THE INFLUENCE OF THE BUILT ENVIRONMENT ON POOR HISPANIC YOUTH

A Dissertation

by

LEI ZHOU

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2009

Major Subject: Recreation, Park, and Tourism Sciences

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Approved by:

Chair of Committee,	Corliss Outley
Committee Members,	Chanam Lee
	Alex McIntosh
	Scott Shafer
Head Of Department,	Gary Ellis

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ABSTRACT

The Influence of the Built Environment on Poor Hispanic Youth. (December 2009)

Lei Zhou, B.S., Zhengzhou Institute of Technology; M.S., University of Iowa;

M.A., University of Iowa

Chair of Advisory Committee: Dr. Corliss Outley

Many studies have examined the relationship between youth physical activity and their built environment. However, most of them used subjective measurement tools to measure built environment because of their low cost and convenience. The application of geographic information system (GIS) in this study greatly supported the research in this field because it can provide more detailed objectively measured data of built environment. Three hundred and thirty-eight Hispanic low-income youth enrolled in a local San Antonio Youth Center program participated in the study.

The first study examined the association between youth's household income, and the availability and accessibility of recreational and utilitarian facilities. Results indicated that youth from low income families had longer distances to and less available number of recreational and utilitarian facilities within their neighborhoods.

The second study focused on nutrition environmental features, such as, availability and accessibility of fast food outlets and supermarkets. Findings suggested that the average distance to supermarkets was almost two times that of fast food restaurants. These results indicated that participants need to walk more to access a

supermarket compared to the closest fast food restaurant. On the whole, supermarkets were less accessible compared to fast food restaurants for the participants in the study area.

The third study provided some important supplements to the first two studies by examining both features related to physical activity and dietary behavior with youth's BMI. Results indicated that the available number (availability) of physical activity- and food-related facilities contributed significantly to youth BMI. Lower BMI was related to more available utilitarian (e.g., shopping malls), recreational facilities (e.g., parks) and some food stores (e.g., supermarkets).

This study indicated that youth's individual features (e.g., age and SES) had some associations with their health conditions (e.g., BMI) and built environments (e.g., accessibility and availability of facilities and food outlets). These results may provide some evidence to improve the understanding of the relationship between individual, environmental, and social characteristics, which may be useful to promote children and adolescent health behaviors (e.g., physical activity and eating behavior) in public health.

DEDICATION

To my wife, mother, father, and grandparents

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. Outley, and my committee members, Dr. Lee, Dr. McIntosh, Dr. Shafer, and Prof. Pruitt, for their guidance and support throughout the course of this research.

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Finally, thanks to my wife, mother and father, for their encouragement, patience, support, and love.

TABLE OF CONTENTS

CHAPTER Page

LIST OF FIGURES

LIST OF TABLES

Page

CHAPTER I

INTRODUCTION

Overweight and obesity in children and adolescents are on the rise and have become serious issues in the field of public health (Ogden, Flegal, Carroll, & Johnson, 2002). According to the National Health and Nutrition Examination Survey (HHANES)'s report, about 16 percent of youth who were 6-19 years old were overweight in 2000 (Centers for Disease Control and Prevention [CDC], 2008a). The prevalence of overweight among adolescents of 12-19 years old has increased from 5% to 11% since 1970s (CDC, 2008a). The issue of obesity and overweight in children and adolescents is very serious because overweight youth have greater risks of becoming overweight adults, and may contribute to more health risks in their future.

These chronic diseases bring youth not only immediate health risks but also the long-term risks that make them suffer other health problems. According to Danniel's (2006) study on youth, obesity-related chronic disease may include high blood pressure, type II diabetes, heart disease, disordered breathing during sleep and early symptoms of hardening of the arteries. For example, obesity can harm the cardiovascular system and being overweight can accelerate the development of heart disease. If the prevalence of overweight and obesity continues to increase, youth may ultimately have shorter lives than their parents (Danniel, 2006).

This dissertation follows the style of *Leisure Sciences*.

Although many measurement methods are available, overweight and obesity are commonly measured by body mass index (BMI). BMI for children and adolescents have different calculation formula from adult BMI. It uses age- and sex-specific percentile values and classifies youths as being at risk for overweight (BMI $\geq 85^{th}$ percentile) and/or overweigh (BMI $\geq 95^{th}$ percentile) (CDC, 2008b). According to the latest report of National Center for Health Statistics (NHANES), about 30 percent of youth are at risk of being overweight and 15% of youth are overweight in the United States (Troiano, Briefel, Carroll, & Bialostosky, 2000; National Center for Health Statistics, 2002).

Overweight is the result of positive energy balance. Behaviors that cause positive or negative energy balance are referred to as 'energy balance-related behaviors (EBRB)' (Kremers, Bruijn, Visscher, Mechelen, Vries, & Brug, 2006). Positive energy balance leads to body weight increase. Overweight becomes obesity when there are consistent weight gains during a period for an individual; usually they are associated with physical inactivity and various dietary behaviors (e.g., a diet high in fat or carbohydrates). According to Kremers et al. (2006)'s study, physical activity and dietary behaviors are two major behaviors that influence energy balance.

Physical activity and dietary behaviors co-exist and interact with each other; it is impossible to identify a single factor as the universal causes of youth obesity. In addition, both physical activity and dietary behaviors are complex and consist of various forms. Physical activity includes leisure time activities, sport games, transportation behaviors and work-related activities; dietary behaviors contain soft drink consumption, a diet low in fiber, and frequent snacking (Kremers et al., 2006). Hence, the causes of

weight gain should be the foundation of the studies that examine the determinants of energy balance-related behavior.

Many efforts have been exerted to study the factors contributing to youth obesity and weight status. Some studies investigated individual characteristics that influenced an individual's body weight status, physical activities and dietary patterns (Frank, Andersen, & Schmid, 2004). However, the examination on how the built environment impacts the development of overweight and obesity is still in its beginning stages; and there is even less research on its influence on youth. The following section first reviews obesity and its related built environmental features, and then will present the common associations among physical activity, eating behavior, and youth obesity.

Built Environment and Obesity Risks for Low-income Hispanic Youth

The built environment includes land use, design, transportation, opportunities for physical activity and available healthful foods (Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2003). The built environment may not only promote people's physical activity, but also their healthy eating patterns. For instance, residents have more physical activity when their neighborhoods have more recreational facilities such as recreation centers, parks, trails and open spaces (Humpel, Owen, & Leslie, 2002). Food availability, as another important factor of built environment, has great influences on children and adolescents' eating habits. Male youth' self-reported consumption of juice and vegetables was positively associated with restaurant juice and vegetable availability (Edmonds, Baranowski, Baranowski, Cullen, & Myres, 2001). Therefore, it is important

to study how the built environment in neighborhoods influences youth health behaviors and body weight status.

Many studies showed that various built environmental factors had larger effects on economically disadvantaged and minority youth on their advantaged peers, and thus contributed to disparities in obesity rates (Kumanyika & Grier, 2006; Kwate, 2008; Powell, Slater, & Chaloupka, 2004). In low income neighborhoods, youth had fewer physical activity facilities with poor qualities and accessibilities, more unhealthy food outlets, poorer qualities of foods with higher prices (Kumanyika & Grier, 2006; Kwate, 2008; Powell et al., 2004). All the aspects of the built environment of minority and low-income youth may magnify the effects of factors that cause obesity and other health issues.

The prevalence of obesity among Hispanic youth has been consistently found to be higher than compared to non-Hispanic children (Kumanyika & Grier, 2006). Specifically, obesity rate of Hispanic youth exceed that of white peers by 12 percent (National Center for Health Statistics [NCHS], 2009). Within this group, the obesity rate of boys was higher (25%) compared to boys in other ethnicity groups such as African American boys (19%) and Whites (15%) (NCHS, 2009). The obesity rate of Female Hispanic youth was reported as 20% compared to 24% and 13% among African American and White girls, respectively (NCHS, 2009). One the whole, Hispanic youth had a much higher obesity rate than other ethnicity groups.

Socioeconomic status was reported to have close correlations with Hispanic youth (Kumanyika & Grier, 2006). Low-income youth are generally at excess risk of

obesity. However, the association between socioeconomic status and obesity among low-income Hispanic youth had a different pattern. Among low-income Hispanic girls, the obesity rate was positively related to their family household income; no consistent patter was found for boys in this special group (Troiano, & Flegal, 1998). The obesity rate was significantly lower when the parents of low-income Hispanic youth reported higher education.

Low-income Hispanic youth were more likely to experience some of the obesity-related health problems. For instance, type 2 diabetes was reported more among low-income Hispanic youth than non-Hispanic groups (Fagot, 2000). This special group also reported higher prevalence of symptoms of metabolic syndrome, which was an important risk for diabetes and cardiovascular disease (Cook, Weitzman, Auinger, Nguyen, & Dietz, 2003). In addition, left ventricular hypertrophy was also more prevalent among this group: one study reported that 70% of Hispanic youth had this problem compared to 39% of African American and 33% of Whites (Hanevold, Waller, Daniels, Portman, & Sorof, (2004). The higher rate of obesity among low-income Hispanic youth would bring other adverse health effects and produced a further economic difference in health outcome.

Obesity-related Built Environment for Low-income Hispanic Youth

The characteristics of neighborhoods where low-income Hispanic youth live has been shown to influence their food access and availability (Kumanyika & Grier, 2006). According to Morland, Wing, Diez, and Poole's (2002) research, low-income Hispanic youth had fewer than average supermarkets and more than average fast food restaurants

compared to wealthier groups. Youth in this group may be more likely to shop in small corner stores which offer less healthful food when there were fewer supermarkets available in their communities (Morland et al., 2002). Evidence has also been documented that the prices for healthful foods were higher and had a negative impact on low-income Hispanic youth intake of more vegetables and fruits (Hanevold et al., 2004). These effects were larger for low-income group because of their lower family income leveland higher sensitivity to food prices.

Evidence was not conclusive on the effect of how fast food restaurants related to obesity. One recent study examining the spatial distance of fast food restaurants in a local community indicated that there was no significant connection found between the body weight status and the proximity of those fast food outlets for low-income youth (Burdette & Whitaker, 2004). However, in another study it was found that when fast food restaurants were close to low-income Hispanic youth, they consumed more fast food and were more likely to become obese (Kumanyika & Grier, 2006).

Built environments that provide physical activity opportunities also plays an important role in influencing body weight status for low-income Hispanic youth (Burdette & Whitaker, 2004). Enough physical activity can provide more energy expenditure and provided a major outlet for daily caloric usage (Kohl III & Hobbs, 1998). For low-income minority Hispanic group, the built environment affected their physical activity much more that it did for adults. Low income adults used public transportation when they did not have cars; in this process they had to walk to nearby transit stops and thus they had chances to be physically active although this was not

voluntary. For youth, they may face more restrictions if they wanted to go outside to play or walk in low-income neighborhoods because their parents may restrict their activity for safety reasons or other unknown reasons. In addition, family work schedules, time, money, and road conditions may make it harder for parents to transport youth to recreational facilities (Kumanyika & Grier, 2006). For instance, the available recreational facilities and parks were reported to have a link to the body weight status of low-income youth (Powell, Slater, & Chaloupka, 2004).

As two major activities that are closely related to youth obesity, physical activity and eating behavior will be discussed in the following section.

Physical Activity and Health

According to the definition of physical activity outlined by Caspersen, Powell, and Christensen (1985), it is referred to as any bodily movement produced by the contraction of skeletal muscle that increased energy expenditure above the basal level. The CDC recommends that people should have equal to or more than 30 minutes moderate-intensity activities (i.e., bicycling, jogging, or anything else that causes small increases in breathing or heart rate) for more than 4 days per week; or vigorous-intensity activities for equal to or more than 20 minute (i.e., running, playing tennis, or anything else that cause large increases in breathing or heart rate) for more than 2 days every week or both (CDC, 2007b).

Physical inactivity or sedentary life-style causes many different health problems. Generally, these problems include not only physiological but also psychological aspects of people's health. For the general population, a variety of negative effects of physical

inactivity on people's physical and psychological health has been documented. First of all, research has documented that the least active participants have higher risk of dying from coronary heart disease than the most active group, and there is a strong relationship between level of physical activity and risk of coronary heart disease (Berlin & Colditz, 1990). According to Powell and Blair's (1994) study, about 35% of deaths from coronary heart disease were attributable to sedentary living, and this number would drop to 30% if the recommended physical activity level of the Healthy People 2000 were followed (U.S. DHHS, 1991).

In addition, lack of physical activity is believed to increase the risk of becoming overweight. In a large scale study, the risk of having a major weight gain over 5 years was twice higher for those who rarely exercised, compared with frequent exercisers (Rissanen, Heliovaara, Knekt, Reunanen, & Aromma, 1991). Another study indicated that participants who reported physical activity at both baseline and follow-up had much less weight gain than inactive participants (Kahn, Tatham, Rodriguez, Calle, Thun, & Heath, 1997). Grilo (1995) summarized previous literature on the contribution of physical activity to the treatment of obesity. He found that exercise alone typically produced modest weight loss of around 3 kg and weight loss was more for males than females. However, this amount was not satisfying to those people who wanted to lose more weight. Physical activity's effect on obesity prevention and treatment may be the long-term continuation of even modest activity level (Stefanick, 1993).

Negative effects of physical inactivity for children and adolescents may have larger potential to damage their health than adults because several common chronic

diseases are known to have their beginnings in childhood. Physical inactivity places youth at risk for chronic disease later in life (Lowry, Kann, Collins & Kolbe, 1996). Obesity is one of the possible chronic diseases, and it is one of substantial clinical and public health concerns. Childhood obesity has increased at least 50% since 1976, and more than three quarters of obese youth become obese adults (Warden & Warden, 1997).

One profound trend is the increasing obesity among minority youth, and their rates of obesity continue to rise and exceed obesity rates among white peers (Mamie, 2003; Popkin & Udry 1998; Troiano, Flegal, Kuczmarski, Campbell, & Johnson 1995). For example, Hispanic American boys had a higher rate of being overweight than non-Hispanic white boys (Mamie, 2003). In Ogden et al. (2002)'s study, the research results also indicated that the prevalence of obesity among African American and Hispanic American youth has increase by more than 10% during the last decade; and this rate was greater than their White peers. Furthermore, minority youth groups in some areas, such as African American youth in the urban low-SES neighborhoods, faced more challenges in avoiding the growing obesity risks than other groups (Kumnyika & Odoms, 2001).

Diabetes is a common chronic disease among youth that is exacerbated by lack of adequate physical activity. Blacks and Hispanics had higher prevalence rates of Type 2 diabetes mellitus as compared to whites, and there was an inverse relationship between physical activity levels and the risk of developing this chronic condition (Helmrich, Ragland & Leung, 1991; Manson & Nathan, 1992; Manson & Rimm, 1991). Physical activity is believed to be helpful in the prevention and treatment of Non-Insulin-Dependent Diabetes mellitus (NIDDM) which counted for about 90% of all diabetes

cases. Approximately 35% of deaths from NIDDM were attributable to physical inactivity.

Physical activity in youth was shown to affect bone density, and it reduced the risk of osteoporosis. Osteoporosis was a serious health problem for elderly women. The bone loss in older adulthood was influenced by peak bone mass, which occurred during late adolescence or young adulthood. Bone mineral acquisition required forces which varied in intensity and were dynamic so that bones can uptake enough calcium (Loud & Gordon, 2006). Another recent literature review also confirmed that the bone mass of adults was positively associated with physical activity of childhood (Kohrt, Bloomfield, Little, Nelson, & Yingling, 2004). In addition, an intervention study pointed out that the bone health of children, adolescents, and adults were positively correlated with physical activity (Strong et al., 2005). Therefore, physical activity plays an important role in preventing the bone loss during an individual's whole life period.

Eating Habits and Health

Dietary behavior is frequently called eating habits, and refers to someone's choice about what to eat to maintain good health. A healthy diet provides enough nutrients and energy to promote normal growth and development. Dietary guidance for children and youth changed from a focus on supplying enough nutrient and energy to ensuring dietary balance to avoiding calorie excess intakes. Diets of youth in America are off the recommended standards and that makes them susceptible to health risks including chronic disease (IOM, 2005). As a whole, youth consume too many calories and sugars and have much higher level of consumption of sodium, total fat and saturated

fats than recommended level (IOM, 2005). Furthermore, their intakes of whole grains, fiber, calcium, magnesium and vitamin E are much lower than the recommended level.

The Associations Between Youth Eating Habits and Health

Eating habits represent an important facet of youth health. Good eating habits are essential for proper growth and development, reduction of chronic disease prevalence, and long-term quality of life (Caldwell, Nestle, & Rogers, 1998; Perry, Story, & Lytle, 1997). The relationship between eating habits and health is complex and it mainly includes the following three aspects.

First, eating habits are associated with youth obesity. Obesity is a complex medical disorder that is affected by genetics and the environment. One of the environmental factors is high caloric intake such as high-fat and –sugar food consumption (Perry, Story, & Lytle, 1997). When youth have too many calories consumption, they have high risks of being obese. Obesity had both short-term and long-term negative outcomes for emotional, physical, mental well-being as discussed in '*Physical Activity and Health'* (Williams, Wake, Hesketh, Maher, & Waters, 2005), including other related chronic diseases such as blindness, coronary artery disease, type II diabetes and kidney failure (IOM, 2005).

Secondly, poor eating habits may lead undernutrition which included malnourished or misnourished conditions. According to Massey-Stokes's (2002) research, undernutrition meant that youth did not have enough food (malnourished), or had enough to eat but consumed nutrient-deficient diets. Undernutrition may exert negative effects on cognitive development and academic performance of children and

adolescents (Center on Hunger, Poverty, and Nutrition Policy, 1995). When youth are hungry they are irritable, can not concentrate, and experience low energy; these effects would impede their learning process (National Health/Education Consortium, 1993). In addition, poor eating habits may cause iron deficiency which decreases the youth body's ability to produce hemoglobin, which is essential to transport oxygen in the blood (USDHHS, 2000). Minority youth had higher risks of this health issue. For instance, Non-Hispanic African American girls from 12 to 19 were found to have greatest risks of iron deficiency (Cheung, 1995).

Thirdly, eating habits may be related to some chronic diseases. Four of the ten leading causes of death in the U.S were diet-related chronic diseases: coronary heart disease, certain cancers, strokes, and Type II diabetes (USDHHS, 2000). Many studies stated that lower blood cholesterol levels in children and adolescents may reduce their risk for coronary heart disease after they became adults. Some recommended nutrient intake was made by American Academy of Pediatrics (AAP) such as total fat over several days is no more than 30% of total calories and no less than 20% of total calories (AAP, 1998). Good eating habits may provide youth enough nutrition and avoid potential health behavioral risks such as purchasing less high-fat and –sugar foods and increasing visits to food outlets with more healthful foods (e.g., supermarkets).

Problem Statement

Many determinants of physical activity and eating behavior have been examined (e.g., personal, interpersonal and policy factor). However, it is less conclusive how the built environment, youth demographics and socioeconomic status, and their ERBRs

relate to one another. It is hard to randomly assign a built environment, such as a neighborhood, to youth. Therefore, it is difficult to control the environmental change in youth's living area. Moreover, Kremers et al. (2006) pointed out that there lacked a comprehensive theoretical framework in studying how built environment influences ERBRs. The research on environmental determinants of EBRBs lacked a systematically theoretical base, and the issue of lacking conceptual models makes it difficult to study the causal role of environmental factors. Bruijn (2005) further proposed that it was useful to examine the more complex interaction involved in the mechanisms of EBRBs so that the research could provide more insights into causal pathways. For example, demographic factors have been suggested to be important moderators in the study of how demographic factors influence the relationship between the environment and EBRBs (Kremers et al., 2006). Evidence has shown that environmental factors may have different impact on EBRBs with respect to gender, age, ethnicity and socioeconomic status (Kremers et al., 2006), however, little has been explored for youth. Therefore, demographic information will also be studied as a part of herein study.

Neighborhood is a very important context for youth. First of all, it provides all kinds of inexpensive forms of physical activity such as playing in the backyards or playing on the neighborhood streets with friends. These activities do not require purchasing any requirements or paying admission fees. In addition, physical activity in neighborhoods is more youth accessible because most activities occur around their houses (e.g., lawn in front of houses and playground close to home). Youth do not have to travel for a very long distance or ask for parents' assistance to transport them to the

destinations. Therefore, youth can easily participate in physical activity in their neighborhoods. Moreover, when youth are exposed to neighborhood environment, most activities are recreation-oriented and they are just for entertainment. Thus, they may feel more relaxed and comfortable about those activities in schools.

Secondly, empirical data from the fields of public health and urban planning indicated that community nutrition environment might be important influences on youth dietary behavior (Sallis & Glanz, 2006). When youth are outside schools and homes, the density and accessibility of local food providers may exert significant influences on their eating behaviors. For example, the number, type and location of food outlets may influence youth decision making of where, when and what kind of food to choose. Usually youth have to choose local food outlets without transportation assistance because most of them can not travel too far to purchase healthier foods. Consequently, neighborhood nutrition environment is a critical factor in changing youth eating behavior.

Since neighborhood plays an important role in impacting youth physical activity and dietary behavior, the three studies in this research highlighted the neighborhood built environment and focused on examining how factors within this domain influenced one another.

Study Purpose and Objectives

The purpose of these series of studies was to examine the associations among adolescents' social economic status, neighborhood environments (built environments), and BMI. The study hypotheses included:

- Study 1 – The purpose of this study is to examine the associations between youth household income and the availability and accessibility of physical activity-related facilities.
    - Hypothesis 1 aimed to test whether low-income youth had poorer accessibility to facilities: *Youth living in lower household income families had longer distances from their residences to the recreational and utilitarian facilities within their neighborhoods (1-mile radius distance);*
    - Hypothesis 2 was designed to test whether the presence of facilities was poorer for low-income youth: *Youth living in lower household income families had fewer recreational and utilitarian facilities within their neighborhoods (1-mile radius distance).*
- Study 2 – The purpose of this study was to examine the associations between youth household income and the availability and accessibility of food outlets.
    - Hypothesis 1 expected that low-income youth had more food outlets providing unhealthful foods: *Youth living in lower SES neighborhoods have more available fast food outlets with shorter distances within 1 mile distance from their residences;*
    - Hypothesis 2 was used to predict that low-income youth had fewer food outlets providing healthful foods: *Youth living in lower SES neighborhoods have fewer available supermarkets with longer distances within 1 mile distance from their residences*.

- Study 3 – To purpose of this study was to examine the relationships between youth BMI and the built environment.
    - Hypothesis 1 wanted to examine how youth SES was associated with BMI: *Youth's BMI was negatively related to their SES*;
    - Hypothesis 2 targeted on the link between the spatial presence of facilities and BMI: *Youth's BMI has an association with the available number of facility within one mile distance*;
    - Hypothesis 3's purpose was to predict the influence of facilities' spatial distances on BMI: *Youths' BMI had an association with the distance of facility within one mile distance*.

Theoretical Framework

There is currently a need for a well developed theoretical framework which can explain and predict human being's health behaviors. Social ecological models (SEM) provided a very unique perspective which combines both individual characteristics and environmental factors, and studied the transaction between people and their environments. Therefore, the present paper chose the SEM as the theoretical framework.

Social Ecological Model

Foundations and Assumptions

Ecology describes interrelation between organisms and their environment (Hawley, 1950); based on this conception, social ecology refers to people's transactions with their physical and sociocultural environments (Sallis, Bauman, & Pratt, 1998). Ecological models specific to health promotion included several important aspects such

as environmental, behavioral, and social policy changes that help individuals adopt healthy behaviors (Quinn, Thompson, & Katherine, 2005). Social ecological models are distinctive because they not only examine the individuals' behaviors, but also the physical and social environments and its relationship to people at different levels within the model (i.e., individual characteristics, built and social environment; see Figure 1) (Quinn, Thompson, & Katherine, 2005). Many important theories and models of health behavior apply one dimension method in health promotion like experience, skills, or education (Quinn, Thompson, & Katherine, 2005). Social ecological models of health behavior promotion focus on individual behaviors and environmental influence on behavior (Green, Richard, & Potvin, 1996).

According to Stokols (1992) there are four basic assumptions about the social ecological theory as the following.

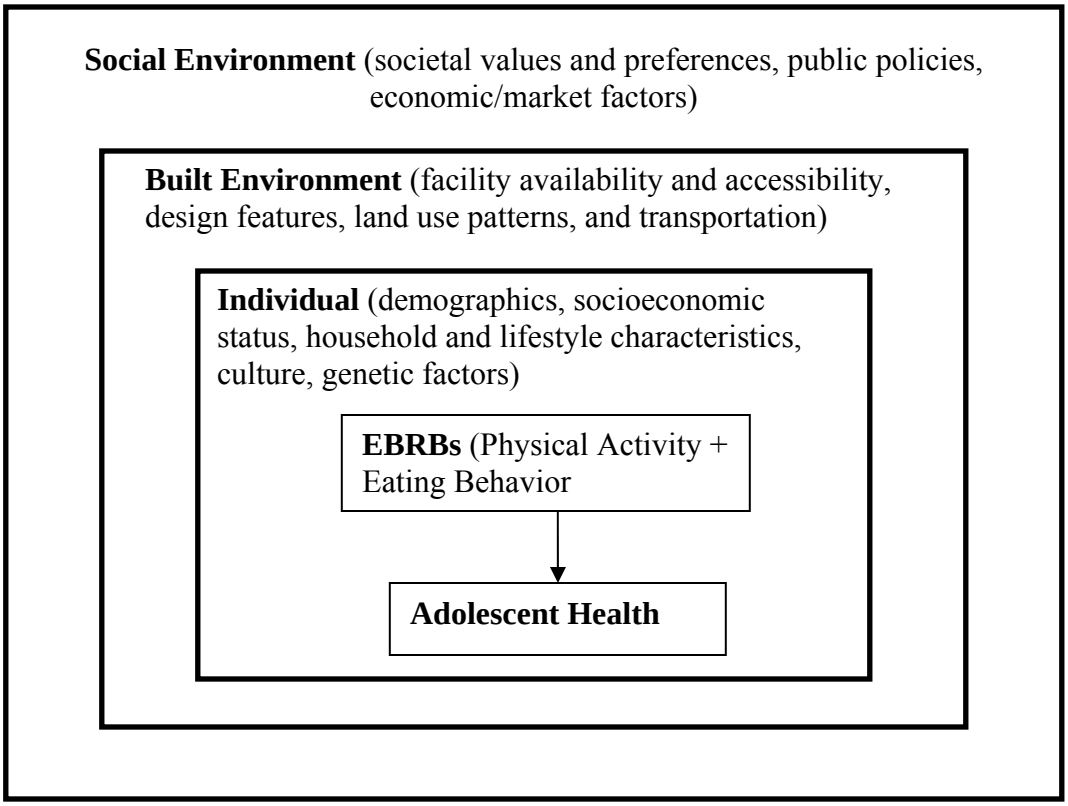

Figure 1 Social Ecological Model of Youth Physical Activity and Eating Behavior

1) The wellbeing of participants in a situation or setting was influenced by multiple facets of both physical environment (e.g., geography, architecture and technology) and the social environment (e.g., culture, environment and politics). Moreover, the health status of an individual and groups was influenced not only by environmental factors but also personal attributes such as habit, genes, and psychological disposition. Therefore, to promote individuals' health, it is important to study the

interplay among diverse environmental and personal factors, rather than analyses which focus only on single environmental or personal factor.

