for the training sample. Thus, the validation analysis supported the generalizability of the modified final model findings to the population represented by the study same.

A test of the modified model against a constant only model was statistically significant, indicating that the predictors as a set reliably distinguished between overweight and non-overweight (chi square = 175.363, $p < 0.000$ with $df = 5$). The Hosmer-Lemeshow (H-L) inferential goodness-of-fit test yielded a χ^2 (8) of 5.889 and was insignificant ($p > 0.05$) with a p value of 0.660, suggesting that the model was fit to the data well. Nagelkerke's R^2 of .023 indicated a weak relationship between prediction and the multivariate grouping. Prediction success overall was 71.6 % which was equivalent to the constant prediction success. The Wald criterion demonstrated that education, socioeconomic status; family history of heart disease; family history of diabetes, and crime made a significant contribution to predicting ($p < 0.05$) BMI greater or equal to the 95th percentile.

Findings indicated a 1% increase in the percentage of the population age 25 years or older with a high school degree, decreased the odds of obesity by 60%. A 1% increase in 5th grade children eligible for free or reduced lunch increased the child's odds of obesity by 179%; whereas, a family history of heart disease or diabetes increased a child's odds of obesity by 16 and 35% respectively. For each unit increase in county crime rate per 100 persons, the odd of obesity increased by 27%. See **Table 3-15**.

Table 3-15. Final Model: Forward (LR) Stepwise Analysis of Predictors of BMI Equal to or Greater than the 95th Percentile in WV 5th Grade Children

Predictor	p	Odds Ratio	95% C.I. for EXP (B)	
			Lower	Upper
Education	.000	.394	.247	.630
Socioeconomic Status	.000	2.796	2.073	3.771
Family History of Heart Disease	.002	1.159	1.058	1.269
Family History of Diabetes	.000	1.353	1.229	1.449
Crime	.009	1.273	1.232	1.463

DISCUSSION

Within the state of WV, overweight and obesity appear to disproportionately affect those with limited economic resources as defined by free or reduced lunch eligibility. Seventy-two percent of overweight/obese subjects attended schools in which 50% or more of the 5th grade population was eligible for free or reduced lunch; in other words, living in households with an annual income below 130% to 185% of the poverty line. Household income was less of a determinant of overweight or obesity with low socioeconomic status being the strongest predictor. Such findings could attest to the fact that median household income is an estimate of the general population (larger geographical scale); thus subject to greater fluctuations due to community dynamics. In comparison, low socioeconomic status as defined according to the percentage of 5th grade children (by school) eligible for free or reduced lunch more closely represents a child's household income; a stronger predictor of poverty. Therefore, free or reduced lunch eligibility may be a stronger social determinant of childhood overweight and obesity than other socioeconomic measures. Education was found to be a significant predictor of obesity, but not for overweight. This, theoretically, could be due to the difference in parental and child behavior. Parents with less than a high school education may lack the knowledge necessary to prevent the transition from overweight to obesity. Nayga (2000) contends that diet-disease knowledge decreases the probability of obesity. Findings are similar to work by Drewnowski & Specter (2004), indicating that population groups with the highest poverty rates and the least education have the highest obesity rates.

A substantial number of studies demonstrate the association between childhood obesity, low household income, and food insecurity (Casey et al., 2001; Crooks, 1999, 2000; Wang & Lobstein, 2006). As hypothesized, findings from this study were similar to those reported in the literature, in that an inverse relationship between overweight and obesity and attributes of the physical environment including number of supermarket and other grocery stores, fruit and vegetable markets, and the number of recreational facilities was observed. Among the physical attributes, fruit and vegetable markets played the most significant role in obesity development. Within the literature, food store availability has been linked with negative outcomes such as obesity (Beaulac et al., 2009; Blanchard & Lyson, 2006; Moore, 2003); with poorer communities having limited access to fruit and vegetable markets and natural food stores. Additionally, fruit and vegetable consumption has been associated with the presence of supermarkets, and supermarkets are more likely to be located in wealthier neighborhoods (Morland et al., 2002). However, the increase in odds was non-significant when examined within the context of other study variables (socioeconomics and personal environment). Findings indicate that as an independent predictor attributes of the physical environment may play a role in overweight and obesity development; but when combined with an environment consisting of low education attainment and/or low socioeconomics, their influence is less. Nevertheless, examining the impact that the physical environment has upon overweight/obesity development as independent predictors is reasonable due to the complexities of the socioeconomic environment.

According to researchers, the number of convenience stores (Galvez et al., 2009; Powell et al., 2007) within a community is associated with a higher BMI and lower levels

of fruit and vegetable consumption in children (Timperio et al., 2009). Contrary to our hypothesis, this study revealed an inverse association in that as the number of convenience stores increased the odds of overweight decreased. However, this relationship was not observed, among obese children. Such findings are perplexing and the dearth of the literature fails to aid in providing an explanation for the observed phenomenon.

Sallis and Glanz (2006) contend that access to safe places affects activity behavior, which may influence obesity development. Findings from this study indicate that the odds of obesity increase in association to crime; however, how crime influences behavior was not examined. Nevertheless, researchers contend that parents who perceive their community to be unsafe may be less likely to permit their children to play outside (Nestle & Jacobson, 2000). In fact, parental concern about crime is among the leading reasons why parents keep their children indoors (Gordon-Larsen et al., 2000; Molnar et al., 2004). Therefore, findings from this study warrant additional investigation regarding crime perception, safety, physical activity, and obesity.

West Virginia is the 4th most obese state in the nation with an adult obesity rate exceeding 30% (Trust for America's Health, 2011). As a result, many WV children are living in households in which obesity is a common occurrence. Parental obesity increases the risk of obesity development in children (Freeman et al., 2011; Pryor et al., 2011) with the odds of a child becoming obese as an adult increasing threefold if one parent is obese and tenfold if both parents are obese (Summerbell et al., 2005). Parental BMI was not available for the current study; however, family history of heart disease and diabetes were self-reported by parents of subjects. Studies support increased risk of obesity among offspring of parents with a history of heart disease (Youssef, Valdez, Elkasabany, Srinivasan, & Berenson, 2002) or diabetes (Kim, England, Sharma, & Njoroge, 2011; Malcolm, Lawson, Gaboury, Lough, & Keely, 2006).

Understanding the dynamics of the family in relation to obesity related behaviors; history of cardiovascular disease and/or diabetes, may provide clues to childhood obesity risk factors. As hypothesized, this study indicates that WV children are at greater odds of overweight/obesity due to family history of heart disease and/or diabetes. Such findings are similar to reports in the literature indicating that children with parents with early heart disease are at an increased risk for obesity (Slyper, 1998). Furthermore, children who are overweight, have a family member with type 2 diabetes, and are over 10 years of age are at increased risk for developing type 2 diabetes during childhood, adolescence, or adulthood. Type 2 diabetes observed in youth is perceived to be a “first consequence” of the obesity epidemic in children (Fagot-Campagna, 2000; Fagot-Campagna et al., 2000; National Diabetes Education Program, 2008).

