ANALYSIS ON CORRELATION BETWEEN URBAN FORM FACTORS AND CHILDREN'S WALKABILITY TO SCHOOL

By

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To my Family and Friends

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Childhood obesity has been constantly increasing in the United Stated. Research studies suggest that one of reasons responsible for childhood obesity is the loss of physical activity. One solution to increase the amount of physical activity children engage in is the provision of environment where children can walk and bicycle to school safely.

This study tests the correlation between urban form factors and children's walkability to school. The study is conducted based upon the data from 40 public schools in Orange, Seminole, Pasco and Hillsborough Counties in Central Florida. The study areas are created using School Attendance Zone (SAZ) at the distance of half-mile and one-mile around school. The indicators are developed, representing urban form variables ---school attendance zone geometry, street connectivity and residential density. The dependent variable is represented by children potential walkabiltiy, assuming that all children within study zone could walk or bike to school. The Ordinary Least Squares

regression model tool in ArcGIS is used to test the relationship between dependent variable and explanatory variables.

The findings from this study suggest that school attendance zone geometry is not significant associated with children’s potential walkability; street connectivity and residential density show the different levels of correlation to children’s potential walkability. The results from half-mile and one-mile study zones present the different correlations among variables.

Due to the limitation of this study, the actual children’s walkability to school cannot be predicated based on the results. The future study could take into account other social, economic and family factors to further explore the correlation between the actual children’s walkability and urban form factors.

CHAPTER 1
INTRODUCTION

Background

Over last forty years, planning in United States has put too much attention on automobile usage, which created the automobile-oriented community where walking has become increasingly undesirable and unsafe. With the more concern on environmental and health issues, people start realizing that their over-dependence on automobile has been responsible for many health issues. The awareness towards the negative consequence of automobile usage has drawn attention to the benefits of walking and the importance of walkable community.

Walking is the most basic form of transportation. Pedestrian access between home, work, and facilities improves people's quality of life by providing residents with options of daily exercise and healthy lifestyle. The good connectivity of pedestrian network provides residents without access to automobile access to employment, recreation, and education opportunities in a safe and efficient way. Thus, provision of pedestrian infrastructure that facilitates safe travel is a key issue for urban planners and public policy makers.

Problem Statement

Elementary and middle school students are unique in their reliance to walking and biking modes of transportation. In the past, walking to/from school used to be one of main options for physical activity available to elementary and middle school students.

However, recent research finds that the number of youth driven to/from school has a constantly increase compared to students in the past. In 1962, through k-12 42% school children walked or bicycled to school while this number declined to 16% in 2001(CDC, 2005*).* It is generally accepted that the loss of physical activity acquired by walking is one factor responsible for a nationwide rise in childhood obesity rates. One solution to consider in addressing this issue is the encouragement of physical activity by providing safe and accessible opportunities for children to walk and bicycle to school. Urban planners and policy makers have the opportunity to address this issue by designing and providing safe and well-connected pedestrian routes to promote the community environment where the children can improve health by increasing daily physical activity.

Study Objectives

The time children spend on physical activity could be increased by providing children with safe routes to/from schools. One of many aspects involved in safe routes to/from school is urban form, which consists of many factors such as school location, street connectivity, residential density etc. The study on these factors could help to create the urban form where children can walk and bicycle to school safely.

The purpose of study is to understand the correlation between children's walkability to school and urban form factors. Children's walkability is measured by children's potential walkability, assuming that all students living within study zone could walk to school. Urban form factors in this study include street connectivity and residential density within school attendance zones.

The study is conducted with data from forty public schools in the State of Florida—thirty three elementary schools and seven middle schools. Forty schools are respectively from Orange County, Seminole County, Hillsborough County and Pasco County in the State of Florida. GIS data is obtained from Geoplan Center at University of Florida, including school location, school attendance zone, students' home location and street network, based on which indicators used to measure children's walkability and urban form are developed. A regression model in ArcGIS was chosen to test if there are correlations between children's walkability and urban form factors.