2) Health promotion should address the complexity of human environments. Environments can be described in terms of physical and social environment. But they can also be characterized in terms of objective or subjective qualities, and distal or proximal factors. Moreover, they can also be described using many individual variables (e.g., street light, noise, and distance from home to the closet grocery shops) or composite relationships with other elements such as social climate.

3) The participants can be studied at different levels ranging from individuals, small groups to large organizations and population. The social-ecological perspective applies diverse methods like questionnaires, observations, medical examinations and interviews. In addition, it is assumed that effectiveness of health promotion programs can be enhanced significantly through the coordination of individuals and groups at different levels, such as parents who support their children to have more physical activity and peers who influence children's fruit, juice and vegetables intake.

4) The social-ecological perspective applies many concepts from system theory (e.g., negative feedback) to understand the interaction between human being and environments. Therefore, this kind of interaction/interplay is described as cycles of mutual influence. As much as the physical and social environments influence individuals, the individuals also shape and change their environments and settings. Accordingly, both immediate and distal environments should be considered in health promotion studies.

How to Apply SEM to Study Youth Physical Activity, Dietary Behavior, and Obesity

Social ecological models have been applied to study human being's behaviors for decades and they were proved to be very effective and widely recognized (Breslow, 1996). Since physical activity and dietary behavior are human behaviors, the ecological theory and supporting models can be applied to study these two behaviors.

One of the most applicable social-ecologic models was developed by McLerory, Bibeau, Steckler and Glanz (1998), which mainly included five factors that may influence human behavior: "intrapersonal factors, interpersonal processes and primary social groups, institutional factors, community factors and public policy".

1) Intrapersonal factors. Intrapersonal factors represent the characteristics belonged to individuals (e.g., personality, self-efficacy, self-esteem, motivation, experience, attitude and education). Personality is one of the concepts of psychology; therefore, it is also belonged to intrapersonal factor. The developmental factors (e.g., gender) are also part of the intrapersonal factors. Besides those, self-efficacy is also considered as a factor to promote physical activity.

2) Interpersonal processes and primary social groups. It means the relationships between an individual and his/her families or peer groups can also influence a person's behavior including physical activity.

3) Institutional factors. It represents the organizations that may influence, limit, or encourage an individual's physical activity (e.g., school).

4) Community factors. It includes the relationships among organizations, institutions, and social networks in a defined area.

5) Public policy. The laws, regulations and policies around an individual may also influence her/his behaviors and these regulations at different levels may influence human beings' behaviors differently (McLerory, et al., 1998).

These factors have also been summarized as three major domains such as individual, social, and environmental features (Sallis & Owen, 1997). Intra- and extra-individual features are independent and meanwhile they can exert direct effects on each other (Kelly, 1990). When a change happens at one level, all other level factors may be effected by this change. For instance, when a school starts a program to promote student physical activity such as providing education of how physical activity may promote health or curriculum teaching students the skills of exercise, which may encourage students to be more active. When students go outside to have more physical activity in their neighborhoods, their activity may send a message to the community and local government that there should be more recreational facilities to satisfy residents' needs. Then a policy level change may occur, for instance, to establish rules or legislate to better planning the built environment of the local community.

An individual's behavior such as physical activity and dietary behavior is influenced not just by intrapersonal characteristics like age, gender, and race/ethnicity. Youth always live in social environments; therefore, their behaviors are also affected by interactions with cultural, social, and environmental contexts (Davison, & Birch, 2001). The social ecological models have identified that environmental factors are critical in

shaping people's behaviors (Sallis & Owen, 1997). According to Sallis and Owen (1997)'s study, the features of different contexts (e.g., community and home) may exert positive or negative impact on youth physical activity and dietary behavior.

To study the built environment, researchers investigated a variety of aspects such as accessibility and availability of recreational facilities and food outlets (Davison & Lawson, 2006; Cotterill & Franklin, 1996). In addition, the SES of youth' families may be also associated with their health behavior and obesity rate (Ellaway & Macintyre, In Press; Sundquist, Malmstrom, & Johansson, 1999).

It is not practical to examine every aspect of built environment in one study. Thus, this study focused on the availability and accessibility of food outlets (e.g., supermarkets and fast food stores) and physical activity-related facilities (e.g., parks and shopping malls) that are located on the Built environmental levell.

Significance of the Study

Although both empirical evidence and theory support that there were associations among environment, obesity, and energy balance-related behaviors, there were still arguments about the issues such as measurement standard of built environment, commonly recognized conceptual models or theoretical frameworks, and causal relationship between built environment and youth' physical activity and eating habits. The present study contributed to this field in the following fields.

Many studies have examined the relationship between youth physical activity and their built environment (Bedimo-Rung, Mowen, & Cohen, 2005; Davison, & Lawson, 2006). However, most of them used subjective measurement tools (e.g.,

evaluation forms or self-reported survey forms) to measure built environment because of its low cost and convenience. The application of geographic information system (GIS) in this study would greatly support the research in this field because it can provide more detailed objectively measured data of built environment. This objective measurement increased the quality of the environmental data and provided new evidence to support how built environment influenced youth physical activity.

To date, most studies did not provide specific processing information such as how to calculate the proximity to different destinations, how to evaluate the connectivity of the street networks, or how to measure an aesthetically pleasing environment by using GIS. This study described the calculation procedure of the spatial data and provided a detailed guidance for readers. The purpose was to provide a reference method so that other researchers can better understand the whole process of GIS application. Moreover, the application of objective measurement tool (GIS) can move the current study toward a better understanding of the interaction and synergy among intrapersonal factors, physical environment, and youth' energy balance-related behaviors.

This study also did some work in the theoretical framework in studying how built environment influenced ERBRs. Recent studies indicated that there was no consistent evidence regarding the impact of environmental factors on EBRBs (Ferreira, Van der Horst, Wendel-Vos, Kremers, Van Lenthe, & Brug, 2005; McCormack, Giles-Corti, Lange, Smith, Martin, & Pikora, 2004). Kremers et al. (2006) further pointed out that this was because of a lack of conceptual models for differentiating the causal role of environmental influences on health behavior such as EBRBs. Causal pathways beyond

the previous models, such as theory of planned behavior (TB), should be examined so that more complex interactions involved in the mechanisms can be explored. For example, only a few previous studies have explored the moderating role of demographic factors in the relationship between health behavior and environmental factors. The present study tried to fill this gap byexamining the hypothesis that differential impacts of the built environment on youth obesity and EBRB with respect to a variety of demographic characteristics (e.g., age, SES, or gender). This approach tested the possible relationship among environmental factors, youth's demographics, SES, and health conditions.

Dissertation Outline

As discussed above, many studies have documented that health outcomes are associated with these two important health behaviors. The built environmental factors impact these behaviors directly and indirectly. To study these two aspects, we can better understand some issues. First, built environment may directly influence youth weight status, or it may actually work to affect youth weight status through mediators such as physical activity, or is magnified by confounding factors such as socioeconomic status (SES). Second, SES and may be associated with the features of built environment such as spatial access to facilities. For example, residents living in low SES areas had worse access to recreational facilities compared to high SES areas (Powell, Slater, Chaloupka, & Harper, 2006). To better elucidate the above important issues, this study arranged the three studies as the following:

The first two studies examined the associations between youth SES and their spatial access to different types of facilities that were related to their health behaviors. The third study investigated whether the spatial attributes of these facilities influenced youth health outcome (BMI). Each of them are specifically outlined below:

The first study examined the association between youth' household income and both availability and accessibility of physical activity-related facility. Data of accessibility and availability of the recreational and utilitarian facilities were collected. Accessibility and availability was defined as the opportunities for activity in a certain area and the ease of arriving at potential destinations by measuring the available number of and the distance to destinations (Handy, 1996).

Specifically, recreational facility and utilitarian facility were included in this study as physical activity-related resources. Recreational facilities included all the parks (e.g., miniparks, skate parks, and large urban parks), recreation centers/community centers in San Antonio area. Utilitarian facility was selected according to youth' activity pattern, e.g., shopping mall was selected because many youth preferred to hang out in shopping malls. In the study area (San Antonio) of this paper, the utilitarian facilities contained Mini golf courses, shopping malls, video arcades, youth organizations, amusement places, DVD and video games rental stores, and movie theatres.

The distance from each participant's home to the closet resources was calculated using software ArcGIS and Network Analyst extension. The number of each type of physical activity-related facilities was calculated using the Network Analyst tool.

The second study focused on nutrition environmental features such as availability and accessibility of food outlets. This study examined if youth had different exposures to fast food restaurants and supermarkets when they lived in different neighborhoods. Food outlets in this study referred to fast food stores and supermarkets. The fast food restaurants in this study referred to limited-service food outlets, which belonged to a company with more than one franchise nationwide or in multiple states, provided facilities for customers to consume their meals on site, and served complete meals ordered without the assistance of waiters or waitresses (Maddock, 2004). Supermarket was defined as large corporate owned "chain" food stores with a limited selection of foods, including fresh meat, wheat-based Western style bread, fruits, vegetables, and dairy milk (Smoyer-Tomic, Spence, Raine, Amrhein, Camron, Yasenovskiy et al., 2008).

Youth eating habits and physical activity were both energy balance-related behaviors. When youth had less physical activity or unhealthy eating habits (e.g., high-fat food intake), positive energy balance and weight gain were experienced (Kremers, et al., 2006). Therefore, youth nutrition environment was very important; it may interact with physical activity behaviors and cause youth to be overweight.

The nutrition environment was assessed through the study of the number of food outlets and the distance between participants' home and the nearest location of food outlets. Statistical analysis was conducted to study how the nutrition environment was associated with participants' demographics and socioeconomic status.

The third study combined all the features of the built environment from the previous two studies and provided a comprehensive evaluation of how these features were related to youth BMI. The link between built environment and youth obesity was still at its beginning stage. Several studies had explored the issue like how the built environment influenced youth obesity directly (White, 2007). However, few of them examined both features related to physical activity (e.g., the proximity to parks) and dietary behavior (e.g., the presence of fast food stores). This study investigated both of these important features related to youth obesity.

CHAPTER II

STUDY 1: HISPANIC YOUTH SES AND PHYSICAL ACTIVITY-RELATED FACILITIES

In the field of public health, physical activity is considered one of the most important behaviors that can promote positive health. In particular, physical activity has been associated with lower obesity prevalence among youth (Bassult & Manson, 2005; Westerlind, 2004). Sufficient physical activity can increase expended calories, adjust the caloric balance in bodies for youth, and therefore, decrease the prevalence of obesity and other related chronic diseases. People with different demographic backgrounds such as race, ethnicity, and socioeconomic status (SES) have different patterns of physical activity. Some studies revealed that the adults most at risk for leisure inactivity were those who reported low levels of education and income, those who lived in poverty, and those who were members of racial minority groups (Crespo, Smit, Anderson, Carter-Pokras, & Ainsworth, 2000). Among youth, evidence also indicates significant race/ethnicity-specific differences in their levels of physical activity. For instance, in the Youth Media Campaign Longitudinal Survey investigating youth from 9 to 13 years of age, rates of participation in organized sports differed significantly according to race and parental income and education levels (CDC, 2003). Another national longitudinal study of youth health status pointed out that physical activity patterns varied substantially according to ethnicity among youth in grades 7 through 12 (Gordon-Larsen, McMurray, & Popkin, 1999). Although people with different backgrounds have differential physical

activity patterns, their physical activity can usually be summarized as the following four major types.

There are four types of physical activity: 1) leisure-time recreation and exercise (e.g., doing exercise in a neighborhood park), 2) utilitarian travel (e.g., shopping and commuting), 3) housework or home maintenance (e.g., mowing lawns), 4) work-related physical activity (e.g., walking between offices and buildings). Considering their living and studying environments, youth may have more physical activity which falls under the first two categories (Committee on Physical Activity, Health, Transportation, and Land Use, 2005). To study these two types of physical activity, it is important to examine the context where these activities occur in youth daily lives. For low-income minority youth, the places they usually visit for physical activity are for the recreation or utilitarian purpose (e.g., visiting parks for exercise or walking to movie theaters for entertainment).

Therefore, this study focused on examining those facilities that were related to youth leisure-time recreational and utilitarian physical activity among low-income Hispanic youth.

Literature Review

A growing body of evidence indicates that there exists significant associations between the built environment and people's health behaviors (e.g., physical activity). (King, Jeffery, Fridinger, Dusenbury, Provence, & Hedlund, 1995; Humpel, Owen, & Leslie, 2002; Huston, Evenson, Bors, & Gizlice, 2003). Social ecological models, for example, were based on the notions that physical environments designed for or

conducive to physical activity and that these settings were likely to influence types and levels of physical activity (Sallis, Bauman, & Pratt, 1998).

Facility Availability and Accessibility

Recreational and utilitarian facilities within walking distance of residents play an important role in promoting their physical activity (Cooper, Barker, & Wickham, 1988). Residents may choose to have more recreational or utilitarian trips when they perceived more opportunities, such as shorter distances, higher level of connectivity, and more available facilities, to walk or bicycle around their neighborhoods (King, et al., 2005). Some of these studies have quantified access to facilities in terms of participants' self-reported perceptions while others have calculated objective measures (King, et al., 2005; Cohen et al., 2006). It is not well understood that whether there is a strong association between youth's perceptions of access to neighborhood physical activity facilities and the objectively measured number and proximity of these resources (Scott, Evenson, Cohen, & Cox, 2007). One possible reason may be that people do not perceive the physical environment in the same way. For instance, youth and low income individuals may perceive their neighborhood as a smaller setting than others (Scott et al., 2007). In addition, people living in urban areas define their neighborhoods as small areas than those in rural areas (Scott et al., 2007). Based on objective and subjective measurement, the following paragraphs reviewed recreation and utilitarian facilities separately.

Recreation Facilities

Recreation facilities provide a variety of opportunities to satisfy youth's needs of playing outside, doing exercise and other activities. These opportunities not only benefit active facility users, but encourage those inactive participants to have more physical activity. Much research directly supported that the accessibility and availability of recreation facilities had a positive relationship with youth physical activity levels (Davison & Lawson, 2006). First of all, perceptions held by youth and their parents of available facilities may both influence youth physical activity patterns. Youth's perceptions impacted their physical activity levels. For example, Zakarian, Hovell, Hofstetter, Sallis and Keating (1994) found that youth's subjective reports of physical activity were positively correlated to the number of sport and exercise facilities.

In addition, when youth's parents perceived more facilities, they may encourage their kids to be more active. Carver, Salmon, Campbell, Baur and Garnett (2005) reported that subjective evaluations (self-report) of walking or biking among youth were positively associated with their parents' perceptions of presence of sport and recreational facilities in the vicinity of the neighborhoods.

Secondly, the objectively measured number or presence of recreational facilities also has significant associations with youth physical activity. Zakarian, Hovell, Hofstetter, Sallis, and Keating (1994) found that vigorous physical activity among youth was positively associated with the number of recreational facilities such as sport and exercise facilities in youth neighborhood areas. Another study examined the relationship between objectively measured physical activity and the number of recreational facilities

and parks within one-mile of the neighborhood; its results showed the relationship was positive for girls only (Norman, Nutter, Ryan, Sallis, Calfras, & Patrick, 2006). Generally, research indicated that higher levels of youth physical activity were related to more availability of facilities like parks, gyms, sport arenas and swimming pools (Fein, Plotnikoff, Wild, & Spence, 2004; Mota, Almeida, Santos, & Ribeiro, 2005).

As one of important influencing factors and the most popular neighborhood recreation resource, parks (e.g., mini and skate parks) have been reported by many studies to provide great opportunities for local youth to participate in more physical activities (Bedimo-Rung, Mowen, & Cohen, 2005).

Park Use and Physical Activity. According to a study (Cordell, McDonald, & Teasley, 1999), 95% of Americans had one or more recreation activities in low cost settings such as parks or other outdoor recreation areas during the last twelve months. However, only 22% of them reported that they participated in individual sport activities in their closest parks. The most common outdoor activity was walking which was reported by 67% of respondents (Cordell et al., 1999). However, most park user came from a small proportion of the population (7% to 21%) who were active in leisure activities (Cordell et al., 1999). In Sallis et al. (1990) study, only 15% of those survey participants in San Diego used parks. Among those people, 21% of them reported more than 2 sessions of vigorous physical activity every week.

Several studies on youth's park use demonstrated that the use of parks had a positive association with their physical activity. Youth usually need their parents to provide transportation assistances to arrive at activity destinations. When there are

convenient public facilities (e.g., parks) close to their residences, youth may not need this assistance and therefore, these facilities increase their physical activity. Hoefer, McKenzie, Sallis, Marshall and Conway (2001) study pointed out that parks or playgrounds in youth's neighborhoods explained 5.1% of the variance in boys' general physical activity after controlling the influence of parent transportation. This evidence illustrates that when parks were close to male youth's residences, they may not need parent transportation and still have ways to access parks. The results of this study also implied that more available local parks may promote youth physical activity that does not need parent transportation.

In another cross-section study in the New York State, neighborhood park and recreation areas were positively associated with youth physical activity levels (Roemmich, et al., 2006). Two recent studies also supported this finding (Epstein et al., in press; Roemmich et al., in press). Generally, the percentage of park areas may explain about 9% to 10% variance in youth physical activity (Roemmich, Epstein, Raja, & Yin, in press).

Availability and Accessibility. The presence, areas, and ease of access of park and other recreational facilities for youth were important issues that have been explored by many researchers.

In a study investigating sedentary behavior and physical activity of 8 to 15 years old youth, the associations between youth physical activity and neighborhood environment including park areas were studied by using random coefficient models (Epstein, Raja, Gold, Paluch, Park, & Roemmich, 2006). Availability and accessibility

of park areas were measured by the street network as indicators of neighborhood diversity. After calculating the elasticity coefficients, the study found that living in a community with park areas was positively associated with an increase in physical activity for youth. In addition, when the sedentary behaviors were controlled to decrease, a significantly positive link was reported between participants' physical activity and park areas around their neighborhoods.

Usually, the accessibility of facilities was positively associated with youth physical activity (Davison & Lawson, 2006). In a study of Hispanic youth, investigators objectively measured the distance to nearby playgrounds in the parks and reported the distance to playgrounds had an inverse association with male youth's self-reported physical activity (Gomez, Johnson, Selva, & Sallis, 2004). This finding was supported by Timperio et al. (2004)'s study, which found that youth had less walking and cycling when they perceived too many barriers of accessing parks around their homes. Additionally, no consistent results were reported that there existed ethnic or racial differences influencing the link between park accessibility and youth physical activity (Adkins, Sherwood, Story, & Davis, 2004; Carver et al., 2005).

Socioeconomic Status (SES) and Facility Availability and Accessibility

Recent studies have begun to focus on the extent to which the availability and accessibility of facilities or settings which were related to physical activity, varied across neighborhoods on the basis of SES and other demographic characteristics. Duncan, Duncan, and Strycker's (2002) research examined the association between SES and perceived opportunities for physical activity such as playgrounds and parks close to

home in 56 neighborhoods of a Northwest city. The results indicated that residents of neighborhoods with lower poverty levels perceived significantly more physical activity opportunities. The 2003 Youth Media Campaign Longitudinal Survey showed that youth and parents at relatively lower income and education levels perceived significantly higher physical activity barriers, including expense, lack of opportunities to participate in physical activity, and transportation concerns (CDC, 2003).

In addition, more and more studies have begun to use objective measures to examine physical activity–related facility differences across neighborhoods. Estabrooks, Lee, and Gyuresik (2003) examined the availability and accessibility of physical activity-related facilities and settings across 32 different census tracts in a U.S Midwestern town according to neighborhood SES. These facilities and settings included parks, sports facilities, fitness clubs, community centers and bike trails. The study indicated that low and medium SES neighborhoods had significantly fewer resources available for physical activity than those high-SES neighborhoods. Moreover, low and medium SES neighborhoods had significantly fewer no-cost resources although no differences were found for pay-for-use resources across different neighborhoods.

In another study by Powell, Slater, and Chaloupka (2004), census data on SES and race/ethnicity were linked to observational data on public physical activity settings like sport areas, parks and green spaces, were collected from 409 communities across the country. This study attempted to examine how facility availability varies with respect to the socioeconomic and demographic compositions of local populations. The results indicated that communities with higher percentages of African American residents were

likely to have fewer available sports areas, parks and green spaces, and public pools and beaches. Additionally, communities with lower median household incomes, higher poverty rates, and higher percentage of African American and other minority residents were shown to have fewer overall total physical activity-related settings of those measured.

In a large scale investigation, Powell, Slater, Chaloupka, and Harper (2006) examined the association between neighborhood demographic characteristics and the availability of commercial physical activity facilities by zip code nationwide. Multivariate analysis were conducted to evaluate the availability of commercial outlets and how they were linked to different socioeconomic data based on zip code data provide by US census Bureau. The results specifically pointed out those physical activity facilities were less likely to be present in neighborhoods with lower income populations and higher proportions of Hispanic ethnicity.

Utilitarian Facilities

Utilitarian facilities are those destinations that an individual reaches for a specific reason as quickly as possible within minimal delays (Mccrmack, Giles-Corti, & Bulsara, 2008), such as schools, post offices, shopping malls or convenience stores.

Very few studies have examined the association between youth physical activity and utilitarian facilities, especially commercial settings providing entertainment activities (e.g., shopping malls, video arcades, and movie theaters) that were considered "youth attractors". Most research has focused on adult physical activity (Geurs & Wee, 2004; Ball, Bauman, Leslie, & Owen, 2001), therefore, the following literature review is

mainly drawn from research on utilitarian facilities in relation to adults' physical activity.

The distance between a utilitarian facility and a residence can influence a person's decision of whether to walk or bicycle to a destination (King, et al., 2005). Three studies reported similar results: when residents lived within walking distance of commercial settings (e.g., convenience stores or shopping centers), they may have more utilitarian walking or bicycle trips at those locations (Norman, Nutter, Ryan, Sallis, Calfas, & Patrick, 2006). In Ball, Bauman, Leslie, and Owen's (2001) study examining Australian adults' physical activity, 3392 participants reported their environmental barriers and facilitators of physical activity. Logistic regression analysis was implemented to examine participants' the relationship between their walking in the past 2 weeks and their environmental perceptions. The results indicated that more available convenience stores within a walking distance were associated with more walking for the purpose of exercise.

Another study examined the relationship between physical activity levels of women and proximity to neighborhood business settings and facilities in southwestern Pennsylvania (King, et al., 2005). Participants' physical activity data in the last 7 consecutive days was measured by using the Yamax Accusplit pedometer. Business and facilities addresses were geocoded into ArcView GIS and then this information was used to determine whether potential businesses and facilities were within walking distance (1500m). Finally, the number and proximity of business and facilities were calculated in GIS and analyzed with participants' physical activity data. After controlling for

participants' race/ethnicity, age, education, smoking status, body mass index (BMI), and SES, this study reported that commercial settings within walking distance were positively correlated with residents' general physical activity measured by pedometers.

A dose–response relationship was also reported in another recent Australian study between the mix of utilitarian destinations in neighborhoods and residents' walking (Mccrmack, Giles-Corti, & Bulsara, 2008). This study applied GIS to calculate the shortest network distance to utilitarian facilities like shops, post boxes, and convenience stores. Participants' physical activity data and GIS built environmental data were analyzed by using generalized linear mixed models (GLMN). The findings indicated that the presence of convenience stores and shopping centers were significantly correlated with utilitarian walking. In addition, the mix of utilitarian destinations in participants' neighborhoods encouraged higher levels of physical activity among those already active participants and promoted physical activity for those sedentary participants. These results indicate that not only the number, but also the type of utilitarian facilities may promote residents' physical activity in their neighborhoods.

Purpose and Hypothesis

The purpose of this study was to examine the association between youth household income, and the availability and accessibility of physical activity-related facilities. The hypotheses were as followed:

Hypothesis 1: *Youth living in lower household income families had longer distances from their residences to the recreational and utilitarian facilities within their neighborhoods (1-mile radius distance);*

Hypothesis 2: *Youth living in lower household income families had fewer recreational and utilitarian facilities within their neighborhoods (1-mile radius distance).*

Method

Participants

San Antonio is located in south central Texas with a resident population of 1,144,646 (U.S Census Bureau, 2008). In 2008, 61.3% of the residents in San Antonio were Hispanic and 28.5% of the population was under the age of 18; 27.8% of the residents had education less than 9th grade level and the median household income was $36,214 in 2008 (U.S Census Bureau, 2008). The unemployment rate was 4.9% in 2008 (SAMHD, 2008). By 2009, the city reported 193 city parks in the city's park inventory with total area acreage of 15,546 acres (SAMHD, 2008).

Study participants were all current enrollees in a local youth center. *The San Antonio Youth Centers (SAYC)* is a non-profit organization that aims at developing the strengths, talents and skills of inner-city youth and their family member to fulfill their potentials. The SAYC currently has 6 youth centers located throughout the city and services over 750 youth under the age of 18 years. SAYC operates on a neighborhood basis and as such, many of the participants live in the area immediately surrounding the centers. The organization is currently operating a health program, named "San Antonio comprehensive fitness & nutrition program" developed with a federally funded Carol E. White Program Grant. There are 338 participants enrolled in the program at two local youth centers in 2008. These two youth centers are Dan Cook Youth Center and Eastside

Youth Center and are the only two centers in the current study. Both centers are close to the downtown area and are located in high-risk areas (i.e., high numbers of births to single mothers or births to school-age mothers) (San Antonio Metropolitan Health District, 2008). Figure 2 delineates the spatial distribution of the physical activity-related facilities and participants' residences in the study setting.