Associations between BMI and aerobic fitness in children were noted within the literature with the majority of studies focusing on contribution of BMI and fitness to cardiovascular risk factors (DuBose, Eisenmann, & Donnelly, 2007; Eisenmann, Welk, Wickel, & Blair, 2007; Eisenmann, Welk, Ihmels, et al., 2007). Individuals classified with low fitness and high BMI demonstrate the greatest degree of cardiovascular disease (CVD) risk factors including: higher blood lipids and glucose (Eisenmann, Welk,

Ihmels, et al., 2007). Findings from this study demonstrate a significant association between overweight and aerobic fitness; whereas, a one-percentage increase in 5th grade children classified as aerobic fit decreased the odds of overweight by 24%. Interestingly, fitness was not retained in the final prediction model for obesity. The relationship may have been attenuated by the use of aggregate, school level fitness data rather than individual fitness data. Thus, fitness levels in this study may be more reflective of the community in which the students reside rather than a measure of personal attributes. Nevertheless, further exploration of the association between BMI and aerobic fitness is imperative; as previous research indicated that overweight and obese WV children had elevated total cholesterol and elevated systolic blood (Demerath et al., 2003).

SIGNIFICANCE AND RECOMMENDATIONS

This is the first study to explore the relationship of continual environmental attributes to childhood obesity in a large, state-wide sample of WV 5th graders. Results of the binary logistic regression analysis of environmental attributes identified that free or reduced lunch eligibility significantly increased a child's odds for overweight or obesity; whereas, household income as defined on a global scale using census tract data was found to be insignificant. Such findings indicate that low socioeconomic status defined according to free or reduced lunch eligibility may be a stronger social predictor for negative health outcomes such as obesity. According to the criteria, children must reside in a household in which incomes are at or below 130% for free lunch and between 130 and 185% for reduced lunch (West Virginia Department of Education [Data file], 2011). Thus, eligibility is not only associated with increased odds of overweight or obesity, but also a reflection of poverty status.

Education attainment is often used within the literature as an alternate measure for socioeconomic status. Less education is viewed by many researchers as a predictor of health disparities and seen as a contributing factor for poverty and unemployment (Metzler, 2007). Therefore, interventions aimed to enhance educational attainment may play a vital role in childhood obesity prevention.

Food inaccessibility; lack of access to grocery stores and fruit and vegetable markets, appeared to play a significant role in overweight and obesity occurrence independently. However, when examined within the context of other socioeconomic attributes; education and socioeconomic status, food inaccessibility failed to play a significant role in overweight and obesity development. Yet the spatial inaccessibility of food facilities warrants further investigation. Additionally, findings suggest that more attention should be placed upon urban planning and local food accessibility and availability.

CONCLUSION

The purpose of this study was to determine which socioeconomics, physical, and personal environmental attributes contributed to overweight (BMI equal to or greater than the 85th percentile for age, and gender) and obesity (BMI equal to or greater than the 95th percentile) in WV 5th graders. Socioeconomic status of the community and a positive family history of heart disease and diabetes, consistently increased the odds of being overweight (BMI $\geq$ 85th percentile) or obese (BMI $\geq$ 95th percentile). Findings from this study may be useful in determining allocation of physical and financial resources to improve intervention strategies at the community level, specifically targeting students who attend schools where a high percentage of students are eligible for free or reduced lunches. Additionally, cumulative findings of community level data may help develop obesity predictive models.

CHAPTER 4. SPATIAL ANALYSIS

INTRODUCTION

Researchers contend that an obesogenic environment is a major explanation for the increased incidence of overweight and obesity (Boehmer et al., 2006; Giskes et al., 2011; Michimi & Wimberly, 2010); however, what constitutes an environment that promotes obesity is not well understood. West Virginia, a rural Appalachian community, has the 10th highest youth obesity rate (18.9%) in the nation (Trust for America's Health, 2011), yet few studies have examined childhood overweight and obesity among Appalachian children from an obesogenic environmental perspective. Our preliminary analysis of 5th grade WV children who participated in the CARDIAC project identified socioeconomic, personal, and physical environmental attributes associated with childhood obesity and overweight. Additionally, the literature supports the linkages between environmental risk factors and obesity development (Papas et al., 2007). However, there is a paucity of information on the effect of cumulative environmental factors on overweight and obese children. Environmental risk factors associated with obesity are perceived to be distributed continuously over space, yet the obesity epidemic appears to disproportionately affect some communities greater than others (Cochran, 2008). Analysis of spatial distribution may help provide answers to fundamental childhood obesity questions related to environmental risks. Such methods may provide a means to identify geographical obesity patterns and offer the ability to filter information to identify obesity related events.

PROCEDURES AND METHODS

A merged database incorporated de-identified individual child data (BMI and family history of heart disease and diabetes) from the CARDIAC project and publically accessible socioeconomic, physical, and personal environmental data. Using the merged database relationships among the environmental attributes (socioeconomic, physical, and personal) and childhood obesity and overweight were previously analyzed by means of binary logistic regression methods. Individual variables were examined for significance and final models of childhood overweight and obesity were derived through multivariate analysis. The merged database was then utilized to assess the geographic distribution of attributes (socioeconomic, physical, and personal) in relation to overweight (BMI equal to or greater than the 85th percentile for age, and gender) and obesity (BMI equal to or greater than the 95th percentile for age, and gender). The study was approved by the Institutional Review Board of the University of Tennessee Health Science Center.

CARDIAC data (subject data: BMI and family history) layers and environment variable layers were integrated using ARCH GIS 9.3. CARDIAC data contained geographical indicators of county, school, and zip code per subject. Therefore, for spatial analysis purposes, each subject zip code served as the link between data sources and data layers; thus, each subject zip code could be linked to participant's school and each

participant's school linked to a county. Five-digit ZIP Code Tabulation Areas (ZCTAs) and Fipscode for the state and county (FIPSSSTCO) served as the spatial link for data mapping.

The study sample consisted of 12,194 fifth grade children (48% overweight; 29% obese) participating in the CARDIAC project during the academic school years of 2007/2008 and 2008/2009. The sample was drawn from 53 of the state's 55 counties. All 5th grade students enrolled in WV public schools were eligible to participate. Community demographic characteristics are presented in **Table 4-1**.

INSTRUMENTS

Socioeconomics

Household income and education data were obtained from the U.S. Census Bureau one-year estimates derived from the American Community Survey (ACS). U.S. Census Data were compiled by Geolytics and obtained at the zip code and county level for the years 2007 and 2008. Education data (the number of persons 25+ years completing high school) was examined at the zip code level for years 2007 and 2008. The percentage of 5th grade students in a class eligible for free or reduced lunch, based on the National School Lunch Program standards, was used as the measure low socioeconomic status (LSES) for the academic years 2007/2008 and 2008/2009 and was coded by school and county. County violent crime data (rate per 100) for rape, sexual assault, robbery, assault, burglary, motor vehicle theft, and theft were gathered from the WV State Police data website for the years of 2007 & 2008. See **Table 4-2**.