Chapter 2 examines existing research about measures of walkability and urban form factors affecting children's walkability to school. Chapter 3 presents the methodology to establish the study zone and develop indicators to measure urban form factors. Chapter 4 shows the results from running regression models. Chapter 5 explains the results and discusses the limitation of research.

CHAPTER 2
LITERATURE REVIEW

This chapter illustrates the connections between urban form factors and children's walkability. This section will start with a review of research on relationship between childhood obesity and physical inactivity. Then a summary on measures of walkability are made based on existing research. Then the issue of public school siting associated with children's walkability will be discussed. Last, some characteristic of urban form will be described by examining the relationship with children's walkability to school.

Childhood Obesity and Physical Inactivity

It is generally accepted that increased physical activity promotes good health and increases life expectancy. A major national study found that 42% of men and 28% of women were overweight, and 21% of men and 27% of women were obese and that U.S. adult obesity rates increased from 12.1% to 17.9% between 1991 and 1998. In a 1993 study, 14% of all deaths in the United States were attributed to a severe lack of physical activity and poor dietary habits (McGinnis 1993). In a later study, sedentary lifestyles were linked to 23% of deaths resulting from major chronic diseases (Hahn 1998). That is to say, people who exercise reduce their risk of developing or dying from heart disease, diabetes, colon cancer, and high blood pressure. In fact, long-term changes in obesity and being overweight are more closely correlated to physical activity than dietary changes (Prentice 1995). Thus, people who exercise tend to have longer lives than less active individuals (Kushi1997; Lee 1999; Wei 1999). These results suggest policies and programs aimed at increasing physical activity will prove to be effective in addressing the current obesity epidemic in the U.S.

Although physical activity is a critical component of overall health, youth are exercising less today than their counterparts 35 years ago (U.S. Department of Health and Human Services 2002). Over the last 40 years, the rate of childhood overweight has tripled (Figure 2-1). Scientific evidence has shown that physical activity plays a critical role in supporting weight loss. Unfortunately, many children do not participate in the recommended amount of physical activity needed to maintain a healthy weight that supports healthy lifestyles (Dellinger & Staunton, 2002). In many cases, children are not provided with opportunities of engaging in physical activity due to the inadequate of facilities, poor commute system between residential dwellings and service, and the lack of necessary infrastructure such as pedestrian sidewalks and bike lanes.

Walking or bicycling to school is one of the easiest ways for school aged children to gain physical activity on a daily basis. However, in the United States, the number of children walking or bicycling to school has declined to 15% in 2001 compared to the percentage of 48% in 1969 (Steiner, et al 2008). Decrease in the number of children walking and bicycling to school and the reduction in the amount of time children spend in physical education classes both contribute to the reduction in children’s physical activity.

It could be challenging to assess correctly one certain factors without taking into account other built, social, and economic environment factors because they may occur and influence children's physical activity jointly. However, recent research suggests that children's weight is influenced by a number of built environment factors. For instance, a higher level of physical activity in children is associated with better sidewalks (Jago et al., 2006), higher quality recreational facilities (Romero, 2005), easier access to recreational facilities(Gomez et al,2004), greater housing density (Roemmich et al., 2006), and higher neighborhood walkability(Kerr et al., 2006).

There are many methods that encourage children to engage in physical activity, one of which is provision of safe access and route to school. Davison et al(2006),through thirty three quantitative studies, concluded that children's participation in physical activity is positively associated with publicly provided recreational infrastructure (access to recreational facilities and schools) and transport infrastructure (presence of sidewalks and controlled intersections, access to destinations and public transportation). Therefore, children's physical activity could be increased by improving the walkability to school.

Urban Form Factors Influencing Children's Walkability

There have been numerous studies on walkability in the past. In this section of the report, an effort is made to emphasize some of these studies that form the base for identifying the measures of walkability to be used in formulating the model developed in this study.