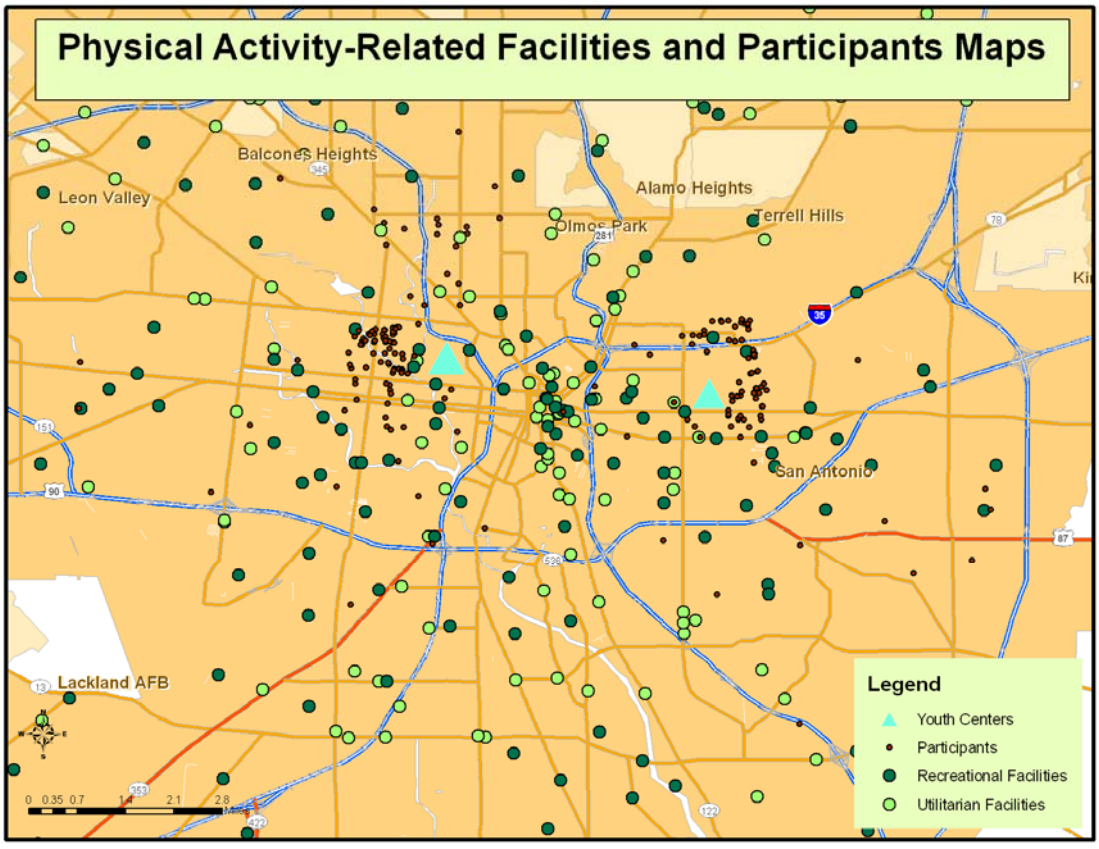

FIGURE 2 Physical Activity-Related Facilities and Participants Maps

Program Information

The health program was launched in the Spring of 2008. The program information was sent to schools which were within the neighborhood service areas of the youth centers. Participants and parents provided assent and consent to participate in the program. The initial program was scheduled to last at least two years. At the beginning of the program, the centers established a database f to record participants' demographics (e.g., age, gender, race and household income) and participation information (e.g., admission date and body mass index [BMI]). The program was evaluated every 4 months.

Participants had several optional activity groups to participate in at each center, such as general fitness education section, basketball and swimming class sections, and nutrition education classes. The actual activities varied by each center's resources. Each participant's address was compiled into this study's datasets which were used for spatial data analysis. Information such as participants' addresses, participation status, and BMI were updated every 4 months. In addition, a survey was administered to assess the programs needs and tackle possible changes in relationship to participants' health conditions (e.g., updated height and weight status) and family status like daily school transportation, daily healthy food intake, and physical activity levels.

Measurements

Participant Level Data

Participant demographic information was collected in Spring 2008 to assess individual nutritional and physical activity behaviors and participant characteristics (i.e.,

age, gender, height, weight, and income level). BMI was collected from trained project staff. BMI is a number calculated from an individual weight and height using the formula: BMI = weight / (height * height) (CDC, 2008a). For children and adolescents, this number needs to be plotted on the BMI-for-age growth charts to get a percentile ranking (CDC, 2008a). Percentiles are the most commonly used indicator to assess the size and growth patterns of youth. The percentiles indicate the relative position of the child's BMI number among peers of the same sex and age. Once the height and weight for participants were obtained the project staff applied a commonly used formula to calculate participants' BMI: BMI = 703 * (weight / (height * height) (Department of Health Care Services [DHCS], 2009). The percentile classified youth as being at risk for overweight (BMI $\geq 85^{th}$ percentile) and/or overweigh (BMI $\geq 95^{th}$ percentile).

Neighborhood Level Data

GIS Data Acquisition. Recreational facilities and utilitarian facilities were included in this study as physical activity-related resources. This study focused on those facilities that provided physical activity opportunities for youth during non-school hours. Youth can either have physical activities inside the facilities or frequently walk or cycle to the facilities for entertainment. Lee and Moudon (2006) pointed out that there were no well-established theories to identify appropriate walking destinations. Therefore, the selection of recreational and utilitarian facilities was based on previous studies examining youth physical activity facilities. Previous studies have identified parks, recreation centers, and community centers as the most commonly used recreational facilities for children and adolescents in local neighborhood areas (Addy, Wilson,

Kirland, Ainsworth, Sharpe, & Kimsey, 2004; Booth, Owen, Bauman, Clavisi, & Leslie, 2000; Deshpande, Baker, Lovegreen, & Brownson, 2005; Duncan & Mummery, 2005; Gordon-Larsen, McMurray, & Popkin, 2000). These facilities may be particularly relevant for youth because their physical activity was limited to the distance that they were able to walk or bicycle. Utilitarian facilities were based on a selection of businesses that were perceived as youth attractors, areas that youth would frequently visit on a daily basis. According to Cooke, Thabit, Ray, Shipp, Corcos, Stepanski, & Smith's (2008) study, movie theaters, mini golf courses, shopping malls, youth organizations, amusement places, DVD stores and video arcades represented the most popular places and facilities that youth most frequently visited for entertainment in their spare time. Based on the above empirical evidence, this study included two distinct categories of physical activity-related facilities: recreational and utilitarian facilities.

Recreational facilities included all the parks (e.g., miniparks, skate parks, and large urban parks), and recreation centers/community centers in the San Antonio area. *Utilitarian facilities* included local businesses such as golf courses, shopping malls, video arcades, youth organizations, amusement places, DVD and video games rental stores, and movie theatres based on Cooke et al.'s (2008) study.

Data Collection and Reduction. It is important to acquire accurate GIS data to implement necessary spatial analysis. In this study, the spatial data (e.g., shape file) of recreational facilities were downloaded from the website of the San Antonio City Department of Park and Recreation (The Department of San Antonio Park and Recreation, 2008). For other utilitarian facilities which were not recorded by the city

government, data were obtained using yellow pages and white pages on the internet. Internet search terms included the key word of these facilities such as "movie theatres in San Antonio, Texas". Some information was requested from or confirmed with parks and recreation department if the data obtained from the internet was fuzzy (e.g., a mini park without an address was confirmed with parks and recreation department whether it still existed in the city's park system). Finally, all the facilities' address information was compiled into database for data analysis.

Additionally, a Bexar street network map was downloaded from the ArcIMS website of the City of San Antonio (The City Government of San Antonio, 2008). This file was used to create a network data set for the later geocoding work and network analysis.

GIS Data Preparation. The spatial data analysis was completed using the GIS software ArcGIS 9.2, ArcView 3.3 and the extension software such as Network Analyst and Spatial Analyst (ESRI, 2002). This software package was the product of Environmental System Research Institute (ESRI). The ArcGIS extension software was usually purchased with the desktop package of the ArcGIS.

The addresses of participants' residence, recreational and utilitarian facilities were geocoded into ArcGIS. Since these address information was not feature class (e.g., shape file), they could not be added to ArcGIS directly. These addresses were geocoded into the GIS by using the *Geocode* function in the *Tool* menu. This process was actually looking for matched locations from the network dataset, which was established based on Bexar street network map as outlined above.

After the geocoding work was done, there were some unloaded addresses. The possible reason was that the road map downloaded might not record some streets in the county, or some street names were changed and it was not updated in the data set. In addition, some participants might report wrong addresses. To solve this problem, the software ***Google Earth*** was used to look for the X and Y coordinates of those addresses unable to be located (Google Earth, 2008). The coordinates were then recorded and saved in DBF files. Then, these DBF files containing X Y coordinates were added to the GIS by using *Add X Y data* from the *Tool* Menu. Finally, all the participants' residences, recreational and utilitarian facilities were displayed on the map.

GIS and Statistical Data Analysis

A one-mile service area was created for each participant as his/her neighborhood because this distance was usually considered as the radius of an individual's neighborhood (Kaczynski, Potwarka, & Saelens, 2008). The size of buffer covering service area needed to take into consideration the abundance or the paucity of the destinations when the neighborhood characteristics were examined. In addition the buffer size should be within a certain distance range so that youth can access facilities by walking or cycling instead of driving. Theories of the built environment did not provide a precise geographic scale for reasonable local neighborhood distance (Boarnet, 2004). However, the common walking speed and average time can be used to calculate the reasonable walking distance. According to transportation engineering theory, normal walking speed was consider to be between 0.75 and 1.2 m/s in urban areas (Oh & Jeong, 2007). Another study also justified the average walking speed as 4.5 km/hour, which

was equal to 1.25 m/s (McCormack, Cerin, Leslie, DuToit, & Owen, 2008). In addition, Tolley (1996) reported that a reasonable walking time was about 25 to 30 minutes. Therefore, the walking distance can be calculated by multiplying speed (1.2 m/s) by walking time (30 minute/1800s), which turned out to be around 1 mile (1609m).

Based on the above calculation, the current study focused on those facilities located within common walking distances using the radius 1-mile (1609 m) as the neighborhood buffer, which contained recreational and utilitarian facilities.

Previous studies supported this decision. Jago, Baranowski, and Harris (2006) used 1-mile buffer to examine the objective distance to the nearest parks, trails, shopping malls, grocery stores, and fast food restaurants from 210 participants. Most participants reported that one mile distance could cover major destinations where they wanted to go. The results showed that most of these facilities were closely related to participants' physical activity. Diez-Roux, Evenson, McGinn's (2007) study surveyed 2723 residents in three states and examined physical activity resources within 0.5, 1, 2, and 5 miles of each participant's residence. This study conducted binomial regression to investigate associations between physical activity and facilities. The results indicated active participants reported using resources mostly within 1 mile of their homes. Associations between physical activity and available recreational facilities were either not significant or not very strong when other distances were used to search facilities such as 0.5 or 2 miles. Additionally, Cohen, Ashwood, Scott, Overton, Evenson, Staten et al.(2006) sampled 1557 grad 6 girls in multiple states and surveyed walking distance destinations within 1 mile of each girl's home. This study reported that there were 3.5 recreational

facilities on average within one mile radius of home. Additional studies reported on larger geographical scale that, for example, nearly two third respondents of American Housing Survey (Committee on Physical Activity, Health, Transportation, and Land Use, 2005) reported having satisfactory neighborhood shopping destinations within 1 mile of their home.

Although a few previous studies used 0.5-mile (804.5 m) or 2-mile (3218 m) as a radius (Mccrmack, Giles-Corti, & Bulsara, 2008; Roemmich, Epstein, Raja, Yin, Robinson, & Winiewicz, 2006), many studies set the distance close to 1 mile, e.g., 1000m (Lee & Moudon, 2006; Kaczynski, Potwarka, & Saelens, 2008; Oh and Jeong's, 2007). In reality, the buffer size should depend on the target destinations, which is determined by the research purpose in the end. For example, open space, river and transit station are usually outside 500-meter of local residents' homes (Mccrmack et al., 2008). If the buffer size is set to lower than 500 meters, then the destinations in the area can not be sufficiently sampled. Therefore, if a study's purpose is to study destinations such as open space, river and transit station, the radius of the buffer should be at least 1500 meters in order to include most target destinations. On the other hand, if the research focuses on common destinations like post offices and bus stops, 1500-meter may be inappropriate because most participants may have access to at least one of these destinations, thus reducing the variability of the target destinations. In the present study, the buffer size was chosen based on previous research and the built environmental characteristics of the study area. There was no formula or mutually agreed upon procedure in selecting buffer size for research thus far. The decision making process

practically depended on the investigator's understanding of the on-going research and previous Literature.

The ArcGIS Extension software Network Analyst was used to calculate the network distance from an individual's residence to the closest recreational and utilitarian facility within one-mile distance. The network distance was used to calculate the shortest path to arrive destinations along certain network of transportation routes. Figure 3 provides an example of how ArcGIS calculated the shortest route from an individual participant's residence to the closest recreational facility (i.e., park) by using the street network. In addition, each participant had a one-mile service area calculated in this study. TA one-mile network service area for each participant is shown in Figure 4. This distance was used as the indicator of facility accessibility. Additionally, the available numbers of facilities within one mile were also counted for each individual by the Network Analyst. The numbers of facilities represented the facility availability.

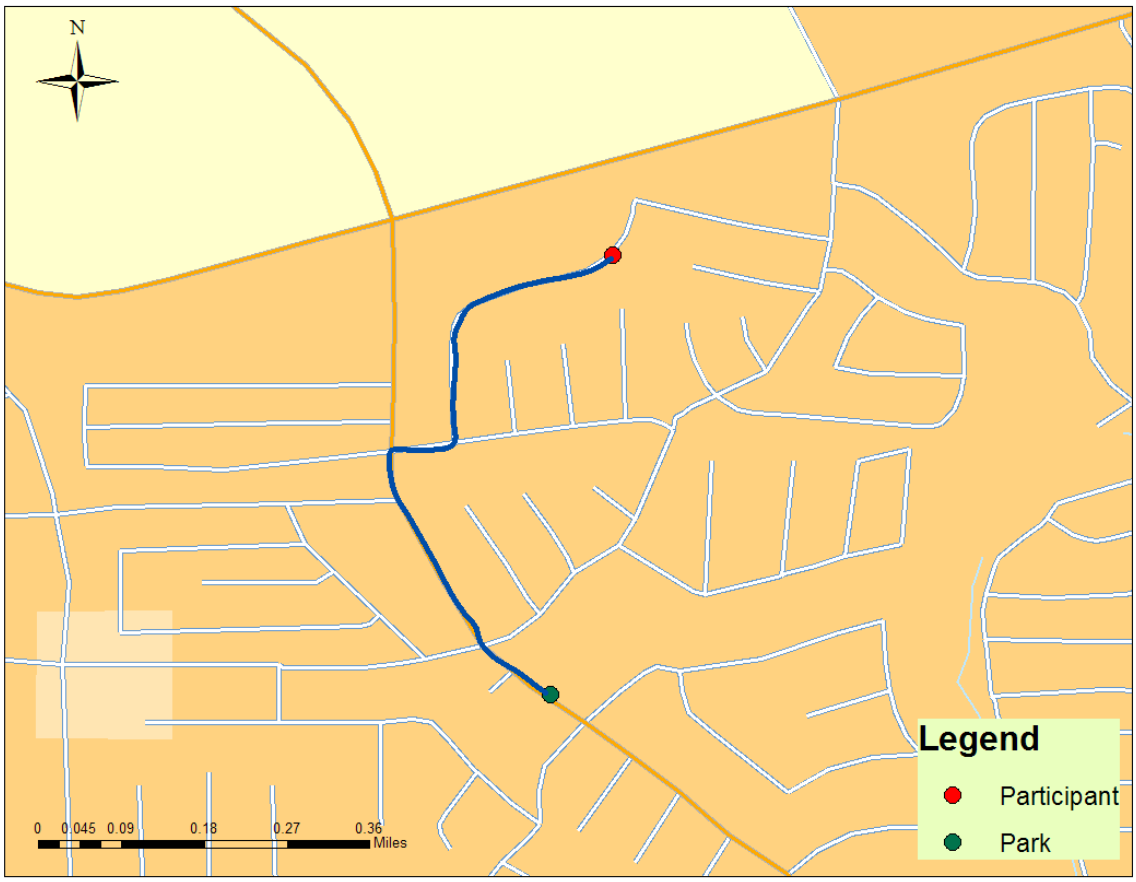

FIGURE 3 Illustration of Network Distance

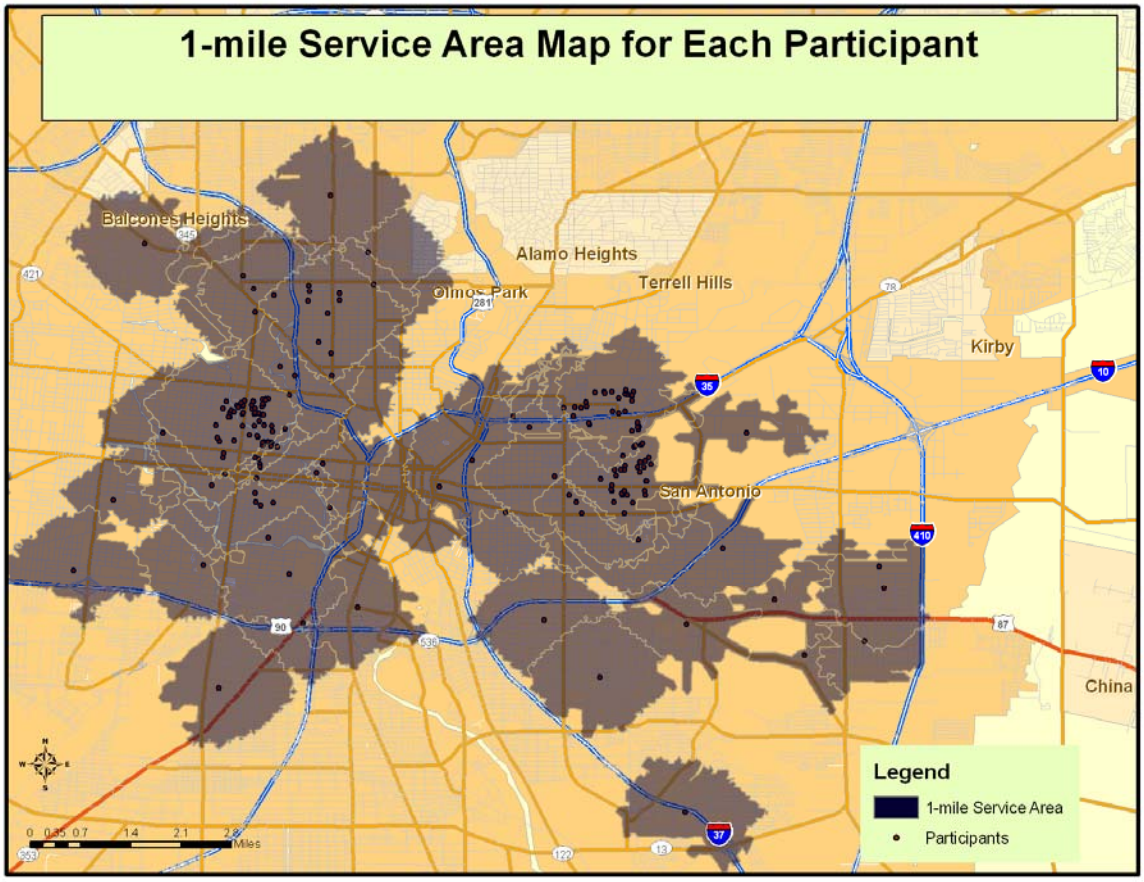

FIGURE 4 Map of 1-Mile Service Area for Each Participant

Dependent and Independent Variables. The number and the distance of the facilities within neighborhoods (1-mile distance) were dependent variables. These variables were used to represent facilities' availability and accessibility. Regression analysis was implemented for both types of facilities. The independent variable included household income. The number and the distance of two types of facilities were also used as each other's predictors and the association between both recreational and utilitarian faculties was examined. Correlation, ANOVA, and hierarchical regression

analysis were conducted to test and predict the association between participants' household income characteristics and the facility availability and accessibility within one mile distance to their residences.

Regression Model

According to Aiken and West's (1991) research, regression analysis was used for modeling and analyzing variables when the focus was on the relationship between a dependent variable and one or more independent variables. It can help researchers understand how the typical value of the dependent variable changes when any one of the independent variable changed, while the other independent variables were not changed (Aiken & West, 1991). When testing the built environment, a regression model can test for moderating effect of environmental variable on the intention-behavior-behavior relationship. Although there was no behavior data in this study, the regression model may help to control for a richer combination of socioeconomic variables and built environmental variables such as the distance and the available number of faculties.

Many studies applied regression analysis to hold constant demographic and socioeconomic variables to isolate the variables of interest (Epstein, Raja, Gold, Paluch, Roemmich, 2007; Powell, Slater, Chaloupka, & Harper, 2006; Roemmich, Epstein, Raja, Yin, Robinson, & Winiewicz, 2006). These studies controlled for socioeconomic variables and other factors that affected residential neighborhoods' characteristics. For example, Roemmich et al. (2006) used hierarchical regression models to predict youth physical activity and reported that SES may explained about 9% of the variance in the presence of recreational facilities. In addition, every 1% increases in recreation area was

associated with 1.2% average increases in youth physical activity levels. One disadvantage of regression model in this study was that it only predicted the temporal relation between variables and evidence of cause and effect was not able to be assumed. More reliable causal relationships required a longitudinal approach such as following household income over time due to its possible change over time and influence on subsequent research results.

Results

Descriptive Characteristics

All the participants were Hispanic (100%), mostly female (55%) and from low-income families. Their demographic information is summarized in Table 1. The average household income of the participants' families was $9,715/year. In San Antonio area, the average median household income was $26,842/year in 2008, which indicated that the majority of families in this study were low-income as defined by 2009 HHS Poverty Guidelines (SAMHD, 2008; U.S Department of Health and Health Services, 2009). Given that the sample had very little variance across multiple income level ranges, the low household income designation was divided into three groups as: Group 1. less than $9,715/year; Group 2. between $9,715 and less than $26,842/year; and Group 3. more than $26,842/year. The household income of the first group was below the average income ($9,715/year) of all the participants' families. This group can be referred to as the 'low low-income' group. The second group was defined as below the average household income of the local area (less than $26,842/year). The last group

represented those whose household income was above the average household income of the local area (more than $26,842/year).

TABLE 1 Demographic Information of the Study Participants

Characteristics	**Number (%)**
Total	338 (100.0 %)
Gender	
Female	187 (55.3%)
Male	151 (44.7%)
Mean Age (Y)	8.8 years old
5	18 (5.0%)
6	46 (13.6%)
7	47 (13.9%)
8	52 (15.4%)
9	49 (14.5%)
10	44 (13.0%)
11	37 (10.9%)
12	25 (7.4%)
13	10 (3.0%)
14	6 (1.8%)
17	2 (0.6%)
18	1 (0.3%)
19	1 (0.3%)
Mean Household Income ($)	$9715/year
Group 1 (<= 9,715)	80.5%
Group 2 (<= 26,842)	13.0%
Group 3 (> 26,842)	6.5%
Ethnicity	
Hispanic	338 (100%)

The average number and network distance to the closest recreational and utilitarian facilities for each individual was summarized in the Table 2. The numbers of recreational and utilitarian facilities were skewed; thus, their natural logarithms were calculated. This transformation can convert multiplicative relationships to additive relationships, and it can convert compound growth of data to linear trends. These data would be helpful to later regression models because in this way, the models were more appropriate for linear analysis of facility characteristics.

TABLE 2 The Average Number and Network Distance to the Closest Facilities for Each Individual

	N	Minimum (ft)	Maximum (ft)	Mean (ft)	Ln (Mean) (ft)
Recreational Facility Distance	338	166.62	5280	2249.14	7.72
Recreational Facility Number	338	0	25	3	1.10
Utilitarian Facility Distance	338	238	5280	3315.64	8.11
Utilitarian Facility Number	338	0	27	1	0.00

In addition, the average number and network distance of facilities were calculated in each participant's one-mile service area as indicated in Figures 5 and 6. Each service area was given a value to represent the available number of physical activity facilities. These two figures showed that the facilities were highly concentrated

in downtown area where most participants' residences were located. Many of service areas contained more than more facility which indicated that many participants had more than one facility available in their neighborhoods.

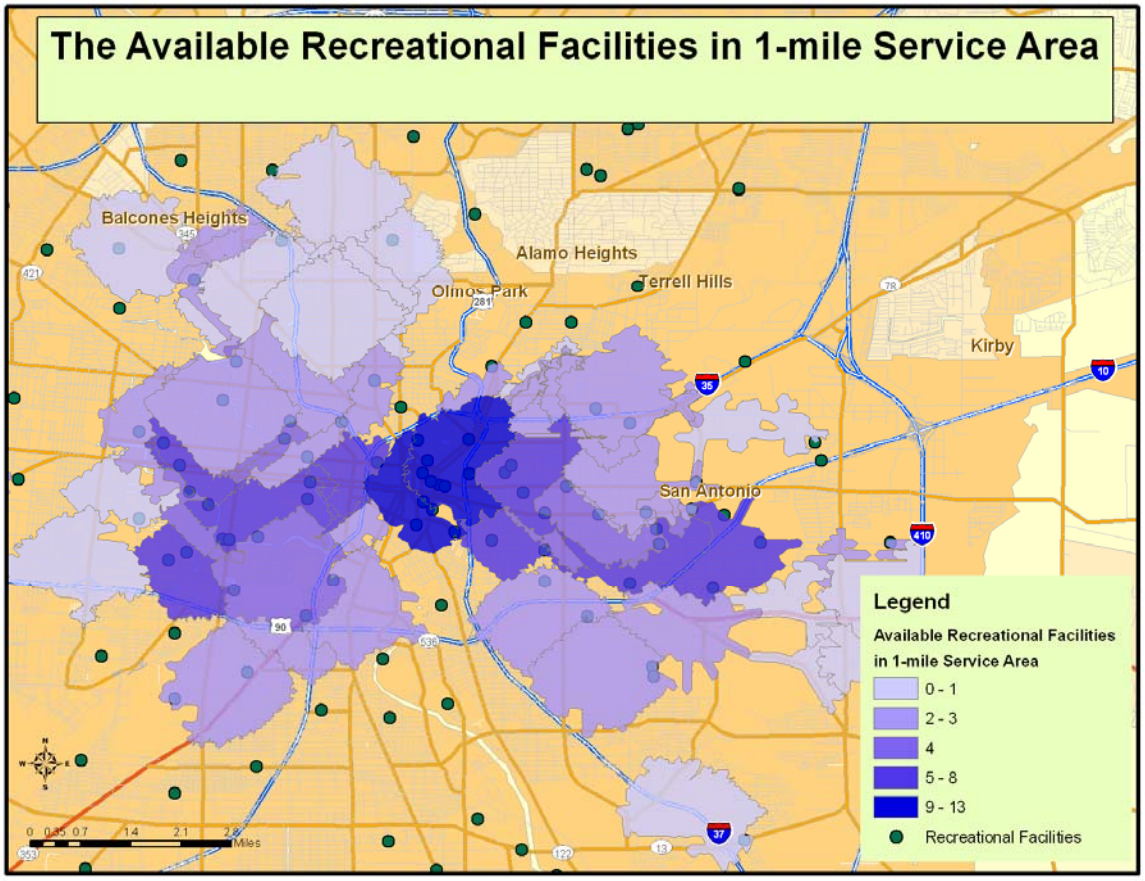

FIGURE 5 Recreational Facilities Available within 1-Mile Network Distance

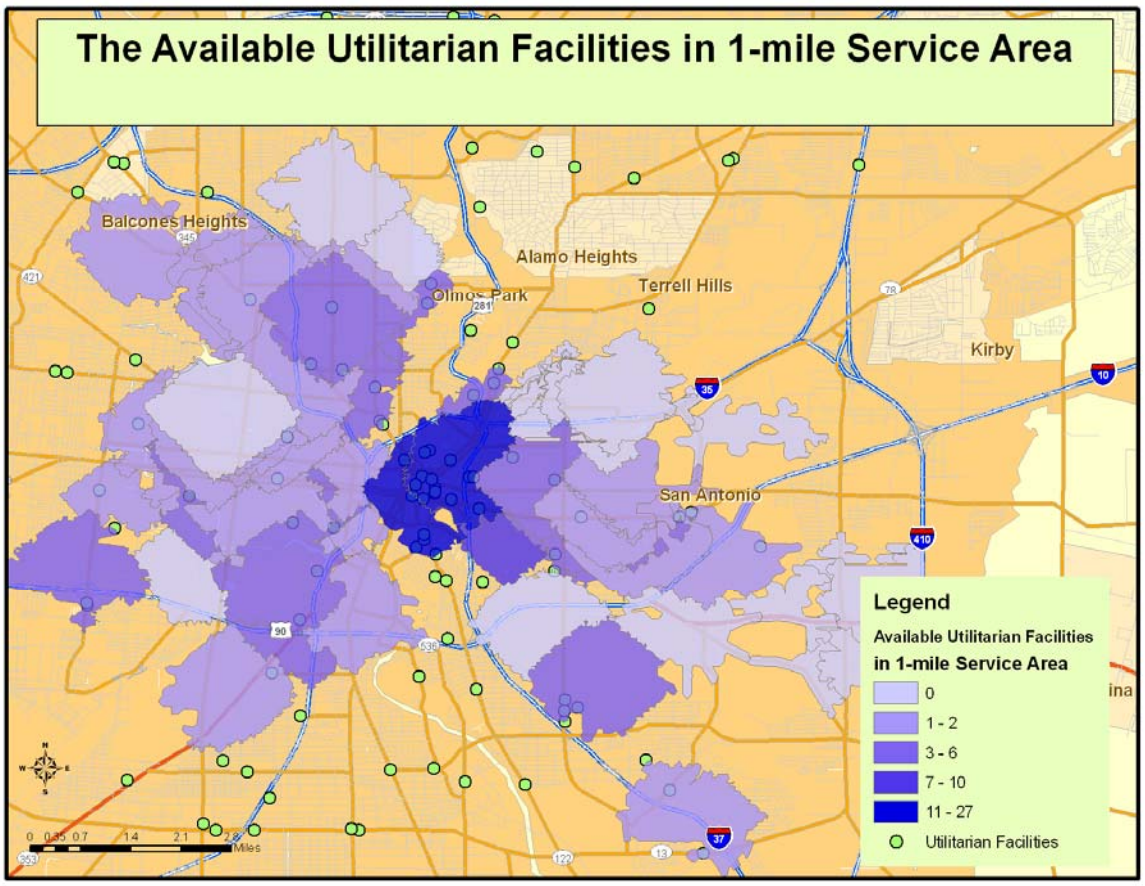

FIGURE 6 The Available Utilitarian Facilities in One-Mile Service Area

Association between Demographics and Facility Availability and Accessibility

The Spearman's rho correlation coefficient was calculated to measure how the demographic characteristics of the participants were related to their physical activity-related facilities around their neighborhoods. The results were reported in the Table 3.