Physical Environment

The physical environment was defined according to attributes of convenience stores, supermarkets and other grocery, fast food restaurants and fitness/recreational facilities and supplied by Geolytics. The level of spatial analysis and data source are presented in **Table 4-3**. Physical data of interest was sorted and retrieved according to

Table 4-1. Community Demographic Characteristics

Characteristics	N (%)
Counties	53 (96)
Zip Codes	730 (88)
Schools (5 th grade class)	315 (80)
Students (5 th graders)	12,194 (30)

Table 4-2. Socioeconomic Environmental Variables, Data Level, and Source

Socioeconomic	Level	Source
Total Population 25+ Years with High School Diploma or Higher.	Zip Code and County	Geolytics: US Census (2007 & 2008 estimates)
Median Household Income	Zip Code and County	Geolytics: US Census (2007 & 2008 estimates)
Total 5 th Grade Student Population Classified as Low Socioeconomic Status (Free or Reduced Lunch Eligibility)	School and County	WV Board of Education (2007 & 2008 academic years)
Total Violent Crime	County	WV State Police (2007 & 2008)

Table 4-3. Physical Environmental Variables, Data Level, and Source

Physical	Spatial Level	Source
Fast Food Establishments (NAICS code 722211)	Zip Code and County	Geolytics: US Census (2008); WV County Business Patterns
Convenience Store Establishments (NAICS code 445120)	Zip Code and County	Geolytics: US Census (2008); WV County Business Patterns
Supermarket and Other Grocery Establishments (NAICS code 445110)	Zip Code and County	Geolytics: US Census (2008); WV County Business Patterns
Fruit and Vegetable Markets (NAICS code 445230)	Zip Code and County	Geolytics: US Census (2008); WV County Business Patterns
Fitness and Recreational Sports Centers (NAICS code 713940)	Zip Code and County	Geolytics: US Census (2008); WV County Business Patterns

the 6 digit North American Industry Classification System (NAICS) code: 722211 limited-service restaurants; 722110 full service restaurants; 445120, convenience stores; 445110, supermarkets; 445230, fruit and vegetable markets; and 713940, fitness recreation and sports (U.S. Census Bureau [Data file], 2007) . An aggregate total of NAICS data at the zip code and county level for each 6-digit level was derived. NAICS data at the zip code level for the years 2007 and 2008 were used for spatial mapping.

Personal Environment

Personal environment variables of interest included family history of diabetes, family history of heart disease, and child fitness. Parents self-reported the presence or absence of heart disease and disease as yes, no, or do not know. Family history data were derived from the CARDIAC Project and examined at the zip code, school, and/or county level. Child fitness was derived from WV FITNESSGRAM® data. Fifth grade students were categorized as being in the healthy fitness zone for aerobic fitness or as needing improvement based upon age-and gender – criterion standards. Fitness data was examined as the school level (percentage of total 5th grade class achieving healthy fitness zone) but mapped at the county level. See **Table 4-4**.

Body Mass Index

Anthropometric measurement of height and weight were obtained as part of the CARDIAC project. See **Equation 3-1**.

$$\text{BMI} = \text{weight in kg} / (\text{height in cm}^2 * 10,000) \quad \text{Eq. 3-1}$$

BMI percentiles were determined based on age and gender-specific growth chart recommendations by the CDC (Centers for Disease Control and Prevention [CDC], 2000). Fifth graders with a BMI $\geq$ 85th percentile were classified as overweight; while those with a BMI $\geq$ 95th percentile were considered obese (Barlow & Dietz, 1998; Centers for Disease Control and Prevention [CDC], 2000; Dietz & Bellizi, 1999).

Table 4-4. Personal Environmental Variables, Data Level, and Source

Personal Environment	Spatial Level	Source
Family History of Diabetes	Zip Code	CARDIAC Project
Family History of Heart Disease	Zip Code	CARDIAC Project
Aerobic Fitness	School & County	WV Board of Education: Fitnessgram Data

DATA MANAGEMENT

Data for spatial analysis were stored on Microsoft Excel spreadsheets. ArcGIS 9.3; a geodatabase, was utilized to compile the geographic data.

SPATIAL MAPPING PLAN

Individual subject data (BMI, family history, zip code of residency, school of attendance, and county for which the school resided) was joined to aggregated data (socioeconomic status, crime, supermarkets and other grocery establishments, convenience stores, fast food facilities, fruit/vegetable markets, sports/recreational centers, and aerobic fitness) using a geographical indicator: zip code, school, and/or county. Zip code and county polygons were downloaded from Environmental Systems Research Institute (ESRI) and utilized as base maps for which data were joined. See **Figure 4-1**.

Polygons were formulated into choropleth maps (colored coded theme maps) and point density for variables of interest. Contrasting map colors were utilized to differentiate variations in values of independent variables (socioeconomic, physical, and personal) and to visually represent the data. BMI percentile values equal to or greater than the 85th and 95th percentiles were mapped utilizing dot density. Each dot on the map represented a single case/occurrence or a defined number of cases/occurrences per zip code area or county and fixed placement was utilized.

To discern the percentage of total 5th grade enrollment represented in the study, subject participation was mapped into choropleth and the distribution inspected. The study sample and BMI percentile values were then mapped using dot density to allow for visual inspection of the statewide distribution of the sample at the zip code level. Choropleth maps layered with dot density were utilized to assess the geographic distribution of attributes (socioeconomic, physical, and personal) in relation to the distribution of overweight and obesity.

FINDINGS

Aim Three

To assess the geographic distribution of attributes (socioeconomic, physical, and personal) in relation to overweight (BMI $\geq$ 85th percentile) and obesity (BMI $\geq$ 95th percentile) among WV 5th graders the distribution of the entire study sample was mapped and examined in comparison to the distribution of overweight and obese children. Choropleth maps were overlayed with point density of BMI percentile values equal to or greater than the 85th and 95th to allow for examination of the association between socioeconomic, physical, and personal attributes and BMI percentile events.

Figure 4-1. Spatial Analysis Plan

Study sample. To discern the total percentage of 5th graders represented in the study (in comparison to total county enrollment) choropleth maps were utilized. Of the 53 counties, examined nine counties had a sample population that represented 51% or more of the total 5th grade enrollment for that county; in total thirty-seven counties had a 5th grade participation rate greater than 31%. Only five counties had a participation rate below 30% with the lowest being at 13%. See **Figure A-1**. To visually inspect the spatial distribution of the study sample at the zip code level, subjects were mapped using point density; whereas, 1 dot = 1 BMI percentile event. Findings indicate that the study sample was evenly distributed across the state of WV. See **Figure 4-2**.