Measures of Walkability

An effective way to provide younger populations the opportunity to engage in physical activity is to provide safe and accessible means for children to travel between home and school by walking or bicycling. Provision of safe and accessible ways could be fulfilled by improving the safety and connectivity of physical environment in the streetscape. To better understand the link between walkability and physical environment, a review on measures of walkability would be helpful.

In his report, Coffee (2005) concluded that studies on walkability show a consistent emphasis on connectivity, proximity, land use mix, density and safety. Due to the characteristic of this research, the author will focus on urban form factors. Although there are differences between adult and children in travel patterns, some research found that there is a similarity in the factors influencing both walkability. Frank et al(2007) concluded that the same indicators of walkability that are related to active transportation and physical activity in adults (i.e., street connectivity, residential density, and mixed land use) are related in similar ways to walking for transportation in children and especially adolescents. Apart from these indicators, school location and siting are also proved to be related to school children’s travel. Ewing et al(2004) examined the relationship between mode of travel to school and the full range of factors related to school location. In this study, students with shorter walk and bike times to school proved significantly more likely to walk and bike. In another study, Steiner and Bejleri(2008) investigated the relation of the school siting with children's potential walkabiltiy throughout Growth Management periods from the 40 public school in Central Florida. This research emphasized the role of public school siting in determining the children's walkability to school.

Given that the unique nature of children's travel between school and home and the limitation on data availability, this study will focus on the issue of public school siting, street connectivity and residential density. The following sections discuss these factors in detail.

Issue of Public School Siting

There are many issues associated with school siting. This study briefly discussed enrollment capacity, school site location and site size.

School enrollment capacity. Since the 1980s, average school size (measured by enrollment capacity) has grown with the increasingly larger school facilities size and longer distance from the neighborhoods they serve. Florida public school enrollment in 1980, for Pre-kindergarden through Grade 12 school-aged students, was approximately 1,510,000 (American Fact Finder, 2008). This number increased by 76.62% based on the approximated 2,667,000 students enrolled in 2007 (American Fact Finder, 2008).

During about 30 years, that's approximately an additional 1,157,000 students across the entire State. Furthermore, the National Center for Education Statistics reported that from 1930 to 2001, public school enrollment in the U.S. nearly doubled, from 26 to 48 million students (across all grade levels), yet the number of public school buildings decreased 60 percent in the same period, from 247,000 to 93,000 (ICMA, 2008). This statistic indicates a shift from an average of 105 students to nearly 516 students per school building. As the average size of a school has grown, so to have the distances between schools and the neighborhoods they serve. This trend not only relates to growth in average enrollment size, but is also causative of the policies and practices that encourage large site locations and discourage expansion and renovation of existing school sites.

School enrollment capacity is partially decided by the district school board's establishment of School Attendance Zones (SAZ). School attendance zones are the geographical boundaries that institute which communities (area) a school will serve. SAZs are established based on a series of factors, of which enrollment capacity plays a critical role.

SAZs are also developed with the purpose of integrating a diversity of students into school facilities. However, balancing the structure of a student body is quite difficult, due to residential development patterns which often produce neighborhoods that are demographically and socio-economically unbalanced. The result is a set of attendance boundaries that vary considerably in shape and size (Steiner, et al., 2008). The location of a school site relative to the neighborhood it is intended to serve may be quite distant, which in turn gives rise to n transportation issue concerning the mode choice of children travel from home to school. While recognizing this problem and understanding its implications, this study is focused on the location of school and students in relation to the center of SAZ.