TABLE 3 Correlations between Demographics and Facility Characteristics

	Age	Household Income	RecDis	RecNum	UtiDis	UtiNum
Age	1	0.126**	0.001	0.079	-0.112**	0.160**
Household Income	0.126**	1	0.16*	0.055	-0.191**	0.154**
RecDis	0.001	0.16*	1	-0.361**	0.129**	-0.044
RecNum	0.079	0.055	-0.361**	1	-0.523**	0.558**
UtiDis	-0.112**	-0.191**	0.129**	-0.523**	1	-0.864**
UtiNum	0.160**	0.154**	-0.044	0.558**	-0.864**	1

***. Correlation is significant at the 0.05 level; **. Correlation is significant at the 0.01 level**
RecDis: Distance to recreational facilities; RecNum: Available number of recreational facilities;
UtiDis: Distance to utilitarian facilities; UtiNum: Available number of utilitarian facilities

One-way analysis of variance (ANOVA) tested whether the average number and distance to recreational and utilitarian facilities were equal according to different household income for the participants. Annual household income was divided into three categories as noted in Table 4. The *F* value was significant for the distance of recreational facilities, and for the distance and number of utilitarian facilities. The means these three variables varied across three household income levels. The group with the

lowest household income ($9,715/year) reported the longest distance to recreational and utilitarian facilities compared to the other two income groups. This group had only about one half and one third of available utilitarian facilities in their neighborhoods compared to group 2 (median-income group) and group 3 (high-income group), respectively.

TABLE 4 One-Way Analysis of Variance (ANOVA) of Household Income

Household Income ($/year)	Group 1*	Group 2*	Group 3*	F	Sig.
Recreational Facility Distance (ft)	2949	2198	1598	0.83	0.001
Recreation Facility Number	1	2.1	4	0.42	0.75
Utilitarian Facility Distance (ft)	4232	3827	2023	0.67	0.001
Utilitarian Facility Number	0.9	1.6	2	1.23	0.001

*** : Household income groups: Group 1: Household Income $\leq$ $9,715; Group 2: $9,715 < Household Income $\leq$ $26,842; Group 3: Household Income > $26,842**

Hierarchical Regression Analysis

Multiple linear regressions were used to estimate the associations between facilities and participants' socioeconomic status. The dependent variables were grouped

into two categories: recreational (Recreational facilities' Number and Distance) and utilitarian facilities (Utilitarian facilities' Number and Distance). For each category, there were two dependent variables: the distance to the facilities (from participants' residence) and the number of facilities within one-mile distance. Participants' household incomes were examined as the independent variables. In addition, one type of facility's characteristics such as its availability and accessibility were also tested as independent variables when the other group of facility was assessed as dependent variables. For instance, recreational facilities' number and distance were added to the regression model as independent built environmental variables when the utilitarian facilities were tested.

Availability and Accessibility of Recreational Facility

Two separate hierarchical regressions were run to predict the number and the distance of recreational facility around the participants' neighborhoods. When the distance to the closest recreational facility was run as a dependent variable (Table 5), variables in step 1 (participants' household income) produced an R^2 of 0.15. Addition of the available utilitarian facilities and the distance to the closest utilitarian facilities did not produce a significant increase in R^2 ($p = 0.07$) in step 2.

TABLE 5 Hierarchical Regression Model Predicting the Distance to the Closest Recreational Facility within Participants' Neighborhoods

	SE *b*	***b***	***β***	R^2	ΔR^2
Step 1				0.15	
Household Income	0.003	-0.94	0.128		
Step 2				0.15	0
Ln (Utilitarian Facility Number)	0.36	-29.3	-0.103		
Ln (Utilitarian Facility Distance)	0.142	0.62	0.32		
				Total R^2 : 0.15	

In another analysis using the number of recreational facility as the dependent variable (Table 6), the same variables were added into the model to test their relationship with the number of recreational facility. In step 1, household income did not significantly increase the value of R^2 ($p = 0.142$). After adding the number and distance of the available utilitarian facilities, an additional 0.4 units was increased for R^2 in step 3.

TABLE 6 Hierarchical Regression Model Predicting the Number of Available Recreational Facility within Participants' Neighborhoods

	SE *b*	***b***	***β***	R^2	ΔR^2
Step 1				0.035	
Household Income	0.006	4.5E-05	0.45		
Step 2				0.435	0.4
Ln (Utilitarian Facility Number)	0.121	0.49	0.35		
Ln (Utilitarian Facility Distance)	0.03	0.009	-0.298		
				Total R^2: 0.435	

Availability and Accessibility of Utilitarian Facility

The similar procedure was implemented to predict the availability and accessibility of utilitarian facilities when they were tested as dependent variables (Tables 7 and 8). To predict the distance to the closest utilitarian facility, household income produced an R^2 of 0.09 ($p = 0.05$). Putting the number and distance of recreational facility produced a significant increase in R^2 for 0.25 units ($p = 0.04$).

In the analysis applying the number of available utilitarian facility as the dependent variable, household gave explanation for 12% of the variance of the dependent variable in step 1. In step 2, the recreational facility information increased R^2 by another 0.24 units ($p = 0.001$).

TABLE7 Hierarchical Regression Model Predicting the Distance to the Closest Utilitarian Facility within Participants' Neighborhoods

	SE *b*	***b***	***β***	R^2	ΔR^2
Step 1				0.09	
Household Income	0.003	-0.305*	-0.192		
Step 2				0.34	0.25
Ln (Recreational Facility Number)	2.92	-100.7	-0.46		
Ln (Recreational Facility Distance)	0.128	0.21	0.94		
				Total R^2 : 0.34	

TABLE 8 Hierarchical Regression Model Predicting the Number of Available Utilitarian Facility within Participants' Neighborhoods

	SE *b*	***b***	***β***	R^2	ΔR^2
Step 1				0.12	
Household Income	0	0.125*	1.26		
Step 2				0.36	0.24
Ln (Recreational Facility Number)	0.091	0.54	0.68		
Ln (Recreational Facility Distance)	0.01	0.0059	0.063		
				Total R^2 :0.36	

Household Income and Recreational Facility

The participants' household income contributed significantly to all the hierarchical regression models except the one predicting recreational facility number. The value of *b* was significantly positive in the model of predicting utilitarian facility number; *b* values were significantly negative when facility distances were tested as

dependent variables. These results indicated that the household income had a positive relationship with utilitarian facility number; it had negative relationship with facility's distance to an individual's residence. The household income accounted for 15%, 3.5%, 9%, and 12% of the variation in the distance to recreational facilities, the number of recreational facilities, the distance to utilitarian facilities, and the number of utilitarian facilities, respectively.

Discussion

Social ecological models provide theoretical support that the built environment plays an important role in influencing youth physical activity. Many studies have investigated a series of different types of facilities in the built environment such as public parks, sport arenas, playgrounds, green space, bike trails, recreation clubs and commercial fitness centers. However, most of these studies did not systematically collect facility data; the facility information (e.g., accessibility, fee, and safety information) was usually reported by the participants according to their perceptions. Actually, most of the research used self-report measures instead of objective measures (e.g., the actual versus perceived distance from an individual's residence to the closest park).

From this perspective, the strengths of this study included a comprehensive and objective assessment of the availability and accessibility of physical activity resources in a representative downtown area of a Southern U. S city. This study collected two types of physical activity related facilitates -- recreational and utilitarian facilities and calculated their available number and distance to the participants as spatial indicators of

availability and accessibility. All the calculations were based on facility's real locations via an objective measurement tool instead of participants' subjective perceptions. Additionally, these facilities were measured within the neighborhood distance (1-mile radius) and the rationale behind was: most people would walk or bike within a certain distance (*see method*); beyond that, usually they would choose to drive or use public transit system.

The purpose of this study was to objectively document physical activity-related facilities and examine whether accessibility and availability of these facilities varied according to participants' SES. Consistent with previous research, the primary two hypotheses of this study were supported by the evidence: youth from low income families had longer distances to and less available number of recreational and utilitarian facilities within their neighborhoods. Participants' SES, as an independent variable, significantly contributed to three regression models where the distance of both types of facilities and the number of utilitarian facilities were run as dependent variables separately. Participants' SES explained about 10% of each of these built environmental factors on average.

This study did not find the participants' SES had any association with the available number of recreational facilities in their neighborhoods. Although the ethnicity of the participants was Hispanic, the result were not consistent with other studies which examined Hispanic adult or general adult population. Studies focusing on the general adult population usually reported that residents' SES had positive associations with the presence of the physical activity-related facilities (Estabrooks, Lee,

Gyuresik, 2003; Powell, Slater, Chaloupka, 2004). These results indicated that when the SES was higher, people were more likely to have more resources and opportunities for physical activity such as walking, jogging, and cycling. For instance, Powell et al. (2006) investigated more than 14 million physical activity-related facilities on nationwide scale and collected socioeconomic data for 28, 050 zip code areas. This study examined the association between neighborhood demographic characteristics and the availability of commercial physical activity-related outlets. The results showed that these facilities were less likely to be present in lower-income neighborhoods and in neighborhoods with higher proportions of Hispanic American residence. In another word, Hispanic neighborhoods had fewer such facilities available.

The possible reason for the contradictory findings in this study and previous research may be that SES was one of the most important factors that influenced adults' residential location selection instead of youth's. When family income was higher, youth's parents may want to live in upper income neighborhoods with more recreational facilities like parks, trails, green spaces, and fitness centers. However, children and adolescents may not be able to make this decision all by themselves. They live with their parents and usually were not involved in the decision making process. Therefore, family household income had stronger association on adults' living environment while did not have too many influences on youth's residences. In addition, those features that adults preferred such as open spaces or landscapes with a lot trees were not what youth liked. For example, youth may prefer to live close to community centers so that they had more opportunities to play; but their parents may chose to live close to grocery

stores to save time and living cost. Therefore, although youth had many physical activity facilities that they preferred, these facilities may have no associations with their household income. In a word, household income in this study may not be a very strong indicator to reflect the actual SES that truly impacted youth's living environments.

To promote youth physical activity, facility availability has also been identified as an important factor to influence their behavior (Flay, 1986). Some studies have provided evidence that the proximity of physical activity-related facility had also associations with youth physical activity pattern and frequency (Sallis et al., 1990). Moreover, a person's physical activity resources vary by social or economic context (e.g., poverty or income) of the neighborhood (MacIntyre, 2000). Therefore, a better understanding of how facility availability and accessibility differ with local residents' SES would also enhance the understanding of what factors may impact or predict youth physical activity more effectively.

Another interesting, but not surprising finding was that there were associations between built environmental factors. First of all, the distance to the closest recreational facility had a positive relationship with that to the closest utilitarian facility. Secondly, the available number of recreational facility had a positive relationship with that of utilitarian facility. These results implied that recreational and utilitarian facilities were close to each other in the study area. Since their locations were close, their accessibility and availability were positively correlated. It represented when an individual had some available recreational facilities within his/her neighborhood, this person may very likely also have the similar amount of available utilitarian facilities. It also indicated that when

a participant reported a longer physical distance to the closest recreational facility in his/her neighborhood, the distance to the closest utilitarian facility also increased with a compatible proportion.

Utilitarian facilities explained about 40% of the variance of recreational facility's information; on the other hand, the recreational facility only accounted approximately 20% of the variance of utilitarian facility. These results were, however, not very frequently reported by other studies. Most previous studies sampled similar facilities as a group (e.g., parks, fitness center, school, and playground) and examined whether they varied according to neighborhoods' economic or social characteristics. The unique feature of this study was to divide the facilities into two categories according to their functions such as recreational and utilitarian purpose. These two types of facilities then were proved to have associations with each other after controlling for individual characteristics.

These associations represent recreational and utilitarian facilities were related, but did not necessarily imply causality. According to the first law of geography, "Everything is related to everything else, but near things are more related than distant things (Tobler, 1970, p.236)." Given the limit space of downtown area, recreational and utilitarian facilities are closer than other "distant things". This close physical distance makes them more related than other distant facilities. In urban area, many parks were located nearby residential areas for the convenience of local residents. In addition, the commercial settings like shopping malls and movie theatres were usually built around neighborhoods in downtown areas. Hence, the research results of the present study

indicated an obvious connection between recreational and utilitarian facilities. But since this study focused on settings in downtown area, it was not clear whether this connection also existed in rural areas or suburban. Furthermore, the utilitarian facilities in the present study included more commercial settings than other studies. Therefore, the research results may reflect the relationship between recreational facilities and commercial utilitarian facilities rather than public utilitarian facilities (e.g., schools, post offices, and public libraries).

Implications

To better understand the spatial attributes of physical activity-related facilities and how they link to youth physical activity further research is needed. The participants in this study were low-income Hispanic youth. This group had some unique characteristics compared to other groups: the obesity rate was higher (National Center for Health Statistics [NCHS], 2009), their neighborhoods had more families living below the poverty levels, their parents' incomes had unique patterns connected with their BMI (Troiano & Flegal, 1998), their family incomes were very low, and their culture was also different. These features may give low-income Hispanic youth very different spatial perceptions and attitudes toward their neighborhoods. Therefore, the factors in the built environment may exert different influences on their physical activity. For instance, the cost to access the physical activity facilities may be a major barrier for youth in this group because of their low household incomes. A lot of them may not be able to pay for activities in community centers and other commercial facilities even if the admission fees are below the average costs. Thus, besides spatial attributes those factors that are

closely related to this group's characteristics should be explored. For instance, the costs of facilities can be compiled to GIS data and the distances to facilities can be transferred to travel costs values that consider not only physical distance, but also include admission fee as an important fact that may impact low-income group's physical activity.

The participants were located in inner city urban areas in this study. Different types of facilities like residential townhouses, commercial facilities, and recreational facilities were located within close proximity to one another. The characteristics of land use were different in this area compared to what may occur in others areas such as the suburbs. In suburban areas, housing is separated from commercial development and most areas have one single use. In urban area, lands are used with different purposes. Commercial facilities, retail stores, public parks, community centers, and residential houses are more likely to be located in one area. This phenomenon may be because of the zoning codes and urban planning regulations proposed by the local government, or it may be because of the land use development history. Many old neighborhoods were established a long time ago. They did not have zoning codes or urban planning regulations at the beginning; different types of facilities were established in their lands. Today, it is difficult to separate one piece of land and define its land use function in urban areas. This feature actually increases the facility accessibility for youth since buildings are close to one another and trip lengths are reduced. The shorten distance thereby increased the likelihood of alternative forms of transportation like walking, bicycling, and transit. However, the results in this study did not find this pattern. In the future, it is interesting to study how these features influence low-income Hispanic youth.

The issues like whether the land use features in urban areas increase youth physical activity and reduce their risks of overweight need future investigations.

Limitations

There are several limitations for this study and are listed as the following: 1)One of the limitations of this study was that the hierarchical regression model usually presumed causal priority for the relationship between dependent and independent variables (Petrocelli, 2003), but as discussed above, the association between recreational and utilitarian facilities could not be proved to be a causality. Their relationships were more related to spatial distribution patterns: many convenient facilities appear in one or several areas and they were distributed like clusters. It was not statistically confirmed that recreational and utilitarian facilities were close to each other in the current study area. But some cluster analysis software like *SaTscan*, *R* or *GeoDa* can be used to further demonstrate that these two types of facilities are spatially related to each other. In the future it may also be possible to prove whether there exists any causal relationship or whether there are any hidden variables between facilities by applying new analysis.

2) The issue related to the scope of the study was that the relationship between the availability and accessibility of facility, and youth physical activity were not examined. This research was the first part of a series of studies, and the ultimate purpose was to apply the research findings to promote youth health behaviors. By studying how facility availability and accessibility were influenced by individual characteristics (e.g., SES), this study may provide more evidence in increasing the opportunities for youth to have physical activity. In the future, when physical activity

data are available, further analysis will be implemented to analyze the relationship between physical activity and the accessibility and availability of facility. SES, as one of important individual characteristics, will also be involved in the model to provide a potential explanation for SES differences in youth physical activity. With different-level parameters, it is possible to establish multilevel models to test how different factors influence youth behaviors. 3) Data were available from only two youth centers in the current stage. The program just started to operate in 2008 fall; therefore, participants of these two available centers were used as a sample to represent the whole youth community. This information may not reflect the true population of youth from low-income families. When more resources for sampling are available, a larger sample size will improve the power of the statistical analysis and provide a better understanding of the research questions.

In conclusion, facility as one of the most important factors discouraging or promoting youth physical activity, has been examined according to participants' individual differences of demographics in this study. To date, most physical activity promotion interventions relied on individual-level approaches, frequently indicating limited success in promoting youth behavior change (Dishman & Buckworth, 1996). This study systematically examined two types of facilities and provided a good potential opportunity in testing how individual characteristics and built environmental facilities together influence youth physical activity for future research. Taken together, individual characteristics need to be expanded to contain built environmental factors that impact the availability and accessibility of facilities to promote youth physical activity.

CHAPTER III

STUDY 2: HISPANIC YOUTH DEMOGRAPHICS AND THEIR FOOD ENVIRONMENTS

Although research on the built environment for youth dietary behavior is less conclusive than physical activity, it is commonly believed that youth obesity and eating habits are closely related to their nutrition environments (Glanz, 2005). Some studies have examined the nutrition environment at school such as the association between available vegetables and fruits and youth overall consumption of vegetables and fruits (French & Stables, 2003). However, few studies examined the nutrition environment outside school. Therefore, this study explored factors related to neighborhood nutrition environment and youth's socioeconomic status.

Literature Review

SES, Food Outlets, and Youth Obesity

While obesity has a broad range of causes (e.g., gene, policy, culture and social relationship), the nutrition environment is a key variable in the rapid development of the obesity epidemic (Bouchard, 1991). Research indicated that youth living in low-income neighborhoods had poorer access to foods and fewer healthy food outlets, and consequently had much higher rates of obesity (Block, Scribner, & DeSalvo, 2004). However, the mechanism of how SES affects youth obesity or dietary choices is still at its beginning stage (Reidpath, 2002).

There are two sources of evidence in studying SES, food outlets and youth obesity. First, some research has investigated the availability and accessibility of both

healthy and unhealthy food stores available within youth's neighborhoods. These studies reported that youth living in inner city and low-income neighborhoods had less access to full-service supermarkets than those in the suburbs (Cotterill R & Franklin, 1995). Furthermore, youth with low SES had to depend on smaller grocery stores or fast food stores to obtain limited healthy food at a higher cost (Bolen & Hecht, 2003).

Another important direction in studying SES, food outlets, and youth obesity is to examine the availability of energy-dense foods in low-income neighborhoods (Morland, et al., 2002). According to a report, the percentage of meals consumed out of home and at a fast-food restaurant has increased by 2000% from 1977 to 1999 in the United States (Bowman & Vinyard, 2004). Youth visited fast-food outlets twice a week on average and they increased their total fat, total calories, soft drinks and French fries intakes by 10% (French, Harnack, & Jeffery, 2000). Furthermore, there was evidence indicating that a disproportionate number of fast-food restaurants were located in low-income neighborhoods (Block, et al., 2004). This suggests that youth living in low-income families may be at a disadvantage in reaching the recommended diet guidelines to avoid obesity and overweight.

Nutrition Environment

To date most research examining youth nutrition environments outside the home and school is from the fields of public health, urban planning, and healthy psychology. According to Sallis and Glanz (2006)'s study, factors of the nutrition environment fall under two domains: consumer and community nutrition environment.

Consumer Factors of Nutrition Environment

Consumer factors refer to price, nutrition information and availability of healthy or unhealthy food from food outlets within neighborhoods (Sallis & Glanz, 2006). Consumer factors contain more micro-level information about a nutrition environment such as promotions, placement or cost of healthy food.

The availability of healthy food represents an important characteristic of the neighborhood nutrition environment. Studies have documented that some healthy foods (e.g., fruit, vegetable, and juice) had poorer quality and were less available in low SES and disadvantage neighborhood areas, especially for minority groups (Edmonds, Baranowski, Baranowski, Cullen, & Myres, 2001; Horowitz, Colson, Hebert, & Lancaster, 2004; Yoo et al., 2006). A 2004 study surveying residents in the Latino area in New York reported that Mexico American had less available healthy foods and the prices of the foods were much more expensive in their neighborhood grocery stores compared to other high SES areas (Horowitz et al., 2004).

Another study in the Houston Area investigated the frequency of food shopping at supermarket, convenience stores and restaurants among different racial groups. The study found African American families living in low-income areas shopped for food less frequently compared to other groups (Yoo et al., 2006). In addition, education level was negatively associated with the use of convenience store.

Edmonds et al. (2001) examined the grocery stores and restaurants available in 11 census tracts among 11-14 years of age African American boys and studied their fruit, juice and vegetable (FJV) consumption. The study conducted face-to-face

interview for youth, phone interviews for parents and direct observations. The results indicated that median household income was significantly associated with restaurant fruit availability; African American boys' self-reported consumption of juice and vegetables was positively associated with restaurant juice and vegetable availability. The grocery stores in lower income neighborhood offered fewer and poorer quality FJV and discouraged their purchase and consumption.

Socioeconomic status has been confirmed to link to an individual's eating pattern. For example, residents with higher SES consume more vegetables than those with lower SES (Anderson et al., 1994; Shepherd et al., 1996). People with low SES had lower budgets to purchasefoods compared to those with higher SES (Senauer, Asp, & Kinsey, 1998); therefore, they were less likely to meet the recommended diets guidelines to prevent obesity (WHO, 2003). For instance, people with low SES had a high consumption of cereals and a low consumption of fruit and vegetables. The possible reason is that the low consumption of fruit and vegetables was associated with relatively lower diet cost and hence, residents living in low-income areas had this eating pattern to reduce their food cost (Drewnowski, Darmon, & Briend, 2004).

It is natural to conclude that people with low SES have higher chances to choose energy dense food (e.g., high-fat and -sugar food) and this eating pattern may contribute directly to the high rates of obesity among low SES populations (Drewnowski, 2003). However, it is not clear whether families with low budgets for food influence food selection. For instance, if an individual has a low amount of money to spend on food, does this mean he/she will choose an energy dense diet?

Darmon, Ferguson, and Briend (2003) used diet optimization to study the impact of income constraints on food selection and dietary quality. It proved that there existed a direction relationship between diet cost and energy dense food selection. Low SES groups had higher chances to select high energy dense food, such as high-fat, -sugar, -calorie and low-fiber foods, which consequently increased their rates of obesity. Generally, an individual's SES was a key element in predicting the prevalence of obesity; a low SES may represent a higher chance of obesity and overweight (Darmon et al., 2003).

Among youth in middle- and high-income families where food cost was not a barrier, evidence indicated that these children and adolescents might also report low consumption of vegetables or fruits (Baxter, Schroder, & Bower, 1999). This implied that besides SES, youth' eating pattern may be also influenced by the perceptions of available healthy food. If this was true, it was straightforward to explain that youth from SES family may be also at a disadvantage in their perceptions of healthy food. Because they usually have lower consumption of fruits, vegetables and higher consumption of high-fat and sugar foods, youth from low-income families may have lower perceptions of the healthy food compared to their higher SES peers (Baxter, Schroder, & Bower, 1999).

Community Factors of Nutrition Environment

Community Nutrition Environments refers to the location, number and type of food outlets in a community (*Glanz, 2005*). Grocery stores, supermarkets and restaurants were the most important food outlets outside the home for youth *(*Bolen & Hecht, 2003).

Some studies have examined how the number and proximity of grocery stores, supermarkets and restaurants influenced youth health behavior. Recent studies provided evidence to support that additional supermarkets within residential areas would increase fruit and vegetable intake in African American, and the proximity to supermarkets was shown to improve the dietary quality of pregnant women (Laraia, Siega-Riz, Kaufman, & Jones, 2004; Morland, Wing, & Diez-Roux, 2002). In addition, there were fewer supermarkets which had farther distance in predominantly black neighborhoods compared to white neighborhoods (Laraia et al., 2004; Morland et al., 2002). Besides number and location, accessibility was also an important issue and may include topics like whether or not and to what extent the food outlets were located in a neighborhood community, the operation style (e.g., with drive-through windows or not) and hours (e.g., 24 hours or less).