Distribution of overweight and obese 5th grade children. A visual inspection of the distribution of 5th grade children was done; whereas, 1 dot = 1 BMI event equal to or greater than the 85th percentile and 1 dot = 1 BMI event equal to or greater than the 95th percentile revealed clusters of overweight (**Figure 4-3**) and obesity (**Figure 4-4**) in regions throughout the state. Spatial patterns indicated that obesity tended to be lowest in the mid and east central parts of WV relative to other regions. Findings support the hypothesis that the geographic distribution of children with a BMI equal to or greater than the 85th and 95th percentile is disproportionately dispersed across the state.

Socioeconomic Environment

To visually represent the data, contrasting map colors (choropleth maps) were utilized to differentiate variations in values of socioeconomic attributes (education, income, low socioeconomic status, and crime). Choropleth maps were overlayed with point density of BMI percentile values equal to or greater than the 85th and 95th to allow for examination of the association between socioeconomic attributes and BMI percentile events. Each dot on the map represented a single case/occurrence or a defined number of cases/occurrences per zip code area or county.

Education. The percentage of the population age 25 years or greater with a high school diploma or more varied across the state with zip code regions ranging from 35% to 93%. The lowest percentages (less than 60% of the population) of high school graduates were distributed mainly in the south/south western zip code regions of the state; as well as east central. Findings support the hypothesis that levels of education are disproportionately distributed across the state of WV.

A visual inspection of the distribution of overweight and obese 5th grade children was done; whereas, 1 dot = 1 BMI event equal to or greater than the 85th or 95th percentile at the zip code level, revealed a greater intensity of occurrence in association to the distribution of low levels of education most notably in the southern and south western regions of the state. The majority of overweight (91%) and obese (90%) children lived in communities in which less than 75% of the population had a high school diploma. See **Table 4-5**.

Figure 4-2. Spatial Distribution of Study Sample at the Zip Code Level

Note: 1 Dot = 1 Child Sample Participant.

Figure 4-3. Distribution of Overweight at the Zip Code Level

Note: 1 Dot = 1 Child Sample Participant.

Figure 4-4. Distribution of Obese 5th Graders at the Zip Code Level

Note: 1 Dot = 1 Child Sample Participant.

Table 4-5. Percentage of Overweight and Obese 5th Graders Living in Communities Where Less than 75% of the Population Aged 25 Years or Older Had a High School Diploma or Greater

BMI Percentile	Less than 75% of Community Members by Zip Code Had a High School Degree N (%)	Greater than 75% of Community Members by Zip Code Had a High School Degree N (%)
BMI Equal to or Greater than the 85 th Percentile (N = 5851)	5327(91)	524(9)
BMI Equal to or Greater than the 95 th Percentile (N = 3483)	3142(90)	341(10)

Spatially, southern zip code regions had a higher percentage of overweight and obese 5th graders relative to the percentage of the population 25 years or older without a high school diploma. However, such associations were not observed amongst other regions of the state exhibiting clusters of overweight or obese 5th graders. Therefore, findings failed to support the hypothesis that overweight and obesity is spatially patterned in association to the distribution of socioeconomic environmental attribute of education. See **Figures A-2 and A-3**.

Low socioeconomic status. The percentage of 5th grade children classified as low socioeconomic status ranged from 17 to 91% in the schools. Among overweight and obese children, 66-69% attended schools in which 50% or more of the 5th grade population was defined as being low socioeconomic status; in other words, living in households with an annual income below 130% to 185% of the poverty line. See **Table 4-6**.

A visual inspection of the distribution of overweight and obese 5th grade children was done; whereas, 1 dot = 10 BMI events equal to or greater than the 85th or 95th percentile at the zip code level, revealed a greater intensity of occurrence in association to the distribution of low socioeconomic status most notably in the southern, west central, and eastern panhandle regions of the state. Zip code regions exhibiting the lowest socioeconomic status followed a similar pattern of distribution to that of BMI equal to or greater than the 85th and 95th percentiles; therefore, supporting the hypothesis that overweight and obesity is spatially patterned in association to the distribution of low socioeconomic status. See **Figures 4-5 and A-4**.

Income. Within the study sample, the distribution of income as compiled by Geolytics at the zip code level range from \$233 to \$74,000; in which, 83% of overweight and 86% of obese children lived in zip code regions with a median household income below the state median income of \$37,494 in 2007 and \$37,989 in 2008 (U.S. Census Bureau [Data file], 2010). See **Table 4-7**.

Table 4-6. Percentage of Overweight and Obese 5th Graders Attending Schools in Which 50% or More of the 5th Grade Population Was Defined as Low Socioeconomic Status

BMI Percentile	50 % or More 5th Grade School Population Defined as LSES (%)	Less than 50% 5th Grade School Population Defined as LSES (%)
BMI Equal to or Greater than the 85 th Percentile (N = 5851)	3865(66)	1987(34)
BMI Equal to or Greater than the 95 th Percentile (N = 3483)	2393(69)	1090(31)

Figure 4-5. Distribution of the Percentage of 5th Grade Children Classified as Low Socioeconomic Status According to Free or Reduced Lunch Eligibility

Note: 1 Dot = 1 Child Sample Participant.

Table 4-7. Percentage of Overweight and Obese 5th Graders Living in Zip Code Regions with Incomes below the State Median Household Income

BMI Percentile	Income Less than \$37,000 for Years 2007 & 2008 at the Zip Code Level	Income Greater than \$37,000 for Years 2007 & 2008 at the Zip Code Level
BMI Equal to or Greater than the 85 th Percentile (N = 5851)	4845(83)	1006(17)
BMI Equal to or Greater than the 95 th Percentile (N = 3483)	3012 (86)	471(14)

Pockets of low income; however, were observed throughout all regions of the state failing to support the proposed hypothesis that income was disproportionately distributed across the state of WV. See **Figures A-5 and A-6**.

Crime. Visual inspection of the distribution of violent crime revealed a greater intensity of violent crime across regions of the state. Fifteen counties exhibited county violent crime rates greater than 6 per 100 persons (**see Table 4-8**). The central region of the state demonstrated the lowest occurrence. Findings support the proposed hypothesis that the socioeconomic attribute violent crime is disproportionately distributed across the state of WV.

Violent crime rates at the county level demonstrated a similar pattern of distribution to that of overweight and obesity. Regions with the highest percentages of overweight or obese 5th graders were clustered in regions with higher rates of violent crime. Obesity demonstrated the strongest spatial relationship to violent crime. Findings supported the hypothesis that overweight and obesity is spatially patterned in association to the distribution of socioeconomic environmental attribute crime. See **Figure 4-6**.

Physical Environment

The physical environment was examined according to the distribution of: supermarkets, convenience stores; fruit and vegetable markets; and fitness recreation and sport establishments. To visually represent the data, contrasting map colors (choropleth maps) were utilized to differentiate variations in values of the physical environment (supermarkets and other grocery stores, convenience store, fruit and vegetable markets, recreational facilities and fast food). Choropleth maps were overlaid with point density of BMI percentile values equal to or greater than the 85th and 95th to allow for examination of the association between socioeconomic attributes and BMI percentile events. Each dot on the map represented a single case/occurrence or a defined number of cases/occurrences per zip code area or county.