School site location and site size. The increase in school site size also plays a critical role in determining school walkability. Over the past thirty years, the acreage required for school sites has been increased so much that it is becoming more difficult to consider walkability as a critical factor in school location siting. In many cases, over-grown school site is resultant of concerning on costs and availability of land within existing urban areas. With scarce budgetary resources under a weakened economy, government dollars are being spent to cover the most crucial needs, particularly wages for teacher's positions, and the cost of text books, among other needs. Citing school walkability as a priority is typically an afterthought (Schmucker, 2009). Due to the increased distances between many schools and the neighborhoods they serve, walking and bicycling is simply not feasible and the school bus is typically acknowledged as the solution to the problem. In the State of Florida, district bussing is not provided within a two mile radius around school sites, unless hazardous walking conditions exist preventing safe and accessible access for children to walk or bicycle to school (e.g., road construction). Under these circumstances, courtesy bussing is provided for those students until such problems hindering access from home to school are remedied. Besides, due to other factors such as safety, parents still drive their children to school even close enough to school (Campbell & Wang, 2008).

Another study, examining the impact of neighborhood walkability (based on street connectivity and traffic exposure) within 2 km of public primary schools on children regularly walking to school, reveals that connected street networks provide direct routes to school(Georgina et al,2010). However, when connected street networks are designed for heavy traffic, the potential for children to walk to school is reduced. This highlights the importance of carefully considering school siting and, particularly, street design in school neighborhoods

Street Connectivity

A central point of contention among urban planners and transportation engineers is the issue of street network design and pedestrian travel options. In designing road networks with the primary goal of increasing automobile efficiency, critics argue transportation planners have built mode choice out of the built environment equation. The development of cul-de-sacs, for example, represent an approach to design efficiency for automobile transportation, but they have the opposite effect on pedestrian access and efficiency; pedestrians often have to take out-of-the-way, circuitous routes because direct routes are truncated by cul-de-sacs, and transit vehicles cannot efficiently serve curvilinear neighborhoods or branch roads. Therefore, many modern suburbs limit pedestrian and transit access in exchange for increased auto-mobility (Cervero 1997). Reform-minded urban designers argue that walking will increase in neighborhoods designed with more pedestrian friendly features, such as connected sidewalk layouts, increased mixed-use development, and high density commercial and residential development (Duany 2001). Street design is one example of measures commonly used to assess neighborhood walkability – researchers also frequently employ provision of sidewalks, streetscape design, miles of street, and access to activities.

There have been many studies of the relationship between active transportation and urban form in adults, but the associated factors for adults may differ from those for children. Few studies have investigated the relationship between street connectivity and children's walkability and physical activity, and results are mixed with some indicating a relationship and others finding no associations.

Norman et al(2006), investigating community design and access to recreational facilities variables derived using geographic information systems (GIS) for799 adolescents, found limited evidence that street connectivity(intersection density as indicator) was associated with adolescence activity. However, this study shows the results that intersection density inversely related to girls' physical activity, which implies that the impact of street connectivity on children's physical activity may differ by gender. Center for Design, Methods, and Analysis(2004) evaluates the relationship between neighborhood design and rates of students walking and biking to elementary school in 34 California communities**.** The results from this study shows that children's biking and walking rates were not associated with intersection density. It is worthy noted that in another study street connectivity was found to be inversely related to physical activity. Timperio A, Ball K, Salmon J, et al(2006) conducted a Cross-sectional study of 235 children aged 5 to 6 years and 677 children aged 10 to 12 years from 19 elementary schools in Melbourne, Australia and found that Good connectivity en route to school was negatively associated with walking or cycling to school among older children.

On the other hand, The City of Raleigh, North Carolina, recently published "Design Guidelines for Pedestrian-Friendly Schools,"(2008) outlining thirteen main characteristics of the area within one quarter-mile radius of a school that indicate high potential for walking and bicycling, which includes street connectivity as indicator. Schlossberg et al (2006) conducted a study by evaluating the effects of urban form and distance on travel mode to school among middle school students in Oregon, which found that urban form does play a role in a child's travel options to school. Schlossberg and colleagues (2006) utilize several indicators of street connectivity, including street density, intersection density and pedestrian route directness. The findings from this study also reveals that students are willing to walk at distances greater than the accepted standard of one-quarter mile, which supports further research investigating the impact of urban form at greater distances around school sites. In addition, this study found that while holding distance and other urban form measures constant, intersection density was a strong indicator which influenced overall walkability (Schlossberg, et al., 2006). In support of the findings from this study, Frank et al(2005) suggest that areas with densities equal to or greater than 30 intersections per square kilometer have been associated with greater overall connectivity and increased levels of physical activity.