One of the important findings in this field was that there were strong disparities among different racial, ethnic and socio-economic status in their nutrition environments. Some studies have found that disadvantaged groups such as black and Latinos groups live in areas with poor access to healthy foods (Inagami, Cohen, Finch, & Asch, 2001). For example, there were further distances to and fewer supermarkets in predominantly black neighborhoods compared to white neighborhoods; in addition, food items at supermarkets were consistently lower in minority neighborhoods (Yoo, et al., 2006).

To date, only a few studies have examined the potential causal relationship between youth obesity and their nutrition environment. Among adults, one study surveyed 2620 residents from 65 neighborhoods in Los Angeles Areas (*Inagami et al.,*

2001). After examining the location of grocery stores and its association with body mass index (BMI) with a multiple linear regression model, the study found individuals living in disadvantaged areas had higher BMI; people had higher BMI if they owned cars and traveled further to grocery stores. Additionally, there was significant correlation between BMI and SES when grocery store location was statistically controlled.

Another recent state-level analysis in the United States reported only a modest association between obesity and the density of restaurants providing fast-food. The density of such restaurants accounted for approximately 6 percent of the variance in state obesity rates (*Simmons et al., 2005*).

Socioeconomic status (SES) is a key variable in studying community nutrition environments such *as* location, number and type of food outlets in a community *(*Turrell & Giskes, 2008). Research has identified that residents living in low-income and inner city neighborhoods have greater exposure to fast foods stores and poorer access to supermarkets (Morland et al., 2006; Zenk et al., 2005). Many studies indicated that the availability of supermarkets may represent more healthy and affordable food such as fruit and vegetable intakes (Kumanyika & Grier, 2006). Other studies on fast food restaurants showed that the availability of fast food stores was associated with more energy-dense and unhealthy food like high-fat and high sugar food. (Bowman & Vinyard, 2004; Satia et al., 2004). For youth, their consumption of fast food increases their calorie, fat and sugar intakes, and decreases their fiber, fruits and vegetables consumption (French et al., 2001). These unhealthy food intakes increase youth's risk of being overweight and obesity (Detournay et al., 2000). Therefore, SES may be related

to the location, number and type of fast food and supermarket stores within youth's neighborhoods; furthermore, it may be also associated with high risks of obesity and overweight for youth.

SES and Fast Food Stores. Fast food restaurants were defined as self-service or carryout eating places without wait service (Satia, Galanko, & Siega-Riz, 2004). Fast food stores provide high in fat, sugar, and salt and low in fiber foods, and regular consumption of fast food increases the chance of being obesity and overweight (Pereira et al., 2005). Research has been documented that the SES differences in the consumption of fast foods may be a possible reason to explain higher rate of obesity among individuals with low SES (Cummins, McKay, & Macintyre, 2005).

Although research has examined the association between SES and dietary behavior, few of them exclusively studied SES and fast food stores (Turrell & Giskes, 2008). There is even less research on youth in this field. Most studies investigated the SES of general population with other factors such as race/ethnicity, education, and gender (French et al., 2000; Satia et al., 2004); these results were not consistent and their reliabilities were questionable.

According to a recent literature review, so far there is no confirmed evidence to support if greater fast-food consumption is associated with living in a low SES area (Turrell & Giskes, 2008). However, some studies examining the link between the presence of fast food stores and SES reported some consistent results. In the U.S, Block et al (2004) and Lewis et al (2005)'s studies both reported that low-income, especially African American neighborhoods, have more available fast food outlets compared to

higher income living areas (e.g., white areas). In addition, Cummins et al. (2005) and Macdonald, Cummins, and Macintyre (2007)'s studies both found the density of fast food outlets was negatively associated with residents' income levels in England and Scotland.

Evidence from Australia also supports the above research findings. Reidpath et al (2002) investigated the prevalence of fast-food stores in Melbourne and examined the relationship between density of these stores and residents' income backgrounds. The results indicated that the density of the fast food stores were significantly associated with disadvantage areas; there were 2.5 times more fast food outlets in those low-income neighborhoods than high-income neighborhoods.

However, there are also inconsistent findings. For example, Morland,Wing, Diez Roux, and Poole (2002) reported that no significant association between income and the presence of fast food stores in the neighborhoods. Another study from England also pointed out that there was no association between the prevalence of fast food outlets and neighborhood disadvantage (Macintyre, Mckay, Cummins, & Burns, 2005).

SES and Supermarket. Supermarkets have been reported to have more healthful food and offer foods at lower costs (Horowitz et al., 2004). Lack of local food stores such as supermarkets may cause residents to have limited access to healthy foods, and in turn negatively influences their dietary behaviors and increases the risk of obesity and overweight.

Research evidence has indicated that supermarket availability differs by neighborhood SES in the United States. Shaffer (2002)'s study found low-income

residents had significantly fewer supermarkets than high-income residents. Other studies collecting multi-state samples reported similar results: low-income neighborhoods (e.g., Black neighborhoods) had fewer numbers of available supermarkets compared to median- and high-income neighborhoods (e.g., white neighborhoods) (Moore & Diez Roux, 2006; Morland et al., 2002b). The same evidence was also reported in nationwide level. For instance, Cotterill and Franklin (1995) reported that low- versus high-SES neighborhoods had fewer available supermarkets.

In addition, the perceptions of youth and their parents toward accessibility of the food environment may also influence youth eating behaviors. For example, when parents perceive the neighborhood as not safe, they may make decisions to not visit eating establishments outside the home with their kids (Booth, Pinkston, & Poston, 2005). These perceptions may be based more on aspects of neighborhood disrepair e.g., graffiti and concentration of vacant residences. In addition, perceptions regarding community risks (violent and crime) may also influence local residents' dietary choices (Carver, Salmon, Campbell, Garnett, Baur, & Crawford, 2005). Although the objective measures such as proximity to the food outlets may be small (Estabrooks, Lee, & Gyuresik, 2003), children and adolescents could report very different perceptions regarding accessibility in their neighborhoods (Zenk et al., 2005). These negative perceptions would make youth feel the neighborhood was very dangerous and dare not go outside. The perceptions may become barriers that decrease the chance youth walk or bicycle to the closest food outlets for food purchasing.

Purpose and Hypothesis

The purpose of this study was to examine the association between youth household income and the availability and accessibility of food outlets.There were two hypotheses in this study:

Hypothesis 1: *Youth living in lower SES neighborhoods have more available fast food outlets with shorter distances within 1 mile distance from their residences;*

Hypothesis 2: *Youth living in lower SES neighborhoods have fewer available supermarkets with longer distances within 1 mile distance from their residences.*

Method

Program and Participants

San Antonio is the eighth largest city and one of the poorest metropolitan areas in the nation (U.S Census bureau, 2008). About 19.8 percent of the population of Bexar County, where San Antonio is located, live below the poverty level compared to national average rate of 13.2 percent (SAMHD, 2008). *San Antonio Youth Centers* is a non-profit organization who aims at developing the strengths, talents and skills of inner-city youth and their family member to fulfill their potentials. Dan Cook Youth Center and Eastside Youth Center participated in a program called "San Antonio comprehensive fitness & nutrition program". Participants in these two centers were all Hispanic youth. These two centers were in the San Antonio Independent School District (SAISD) where 93% of students were classified as economically disadvantaged (SAMHD, 2008). The unemployment rate of local residents in the census tracts of these two centers was 17% according to a recent survey in downtown area of San Antonio (SAMHD, 2008).

This program did not have an admission policy to restrict the eligibility of students in the local area. However, the program encouraged special groups like economically disadvantaged and minority children and adolescents at high risks of obesity to participate. A survey was conducted to take baseline health measurements. Given the ethnic characteristics of the participants (Hispanic youth), all services were delivered in English and Spanish and all materials were low-literacy. Participants from each grade were given standards-based materials and activities according to their interests. Additional fitness and nutrition education workshops were held with participants' parents once a month to help deliver better service to the participants. In the workshops, the health promoter covered key issues regarding physical activity and dietary behavior. Checklists were used to determine whether parents applied the tips provided and to identify healthy problems for youth in their daily lives.

The objectives of the program were to generate a 10% decrease in youth body weight index (BMI), to increase participant physical activity levels for 25%, and to improve 90% of participants' eating behavior such as healthier food menus and food consumption patterns.

GIS Data Acquisition

Fast food restaurants and supermarkets were selected as food outlets in the participants' neighborhoods. Fast food restaurant was defined mainly as limited-service restaurants (NAICS code: 722211) under the category of 'Food Services and Drinking Places' in 2007 NAICS list (U.S Census Bureau, 2009c). It refers to those establishments primarily engaged in providing food services (except snack and

nonalcoholic beverage bars) where customers generally ordered or selected items and paid before eating. Food and drink may be consumed on premises, taken out, or delivered to the customer's location. Fast food establishments were selected if these stores belonged to a company with more than one franchise nationwide or in multiple states, provided facilities for customers to consume their meals on site, and served complete meals ordered without the assistance of waiters or waitresses.

Supermarket has been defined by some studies as large corporate owned "chain" food stores with a limited selection of foods, including fresh meat, wheat-based Western style bread, fruits, vegetables, and dairy milk (Smoyer-Tomic, Spence, Raine, Amrhein, Camron, Yasenovskiy et al., 2008). In this study, the North American Industry Classification System (NAICS) was used as the standard in classifying food establishments in the San Antonio area. The official 2007 NAICS codes were developed under the auspices of the Office of Management and Budget (OMB) and the codes included definitions for each industry, background information and a comprehensive index (U.S. Census Bureau, 2009a).

Supermarket was defined as a subgroup under the category of grocery stores according to NAICS codes (U.S Census Bureau, 2009b). There were two type of supermarket: one referred to supermarket and grocery stores, which were establishments primarily engaged in retailing a general line of food, such as canned and frozen foods; fresh fruits and vegetables; and fresh and prepared meats, fish, and poultry (NAICS code: 445110); the other type was supermarket/general merchandise combination store, which comprised establishments primarily engaged in retailing a general line of

groceries in combination with general lines of new merchandise, such as apparel, furniture, and appliances (NAICS code: 452910). In this study, supermarket referred to the first type (NAICS: 445110) mainly selling a general line of food. In total 271 fast food restaurants and 62 supermarkets were identified in the participants 'neighborhood areas using the yellow and white pages from both the internet and hard copy phone books. Internet search terms included the key words of these facilities such as "supermarket in San Antonio, Texas". Since all the participants' residences were inside the highway 410 loop, food outlets were excluded if they were outside the loop. The addresses of all the food facilities were input into the database for data analysis. In addition, a Bexar street network map was downloaded from the ArcIMS website of the City of San Antonio (The City Government of San Antonio, 2008). This file was used to create a network dataset for the later geocoding work and network analysis. Figure 7 delineates the spatial distribution of the food outlets and participants' residences in the San Antonio study area.

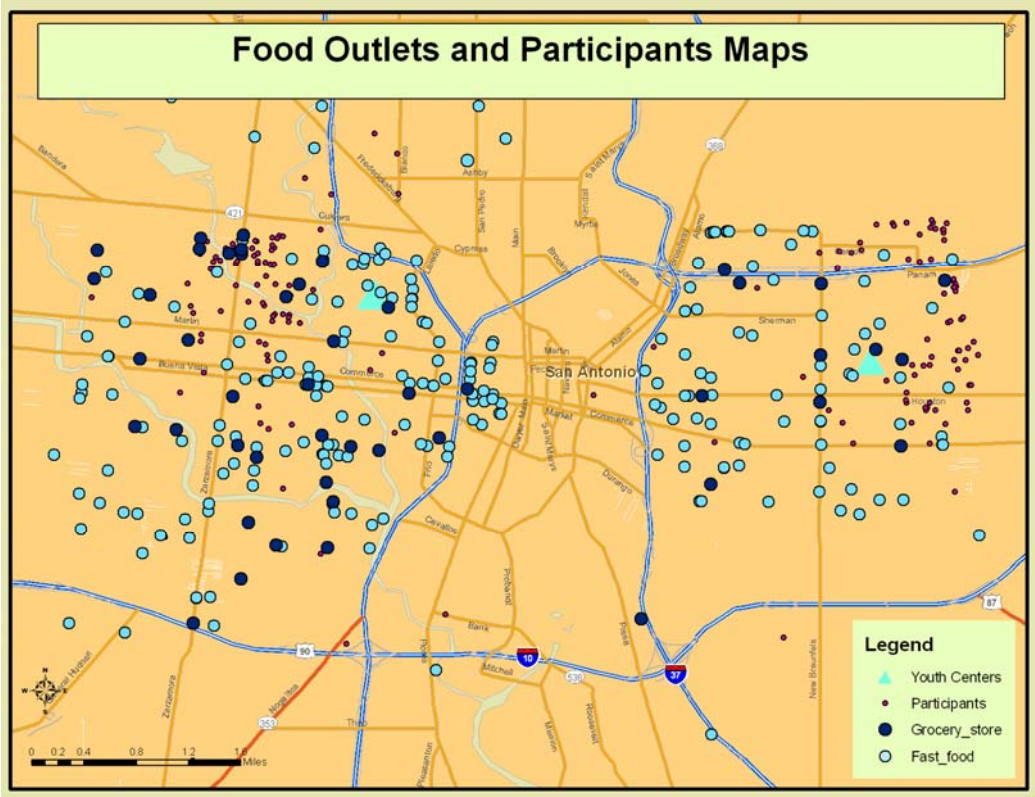

FIGURE 7 Food Outlets and Participants Maps

GIS Data Preparation

GIS software ArcGIS 9.2 designed by Environmental System Research Institute (ESRI) and its extension software such as Network Analyst and Spatial Analyst were used for spatial analysis (ESRI, 2002). Each location of participants' residences, fast food restaurants and supermarkets were manually checked and geocoded into ArcGIS. Facilities' addresses information was geocoded into GIS by using *Geocode* function. After adding the data, the geocoding process would look for matched locations from the

network dataset, which was established based on Bexar street network map as outlined above. The address information could not be added as layers because they were not a feature class in this study.

The geocoding process left some unloaded addresses, which were not able to be located by GIS. The possible reason was that some street names were changed and they were not updated in the data set, or the road map was not complete and did not record every street in the county, or some participants might have reported wrong addresses. To solve this problem, the software ***Google Earth*** was used to look for the X and Y coordinates of those addresses unable to be located (Google Earth, 2008). The coordinates were then manually checked, recorded, and saved in DBF files. Then, these DBF files containing X Y coordinates were added to the GIS by using *Add X Y data* from the *Tool* Menu. Finally, all the participants' residences, fast food restaurants, and supermarkets were displayed on the map.

GIS and Statistical Data Analysis

Setting Buffer Radius

This study set 1-mile distance as the searching radius for the closest food outlets for the participants. This decision was mainly based on empirical evidence. Distance is very important for youth in making decision on whether or not to go shopping. A recent report showed 37% of African American shoppers were willing to travel one mile or less to their primary grocery stores to buy food; beyond this distance they were not very likely to go outside for shopping (The African American Grocery Shopper, 2000). Another study stated that 88% of youth reported that they had fast food restaurants in

1500 meters of their home (Smoyer-Tomic, Spence, Raine, Amrhein, Camron, & Yasenovskiy, 2008).

In addition, one study conducted in New Orleans of Louisiana delineated 1-mile and 0.5-mile buffers as shopping areas; it also mapped all fast food restaurants in 156 census tracts within the city boundary (Block, Scribner, & DeSalvo, 2004). When the study conducted bivariate analysis, the household income had negative association with the presence of fast food restaurant. This association was further explored by regression analysis. The regression equation indicated that household income explained 3.3% of the variance in the model when 1-mile buffer was used as shopping area. Within this 1-mile shopping area, every 4.8% increase in household income, the fast food restaurants number in a unit area increased 10%. However, the result of sensitivity analysis found that household income was no longer a significant predictor when a 0.5-mile buffer was used as a shopping area. The author determined that 1-mile buffer was more reasonable for the study because it represented a distance that an individual was willing to routinely travel to buy food in the local communities (Block et al., 2004). In addition, some commercial companies' marketing strategies also provide some support that 1-mile distance seemed more justified to be defined as shopping areas to buy food. For instance, McDonald selected new store locations within a 3- to 4-driving minute trip for the local residents (Lubow, 1998). This strategy was based on the assumption that on average a person would drive 25 mile/hour or walk 2.8 mile/hour. The strategy could make sure that a store was located within about 1.5 miles of the average American's residences. This distance for buffer designation was more consistent with shopping

areas with 1-mile buffer than those with 0.5-mile or 5-mile buffer and it supported that 1-mile buffer was an appropriate choice for shopping area.

In addition, the one-mile distance was also supported by transportation engineering as an appropriate walking distance. The common walking speed was 1.2 m/s and the maximum time an individual usually wanted to travel on average was 25-30 minute (Macintyre, Macdonald, & Ellaway, 2008; Norman, Schmid, Sallis, Calfas, & Patrick, 2005). The walking distance was about 1 mile by times speed by time. Therefore, 1-mile distance represented a comfortable distance that an individual may go outside for walking or shopping.

Finally, the 1 mile buffer provides a large enough range to display a variety of fast food outlets.

The ArcGIS Extension software Network Analyst was used to calculate the network distance from an individual's residence to the closest food outlets (e.g., fast food restaurants and supermarkets) within one-mile distance. The one-mile network service area for each participant is illustrated in Figure 4. This proximity was used as the indicator of facility accessibility. Additionally, the available numbers of food outlets within one mile were also counted for each individual by the Network Analyst. The numbers of food stores represent the facility availability.

Dependent and Independent Variables

The number and the distance of the food outlets within neighborhoods (1-mile distance) were dependent variables. These variables were used to represent food facilities' availability and accessibility. Regression analysis was implemented for both

types of facilities. The independent variable included household income. The number and distance of two types of facilities were also used as each other's predictors and the association between both fast food restaurants and supermarkets was examined. Correlation, ANOVA, and hierarchical regression analysis were used to test and predict the association between participants' demographic characteristics and the food outlets' availability and accessibility in the neighborhoods.

Regression Model Analysis

According to Aiken and West's (1991) research, regression analysis was used for modeling and analyzing variables when the focus was on the relationship between a dependent variable and one or more independent variables. It can help researchers understand how the typical value of the dependent variable changes when any one of the independent variable changed, while the other independent variables were not changed (Aiken & West, 1991). When testing the built environment, a regression model can test for moderating effect of environmental variable on the intention-behavior-behavior relationship. Although there was no behavior data in this study, the regression model may help to control for a richer combination of socioeconomic variables and built environmental variables such as the distance and the available number of faculties.

Many studies applied regression analysis to hold constant demographic and socioeconomic variables to isolate the variables of interest (Epstein, Raja, Gold, Paluch, Roemmich, 2007; Powell, Slater, Chaloupka, & Harper, 2006; Roemmich, Epstein, Raja, Yin, Robinson, & Winiewicz, 2006). These studies controlled for socioeconomic variables and other factors that affected residential neighborhoods' characteristics. For

example, one recent study applied regression model to predict the fast food restaurant density within 156 census tracts in a Midwest city (Block et al., 2004). The results showed that household income explained about 3% and the percentage of black residents explained 19.1% of the variance in the fast food restaurant presence within 1-mile buffer of census tracts. One disadvantage of utilizing a regression model in this study was that it only predicted the temporal relation between variables and evidence of cause and effect can not be assumed.

Results

Descriptive Characteristics

All the participants were Hispanic youth (100%) and from low-income families. Their average household income was $9,715/year. Most participants were 6 to 12 years old and females represented about 55% of all the participants. The demographic information is summarized in Table 1 (See Study I).

The average number and network distance to the closest supermarkets and fast food restaurants for each individual was summarized in the Table 9. The average distances for fast food restaurants and supermarkets were 1026 feet (0.19 mile) and 2645 feet (0.5 mile), respectively. The average number of fast food restaurants and supermarkets are 3 and 4, respectively. In addition, the average number and network distance of food outlets were calculated in each participant's one-mile service area as indicated in Figures 8 and 9.

TABLE 9 The Average Number and Network Distance to the Closest Outlets for Each Individual

	N	Minimum	Maximum	Mean (ft)
Fast Food Restaurant Distance	338	46.3 ft	5280 ft	1026 ft
Fast Food Restaurant Number	338	0	15	3
Supermarket Distance	338	391 ft	5280 ft	2645 ft
Supermarket Number	338	0	8	4

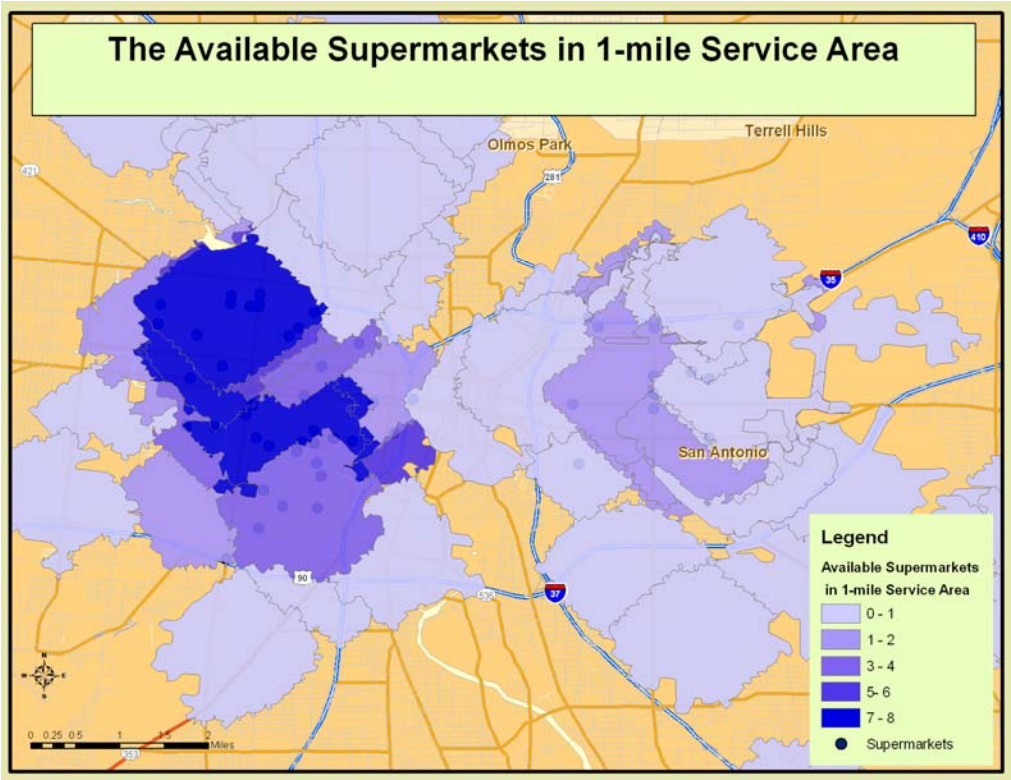

FIGURE 8 The Available Supermarkets in One-Mile Service Area

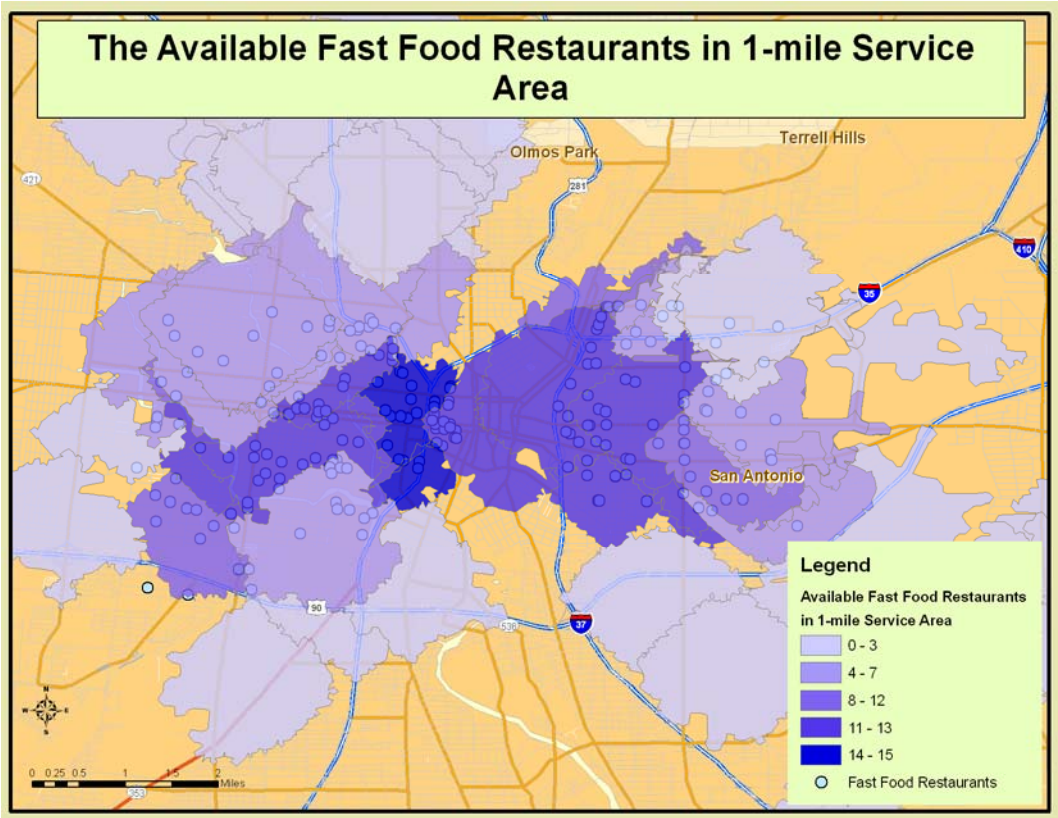

FIGURE 9 The Available Fast Food Restaurants in One-Mile Service Area

Association between Demographics and Food Outlet Availability and Accessibility

The Spearman's rho correlation coefficient was calculated to measure how the demographic characteristics of the participants were related to the food outlets around their neighborhoods. The results were reported in Table 10 as the following. The household income was positively correlated with the available numbers of both fast food restaurants and supermarkets; no significant correlations were found between youth's

household income and the distances to both fast food restaurants and supermarkets. In addition, age was positively related to household income.

TABLE 10 Correlations between Demographics and Food Outlet Characteristics

	Age	Household Income	FFRDis	FFRNum	SuperDis	SuperNum
Age	1	0.126*	0.016	0.032	0.023	-0.043
Household Income	0.126*	1	-0.032	-0.123*	-0.055	0.492**
FFRDis	0.016	-0.032	1	-0.045	0.56**	-0.265**
FFRNum	0.032	-0.123*	-0.045	1	-0.047	0.016
SuperDis	0.023	-0.055	0.56**	-0.047	1	-0.296**
SuperNum	-0.043	0.492**	-0.265**	0.016	-0.296**	1

***. Correlation is significant at the 0.05 level; **. Correlation is significant at the 0.01 level**
FFRDis: Distance to fast food restaurants; FFRNum: Available number of fast food restaurants;
SuperDis: Distance to supermarkets; SuperNum: Available number of supermarkets

One-way analysis of variance (ANOVA) tested whether the average number and proximity to fast food restaurants and supermarkets were equal according to different household income for the participants. Annual household income was divided into three categories as noted in Table 11. The *F* value was significant for all the variables, which represented that the spatial attributes of fast food restaurants and supermarkets varied on the basis of household income levels. One whole, lower income groups had longer distance to supermarkets and shorter distance to fast food restaurants; they had more food restaurants and fewer supermarkets compared to higher income groups.