Table 4-8. Percentage of Overweight and Obese 5th Graders Living in Counties with a Crime Rate Greater than 6 per 100 Persons

BMI Percentile	County Crime Rate > than 6 per 100 Persons (%)	County Crime Rate < than 6 per 100 Persons (%)
BMI $\geq$ 85 th Percentile (N = 5851)	2797(48)	3054(52)
BMI $\geq$ 95 th Percentile (N = 3483)	1641(47)	1842(53)

Figure 4-6. Distribution of Violent Crime at the County Level and Obese 5th Grade Children

Note: 1 Dot = 1 Child Sample Participant.

Supermarkets and other grocery. A visual inspection of the spatial distribution of supermarkets identified pockets of zip code regions with a higher density of no supermarkets or 1-4 supermarkets per zip code. Few zip code regions had greater than five supermarkets with only one zip code having greater than thirteen. Among overweight/obese children, 33% (overweight) and 32% (obese) failed to have a supermarket and other grocery store within their zip code region. See **Table 4-9**.

A visual inspection of the distribution of overweight and obese 5th grade children whereas; 1 dot = 10 BMI events equal to or greater than the 85th or 95th percentile at the zip code level, revealed a greater intensity of occurrence in association to the distribution of supermarkets in the south western regions of the state. Communities with the least number of supermarkets followed a similar pattern of distribution to that of BMI equal to or greater than the 85th and 95th percentiles excluding in the northern region of the state. See **Figures A-7 and A-8**.

Convenience stores. A visual inspection of the spatial distribution of convenience stores identified pockets of zip code regions with no convenience stores per zip code. Few zip code regions had greater than three convenience stores. Findings supported the hypothesis that the physical environment attribute of convenience stores is disproportionately distributed across the state of WV.

A visual inspection of the distribution of overweight and obese 5th grade children whereas; 1 dot = 10 BMI events equal to or greater than the 85th or 95th percentile at the zip code level, revealed a greater intensity of occurrence in association to the distribution of convenience stores. Sixty-three percent of overweight and sixty-two percent of obese children lived in zip code regions without convenience stores (see **Table 4-10**). Statewide overweight and obese 5th graders were less likely to have a grocery store within their zip code

Communities with the least number of convenience stores followed a similar pattern of distribution to that of BMI equal to or greater than the 85th and 95th percentiles; supporting the hypothesis that overweight and obesity is spatially patterned in association to the distribution of physical environmental attributes. See **Figures A-10 and A-11**.

Table 4-9. Percentage of Overweight and Obese 5th Graders Living in Zip Code Regions with No Grocery Stores

BMI Percentile	No Supermarkets or Other Grocery (%)	No Supermarkets or Other Grocery (%)
BMI $\geq$ 85 th Percentile (N = 5851)	1902(33)	3949(67)
BMI $\geq$ 95 th Percentile (N = 3483)	1113(32)	2370(68)

Table 4-10. Percentage of Overweight and Obese 5th Graders Living in Zip Code Regions with No Convenience Stores

BMI Percentile	No Convenience Stores (%)	Greater than 1 Convenience Store (%)
BMI $\geq$ 85 th Percentile (N = 5851)	3695(63)	2156(37)
BMI $\geq$ 95 th Percentile (N = 3483)	2168(62)	1315(38)

Fast food restaurants. Visual inspection of the distribution of fast food restaurants revealed statewide distribution with clusters of zip code regions containing 14-54 facilities per zip code region. A visual inspection of the distribution of overweight and obese 5th grade children whereas; 1 dot = 10 BMI events equal to or greater than the 85th or 95th percentile at the zip code level, revealed a greater intensity of occurrence in association to the distribution of fast food facilities. Among the study sample, 66% of overweight/obese children lived in zip code regions with at least one fast food facility. See **Table 4-11**.

Zip code regions with the greatest number of fast food facilities followed a similar pattern of distribution to that of BMI equal to or greater than the 85th and 95th percentiles; supporting the hypothesis that overweight and obesity is spatially patterned in association to the distribution of physical environmental attributes. See **Figures 4-7** and **A-12**.

Fruit and vegetable markets. Visual inspection revealed a sparse distribution of fruit and vegetable markets statewide with the majority of communities at the zip code level lacking access to fruit and vegetable markets. A visual inspection of the distribution of overweight and obese 5th grade children was done; whereas, 1 dot = 10 BMI events equal to or greater than the 85th or 95th percentile at the zip code level, failed to support the hypothesis that overweight and obesity were spatially patterned in association to zip code regions with the least number of fruit and vegetable markets. The sparse distribution of fruit and vegetable markets was observed in areas with a low prevalence of overweight/non-obese children, as well as in areas with a high prevalence of overweight an obese youth. Findings failed to support the propsed hypothesis. See **Figures A-11** and **A-12**.

Fitness and recreational facilities. Visual inspection revealed a sparse distribution of fitness and recreational facilities statewide with the majority of communities at the zip code level lacking a facility. A visual inspection of the distribution of overweight and obese 5th grade children, whereas; 1 dot = 10 BMI events equal to or greater than the 85th or 95th percentile at the zip code level, failed to support the hypothesis that overweight and obesity were spatially patterned in association to zip code regions with the least fitness and recreational facilities. The sparse distribution of

Table 4-11. Percentage of Overweight and Obese 5th Graders Living in Zip Code Regions with One or More Fast Food Facilities

BMI Percentile	Greater than 1 Fast Food Facility (%)	No Fast Food Facilities (%)
BMI $\geq$ 85 th Percentile (N = 5851)	3858(66)	1993(34)
BMI $\geq$ 95 th Percentile (N = 3483)	2300(66)	1183(34)

Figure 4-7. Distribution of Fast Food Facilities at the Zip Code Level and Obesity

Note: 1 Dot = 1 Child Sample Participant.

recreational facilities was observed among communities with a low prevalence of overweight and obese children, as well as areas where there were a high prevalence of obese and overweight youth. Findings failed to support the proposed hypothesis that overweight and obesity is spatially associated with the distribution or lack thereof of recreational facilities. See **Figures A-13 and A-14**.

Personal Environment

To visually represent the data contrasting map colors (choropleth maps) were utilized to differentiate variations in values of personal attributes (family history of heart disease, family history of diabetes, and child fitness). Choropleth maps were overlaid with point density of BMI percentile values equal to or greater than the 85th and 95th to allow for examination of the association between socioeconomic attributes and BMI percentile events. Each dot on the map represented a single case/occurrence or a defined number of cases/occurrences per zip code area or county.