Schmucker(2009) investigated how urban form impacts children’s potential walkability to school by conducting a case study of Orange and Seminole Counties in Central Florida. This study, using half mile and one mile as walkable distance, reveals that good street connectivity reflects the well-connected urban form which provides a great potential for children walking or bicycling to school.

Residential Density

The U.S. Census compiles data on the characteristics and locations of citizens across the country. Therefore, density measures such as population, housing units, and employees per unit area are the most readily accessible and oft used urban form variable in neighborhood accessibility research.

Neighborhood accessibility research frequently relies on household survey results and personal daily trip diaries (Cervero 1997; Audirac 1999). These data collection methods are designed to spatially locate residents' characteristics and behaviors. In her 1999 article, Ivonne Audirac (1999) explored the likelihood that housing consumers would trade-off living on smaller lots for pedestrian proximity to community amenities. Her analysis of the University of Florida, Bureau of Economic and Business Research (BEBR) consumer attitude survey found residents of single-family homes were willing to trade smaller lot sizes for improved pedestrian access to 2 of 5 types of neighborhood amenities. Residents of apartments and condos, for whom the spatial costs of reduced lot size are minimal, were willing to accept smaller lots for improved access to any community facility. These results suggest higher residential densities may instill a greater appreciation of walkable neighborhoods.

Many studies have been published relating walkability and increased levels of physical activity to various characteristics of urban form including, residential density, mix of land uses, street connectivity, and aesthetics & safety (Saelens, Sallis, Black, & Chen, 2003). Although little research has been conducted specifically examining the impact of residential density on a child's ability to walk and bicycle to school, two studies give a look at the relationship between them.

Kerr et al(2007)conducted a study looking at pedestrian travel in Atlanta by US youths aged 5 – 18 years. Relationships between five urban form variables and walking in specific demographic subgroups are assessed using stratified logistic models and controlling for participant demographics. Residential density and recreation space were strongly related to walking in the highest income group, and residential density was a stronger factor in the larger households. In another study, Center for Design, Methods, and Analysis (2004) evaluates the relationship between neighborhood design and rates of students walking and biking to elementary school in 34 California communities**.** The results from this study supported that the walking and biking rates are higher in denser neighborhoods and to smaller schools.

In this research study, the author will examine the impact of residential density on school walkability. A key issue to consider when using density as a measurable characteristic of walkability is the differences in calculating density types. Depending on the type of research one might be conducting, it is important to differentiate the classification of density calculations being used, as results can sometimes be confusing or misinterpreted (Forsyth, 2003). For instance when calculating either Gross or Net residential density, it's not enough to state the one is calculating "Net" residential density.

This is due to a difference in mathematical equating. Net density refers to densities where the base land area calculation focuses only on the parcel or, if covering larger areas, excludes certain uses (e.g.: commercial and retail uses). Gross densities do not have such exclusions (calculations include all land uses) (Forsyth, 2003). Research suggests that schools be located in neighborhoods with a minimum net residential density of 5 dwelling units per acre (City of Raleigh, N.C., 2008). However, other research has shown that more walkable areas have a net residential density equal to or greater than 6 dwelling units per residential acre while less walkable areas experienced less than 4 dwelling units per residential acre (Frank, et al., 2005). In addition, Students Residential ratio is a good indicator representing students' density within all dwelling units.