TABLE 11 ANOVA Analysis of Youth Household Income

Household Income ($/year)	Group 1*	Group 2*	Group 3*	F	Sig.
Fast Food Restaurant Distance (ft)	595	2964	3192	4.8	0.01
Fast Food Restaurant Number	5.3	2.2	1.6	14.1	0.001
Supermarket Distance (ft)	3664	2357	1993	5.12	0.09
Supermarket Number	2.8	4.1	5.5	9.03	0.001

*: **Household income groups: Group 1: Household Income ≤ $9,715; Group 2: $9,715 < Household Income ≤ $26,842; Group 3: Household Income > $26,842**

Hierarchical Regression Analysis

The dependent variables were grouped into two groups: fast food restaurants (number and distance of fast food restaurants) and supermarkets (number of distance of supermarkets). For each category, there were two dependent variables: the distance to the food outlets (from participants' residence) and the number of food outlets within one-mile distance. Hierarchical regression models were used to estimate the associations between food outlets and participants' demographic characteristics. Participants' household incomes were examined as the independent variables.

Availability and Accessibility of Fast Food Restaurants

Two separate hierarchical regressions were run to predict the number and proximity of fast food restaurants around the participants' neighborhoods. When the distance to the closest fast food restaurant was run as a dependent variable (Table 12),

the value of R^2 increased to 0.005 by including participants' household income in the model. This step did not produce R^2 value significantly. In step 2, addition of the available supermarkets and the proximity to the closest supermarket produce a significant increase in R^2 ($\Delta R^2 = 0.057$). This indicated that the spatial attributes of supermarkets contributed 5.7% to the change of spatial feature (proximity) of fast food restaurants.

TABLE 12 Hierarchical Regression Model Predicting the Distance to the Closest Fast Food Restaurant within Participants' Neighborhoods

	SE *b*	***b***	***β***	R^2	ΔR^2
Step 1				0.005	
Household Income	0.001	0.0059	0.003		
Step 2				0.062	0.057
Supermarket Number	0.22	-0.019	-0.054		
Supermarket Distance	0.063	0.75	0.71		
				Total R^2 :0.062	

In another analysis using the number of fast food restaurants as the dependent variable (Table 13), the same variables were added into the model to test their

relationships with the number of fast food restaurants. In step 1, household income significantly increase the value of R^2 ($p = 0.001$) to 0.027. After adding the number and proximity of the available supermarkets, an additional 3% was increased for R^2 in step2. Totally, these variables explained 5.7% of the available numbers of fast food restaurants.

TABLE 13 Hierarchical Regression Model Predicting the Number of Available Fast Food Restaurants within Participants' Neighborhoods

	SE *b*	***b***	***β***	R^2	ΔR^2
Step 1				0.027	
Household Income	0.001	0.004	-0.154		
Step 2				0.057	0.03
Supermarket Number	0.07	-0.074	-0.033		
Supermarket Distance	0.185	0.17	0.036		
				Total R^2 :0.057	

Availability and Accessibility of Supermarkets

A similar procedure was implemented to predict the availability and accessibility of supermarkets when they were tested as dependent variables (Tables 14 and 15). To predict the distance to the closet supermarket, household income produced a R^2 with a value of 0.006 ($p = 0.001$). Adding the number and proximity of fast food restaurants

produced a significant increase in R^2 for 0.025 units ($p = 0.04$). The final value of R^2 is 0.031 (Table 14).

TABLE 14 Hierarchical Regression Model Predicting the Distance to the Closest Supermarket within Participants' Neighborhoods

	SE *b*	***b***	***β***	R^2	ΔR^2
Step 1				0.006	
Household Income	0.001	0.005	-0.021		
Step 2				0.031	0.025
Fast Food Restaurant Number	0.021	-0.038	-0.14		
Fast Food Restaurant Distance	0.067	0.7	0.68		
				Total R^2 :0.031	

In the analysis applying the number of available supermarket as the dependent variable (Table 15), household income gave explanation for about 5% of the available supermarkets in step 1. The value of R^2 was raised to 0.103 ($p < 0.001$) after adding fast food restaurant features to the model. This result showed that the spatial features of the fast food restaurants may explain about 10% of the change in the supermarkets' availability.

TABLE 15 Hierarchical Regression Model Predicting the Number of Available Supermarkets within Participants' Neighborhoods

	SE *b*	***b***	***β***	R^2	ΔR^2
Step 1				0.051	
Household Income	0.001	0.009	0.148		
Step 2				0.103	0.052
Fast Food Restaurant Number	0.085	-0.21	-0.23		
Fast Food Restaurant Distance	0.27	-0.284	-0.11		
				Total R^2 :0.103	

Household Income and Food Outlets

The participants' household income contributed significantly in predicting food outlet numbers in participants' neighborhood areas. The values of *b* were significantly positive in both models, which indicated positive correlations between household income and the available food outlets. The values of *b* for household were not significant when food outlet proximity was tested as dependent variables. The household income accounted significantly for 2.7% and 5.2% of the variation in the available number of fast food restaurants and supermarkets, respectively. This also confirmed the correlation coefficients from the Table 10: household income has only two significant correlation coefficients with the number of fast food restaurants (*-0.123, p = 0.001*) and supermarkets (*0.492, p = 0.003*). However, the household income was not significantly associated with the distance to fast food restaurants and supermarkets.

Discussion

Within one mile (5280 feet) from participants' residences, there were on average 3 fast food restaurants and 4 supermarkets for each study participant. The average proximity to supermarkets (2645 feet) was almost two times that of fast food restaurants (1026 feet). The results indicated that participants need to walk more to access a supermarket compared to the closest fast food restaurant. On the whole, supermarkets were less accessible compared to fast food restaurants for the participants in the study area. This finding was similar to other studies that compared the proximity of fast food restaurants and supermarkets with residents (Kwate, 2008; Maddock, 2004).

All the participants in this study were Hispanic youth; the race was not very diverse for this population and therefore was not among the demographics being examined. Household income was selected as an indicator of participants' SES in this study. This study found that participants' household incomes significantly contributed to the variance of food outlets' availability. Specifically, household income explained 2.7% and 5.2% of the availability of fast food restaurants and supermarkets within 1 mile of participants' residents, respectively. The ANOVA analysis further demonstrated that there were fewer supermarkets and more fast food restaurants for participants with lower household income in the neighborhoods. Previous studies also provided evidence to support that poor neighborhood had fewer available supermarkets in comparison to fast food restaurants (Moore & Diez Roux, 2006; Zenk, Schulz, Israel, James, Bao, & Wilson, 2005). In comparison to other studies, one exception in this study was that the majority of the participants were from low-income families and among them, about 60%

of their families reported even lower household income than the local average income ($9,715/year). This 'low low-income' group represented a very special group whose family incomes were below the average level for low-income residents in the study area. This group had some very unique characteristics. The significant result here is that even among low income households, the poorest families had the fewest number of available supermarkets and a higher number of fast food outlets. For example, their average distance to the closest fast food restaurants was only 585 ft and there were more than 5 fast food restaurants within one-mile of their home. This indicated that this group had a greater exposure to unhealthy food environments. More research and interventions need to pay more attention to these extremely low income groups.

On the whole, there were fewer supermarkets and more fast food restaurants in low-income neighborhoods. The reasons are complex. Wrigley (1999, 2002) analyzed this issue and pointed out that the decrease of supermarkets can be traced back to 1950s because of pervasive restructuring in the supermarket industry, and firm mergers and leveraged buyouts in the 1980s. Supermarkets have evolved from small grocery stores providing essential food and products to larger stores selling all kinds of food and non-food items. These developments made many older stores in urban neighborhoods unprofitable and caused them to close or move out of the residential area. As a consequence, fast food restaurants started to appear because of lower rents and less competitive retail environments (Kwate, 2008). In addition, fast food industry targeted children and adolescents in their advertisements and they selected outlet locations that were accessible and proximate to their target customers (Austin, Melly, Sanchez, Patel,

Buka, & Gortmaker, 2005). With all these trends, supermarkets are distributed more in suburban areas while fast food outlets appear more within downtown, usually low-income areas.

One important exploration of this study was to compare the availability and accessibility between fast food restaurants and supermarkets within one study. Previous studies had provided limited comparative evidence on this issue (Regan, Lee, Booth, & Reese-Smith, 2006). Fast food, when available in one area, may fill in the food gap in the nutrition environment if the area lacks a supermarket (Kumanyika &Grier, 2006). The findings from the present study provide supportive evidence that supermarkets and fast food restaurants have associations. In one neighborhood when there are more fast food restaurants, usually there are fewer supermarkets available. Furthermore, these two types of food outlets can explain approximately 4% of each other's accessibility and availability. This relationship justifies the study's analysis and adds more evidence to demonstrate that supermarkets and fast food restaurants interact with each other.

The density of fast food restaurants and supermarket were beyond the normal expectation in this study. It could be due to San Antonio zoning regulations and policies that restrict development of fast food restaurants and supermarkets in downtown areas. These food outlets might be only allowed to be located in a certain zones (i.e., River Walk area) for the convenience of tourism development. Another possible explanation was that population density in area was very high. Commercial companies made investment decisions based on local areas' population information to boost their sales.

Given many attractions such as the River Walk and city parks in the downtown area, more food outlets were established in that area.

One study conducted in Minnesota reported similar results: it showed there were 15 fast food restaurants within 2 miles of local residents' home on average (Jeffery, Baxter, McGuire, & Linde, 2006). The available number of fast food restaurants it reported was 5 times that of the present study. Given the land use mix in urban area, the characteristics of that study was similar to this study: they were all inner city urban areas and had similar densities of buildings. The specific land use pattern was not clear in Minnesota urban areas, but that study provided some kind of support to what was found in this study.

Additionally, the high density of food outlets did not necessarily represent a great availability for local residents. Actually, the food facilities in downtown area usually had poorer qualities compared to suburban areas. Local residents would choose not to use these food outlets intentionally and the real number of accessible fast food restaurants and supermarkets could be very limited for this special population.

This study also identified poor supermarket access for participants from low household income families. It was consistent with other studies, e.g., low SES neighborhood, particularly those in the inner city, reported lower supermarket accessibility than those with higher SES (Morland, Wing, Diez-Roux, & Poole, 2002). Many studies identified poor supermarket access for low-income and predominantly African American or Hispanic neighborhoods within US urban areas (Eisenhauer, 2001; Morland, Diez Roux, & Wing, 2006; Weinberg, 2000). These demographics were also

similar to this study: the majority of the participants were Hispanic youth and most of them were from low-income families.

The study also illustrated that the longer the distance the more youth had to overcome barriers (e.g., more time) to access the closest food outlets. Besides the distance to the food outlets, transportation in regards of lack of walkability was another important barrier for local residents. After examining the literature from different fields that investigated pedestrian performance and streetscape factors that influenced the quality of the pedestrian environment, Hutabarat (2009) defined walkability as the following key factors: 1) Presence of continuous and well-maintained sidewalks; 2) Universal access characteristics; 3) Path directness and street network connectivity; 4) Safety; 5) Absence of heavy and high-speed traffic; 6) Pedestrian separation or buffering from traffic; 7) Land-use density; 8) Building and land use diversity or mix; 9) Street trees and landscaping; 10) Visual interest and a sense of place as defined under local conditions; 11) Perceived or actual security. Participants may perceive lack of access to food outlets when any of the above characteristics was missing. For example, less walkable neighborhoods may have characteristics like lack of the sidewalk or bike lane connectivity, bad quality of the roadside environment, and bad street-crossing conditions; all these factors contributed to poor access to facilities and therefore discouraged an individual's decision to go outside to walk or cycle (Lee & Moudon, 2004). In addition, lack of high-quality and route-related facilities also contributed to poor walkability and made local residents feel the accessibility in the local communities was awful even the actual spatial distance was short (Lee & Moudon, 2004).

Safety, as an important indicator of walkability, also impacted local residents' decision to walk outside. When there were many vehicles with high speed on the road, an individual would feel not safe and reduce walking on the street. If this situation happened when the person was going to go outside to buy food, it worsened the accessibility to the food outlets. For children and adolescents, the situation was even worse. The current street network and transportation system were not friendly to youth. Among the youth who were reported deaths caused by motor vehicles, one-half of them were fatally injured while walking or bicycling (Walker, Barker, & Szocka, 1989). To solve this problem, some facilitators may be helpful. More sidewalks would provide safer walking paths for youth to walk to closest food outlets without worrying heavy traffic volumes and high vehicle speeds. In addition, more traffic lights and signs would also facilitate youth to walk or bicycle more safely especially when they passed through streets.

A recent study indicated that local food environment influenced the risk of obesity especially when an individual did not have a car and was exposed to a large number of fast food outlets (Inagami, Cohen, & Finch, 2007). People who were able to travel farther may have wider access to more healthful foods while those without cars may be more likely to purchase energy-dense foods which contributed to obesity risk (Horowitz, Colson, Hebert, & Lancaster, 2004). Available cars may reduce the local effect of food outlets. Those who did not own cars may be more likely to visit fast food outlets than most costly full-serviced restaurants in their neighborhood (Morland, Wing, & Diez-Roux, 2002). When youth's families did not own cars, they may be limited to

local communities to buy food and exposed to those fast food outlets that were in walking distances. To summarize, car ownership, as another aspect of transportation, may also influence the accessibility of food outlets in local communities.

Demographics as Moderators in the Theoretical Framework

In Energy Balance-Related Behavior mode, the food environment as one aspect of built environment was assumed to directly and indirectly impact EBRB (Kremers, Brujin, Visscher, Mechelen, Vries, & Brug, 2006). As discussed in the literature review, the accessibility (e.g., distance and density) and availability (e.g., the presence) of food outlets impacted youth eating behaviors and BMI. The direct relationship reflected the influences of built environments on youth health behaviors. Although this influence had been reported significantly, behavior models usually did not stated causal mechanisms that link the built environment to eating behaviors (Koplan, Liverman, & Kraak, 2005). In EBRB framework, causal relationship was not denied, but it stated that the interaction among different factors was very complex in studying the relationship between built environment and behavior. Some moderators such as age and gender should be examined when EBRB framework was used to test the causal relationship (Kremers et al., 2006). Previous studies have documented that built environmental factors exerted differential effects on youth dietary behaviors on various groups with different demographics (Duncan, Spence, & Mummery, 2005). The correlation analysis in this study indicated that three income groups had differential accessibility and availability of the food outlets. But there was no significant results indicating that these features were differential on the basis of age and gender. This study did not use age and gender as

predictors in regression because the EBRB framework did not support that they were mediators; actually they were clearly stated as moderators (Kremers et al., 2006). In the future, age and gender can be used to stratify the sample and play moderate roles in multi-level statistical analysis.

Possible Bias toward Fast Food Restaurants

Besides fast food restaurants, other non-traditional food outlets such as convenience stores also provide fast food services. A recent study examining six rural areas' fast food environments showed that supermarkets, grocery stores, and convenience stores actually provided more fast food than traditional fast food restaurants such as chain brand stores (Creel, Sharkey, McIntosh, Anding, & Huber, 2008). Supermarket and convenience stores added more fast food to their service menus to attract customers and increase revenues (Creel et al., 2008). So far little is known about the availability of healthier fast food options in addition to traditional chain stores proving fast food services (Burton, Creyer, Kees, & Huggins, 2006). Our knowledge about food outlets providing fast food still focuses on those traditional food outlets and more explorations will be needed to understand this new field.

In addition, traditional fast food restaurants have begun to provide more healthier food options than before. Some fast food restaurants have increased their healthy food options and added new menu functions to attract health conscious customers (Burton et al., 2006; Wootan, Osborn, & Malloy, 2006). Our old attitudes and preferences will be changed by this new trend and new food environment. The research direction will also

transformed from focusing on the accessibility and availability of fast food restaurants to concentrating more on the food resources among varying food outlets.

Limitations

Although the above evidence indicated that SES was an important factor that deserved more attention in studying food environment and youth obesity, there were several limitations in this study. First of all, the study assumed participants would usually shop at the food outlets within 1 mile from their residences. In the real world, participants may have different food shopping behaviors, e.g., some of them may prefer to use public transportation or drive further distances to buy food.

Secondly, only fast food restaurants and supermarkets were selected in this study as food outlets. Participants may shop for food in more diverse food outlets such as local food stands, gas stations, convenience stores, and even farmers markets. The two types of food outlets identified in the study can not represent the whole food outlet nutrition environment for the participants in this study.

Thirdly, this study only used objective measurement for food environments. Subjective measurements like perception surveys and other qualitative investigations including interviews with participants and observations of food facilities, should be added to indentify barriers and facilitators of food environment for children and adolescents.

Fourthly, parents also play an important role in impacting youth food intake. Parents and their kids are actually part of each other's environment and they have mutual interactions. When a family chooses food for consumption, parents are the gatekeepers

of the home food supply and selection of places to eat. Parents can frequently limit their kids' consumption of unhealthy food and encourage them to consume more healthy food. Therefore, it is critical to understand parents' beliefs, preferences, values, and attitudes toward food intake because these characteristics influence youth's dietary outcomes.

Fifth, the walkability in local residential areas should be examined. This study did not include the factors that influence the walkability of youth's food environment because of data availability and cost. Walkability may be a key element that block or encourage youth to access to the closest food outlets. For example, the sidewalk conditions such as its length, clearness, lighting, and safety can be included in the future so that a more comprehensive evaluation can be conducted for local nutrition environment.

Finally, SES is usually evaluated through three indicators: income, education and occupation (Monteiro, Moura, & Conde, 2004); household income is just one of them. Given the participants' age and available data source, only household income is evaluated and it may not accurately describe these youth' SES. In the future, if additional SES-related information can be collected from parents, the quality of data will be further improved.

Research Implication

Although many factors may cause obesity and overweight, the food environment played an important role in the rapid development of the obesity epidemic (Koplan & Dietz, 1999). Despite no direct evidence, more and more recent studies have pointed out

that there are associations between the availability of places to obtain foods and obesity (Maddock, 2004; Sturm & Datar, 2005). Differences in the availability of certain types of food outlets may have significant influences on an individual's eating habits, which may bring very different health outcomes for the person. For instance, the growth of the fast-food industry has been an important factor that increases youth energy consumption (French, Harnack, & Jeffery, 2000). Among youth of 12-18 years of age, the total energy intake consumed from fast-food and other restaurants has increased from 6.5 in 1978 to 19.3 in 1996 (Nielsen, Siega-Riz, & Popkin, 2002). Fast food contained high in fat and sugar; many studies have provided evidence that fast food intake increased body mass index (BMI) (Edelstein, Knowler, & Bain, 1997; Melaniphy, 1992). On the other hand, some studies reported that supermarkets often provided a large variety of healthy foods; there were associations between healthy diets and the number of available supermarkets in the neighborhoods (Morland, Wing, & Diez Roux, 2002; Laraia, Siega-Riz, Kaufman, & Jones, 2004).

Besides fast food restaurants and supermarkets, future research should also explore other food outlets such as convenience stores located in the neighborhoods. Convenience stores build their business on fast service and they usually operate for longer hours in local residential areas. The convenient shopping styles are popular among consumers. Convenience stores provide a great variety of fast service including healthy fast food such as lunch and dinner entrées. These stores play an important role in influencing youth eating behavior and daily nutrition intake. The spatial locations of convenient stores are accessible to local communities and this feature makes them

influential in shaping youth food environments. In the future, convenient stores deserve more attention in regards to offering more healthy or unhealthy food for children and adolescents.

Finally, this study called attention to the implications of research results for low-income, especially Hispanic youth groups. This group was underserved by supermarkets providing healthy foods while being surrounded by more fast food restaurants. These factors actually put this group of youth at disadvantage in having more healthy foods and healthy eating habits. With those barriers, they may have higher risks of being obese or overweight.

To improve the current situations, Hispanic youth need better access to and more available healthy food outlets (e.g., supermarkets). New regulations need to be created to limit unhealthy food outlets (e.g., fried burger stores) close to youth' neighborhoods. Public health department needs to establish strategies such as modifying land use policies, establishing community partnerships to foster development, and helping to reduce any systematic barriers that prevent youth from accessing healthy food outlets.

CHAPTER IV

STUDY 3: HISPANIC YOUTH DEMOGRAPHICS, BMI, AND THEIR NEIGHBORHOOD ENVIRONMENTS

In the United States, adolescent obesity has become a serious public health concern (Troiano & Flegal, 1998). Obesity rates of both children and adults have been increasing dramatically in the past two decades (Ogden, Flegal, & Carroll, 2002). According to a report, the prevalence of overweight was 15.5 percent among adolescents during 1999-2000 (Sallis & Glanz, 2006). Since 1970s, the prevalence of overweight has more than doubled among adolescents aged 12 to 17 years of age (Sallis & Glanz, 2006).

Many studies have pointed out that low income neighborhoods face more risks of obesity including fewer physical activity opportunities (e.g., bad facility conditions and long distances to recreational facilities), poor exposure to healthy foods, and fewer supermarkets available in their neighborhoods (Turrell, Blakely, Patterson, & Oldenburg, 2004; Rose & Richards, 2004; Giles-Corti & Donovan, 2002). When adolescents have less physical activity and more unhealthy food intake (e.g., high-fat, -sugar and low-fiber foods), they have increased chances of being overweight and obese (Sallis & Glanz, 2006).

Although there has been a growing body of evidence to indicate there is a link between built the environment and obesity, research in this field is still at its beginning stage (Booth, Pinkston, & Poston, 2005; Cummins & Macintyre, 2006; Popkin, Duffey, & Gordon-Larsen, 2005). The built environment includes all aspects of a person's surroundings that are human-made (Papas, Alberg, Ewing, Helzlsouer, Gary, & Klassen,

2007). A common belief about the mechanism of how the built environment affects youth body weight is that a good built environment may increase youth energy expenditure (e.g., more facilities for physical activity) and reduce their energy consumption (e.g., less high-fat food intake). Therefore, energy balance-related behavior has received the most focus in studying youth obesity. Nevertheless, only a few studies have explored how the built environment influences youth obesity directly. The goal of this study was to examine how the built environmental characteristics, such as the availability and accessibility of recreational and utilitarian facilities, fast food outlets, and supermarkets, influenced youth BMI.

Literature Review

To study obesogenic environment, many researchers in the field of public health began to apply concepts and methods from transportation and urban planning, such as land use mix, to study BMI. Land-use mix is the degree to which residential, commercial, and institutional parcels of land are located close together (Ewing et al., 2006). Greater land use mix creates a variety of options for living, working, shopping, exercising, and entertaining. Saelens, Sallis, and Frank (2003)'s study compared neighborhood residents based on physical activity measurements, weight status, and self-reported neighborhood perceptions. Then this study divided neighborhoods into high-walkable and low-walkable neighborhoods. The results indicated that residents from high-walkability neighborhoods had more chances to be physically active compared to residents from low-walkability neighborhoods. As a result, residents from low-

walkability neighborhoods reported higher BMI and had higher rates of being overweight than high-walkability neighborhood residents.

Another study in Atlanta, Georgia showed that residents' obesity and land use mix may have an indirect relationship -- physical activity could possibly mediate the relationship between them (Frank, Andresen, & Schmid, 2004). This study used land-use mix data from the county tax assessors and the 2000 census data base. The data was then geocoded into GIS and after adjusting for the effects of age, income and level of education, and the study results indicated that there was a significant indirect association between the prevalence of obesity and land-use mix, which was mediated by physical activity. Specifically, the results indicated that every quartile increase in land-use mix was associated with a reduction (12.2%) of the risk of obesity.

As an important element of land use mix, facility received recent attention in studying youth BMI. Two previous studies collected the number of physical activity-related facilities within a multivariable model (Nelson et al., 2006) and the numbers of recreational facilities within census block groups (Gordon-Larsen et al., 2006). Then they examined whether youths' BMI were influenced by these facilities. In the end, both of the studies reported positive links between the likelihood of being overweight and the number of facilities. Another study investigating this issue on adults reported that the proximity to the nearest facility was also associated with the risk of overweight (Giles-Corti, Macintyre, & Clarkson, 2003). These facilities may increase youth's opportunities for physical activity and impact their body weight status.

The associations between the objectively measured number and proximity of facilities (e.g., food outlets and physical activity facilities) and youth's perceptions toward these facilities have not been clearly understood in the field of built environment. Most studies have focused on adult population (Scott, Evenson, Deborah, Cohen, & Christine, 2007). For instance, one study reported fair to slight agreement between objectively measured and self-reported neighborhood characteristics such as the proximity and number of recreational facilities (Kirland, Porter, & Addy, 2003). Children and adolescents may have very different feelings, attitudes, and preferences toward the ease of access to facilities from adults. In urban areas, it may be very difficult for youth to walk or bicycle for a certain distance when there were heavy volume of traffic, high speed vehicles, and crime in their neighborhoods. When the objectively measured facility proximity indicated a short distance, it may actually reflect a much worse walking environment in the real world for children and adolescents. For instance, kids' attention spans were shorter and they may not understand complex traffic rules and situation like adults (Appleyard, 1981). Physically, youth are shorter than adults and they were not able to watch all the traffic conditions when they tried to cross streets to access facilities. All the above factors contributed to the differences between youth perceptions and objective measurements of facility accessibility in neighborhood environments.

Demographic Characteristics

Social-Economic Status (SES)

Given the patterns of dietary- and activity-related environment, one common expectation was that residents in poor neighborhoods would have higher BMI compared to middle- or high-income residents. A recent study has supported this by proving the evidence that there was a positive association between residents' BMI and their poverty status (Proctor & Dalaker, 2003; Rutt & Coleman, 2005). Previous research has also shown that children living in poor neighborhoods had three times the level of risks of developing obesity during adolescence than those in wealthier areas after controlling the initial BMI. Another study investigating 6 to 11 year old youth further pointed out that higher BMI was negatively associated with participants' social status (Leino, 1997). However, the results on this topic were in opposition to what has been previously found. For instance, Davey, Hart, Watt, Hole, and Hawthorne (1998) found no association between BMI or obesity and participants SES. Besides SES, other factors of social status may also have impact on youth body weight status.