Family history. A visual inspection of the distribution of family history of heart disease and/or diabetes indicates a greater intensity of occurrence in some regions of the state. Among overweight children, 32% reported a family history of heart disease; whereas, 62% reported a family history of diabetes. Thirty-two percent of obese children reported a family history of heart disease and 54% reported a family history of diabetes. See **Tables 4-12 and 4-13**. The pattern of distribution is similar to those observed for overweight and obesity. See **Figures 4-8 and 4-9 and Figures A-15 and A-16**.

Aerobic fitness. Forty percent of overweight and 42% of obese children attended schools in which less than 70% of the 5th grade population failed to be aerobic fit. Several schools failed to report data for both years with some 5th grade classes lacking data. See **Table 4-14**. As a result, conclusions regarding the distribution of aerobic fitness in association to overweight or obesity distribution could not be made. See **Figures A-17 and A-18**. Findings failed to support the hypothesis that overweight and obesity is spatially patterned in association to the distribution of the physical environmental attribute of aerobic fitness.

SPATIAL CHALLENGES AND LIMITATIONS

Geocoding data at the zip code level proved to be problematic initially. Several children shared the same zip code but attended different schools. Therefore, to adequately describe the individual child's low socioeconomic environment and the percentage of 5th graders classified as aerobic fit - "healthy zone" each individual child zip code had to be matched to the child's school of attendance which in turn was matched to the county the school belonged to. This allowed different levels of data to be matched to each individual child zip code for the purpose of describing the individual child's environment.

Table 4-12. Percentage of Overweight and Obese 5th Graders Reporting a Family History of Heart Disease

BMI Percentile	Family History of Heart Disease (%)	No Family History of Heart Disease (%)
BMI $\geq$ 85 th Percentile (N = 5851)	1842(31)	4009(69)
BMI $\geq$ 95 th Percentile (N = 3483)	1134(32)	2349(68)

Table 4-13. Percentage of Overweight and Obese 5th Graders Reporting a Family History of Diabetes

BMI Percentile	Family History of Diabetes (%)	No Family History of Diabetes (%)
BMI $\geq$ 85 th Percentile (N = 5851)	062(52)	789(48)
BMI $\geq$ 95 th Percentile (N = 3483)	896(54)	587(46)

Figure 4-8. Distribution of Child's Family History of Heart Disease at the Child's Zip Code Level

Note: 1 Dot = 1 Child Sample Participant.

Figure 4-9. Distribution of Child's Family History of Diabetes at the Child's Zip Code Level

Note: 1 Dot = 1 Child Sample Participant.

Table 4-14. Percentage of Overweight and Obese 5th Graders Attending Schools Where 70% or More of 5th Graders Were in the Healthy Zone for Aerobic Fitness

BMI Percentile	More than 70% of 5th Graders Aerobic Fitness (%)	Less than 70% of 5th Graders Aerobic Fitness (%)
BMI $\geq$ 85 th Percentile (N = 5851)	2370(41)	3481(59)
BMI $\geq$ 95 th Percentile (N = 3483)	1476(42)	2007(58)

The enumeration units of variables of interest within zip code regions had a great deal of variation, most notably amongst rural and urban regions, resulting in cells with small sample sizes. Therefore, the dot density units were adjusted / set to allow visualization of patterns in both urban and rural regions and zip code regions with small sample sizes. A disadvantage was that the more populated regions formed a solid fill of indiscernible dots.

Dots used for density were randomly placed within zip code regions due to the nature of the GIS software utilized. Therefore, dot locations displayed within each zip code unit were approximate in regards to location. Additionally, land cover data was not utilized to discern location of geographical barriers influencing habitability of a region.

The purpose of this exploratory study was to visually inspect the spatial arrangement of overweight, obesity, and associated risk factors throughout the state of WV; therefore, the significance of the distribution and identified “clusters” were not examined statistically using GIS software. Findings can only attest to the relative magnitude of the problem.

Proximity between subject and physical environmental attributes (supermarket and other grocery, convenience stores, fruit and vegetable markets, recreation facilities, and fast food establishments) was not examined. Access was discerned according to the presence or absence of attributes within zip code regions and adjacent zip code communities.

The use of NACIS classification codes according to the U.S. Economic Census Bureau is not without controversy. How variables of the physical environment; supermarket and other grocery stores, convenience stores, fast food restaurants, fruit and vegetable markets, and fitness and recreational facilities, were defined may result in over or under estimations. Data gathered by Geolytics was based on census estimates for the years 2007 and 2008.

DISCUSSION

Attributes associated with overweight/obesity development appear to be disproportionality distributed across the state but spatially grouped. Findings indicate that many WV children are at an increased risk for overweight or obesity development due to the cumulative impact of attributes of the socioeconomic, physical, and personal environment. However, the cumulative impact of risk appears to disproportionately impact some regions of the state greater than others. Zip code regions impacted by the greatest number of risk factors were disproportionately distributed in the southern and southwestern regions of the state.

Spatially, overweight and obese children were more likely to have a family history of heart disease or diabetes and attend schools with a high percentage of low socioeconomic status classmates. Multivariate regression also indicated that family history and low socioeconomic status had a significant impact on the prevalence of overweight and obesity. Whereas, the number of 5th grade children reporting a family history of heart disease or diabetes was positively and significantly correlated with overweight or obesity, as was the percentage of 5th grade children eligible for free or reduced lunch.

Education was spatially associated with overweight and obesity in the southern zip code communities of the state but not the northern. Spatially southern zip code regions had a higher percentage of obese fifth graders and relatively lower levels of education. The northern region of the state also demonstrated a high concentration of obese children yet demonstrated amongst the highest percentages of individuals over the age of 25 with a high school diploma or greater. Multivariate binary regression indicated that educational level had a significant impact on the prevalence of obesity; whereas, the number of residents with at least a high school diploma was negatively and significantly correlated with obesity. However, such a relationship was not observed in children classified as overweight. Findings indicate that although statistically significant in association to obesity education may be spatially auto correlated with other environmental risk factors.

Crime was disproportionately distributed but spatially associated with overweight and obesity. Multivariate binary regression also indicated that county crime rate had a significant impact on obesity. Findings indicated that crime was positively and significantly associated with obesity. A visual inspection of crime and low socioeconomic status indicated similar distribution patterns signifying that crime may be an environmental element that when combined with poverty increases a child's risk for obesity. According to Wilson & Kelling (1982) poverty within one given community may influence personal crime rates of nearby locations. Therefore, understanding the spatial distribution of crime in relation to poverty and the influence on obesity development is defensible.