Summary

Childhood obesity has been a national trend in the United States. A number of research has proved that the decline in physical activity could contribute to childhood obesity. Walk and bicycle to school could be an effective way to encourage children to engage in physical activity. Throughout the literature, there are a number of factors affecting walkability. Studies on measures of walkability show a consistent focus on connectivity, proximity, land use mix, density and safety. Due to the characteristic of children's travel between school and home, several studies about urban forum factors put an emphasis on school location, size and siting, street connectivity and residential density. Most research agreed with the findings that both school location and residential density are associated with children's walkability. However, it is contentious among literature that if street connectivity has a relationship with children's biking and walking to school. This research will investigate if there are correlations between these urban form factors and children's walkability to school.

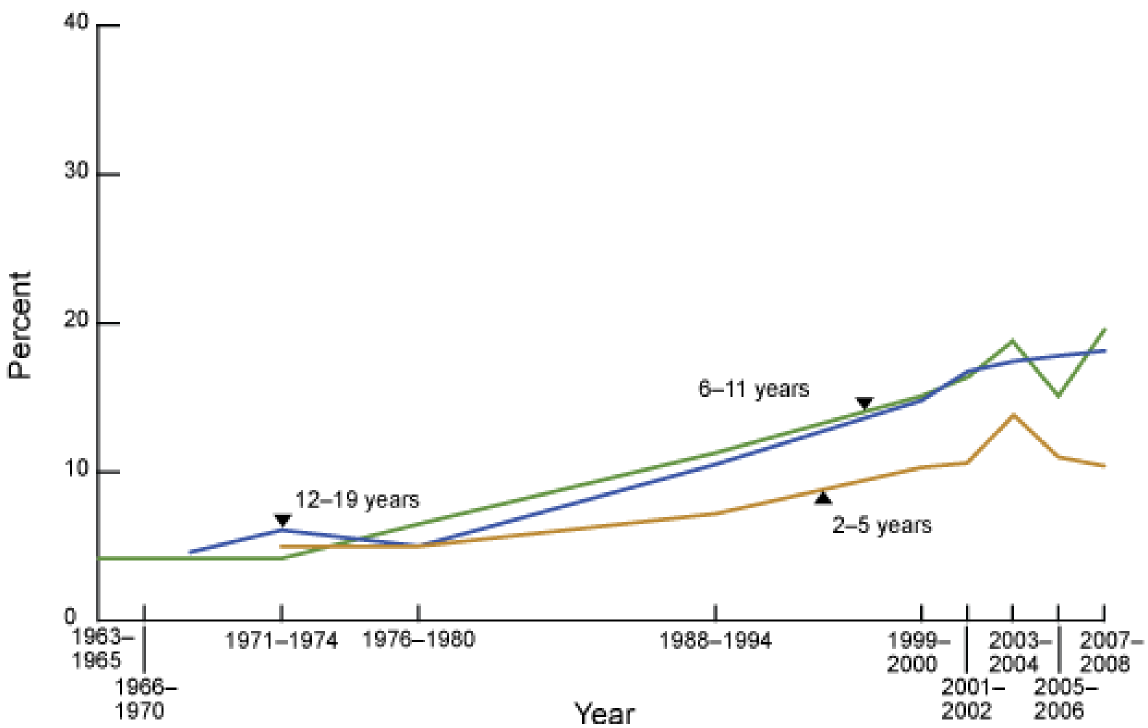


Figure 2-1. Prevalence of Overweight Children and Adolescents (CDC,2011)

CHAPTER 3
METHODOLOGY

This chapter describes the methods used to examine the correlation between urban form factors and children's walkability. Children's walkability is measured by children's potential walkability to school, assuming that all students living within study zone could walk to school. The measures of urban form factors included in this research are street connectivity, residential density and school attendance zone location.

Establish Study Zone

In order to develop the measures of students' walkability and urban form factors, the research establishes the study zone by taking into account school attendance zone and walkable distance.