Racial/Ethnicity & Age

Different racial or ethnicity groups may have different culturals and behavioral norms, the understanding of this difference may contribute to the further investigation of the relationship between built environment and obesity among racial or ethnicity groups. Rutt & Coleman's (2005) findings indicated that there was a positive link between BMI and land use mix among Mexican-Americans living along the US/Mexico border. The study assumed that the community would be more walkable when the level of mixed

land use was greater. In addition, one study provided evidence that BMI had positive link with youth's age (Frank, Andresen, & Schmid, 2004). However, another study reported a different result. In a national survey sampling 8165 children and adolescents as part of National Health and Nutrition Examination Survey (NHANES) in the time periods of 2003-3004 and 2005-2006, although BMI varied by age and racial/ethnic groups, no statistically significant differences were found in the prevalence of high BMI for age or race/ethnicity (Ogden, Carroll, & Flegal, 2008). These research findings need to be further examined and new studies are need for additional explanations.

Purpose and Hypothesis

The purpose of this study was to examine the relationship between youth BMI and the built environment. The hypotheses were as the following:

Hypothesis I: *Youth's BMI will be negatively related to their SES;*

Hypothesis II: *Youth's BMI has an association with the available number of facility within one mile distance;*

Hypothesis III: *Youths' BMI has an association with the distance of facility within one mile distance*.

Method

Participants

San Antonio has the second and seventh largest population in Texas and U.S., respectively (U.S Census Bureau, 2008). There are 405,474 households and 280,993 families residing in San Antonio. The population density is 2,808.5 people per square mile. Twenty-nine percent of the population is under 18 years of age. Out of the total

population, 24.3% of those under the age of 18 are living below the poverty line. Forty-eight percent of the population is male and 52% of them female. The median income for a household in the city was $36,214 in 2008 (U.S Census Bureau, 2008).

The 338 subjects in this study came from enrollees in two local youth centers: Dan Cook Youth Center and Eastside Youth Center. These two centers belong to t*he San Antonio Youth Centers (SAYC)* which is a non-profit organization who aims at developing the strengths, talents and skills of inner-city youth and their family member to fulfill their potentials. There are a total of 6 centers operated by SAYC providing services to the whole city and more than 750 children under 18 years that were served in 2008. So far, only data from these two youth centers were available. Ninety-three percent of students from the San Antonio Independent School District (SAISD) where these two youth center were located, were classified as economically disadvantaged (San Antonio Metropolitan Health District, 2008). In addition, nearly 60% of the population lived below the poverty level in SAISD area and 24% of the population served by SAISD received public assistance (SAMHD, 2008).

Program Information

SAYC health and nutrition program is funded by a Carol E. White federal grant to test the efficacy of a comprehensive, integrated intervention that uses multiple community systems to intermediate physical education and nutrition education in a group of 750 low-income Latino and African American children and adolescents in San Antonio, Texas. The purpose of the program is to test the impact of a comprehensive school, community, and physician-based, physical and nutrition education upon the body

mass index (BMI) of at-risk youth ages 5 to 18 in San Antonio – the most obese city nationwide (U.S Census Bureau, 2008). The program assessed whether the interventions improve health outcomes significantly. Qualitative and quantitative methods would be used to evaluate the factors that influenced physical activity and eating behaviors for the participants.

The baseline data (e.g., demographics and BMI) were recorded into a database at the beginning of the program. New participation and health outcome information would be updated every 4 months. Physical and nutrition education classes and activities were provided on the basis of resources each youth center had. The program focused on youth who were economically disadvantaged and at high-risks of obesity. All the services were delivered in both English and Spanish because Hispanic youth represented a large proportion of the participants. Based on participants' grade level, they were provided differential materials and activities for physical and nutrition education. The parents of the participants were also involved in the workshops. The program identified national experts on physical education and nutrition for youth and invited them to give lectures, design the program, and evaluate the outcome of the program. In addition, separate workshops were offered to the staff of the program as trainings.

Measurement

Individual Data

The information such as age, gender, ethnicity, height, weight and address were collected in Spring 2008. Participants' height and weight were used to calculated their BMI using the formula: BMI = 703 * (weight / (height * height)(Department of Health

Care Services [DHCS], 2009). BMI is usually calculated by the formula: BMI = weight / (height * height) (CDC, 2008a). Since children and adolescents are still growing , the BMI number needs to be plotted on the BMI-for-age growth charts to get a percentile ranking (CDC, 2008a). To assess the size and growth patterns of an individual, percentiles are commonly used to evaluate body weight status.

GIS Spatial Data

Two types of facilities (physical activity facilities and food outlets) were selected for examination in this study. Recreational and utilitarian facilities are included in this study as physical activity-related resources (See study I). Recreational facilities include all the parks (e.g., miniparks, skate parks, and large urban parks), recreation centers/community centers in San Antonio area. Utilitarian facility was selected according to youth activity patterns (e.g., shopping mall was selected because many youths prefer to hang out in shopping malls) In this study, utilitarian facilities refer to Mini golf courses, shopping malls, video arcades, youth organizations, amusement places, DVD and video games rental stores, and movie theatres.

In addition, fast food restaurants and supermarkets were included to study the food environment for youth. The fast food restaurants in this study referred to those limited-service stores, which were primarily engaged in providing food services (except snack and nonalcoholic beverage bars) where customers generally ordered or selected items and paid before eating (U.S Census Bureau, 2009c). Supermarkets were defined as those outlets primarily engaged in retailing a general line of food, such as canned and

frozen foods; fresh fruits and vegetables; and fresh and prepared meats, fish, and poultry (U.S Census Bureau, 2009b).

There were totally 516 activity-related and 333 diet-related facilities in this study. The major method to identify these facilities was to use yellow and white page from both the internet and phone books. Internet search terms included the key word of these facilities such as "recreation facilities in San Antonio" or "Food outlets in San Antonio".

Some data of facilities (e.g., parks and community center) and road map (e.g., Bexar street network map) were available from San Antonio city's GIS map server online (The Department of San Antonio Park and Recreation, 2008; The City Government of San Antonio, 2008) These data were directly downloaded from the city's ArcIMS website. The addresses information was finally input to the database for later geocoding and statistical analysis.

Data Preparation. The spatial data analysis was completed using the GIS software ArcGIS 9.2, ArcView 3.3 and the extension software Network Analyst and Spatial Analyst (ESRI, 2002). This software package was the product of Environmental System Research Institute (ESRI).

The information of the participants' residences and facility locations were manually checked and geocoded into ArcGIS. The *Geocode* function in the *Tool* menu in ArcGIS was used to add location information to the spatial map of San Antonio area. Before this process, a network dataset was created in the ArcCatalog window. Then,

each location of participant and facility were given spatial codes, matched to the dataset, and displayed on maps.

One problem after running the *Geocode* function was that some address information was not identified on the map. There were several possible reasons for this: 1) the road map downloaded might not record the complete streets information in the study area; 2) some streets' names were changed and these changes were not updated in the dataset downloaded; 3) wrong addresses like spelling mistakes were recorded. To solve this problem, the software ***Google Earth*** was used to look for the X and Y coordinates of those addresses unable to be located (Google Earth, 2008). The coordinates were then manually checked, recorded, and saved in DBF files. Then, these DBF files containing X Y coordinates were added to the GIS by using the tool *Add X Y data* from the *Tool* Menu. After geocoding work was done, the spatial locations of all the participants' residences and facilities were displayed on the map.

Data Analysis

A one-mile buffer was used to represent the neighborhood area that the participants usually have walking and food shopping activities. As discussed in Study 1 and 2, this distance captured most facilities that influenced youth leisure time physical activity and eating behavior. Theories of the built environment did not provide a restricted geographic scale for reasonable local neighborhood distance (Boarnet, 2004). Therefore, the 1-mile distance selection was mainly based on previous studies which discussed how to define an idea area to study youth physical activity and eating behavior

(Block, Scribner, & DeSalvo, 2004; Diez-Roux, Evenson, McGinn, 2007; Jago, Baranowski, & Harris, 2006; Lubow, 1998).

The ArcGIS Extension software Network Analyst was used to calculate the network distance from an individual's residence to the closest facility (e.g., fast food restaurant or shopping mall) within one-mile distance. This proximity was used as the index of facility accessibility. Additionally, the Network Analyst software calculated the available numbers of facilities within one 1-mile network distance to represent the features of facility availability.

Dependent and Independent Variables. The participants' BMI was the dependent variable. Regression analysis was implemented to examine how the built environment influenced youth BMI. The independent variables included three demographic characteristics: age, gender, and household income. The average number of available facilities and the average proximity were calculated for each participant. These two parameters were independent variables which represented the features of the built environment in the study area. Correlation and hierarchical regression analysis were used to test and predict the association between participants' BMI, their demographic characteristics, and built environmental features (facility availability and accessibility) in the neighborhoods.

Correlation analysis was used because the attributes of facilities were measured at the same environmental setting. This analysis did not investigate the possible cause-effect relationships because all the variables were not manipulated and were measured at the same time period –the facility data and BMI were collected based on 2008's

information. Correlation analysis can test which aspects of built environments were related to youth health outcome – BMI.

Hierarchical regression was used in this study because the purpose of this study was to find out whether demographics, household income, and spatial attributes of facilities were predictors for BMI. These factors were grouped into four blocks based on past research. Demographics including age, ethnicity, and gender have been documented to be related to an individual's weight status (Frank, et al., 2004; Kahn, Tatham, Pamuk, Heath, 1998). In this study, all the participants were Hispanic youth; therefore, ethnicity could not provide enough variety as a variable and was not used in the model. Household income was used as an indicator of SES and was grouped in block 2. Previous studies pointed out that SES was negatively associated with BMI in developed countries while positively related to BMI in some developing countries (Fernald, 2007; Martorell et al., 1998; Proctor & Dalaker, 2003; Rutt & Coleman, 2005; Volkow et al., 2008). This model tested how much household income contributed to the weight status of the participants. The last two blocks were the available number and distance of facilities. Some studies have documented that features of facilities (e.g., proximity of food outlets and physical activity facilities) were correlated with youth BMI (Ewing, Brownson, & Berrigan, 2006; Inagami, Cohen, Finch, & Asch, 2006). Therefore, this study examined the role how built environments played in influencing youth BMI.

Results

Descriptive Characteristics

All the participants were Hispanic and from low-income families. Their demographic information was summarized in Table 1.

The average number and network distance to the four types of facilities (recreational and utilitarian facilities, fast food restaurants, and supermarkets) were summarized in the Table 16. On average, there were 3 recreation facilities, 1 utilitarian facility, 3 fast food restaurants, and 4 supermarkets available within 1 mile from each participant' residence. As indicated in Table 17, the average distance to the closest facilities was 3059 ft (0.58 mile). Among these facilities, the distance travel to the closest utilitarian facilities was largest – 5316 ft (about 1.0 mile); the proximity to the closest fast food outlets has the shortest average distance – 1026 ft (0.19 mile). Figure 10 delineates a map of all the facilities and participants' residences in the downtown area of San Antonio.

Table 16 The Available Facilities within One Mile Distance

Average Available Number of Four Types of Facilities	**Mean Number**
Average Available Number of Recreation Facilities	3
Average Available Number of Utilitarian Facilities	1
Average Available Number of Fast Food Outlets	3
Average Available Number of Supermarkets	4
Total Average	3

Table 17 The Average Distance to the Closest Facilities within One Mile

Average Distance to Four types of Facilities	Mean (ft)
Average Distance to the closet Recreation Facility	3249
Average Distance to the Utilitarian Facility	5316
Average Distance to the Fast Food Outlet	1026
Average Distance to the Supermarket	2645
Total Average	3059

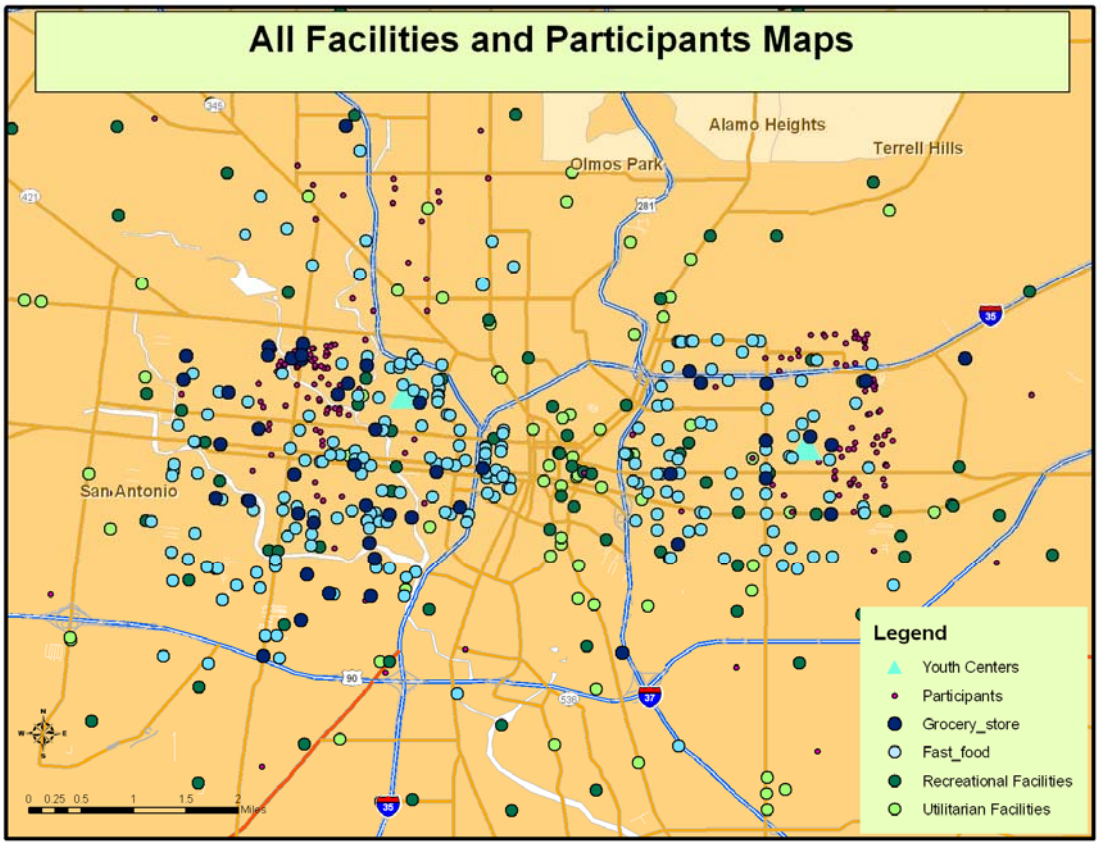

Figure 10 All Facilities and Participants Maps

Correlation Analysis

The Spearman's rho correlation coefficient was calculated to examine how youth BMI was related to their demographics and facilities around their neighborhoods. Youth BMI was positively related to their ages ($\rho = 0.41$, $p = 0.01$) and household income ($\rho = 0.25$, $p = 0.01$) as indicated in Table 18. Facility's availability was negatively correlated with youth BMI ($\rho = -0.14$, $p = 0.05$) while facility's accessibility had a positive relationship with their BMI ($\rho = 0.64$, $p = 0.05$). In addition, household income was positively related to facility availability ($\rho = 0.401$, $p = 0.01$) and negatively to facility accessibility ($\rho = 0.198$, $p = 0.01$).

Table 18 Correlation between Youth BMI, Demographics, and Availability and Accessibility of all Facilities

	BMI	**Age**	**Household Income**	**Facility Number**	**Facility Proximity**
BMI	1.000	0.41**	0.25*	0.14*	-0.64*
Age	0.41**	1.000	0.126*	0.083	-0.084
Household Income	0.25*	0.126*	1.000	0.401**	-0.198**
Facility Availability	-0.14*	0.083	0.401**	1.000	-0.515**
Facility Accesibility	0.64*	-0.084	-0.198**	-0.515**	1.000

***. Correlation is significant at the 0.05 level; **. Correlation is significant at the 0.01 level**

Among four types of facilities, their availability and accessibility had different correlations with youth BMI (See Table 19 and Table 20). The available number of recreation facility, utilitarian facility, and supermarket had negative relations to youth BMI; their correlation coefficients were -0.064, 0.13, and -0.075, respectively. These coefficients were significant, but the values were very small. Moreover, the availability of these three facilities was positively correlated with each other (Table 19).

Table 19 Correlation between Youth BMI and Availability of Four Types of Facilities

	BMI	RecNum	UtiNum	FFRNum	SuperNum
BMI	1	-0.064*	-0.13*	0.15*	-0.075*
RecNum	-0.064*	1	0.15*	0.075	0.43**
UtiNum	-0.13*	0.15*	1	0.155	0.273**
FFRNum	0.15	0.075	0.155	1	0.086
SuperNum	-0.075*	0.43**	0.273**	0.086	1

***. Correlation is significant at the 0.05 level; **. Correlation is significant at the 0.01 level**
RecDis: Distance to recreational facilities; RecNum: Available number of recreational facilities;
UtiDis: Distance to utilitarian facilities; UtiNum: Available number of utilitarian facilities

Youth BMI had positive relationships with the distance of these facilities (Table 20); the correlation coefficients were 0.011, 0.031, and 0.09 for recreation facility, utilitarian facility, and supermarket, respectively. In addition, the distances of these facilities were also positively related to each other Table 20).

Table 20 Correlation between Distances of Facilities and Youth BMI

	BMI	RecDis	UtiDis	FFRDis	SuperDis
BMI	1	0.011*	0.031*	0.08	0.09*
RecDis	0.011*	1	0.261*	0.289	0.434**
UtiDis	0.031*	0.261*	1	0.401	0.321**
FFRDis	0.08	0.289	0.401	1	0.561
SuperDis	0.09*	0.434**	0.321**	0.561	1

***. Correlation is significant at the 0.05 level; **. Correlation is significant at the 0.01 level**
RecDis: Distance to recreational facilities; RecNum: Available number of recreational facilities;
UtiDis: Distance to utilitarian facilities; UtiNum: Available number of utilitarian facilities

Hierarchical Regression Analysis

The dependent variable was participant BMI in this model (Table 21). Hierarchical regression analysis was conducted to predict the associations between BMI, participants' demographics, household income, and the built environmental characteristics. Participants' demographics (e.g., age, and gender) and household income were examined as the independent variables. Additionally, the available number and the proximity of facility were also tested as two important predictors.

In the first step, age and gender were added to the model and the value of R^2 was 0.136. Next, the value of R^2 increased to 0.176 by including household income in the model; household income increased R^2 significantly by 0.04. In step 3, addition of the available number of facilities produced a significant increase in R^2 ($\Delta R^2 = 0.015$). Finally, after adding the facility accessibility as another predictor, an additional 0.027 units were increased for R^2. These predictors explained about 20% of the variance of youth BMI on the whole.

Table 21 Hierarchical Regression Model Predicting BMI

	SE *b*	***b***	***β***	R^2	ΔR^2
Step 1				0.136	
Age	0.178	0.884*	0.371		
Gender	0.795	-0.297	-0.028		
Step 2				0.176	0.04*
Household Income	0.001	0.17*	-0.002		
Step 3				0.191	0.015*
Facility Number	0.179	-0.169*	0.077		
Step 4				0.218	0.027*
Facility Proximity	0.001	0.121*	0.081		
				Total R^2: 0.218	

The participants' household income contributed significantly in predicting their BMI. The values of *b* were significantly positive in the model, which indicated positive correlations between household income and the BMI. This was also confirmed by their correlation coefficient in Table 18. Gender was not significantly related with youth BMI; therefore, 13.6% of the variance in BMI was actually explained fully by age in step 1. The coefficient of facility number was negative (b = - 0.169); this indicated that youth BMI was negatively related to the facility number, which was also confirmed by the correlation analysis in Table 18. Opposite to this, the coefficient of facility proximity was positive but not significant, which showed a positive relationship between youth BMI and the facility proximity in their neighborhoods. The positive correlation coefficient in Table 18 also verified this result (b = 0.64).

Discussion

Well-planned communities with a balanced mix of land uses (e.g. retail, entertainment, and residential uses) provided residents comfortable places to walk or bike, and many options to purchase healthful food at nearby food outlets. All these encouraged residents to have more energy expenditure and less energy intake. As a result, residents living in the well-planned communities were more likely to have normal body weight status. In the current study, two types of facilities were examined: food outlets (fast food restaurants and supermarkets) and activity-related facilities (recreational and utilitarian facilities); the available number and distance were used to roughly represent the spatial attributes of the facilities in the study area. By implementing hierarchical regression model, this study reveled that youth BMI was significantly associated with SES, the distance to facilities, and the available number of facilities within their neighborhoods (within a 1-mile radius). Although no strong evidence indicated causality existed between them, the findings provided some evidence to link high BMI and the built environment.

In the built environment, diet- and activity-related facilities were closely related to youth energy balance-related behaviors (EBRBs). The EBRBs mainly included dietary behavior and physical activity (Kremers, Brujin, Visscher, Mechelen, Vries, & Brug, 2006), which co-existed and interacted with each other to determine whether or not positive energy and weight gain were experienced. Excessive positive energy intakes would lead to obesity and many chronic diseases. Facility, as one of the most important determinant of EBRBs, can directly encourage or block youths to have healthy

living styles. In the current study, these facilities referred to those that had close associations with youth physical activity and eating behavior based on their own popular living styles, such as hanging out with peers in shopping malls or eating at fast food restaurants.

The availability and accessibility of facilities were examined for those selected facilities in the study model. Results indicate that the available number (availability) of diet- and activity-related facilities contributed significantly to youth BMI and can explain 1.5% of BMI. In addition, the distance to facilities (accessibility) explained 2.7% of youth BMI. Previous studies have also demonstrated that facility availability and accessibility had associations with youth BMI. Lower BMI was related to more available utilitarian facilities (e.g., shopping malls), recreational facilities (e.g., parks), and some food stores (e.g., supermarkets) (Rutt & Coleman, 2005; Smoyer-Tomic, Spence, Raine, Amrhein, Camron, Yasenovskiy et al., 2008). Additionally, the shorter distance of these facilities was linked with a lower BMI among youth (Ewing, Brownson, & Berrigan, 2006).

On the other hand, overall the facilities contributed only a small part (4.2%) in explaining youth BMI. This may be due to the fact that the current analysis did not account for a variety of potential mediators through which the built environment influenced youth BMI, such as physical activity participation or eating behavior. Many studies have already documented evidence that built environment (e.g., proximity and availability of facilities) may change youth physical activity from a variety of perspectives (e.g., patterns, levels, frequencies, and safety perceptions). For instance,

recreation facilities such as parks, sidewalks, fitness centers have been linked with physical activity (Humpel, Owen, & Leslie, 2002). The ease of accessibility of food outlets has also been shown to be positively related to youth eating behaviors (USDHHS, 1990). Numerous studies have shown that people, who have better proximity to numerous facilities, were more physically active and less overweight than those in less walkable community. However, it was not clear how physical activity and eating behavior impact the association between built environment and BMI. More work needs to be done to integrate these mediators into the study of the interactions among the built environment, health behavior, and BMI. For instance, when there were more facilities, youths have more opportunities to walk and exercise, or have more access to healthier foods. These opportunities would bring changes in their physical activity and eating behaviors, which would then change their body weight status.

The current study also found that there were associations between different features of facilities such as their accessibilities and availabilities. The available number of recreation facilities was positively related to that of utilitarian facilities and supermarkets. The accessibility of these facilities also had this relationship: the distance of recreation facilities, utilitarian facilities, and supermarkets were positively correlated with each other. It indicated that when there were more recreation facilities in participants' neighborhoods, the available number of the other two types of facilities also increases; when the distance to recreation facilities was longer, utilitarian faculties and supermarkets were also farther from participants' residences. The built environmental factors were closely related to each other. Similar elements were distributed at the

similar locations. This also implies there may exist spatial cluster distributions for these facilities. However, it was beyond this study's scope to conduct a further spatial cluster analysis. If possible, the analysis should be implemented in follow-up studies to examine how these facilities were distributed spatially after controlling all the other connections.

One unique finding in this study was that it confirmed a significantly positive relationship between SES and BMI among the participants. When youth BMI was examined as the dependent variable in the regression model, the SES explained 7.6% of BMI. Most studies in the U.S and other western counties reported a negative relationship between SES and BMI (Volkow et al., 2008). In the EBRB framework, SES may also act as a moderator in the connection between BMI and built environment. Proctor and Dalaker's (2003) study pointed out that poverty in overcrowed urban settings was associated with higher BMI. SES may actually correlate with both BMI and built environment; its relationship with BMI may be just a part of the whole story. In the future, SES needs to be examined with BMI, built environment, and other data (e.g., physical activity) so that the determinants of BMI can be better explored.

Although the current finding was different from the original hypothesis which assumed that SES was negatively correlated with BMI, it was consistent with some other studies which focused on low-income population in developing countries. For instance, after reviewing 140 studies, Sobal and Stunkard (1989) reported that higher SES was actually related to larger BMI, especially greater rates of obesity and overweight in developing counties.

In developing counties, many people faced malnutrition especially for children and youth. The wealthier families in those countries might still be considered relatively poor compared to those in developed western countries. Many people in developing countries still believed that addressing malnutrition was a priority despite the emerging increases of obesity and overweight (Martorell et al., 1998). Most parents believed that high energy dense food such as high-sugar, fat, calories represented good food resources. In addition, these negative attitudes and beliefs became worse because of lack of intervention and consensus on how to address obesity in these countries (Fernald, 2007). For example, in Guatemala, better education was positively correlated with obesity (Martorell et al., 1998). In Mexico, low-income population consumed greater quantities of total energy, cholesterol, saturated, and total fat than others; a positive correlation was confirmed between BMI and SES among this special population (Fernald, 2007).

Participants in this study had some similar characteristics to those people in the developing countries. One possible explanation was that the extremely low household income played a similar role among this group. The average household income level of this group ($9,715/year) was very low even when compared to the average local poverty level ($26,842/year). Families with this level of income may look to food as a priority in their daily lives and children and adolescents were given the ability to have more than the 'needed' nutrition intake. Additionally, the participants in this study were all Hispanic American. It was possible that a large proportion of youth in this group had immigrant parents or family members. These family members might have very similar perceptions and attitudes toward food choice and nutrition intake to those in developing

countries. For that reason, study results that indicated a positive relationship between SES and BMI among the extremely low income population was an important finding.

One of the unique connections between this study and the theoretical framework was that both physical activity-related and eating behavior-related facilities were examined in one single study. The theoretical support behind this method was that the Energy Balance-Related Behavior (EBRB) framework stated that the engagement in clustered behavior played as an important moderator in studying youth's health environment (Kremers, Brujin, Visscher, Mechelen, Vries, & Brug, 2006). Physical activity and healthy dietary behaviors have been shown to have close correlations and there existed co-occurrence of behaviors as clustering (Nichols, Sallis, Calfas, & Hovell, 1998; Raitakari et al., 1995; Johnson, Nichols, Sallis, Calfas, & Hovell, 1998). An active individual had a higher chance to have healthier food than an inactive person. One study sampled adolescents in a community and studied their health behaviors; the results indicated that their leisure time physical activity was positively associated with fruit consumption; the using of high-fat sandwich fillings was positively correlated with snacking behavior (Kremers, Bruijn, Schaalma, & Brug, 2004). To get a clearer picture of youth physical activity and nutrition environment, it was more helpful to study the clustering of behaviors within the EBRB framework than to study them in isolation.