Geographically, the distribution of fresh fruit and vegetable markets was sparse; indicating WV residents lack access. Such findings support previous research indicating

that only 18.2% of WV students and 18.6% of WV adults regularly consume the recommended daily allowance of fruits and vegetables; ranking WV the 16th state for the lowest fruit and vegetable consumption in school children and 4th for adults (Trust for America's Health, 2011). Fruit and vegetable consumption is associated with the presence of supermarkets and supermarkets are more likely to be located in wealthier neighborhoods (Morland et al., 2002). Families who have easy access to affordable fruits and vegetables report higher levels of fruit and vegetable consumption (Sallis & Glanz, 2006). Findings from this study indicate a lack of access to grocery facilities and an association between lack of access and income. Such findings are similar to previous reports by Halverson et al. (2004) and Amarasinghe and D'Souza (2010) indicating many WV communities do not have enough supermarket and other grocery stores. Univariate analysis of the number of supermarket /other grocery stores and fruit / vegetable markets found a significantly negative association. Thus, as the number of facilities increased, overweight and obesity decreased.

Gordon-Larsen et al. (2006) found that availability of physical activity facilities was associated with overweight patterns and that the inequality in availability contributed to decreased activity and an increase in overweight. Tucker et al. (2009) found that recreational opportunities and physical activity were positively associated; thus as recreational opportunities increased, physical activity increased. However, findings from this study indicate that the lack of access is a problem throughout the state; thus, inferences to the impact on overweight/obesity development are difficult to assess.

Regardless of the distribution of overweight and obese children, findings indicate the spatial distribution of supermarket / other grocery stores, fruit / vegetable markets, and recreational facilities appear to be unequally dispersed across the state. Spatial findings suggest that WV communities have pockets of “food deserts”. According to Blanchard and Lyson (2006), food deserts are the result of physical and economic barriers to healthy food.

Findings from this study support earlier works documenting the geographic correlation between the number of and proximity to fast-food and the risk of obesity in children (Currie et al., 2010; Kipke et al., 2007; Kwate et al., 2009; Li et al., 2009; Powell et al., 2007). Within the state, the ratio of fast food to supermarket and other grocery was 3.5 to 1. Across the state, there were 5.45 fast food facilities per 100 study participants vs. 1.5 supermarket and other grocery stores. Such findings are reflective of research by Schwartz & Brownell (2005) which identified that over the last 35 years, the number of fast food establishments has doubled, whereas the number of supermarkets has declined by 15%. Evidence from this investigation indicates that communities have greater access to fast food in comparison to supermarket and other grocery establishments; as well as fruit and vegetable markets. However, proximity to fast food and other physical attributes was not examined.

Results of spatial mapping indicate that WV youth are disproportionately at greater risk for obesity and obesity related consequences because of an obesogenic environment. As noted in the literature, obesity when combined with poor economic

conditions has a greater impact upon quality life years. For example, obese adults (18-years or older) can expect to live 47 quality-adjusted life-years; whereas obese adults living under the poverty line can expect to live 43 quality-adjusted life-years (Muennig, Lubetkin, Haomial, & Franks, 2006).

SIGNIFICANCE AND RECOMMENDATIONS

Food inaccessibility; including lack of access to supermarket and other grocery stores and fruit and vegetable markets, appears to play a significant role in overweight and obesity occurrence. The spatial inaccessibility of food facilities warrants further investigation. Additionally, findings suggest that more attention should be placed upon urban planning and local food accessibility and availability.

Spatially clustering of overweight and obesity was observed, as well as clustering of identified risk factors. However, the significance of the clustering was not examined statistically. Findings from this study support the need for additional research to examine the significance of spatial clusters and associated risk factors. Additionally, the health consequences of childhood obesity would be of interest in light of the strong association between family history of heart disease and diabetes.

The distribution of overweight and obese children correlates with previous research that indicates that life expectancy in counties such as McDowell has fallen to third world levels. Children within these communities are expected to die at a younger age than their parents (West Virginians for Affordable Health Care [WVAHC], 2008). Findings from this study indicate that overweight and obesity may play a role in the decline in life expectancy in these WV communities.

Findings from this study may be useful in determining allocation of physical and financial resources to improve intervention strategies at the community level. Analysis of risk factors at smaller geographical increments beyond county mapping may prove useful in targeting communities at greatest risk. Additionally, cumulative findings of community level data may help develop obesity predictive models.

Findings from this study support the hypothesis that overweight and obesity are the consequence of the cumulative impact of environmental factors that are disproportionately distributed across the state. Findings warrant further examination of the spatial significance of overweight and obese children in the state of WV.

CONCLUSION

Findings from this study demonstrate the impact cumulative environmental risks have upon obesity development. Although the phenomenon of an obesogenic environment is not well understood within the literature, evidence from this study supports the theory that obesity risk factors are spatially but disproportionately dispersed in association with overweight and obesity. The binary logistic regression analysis aided

in identifying environmental attributes associated with increasing the odds of overweight and obesity; whereas, spatial mapping techniques allowed for a visual inspection of the distribution of overweight/obesity and associated risk factors.

Results of the binary logistic regression analysis of environmental attributes identified that free or reduced lunch eligibility significantly increased a child's odds for overweight or obesity; whereas, household income as defined on a global scale using census tract data was found to be insignificant. Such findings indicate that low socioeconomic status defined according to free or reduced lunch eligibility may be a stronger social predictor for negative health outcomes such as obesity. According to the criteria, children must reside in a household in which incomes are at or below 130% for free lunch and between 130 and 185% for reduced lunch (WV Board of Education, 2010). Thus, the criterion is a reflection of poverty status. A positive family history or heart disease of diabetes, lack of aerobic fitness, and lack of access to convenience stores was also associated with an increased risk for overweight; whereas, low education, high prevalence of crime, and positive family history of heart disease or diabetes placed a child at greater risk for being obese.

Results of spatial mapping indicated that WV youth are disproportionately at greater risk for obesity and obesity related consequences because of an obesogenic environment. As noted in the literature, obesity when combined with poor economic conditions has a greater impact upon quality life years. For example, obese adults (18-y-olds) can expect to live 47 quality-adjusted life-years; whereas, obese adults living under the poverty line can expect to live 43 quality-adjusted life-years (Muennig et al., 2006). The distribution of overweight and obese children correlates with previous research that indicates that life expectancy in counties such as McDowell has fallen to third world levels. Children within these communities are expected to die at a younger age than their parents (West Virginians for Affordable Health Care [WVAHC], 2008). Findings from this study indicate that overweight and obesity may play a role in the decline in life expectancy in these WV communities.

An examination of the spatial distribution of environmental attributes in association with overweight and obesity events support the view that the more obesogenic the environment, the stronger the influence towards obesity (Kirk et al., 2010; Papas et al., 2007). Communities with combined risks demonstrated more dense populations of overweight or obese children. Findings warrant further investigation to identify if there is any statistical significant association between overweight and obesity prevalence clusters at the zip code level and to define the significant association to environmental attributes; as well as to further delineate the observed geographically differences between the northern and southern regions of the state.