To study physical activity and dietary behavior together, the features of facilities influencing these two behaviors also needed to be examined in the same setting. When specific activities were more prevalent than that of the separate behaviors, they may be simultaneously influenced by identical or similar built environmental factors (Kremers et

al., 2006). This study combined both types of facilities' characteristics and the results provided evidence for the future study on how built environmental factors influenced health behaviors and the reasons of their co-occurrence such as having exercise and consuming more fruits and vegetables.

In addition, this study found an association between age and BMI. This is not consistent with previous studies which indicated that to the extent that BMI increases with age it would be relevant to assess the contribution of BMI to the age-related decreases in prefrontal metabolism (Volkow et al., 2008). The different results between this study and other study (Volkow et al., 2008) may be due to they did not report the same confounders because BMI maybe influenced by different factors besides age such as metabolism. Furthermore, the two studies used different methods to measure youth BMI; this may be another important reason why there existed a mixed picture.

After combining the features of both the physical activity-related and dietary behavior-related facilities, this study found a very high density of facilities in the targeted study area. The density of both types of facility may include the interaction effect among them, which means children and adolescents had opportunities to be influenced differently by both physical activity resources and food outlets within the same neighborhoods than by one single type facility. More research will be needed to investigate the combination effects such as quality and walkability on youth health behavior in the future (See study *Implications* below).

In addition, to access these facilities children and adolescents may face more environmental barriers besides the objectively measured proximity of facilities.

Transportation was one of the major barriers to low-income minority youth. Low-income population was thought to be more affected by their built environments because their activity spaces were smaller and they were more constrained by lack of transportation (Saelens, Sallis, & Frank, 2003). The majority participants in this study came from low-income families. Lack of safety perceptions, high speed vehicle, and bad local street conditions had a greater impact on their opportunities to go outside to walk, bicycle, and purchase healthy food.

Limitation

There were several limitations in this study. First, only spatial attributes were calculated as surrogates for characteristics of built environment. Specifically, the available number and the proximity of physical activity facilities and food outlets were used to reflect the accessibility and availability for the neighborhood environments. These attributes may only capture one dimension of access to facilities. For example, the available number of fast food restaurants and supermarkets only presented one aspect of food environment.

The nutrition environment can also be measured by means of food price, variety, and quality. The distance to physical activity facilities may provide information with the closest built environmental features to local residents because the closer facilities had stronger influences than others farther away. In the real world, other features such as density or quality of facilities may also have important impacts on children and adolescents. The facilities may be underutilized if they were of low quality or perceived as an unsafe environment. For instance, many residents reported that they did not visit

nearby city parks because the facilities and equipments had very poor conditions (Kaczynski, Potwarka, & Saelens, 2008). For children and adolescents, they may perceive spatial attributes of facility as only one of the factors that influenced their decisions to walk outside or purchase food. This group may evaluate their neighborhoods with a very different perspective compared to adults.

Secondly, this study collected and calculated spatial data using objective measures and did not bring in subjective data such as interview questions or self-report survey information. Without this type of data the results can not provide deeper understanding regarding how youth perceived the accessibility of the built environments and what really mattered to them. For example, special populations like low-income residents, foreign born immigrants, and children may perceive their neighborhood as a smaller place than others (Macintyre, Macdonald, & Ellaway, 2008). In addition, parks with more features, such as organized activities, trails, paths, playgrounds, and sport fields, were more likely to attract youth to visit (Kaczynski et al., 2008; Macintyre et a., 2008). In the future, those environmental attributes that are particularly sensitive to youth should be added to research.

Thirdly, this study did not acquire GIS data on walkability that could further delineate the real accessibility of local neighborhood environments. Spatial GIS data like sidewalk length, presence of traffic lights, street lightening conditions, abandoned animals, and other spatial attributes that may impact the accessibility of neighborhoods were not obtained because of data cost and availability. The network distance examined in this study may not represent real road conditions because many streets did not have

sidewalk and were only accessible for automobiles instead of pedestrians. These spatial GIS data should also be added to future research studies when resources are available; they will be very helpful to provide insight in examining the entire accessibility of the residential areas.

Implications

Spatial access (e.g., physical distance) to outlets have been documented in many studies as a major barrier for low-income and minority youth to access healthful food in their communities (Block, Scribner, & DeSalvo, 2004; Chung, & Myers, 1999; Moore, & Diez-Roux, 2006). However, spatial access to food outlets was only one aspect of the nutritional environment (Bustillos, Sharkey, Anding, & McIntosh, 2009). The access to more varieties of healthful food was also one important attribute of food environment. Lack of accessibility could mean youth did not have ease of access to enough food outlets and/or, it could also represent that the current food outlets in our research line (e.g., supermarket, grocery, fast food restaurants) did not provide appropriate food prices, or quality of food, or enough variety of food options.

Bustillos et al. (2009) recently used onsite observation survey to investigate the availability and variety of fruit, vegetables, meats, dairy, and grains in not only traditional food outlets, but nontraditional food stores and convenience stores in Texas rural areas. This study reported that nontraditional food stores and convenience stores also provided great healthful food choices such as vegetables, milk, grains, canned fruits, meat and fish. This research opened a new window in studying food availability and gave a very good reminder to researchers that our previous image of food availability in

urban and rural areas may need some changes. Besides supermarkets and grocery stores, those nontraditional food outlets (e.g., dollar stores and mass merchandisers) and convenient stores also provided opportunities for increasing availability of healthful food items for residents (Bustillos et al., 2009). For example, more than 75% of convenient stores provide 100% fruit juice and 100% vegetable juice, and more than half of them provided canned fruits and vegetables (Bustillos et al., 2009). In the future, more work needs to examine the food availability in other nontraditional type of food outlets such as convenient stores, gas stations, and drug stores in urban areas. These stores may represent very critical elements in influencing children and adolescents' food availability and their eating behaviors.

Physical activity and eating behaviors, as two major energy balance-related behaviors should be studied as clustered behavors because the combination of these two behaviors is more prevalent than can be expected on the basis of the prevalence of the separate behaviors. For example, physical activity had a positive association with prudent diet (Raitakari et al., 1995). Physical activity and eating behavior may be influenced by identical environmental factors simultaneously. From this perspective, those facilities that may influence clustered behaviors concurrently were worthy of more investigations. For example, shopping malls provide not only a good place for walking but also fast food service to youth in their leisure time. Shopping malls' characteristics such as food availability may have an impact on youth food choice and its accessibility or walkabiltiy may influence youth's recreational and utilitarian physical activity. Additionally, some features of building structures of shopping malls may directly impact

youth physical activity. To study the associations between built environment and energy balance-related behaviors, it will be every effective if research can focus more on facilities like shopping malls, game arcades (e.g., bowling court), and movie theaters, which provide opportunities for food choice and physical activity.

In addition, the features of these facilities which provide opportunities for increasing physical activity and improving eating habits may have interactions among themselves. For instance, the accessibility of food concessions in shopping malls may have influence on youth's utilitarian physical activity. The distance from inside shopping stores to food service areas may be an important facilitator or barrier for youth utilitarian walking activity. In the future, more empirical evidence needs to be added to this important line of research.

In conclusion, in this study several relationships were found among BMI, SES, and built environment in a low-income Hispanic youth group, who lived around the downtown area of a middle-sized city in the U.S. These findings were: BMI was positively correlated with SES; facility accessibility and availability contributed significantly to youth BMI. Built environment variables (facility accessibility and availability) explained only about 4% of the variance of youth BMI in the present study. However, this amount of variance could have public health significance because the environmental variables affect large population over a long period of time.

In the future, more research is needed to define the most important variables effecting youth BMI. More advanced model needs to be established to determine the more precise mechanism of how a variety of factors influence BMI at different levels,

especially in low-income minority communities. In addition, physical activity and eating behavior data should be added to the future research so that the influence of environmental factors linking health outcomes can be further tested through health behaviors. This study is an early analysis of a complex social phenomenon that needs continued investigation.

CHAPTER V

CONCLUSION

The purpose of these series of studies was to examine the associations among youth's social economic status, neighborhood environments (built environments), and BMI. According to the social ecological model proposed by Sallis and Owen (1999), these elements fit in intra and extra individual features and may have an impact on each other. When a change happens at one level, all the other level factors may be impacted by this change. The three series of studies implemented quantitative objective methods to analyze youth's neighborhood environments (e.g., accessibility and availability of facilities within 1-mile distance) and individual information (e.g., age, gender, SES, and BMI). The results indicated some significant associations among them:

1. Study 1 - Associations among age, gender, SES, and physical activity-related facilities:
    a. SES was positively correlated with the distance of recreational facilities;
    b. SES was negatively correlated with the distance of utilitarian facilities;
    c. SES was positively correlated with the number of utilitarian facilities;
    d. The distances of both types of facilities were positively associated with each other;
    e. The numbers of both types of facilities were positively associated with each other.
2. Study 2 - Associations among age, gender, SES, and food-related stores:
    a. SES was positively correlated with the number of supermarkets;

b. SES was negatively correlated with the number of fast food restaurants;
c. The distances of both types of food stores were positively associated with each other.

3. Study 3 – Associations among age, gender, SES, BMI, and all types of facilities:
   a. BMI was positively correlated with SES;
   b. BMI was positively correlated with the distances of all facilities except fast food restaurants;
   c. BMI was negatively correlated with the numbers of all facilities except fast food restaurants;
   d. Age was positively associated with SES.

Low-income Minority Youth

Low-income minority youth represent a special population and have some unique characteristics in their use patterns of facilities and health conditions.

First of all, they occupied less resources in their neighborhood compared to those living in the middle- and high-income neighborhoods (Powell, Slater, & Chaloupka, 2004). Since youth from low-income families do not have enough activity-related facilities or healthful food outlets, they are in relatively disadvantaged positions. They have fewer opportunities to go outside for exercise or recreation, fewer food stores providing fresh and healthful foods, greater exposure to fast food environment providing dense-energy foods (Estabrooks, Lee, & Gyuresik, 2003). All these factors put low-income minority youth at high risks of being obese.

Secondly, even they have enough number of facilities and healthful food outlets, low-income youth may have poor access to these destinations (e.g., the distance is too far or the safety issue in the neighborhood). Low SES neighborhoods had poorer qualities for physical activity facilities (Estabrooks, Lee, & Gyuresik, 2003) and food outlets in low SES neighborhoods had fewer healthful foods available (Estabrooks et al., 2003). Access issues in regard to lack of transportation, poor qualities of facilities and sidewalks, and lack of interesting destinations would gave youth negative perceptions of accessibility in their local communities and reduce their healthful food consumption and physical activity. Ultimately, the disparities of their SES may bring inequities in health outcomes and related social economic problems.

Thirdly, the SES may exert a different influence on health outcome for low-income youths compared to other groups of youth. For instance, this study has confirmed a significantly positive relationship between Hispanic youth SES and BMI; while other studies indicated that this relationship was negative (Proctor & Dalaker, 2003). As discussed in study 3, among low-income youth those with relatively higher SES backgrounds consumed greater quantities of total energy, cholesterol, saturated, and total fat than others with relatively lower SES backgrounds. The reasons could be culture differences or parents' beliefs and attitudes toward nutrition, but they were not conclusive. In a word, BMI may have a different relationship to SES among minority youth living in poor neighborhoods compared to other groups.

Finally, researchers need to develop more applicable and effective theoretical frameworks and conceptual methods focusing on low-income minority youth to better

understand those factors that may particularly influence their unique living environments, life styles, and health outcomes. A potential promising direction in the future is to study minority youth obesity, clustered behaviors (physical activity and dietary behaviors), and low-income neighborhoods in an appropriate theoretical framework (e.g., EBRB framework) to meet recommendations for multiple healthy lifestyles. Adherence to multiple healthy lifestyle factors for low-income youth represents a more person-centered approach to health outcome and conveys meaningful information and may be more aligned with the objectives of public health than monitoring single risk factors. In this study, only BMI, spatial attribute of facilities, and youth SES were included. This measure may not fully reflect the picture of energy balance-related factors in the comprehensive lifestyle-related health behaviors for low-income minority youth. There are some other factors that may be very sensitive to this group's perceptions of accessibility such as safety, qualities of facilities, and food prices. With only one or several factors, the health issues for low-income minority youth may not be well solved.

The growing interest in studying the associations between built environments, individual characteristics and youth health conditions are attested to by new initiative of governmental organizations like the CDC, with its Active Community Environments (ACES) research committee, and non-profit organizations such as Robert Wood Johnson Foundation. These studies indicated that youth's individual features (e.g., age and gender) have some associations with their health conditions (e.g., BMI) and built environmental factors (e.g., accessibility and availability of facilities and food outlets).

These results may provide some evidence to improve the understanding of the relationships among youth individual, environmental, and social characteristics, which may be useful to promote youth health behavior (e.g., physical activity and eating behavior) in public health.

The research results in this study may have the following implications to research in this field:

Theoretical Implications

Social ecological models (SEMs) addressed multi-levels of determinants that may influence people's health conditions and behaviors. Three domains in this study – individual characteristic, built environment, and social environment, have been investigated. Participants' demographics, as their individual characteristics, were tested to find out whether they had associations with their BMI. Facility distances and their available numbers were examined as the features of built environments; the associations between these features and BMI were explored. Youth families' SES has close relationships with social environment; therefore, the SES was investigated as one of social factors in this study. The research results indicated that all these three domains had some associations with health outcome (BMI). In addition, the connections among these three domains were also tested. For example, participants' demographics and SES were associated with one another and they were related to the features of facilities.

These results supported the basic assumptions and foundations of SEMs (See Figure 1 in Chapter I) such as the factors in SEM not only influenced people's heath behaviors and outcome directly, but also interacted among themselves. First, the

research results in this study supported that built environment was associated with youth health behaviors and outcomes, but the results were not conclusive. BMI was positively correlated with the distances to supermarkets, recreational, and utilitarian facilities; BMI was negatively related to the available number of physical activity-related facilities. It is commonly believed that built environments affect youth's weight status by shaping both their physical activity and eating habits (Sallis & Glanz, 2006). Since these two behaviors are closely related to features of facilities in youth neighborhoods (Bedimo-Rung, Mowen, & Cohen, 2005; French, Harnack, & Jeffery, 2000), the research results in this study provided some evidence that an association existed: participants had lower body weights when they had shorter distances to some facilities, such as parks, community centers, shopping malls, and supermarkets. Although the correlation analysis supported these findings, the regression models did not fully support that every spatial feature of facilities contributed to BMI significantly. Other investigators also pointed out that certain development patterns in the built environment, such as lack of sidewalks, long distances to schools, and the need to cross buy streets, discouraged residents' walking and bicycle activities (Sallis & Glanz, 2006). However, it was not conclusive that more activity would reduce youth obesity since this was not a primary focus in this study. Recent studies also investigated some new changes in youth food environment, including greater reliance on fast foods, insufficient fruits and vegetables intake (Block, Scribner, & DeSalvo, 2004). But again, these pieces of evidence could not prove that these changes decrease youth obesity rates.

Secondly, the causal relationship between built environment and health behavior and outcome was not clear. The variables regarding characteristics of built environment have been collected on a non-theoretical base. For instance, well-established theories in searching GIS variables for walking destinations were lacked according to Lee and Moudon's (2006) research. A lack of conceptual models made it difficult to discover or study the causal role of built environmental features on physical activity and eating behaviors. Some researcher suggested that researchers in this field should investigate attributes of built environments on their own and establish a system to study the most relevant environmental influences of energy balance-related behaviors (Owen, Humpel, Leslie, Bauman, & Sallis, 2004). From this perceptive, research is needed to document how and to which degree the environment impacted physical activity and dietary behaviors.

This study indicated that features of facilities contributed 4.2% to the variance of youth BMI and this result may only represent a possible causal mechanism between built environment and health outcome. In the SEM, the causal mechanisms linking built environmental features with energy balance-related behaviors (EBRBs) like physical activity and eating behaviors were stated (Kremers et al, 2006). When environmental features impacted health behaviors, mediators such as automatic mental process may play an important role in a causal path (Moskowitz, Skurnik, & Galinski, 1999). Automatic process represented that environmental features can affect behaviors without individuals being aware of it (Berridge & Winkielman, 2003). For instance, one study showed that thirsty participants exposed to happy faces consumed 50% more of a fruit-

flavored drink than those who were exposed to neutral faces (Berridge & Winkielman, 2003). With similar process, in the study the spatial attributes of the facilities such as shorter distances to fast food restaurants may give youth better perceptions to accessibility and increase their consumption of high-fat and –sugar foods without youth being aware of it. As a result, youth increased their body weights because they were exposed to shorter spatial distances to fast food restaurants.

Thirdly, there are other possible relationships between health outcome and built environment. The results of this study on the link between facility attributes and BMI may indicated that built environmental features affect youth BMI through mediators such as physical activity. In another word, physical activity may play as a mediator. For example, a child living in an urban environment with many parks and recreation centers, which were facilities of walking for exercise. But this area also had a lot crimes and dangerous road hazards, which were barriers for physical activity. In this situation, an individual needed to make decisions based on his/her evaluation on the surrounded environments. More or less walking may bring different health outcome such as overweight or normal weight. Therefore, the associations between walking and different aspects of urban built environments may influence whether or not a child was obese.

Fourthly, SES had associations with the built environment and BMI. The ANOVA analysis indicated that the features of facilities varied across different income groups. The lower income groups had fewer available physical activity facilities and supermarket, and more fast food restaurants in their communities. In addition, lower income groups had longer distance to recreational and utilitarian facilities and shorter

distance to fast food restaurants. As a result, low SES should lead to high BMI since less physical activity opportunities and more fast food were available for youth. However, this study showed SES was positively related to BMI and the possible reasons were discussed in Study 2. In SEM (Kremers et al., 2006), environmental factors have been stated to have differential effects on various demographic sub-groups of the population. The indirect causal mechanism which reflected the moderating role of SES in the influence of the environment on behavior was pointed out as well. But the research on low-income Hispanic youth was limited. The results in this study provided some evidence on this topic. In regression modes of this study, SES contributed to the features of facilities significantly. When physical activity data is available, SES can be further tested whether it moderates the association between the built environment and health behaviors.

Finally, one thing needs to be noted was that the variables that were tested in this study can not represent all the features in those three domains of SEM. For instance, the spatial attributes of facilities in participants' neighborhoods may represent only some aspects of the built environments. There are also other important attributes of built environments in the study area (one mile distance of each individual's residence) such as walkability, safety and crime, road conditions and traffic.

Take 'perceived neighborhood safety' as an example, it is one of the most important community and environmental variables that may influence an individual's physical activity behavior (Fleury & Lee, 2006). The design of neighborhoods such as the unsafe perception of a local community may cause people to have less physical

activity and decrease fitness over time (Fleury & Lee, 2006). In addition, different racial groups have different safety perceptions of their neighborhood. Minority youth have reported that neighborhood safety was an important correlate of their participation in physical activity (Adkins, Sherwood, Story, & Davis, 2004). Some previous reports also suggested that the perception of unsafe neighborhoods results in less physical activity and the perception of safe adults at local facilities were associated with more frequent physical activity (Warden & Warden, 1997).

Although it is not very practical to collect all the information, this study explored different level factors of SEM and its application in studying a special population (low-income Hispanic youth). In the future, more data should be added to those three levels of domains in SEM and make the research results more comprehensive and richer when information available.

SAYC Programmatic Implications

This study focused on individual factors and the built environment, which were both important facets of social ecological models. Through examining them, the SAYC participants were studied at different levels, e.g., at individual and neighborhood levels. In addition, the results of this study provided important supplemental evidence to support that it was possible that individual and built environmental factors impacted youth health conditions (e.g., BMI) in potential causal paths, although it was not proved in this study.

The research findings indicated that the following strategies may promote youth physical activity and improve their eating habits:

1) SAYC may post more information to youth (and their families) on available physical activity facilities in local communities. This study indicated that facilities like parks, recreation centers, movie theaters, shopping malls, game arcades, DVD stores, mini gold courses, and youth organizations were very good facilitators for youth physical activity. These facilities represented the most frequently visited places during youth's spare time after school. Youth may spend a lot time to visit, shop, play, or eat in these places. Therefore, it will be an effective way to give youth more opportunities for physical activity by providing them more information of available facilities such as the schedules, locations, programs, fitness equipments, activities, and walking routes to the nearby facilities. When youth have enough information on facilities, they may be more willing to walk or cycle outside, or attend many programs available to them;

2) Given the high density of fast food restaurants in youth's neighborhoods, SAYC may provide more education to youth on nutrition and food choice. According to this study's results, the average distance to the closest fast food restaurants was only 1000 ft in the study area. Youth in this area had increased exposure to unhealthful food environment such as high-fat, -sugar, -low fiber foods. SAYC may provide youth nutrition knowledge on topics like what healthful foods are (e.g., fresh fruits and vegetables), where to find them (e.g., supermarkets), and why fast foods increase the risks of obesity.

In addition, education sections should also encourage youth's parents to attend because parents' attitudes and beliefs toward nutrition would greatly influence youth daily food choice (Adkins, Sherwood, Story, & Davis, 2004). By doing so, the program

can effective deliver nutrition information to youth and their family, and reduce their chances to go to fast food restaurants in local communities.

Usually, youth's health behaviors directly influence their health conditions. It was a limitation that this study did not get a chance to examine the mechanism of how participants' characteristics and neighborhood environments influenced their health behaviors (e.g., physical activity and eating behaviors) because no behavioral data was available during the period of dissertation writing. However, that did not mean this part of the study was not important and can be ignored. In the future, researchers should examine whether there is any association between participants' health behaviors and their individual and built environmental factors once data is available.

The current data on participants' demographics (e.g., age and gender) and their health conditions (BMI) can be tracked and a longitudinal dataset can be established. In this way, both cross-sectional and longitudinal studies may be conducted. This may explore the issue of how built environments influence an individual's health behavior with a deeper understanding. For example, when data of participants' physical activity or eating behaviors are available, a hierarchical regression model can be established to examine whether more recreational facilities may increase participants' physical activity, or whether more fast food restaurants may decrease youth's fruit and vegetable intake.

Furthermore, a linear hierarchical model will be appropriate to examine what factors influence participants' physical activity and eating habits. Participants' demographics will be controlled to examine whether their health behaviors are impacted by any of the individual factors such as age, gender, and SES.

Methodological Implications

GIS Standards

The ability to describe and measure neighborhood characteristics, such as the accessibility and availability of facilities, is significantly facilitated by the application of geographic information system (GIS). Since GIS methods are becoming more and more popular in studying the built environment, it is essential to establish a set of standards in detail to better display and examine the data spatially. However, there are only a few studies that described the processing decisions applying GIS in research. The lack of such information makes it difficult to compare different studies in the same field because of various processing methods in GIS. This is also the reason why each of the three studies contain a separate part discussing *GIS data Acquisition and Preparation*—including details on where the data came from and how the study processed the data (e.g., discussing in detail how to geocode the address information using ArcGIS software). In the near future, when there are more and more GIS data processing information discussed in this field, it will be more practical to establish a set of rules or some commonly used standards that may be accepted by GIS users in published research so that different users and researcher can share their information on the same platform.

Buffer Size

The size of buffer may need to take into consideration the abundance or the paucity of the destinations when the neighborhood characteristics are examined. The buffer size should be within a certain distance range so that youth can access facilities by walking or cycling. Theories of the built environment did not provide a precise

geographic scale for reasonable local neighborhoods (Boarnet, 2004). The present study focused on those facilities within common distance of walking. It used the radius 1-mile (1609 m) as the neighborhood buffer, which contained facilities ralted to youth physical activity and food accessibility. Some previous studies supported this decision. Jago, Baranowski, and Harris (2006) used 1-mile buffer to examine the objective distance to the nearest parks, trails, shopping malls, grocery stores, and fast food restaurants from 210 participants. Most participants reported that one mile distance could cover major destinations that they want to go. The results showed that most these facilities were closely related to participants' physical activity. In addition, some other studies also reported that local residents reported they had enough facilities to use and felt comfortable to arrive at these destinations within 1-mile distance (Cohen, Ashwood, Scott, Overton, Evenson, Staten et al., 2006; Committee on Physical Activity, Health, Transportation, and Land Use, 2005; Diez-Roux, Evenson, McGinn, 2007).

In reality, the buffer size should depend on the target destinations, which are determined by the research purpose in the end. For example, open space, river and transit station are usually outside 500-meter of local residents' home (Mccrmack et al., 2008). If the buffer size is set to lower than 500 meters, then the destinations in the area can not be sufficiently sampled. Therefore, if a study's purpose is to study destinations such as open spaces, rivers and transit stations, the radius of the buffer should be at least 1500 meters in order to include most target destinations. On the other hand, if the research focuses on common destinations like post offices and bus stops, 1500-meter may be inappropriate because most participants may have access to at least one of these

destinations, thus reducing the variability of the target destinations. In this study, the buffer size was chosen based on previous research and the built environmental characteristics of the study area. As discussed above, there is no formula or on hand procedure in selecting buffer size for research so far. The decision making process practically depends on the investigator's understanding of the on-going research and previous experience from past literatures.

Final Thoughts

In the end, I would like to cite a very famous Chinese saying, which states, "Persons who have the same personalities stay together, and things that have the same characteristics stay together". In English, it means things of one kind come together. Low-income Hispanic youth are at a disadvantaged position: they have fewer opportunities for physical activity, fewer healthful foods to access, higher prices to buy more healthful foods, higher BMI, more families in poverty and more crimes in their neighborhoods than youth in other groups in the U.S. It seems many adverse factors do '*stay together*' and give this group a living environment that would bring various health risks. When obesity risks of low-income minority youth are combined with all of these other adverse health effects, it is possible to produce cumulative disadvantages based on race, income, and neighborhood resources. Does that mean we can not prevent all the negative factors from '*staying together'?* Or, can we let those positive factors happen and 'stay together'? I think as long as more talented researchers start to work on this issue, more research contributes to this phenomenon, and more actions are taken, we can always find a method to reduce or break down those negative factors and increase

positive factors. To end the negative trend of health effects for low-income minority youth, all the factors need to be considered in a comprehensive system including cultures, attitudes, education, families, schools, communities, health care, and policies. The efforts to fight against obesity in low-income minority will depend on all levels of efforts in this society to change this special group's adverse physical and social environments.

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accessibility of supermarkets in Metropolitan Detroit. *American Journal of Public Health, 95*(4), 660–667.

VITA

Lei Zhou received his Bachelor of Science degree in industrial engineering and trade from Zhengzhou Institute of Technology in 2000. He entered the Environmental Science program and Leisure Studies programs at the University of Iowa in September 2001 and received his Master of Science and Master of Arts degrees in December 2004 and December 2005, respectively. In 2006 he was admitted to the Recreation, Parks and Tourism Sciences doctoral program at Texas A&M University and received his Doctor of Philosophy in December 2009. His research interests include built environment, youth obesity, physical activity, and eating behavior.

Dr. Zhou may be reached at: Houston Department of Health and Human Services (HDHHS), 8000 N. Stadium Dr., Houston, TX 77054. His email is zhouleizhou@hotmail.com.