In conclusion, over the last 5 years WV has consistently ranked among the top 10 most obese states in the nation for both adults and children and residents experience among the highest rates of chronic conditions associated with obesity including diabetes and hypertension (Trust for America's Health, 2011). Obese children are more likely to become obese adults (Biro & Wien, 2010; Serdula et al., 1993; Trust for America's Health, 2011) and are at increased risk of morbidity, mortality, (Flegal et al., 2010;

Flegal et al., 2005; Fontaine et al., 2003; Franks et al., 2010) disability, and premature death due to cardiovascular disease (Freedman et al., 1999; Freedman et al., 2005; Mokdad et al., 2001; Must et al., 1999; Must & Strauss, 1999) increased insulin resistance and type 2 diabetes in adulthood (Whitlock et al., 2005). Medical expenditures associated with overweight and obesity in WV were estimated to be \$668 million in 2008 and if current trends continue is estimated to be between \$1,556 – 3,212 million by 2018 (Thorpe, 2009). Therefore, findings from this study warrant urgent attention. Although this research does not address all the complexities involved in the development of childhood obesity, it does help us understand the spatial distribution of childhood obesity prevalence in WV and associated risk factors. Findings from this exploratory analysis may provide greater insight into the spatial epidemiology of childhood obesity, lead to modeling of environmental attributes that are predictive of childhood obesity, and aid in targeting at risk communities based on spatial distribution.

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APPENDIX A. SPATIAL DISTRIBUTION OF STUDY VARIABLES

Figure A-1. Percentage of 5th Grade School Enrollment by County Represented in the Study

Note: 1 Dot = 1 Child Sample Participant.

Figure A-2. Percent of Total Population Aged 25+ Years with a High School Diploma or Greater and Distribution of BMI Equal to or Greater than the 85th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-3. Percent of Total Population Aged 25+ Years with a High School Diploma or Greater and Distribution of BMI Equal to or Greater than the 95th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-4. Percent of Total 5th Grade Population Defined as Low Socioeconomic Status and Distribution of BMI Equal to or Greater than the 95th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-5. Median Household Income and Distribution of BMI Equal to or Greater than the 85th

Note: 1 Dot = 1 Child Sample Participant.

Figure A-6. Median Household Income and Distribution of BMI Equal to or Greater than the 95th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-7. Distribution of Super Markets and Grocery Stores by Zip Code and BMI Equal to or Greater than the 85th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-8. Distribution of Supermarkets and Other Grocery Stores by Zip Code and BMI Equal to or Greater than the 95th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-9. Distribution of Convenient Stores by Zip Code and BMI Equal to or Greater than the 85th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-10. Distribution of Fast Food by Zip Code and BMI Equal to or Greater than the 85th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-11. Distribution of Fruit and Vegetable Markets by Zip Code and BMI Equal to or Greater than the 85th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-12. Distribution of Fruit and Vegetable Markets by Zip Code and BMI Equal to or Greater than the 95th Percentile

Note: 1 Dot = 1 Child Sample Participant.

Figure A-13. Distribution of Fitness and Recreation Facilities by Zip Code and BMI Equal to or Greater than the 85th Percentile

Note: 1 Dot = 1 Child Sample Participant.

Figure A-14. Distribution of Fitness and Recreation Facilities by Zip Code and Distribution of BMI Equal to or Greater than the 95th Percentile

Note: 1 Dot = 1 Child Sample Participant.

Figure A-15. Distribution of Subjects Reporting a Family History of Heart Disease by Zip Code and BMI Equal to or Greater than the 95th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-16. Distribution of Subjects Reporting a Family History of Diabetes by Zip Code and BMI Equal to or Greater than the 85th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-17. Percentage of 5th Graders by Class Defined as Aerobic Fit and BMI Equal to or Greater than the 85th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

Figure A-18. Percentage of 5th Graders by Class Defined as Aerobic Fit and BMI Equal to or Greater than the 95th Percentile by Zip Code

Note: 1 Dot = 1 Child Sample Participant.

APPENDIX B. COUNTY CRIME DATA

County	Number Crime Events 2008	County Population 2008	Number Crime Events 2007	County Population 2007
Berkeley	5,983	106,335	12,640	100,513
Boone	868	24,927	2,137	25,389
Braxton	465	14,495	899	14,752
Brooke	499	23,140	912	20,173
Cabell	9,650	92,113	18,662	96,934
Calhoun	249	7,363	449	7,318
Clay	191	9,966	432	10,195
Doddridge	121	7,317	218	7,429
Fayette	1,891	45,694	3,087	46,919
Gilmer	178	6,835	408	6,904
Grant	135	12,099	376	11,950
Greenbrier	898	34,382	1,620	33,829
Hampshire	705	22,970	1,710	22,697
Hancock	1,112	29,865	1,990	34,196
Hardy	456	13,471	1,091	13,462
Harrison	4,060	68,497	8,372	68,434
Jackson	642	28,072	1,099	28,370
Jefferson	2356	52,925	4,885	51,455
Kanawha	15,908	188,705	34,821	191,088
Lewis	449	16,887	922	17,082
Lincoln	769	21,891	1,628	22,281
Logan	2,589	35,575	6,124	35,854
Marion	1,994	22,828	4,133	56,459
Marshall	1,692	56,092	3,452	33,189
Mason	1,074	32,620	2,347	25,601
McDowell	432	25,097	910	23,334
Mercer	4,019	60,174	8,944	60,749
Mineral	1,200	26,383	2,458	26,782
Mingo	1,065	26,607	2,184	26,840
Monongalia	4,025	84,218	8,915	84,762
Monroe	444	13,572	818	14,402
Morgan	479	16,630	886	16,455
Nicholas	1,573	26,190	3,084	26,302
Ohio	2,894	43,427	5,950	44,412
Pendleton	89	7,435	190	7,575
Pocahontas	311	8,524	719	8,664
Preston	531	30,458	814	30,394
Putman	2,782	55,565	6,169	53,923

County	Number Crime Events 2008	County Population 2008	Number Crime Events 2007	County Population 2007
Raleigh	5,877	78,686	12,748	78,950
Randolph	1,215	28,033	2,396	28,362
Richie	380	10,575	794	10,619
Roane	534	15,527	1,016	15,525
Summers	424	12,310	721	13,357
Taylor	116	16,171	248	16,254
Tucker	160	6,548	335	6,762
Tyler	63	9,033	81	10,969
Upshur	740	23,274	1,532	23,611
Wayne	1,537	40,302	3,058	37,399
Webster	210	9,476	480	9,649
Wetzel	181	16,140	395	14,673
Wirt	244	6,039	466	5,965
Wyoming	647	23,620	1,340	23,918

^a Population reported by the WV State Police.

VITA

Sherry L. Martin Roper was born in 1966 in Richwood, West Virginia. She received an Associate of Liberal Arts from the Pennsylvania State University. She received a Bachelor of Science in Nursing and a Master of Science in Nursing with a focus in community and public health nursing from The Pennsylvania State University. Her thesis research explored childhood obesity among Cherokee Indian children. She was accepted in the PhD in Nursing in 2008. Her research in the PhD program focused on risk factors associated with childhood obesity children and spatial associations. She has been a nurse educator for over 12 years and is currently an Assistant Professor of Nursing at Sacred Heart University.