School Attendance Zone

Given that the students who are zoned within school attendance zone are eligible for attending certain school, the research mapped the school attendance zone for each school and identified the students who are eligible for certain schools accordingly (Figure 3-1).

Walkable Distance

The school attendance zone defines a boundary by which the study measures could be picked and developed. However, on one hand the fact that the different school attendance zones vary in size gives rise to the difference in the size of study measures. For example, the number of residential units largely depends on the size of school attendance zone. The larger school attendance zone would be, the more residential units could be produced. On the other hand, in certain case some students who are zoned within school attendance zone may live beyond the reasonable walk distance as we discussed before in Chapter 2. For these students who have least potential to walk to/from schools, the research cannot take them as study subjects.

In order to eliminate the effect of size of school attendance zone on study, the conception of reasonable walk distance is used to adjust the school attendance zone. Some research on walkability before has cited one-quarter mile (or 400 meters) as an acceptable distance an individual might be expected to walk to any given destination (Atash, 1994). However, in the State of Florida (where this research study takes place), a two-mile radius shed has been established around school sites, defining the boundary by which parents are responsible for getting their children to school. On one hand, as mentioned above the acceptable distance a person might be expected to walk is approximately one-quarter mile. This suggests that the two-mile radius established in the State of Florida is not a reasonable distance to expect a child to walk or bicycle to school. On the other hand, taking into account the real condition (two-mile radius shed) in the State of Florida, one-quarter mile boundary would exclude too many students out of the category that has potential to walk to school. To investigate the potential walkability of children who walk or bicycle to school in the State of Florida, one-half mile would be a reasonable distance for most students to walk or bicycle to school and even one mile would be still acceptable for biking or for high grade students' walking. Therefore, this research will focus on urban form factors within half-mile and one-mile sheds.

Due to the geographic scale at which it is most potential for students to walk to/from schools, the measures of this research are developed at two scales: 0.5mile radius distance and 1 mile radius distance. Using school location point as center, a circle is drawn at a radius of 0.5 mile and 1 mile.

The overlapping part of school attendance zone and circle is the study zone. (Figure 3-2) Thus the study zone defines a boundary by which students eligible for attending school live within an acceptable walk /bicycle distance.

Dependent Variable

For the purpose of investigating the correlation between children's walkability and urban form factors, this research used Regression Model in ArcGIS to test the potential correlations between walkability and urban forum variables. Students' walkability is established as dependent variable and urban form factors as independent variables.

As noted in last section, it is accepted that students living within study zone have most potential to walk or bike to school. Therefore the number of students within study zone could represent the potential walkability. Taking into account the variation in the shape of different school attendance zones, this study uses the density of students who reside within study zone as the measure of dependent variable. (Figure 3-3)

Measure of dependent variable= the number of students within study zone/ the acreage of study zone.

Independent Variables

The study utilized three characteristics of urban form as independent variables: school attendance zone geometry, street connectivity and residential density. Based on the literature review, three of these characteristics are measured by quantitative indicators illustrated in the following sections.

School Attendance Zone Geometry Indicators

This research used three geographic characteristics to calculate the indicators of school attendance zone location: school location point, geographic mean center of students' location points and geographic mean center of study zone. Based on these three points, the following indicators are developed :(Figure 3-4)

Indicator 1: The Euclidean distance between school location point and geographic mean center of students' location points (DSSP).

DSSP shows the geographic relationship between school site and students residing within study zone.

Indicator 2: The Euclidean distance between school location point and geographic mean center of study zone (DSSZ).

DSSZ shows the centralization of school site in the relation to study zone.

Indicator 3: The Euclidean distance between geographic mean center of students' location points and geographic mean center of study zone (DSPSZ).

DSPSZ shows the shows the geographic relationship between study zone and students residing within study zone.

Street Connectivity Indicators

To measure street connectivity three walkability indicators are used: (1) Street Density (the total number of linear miles of street per square mile); (2) Intersection Density (the total number of intersections per square mile); and (3) Pedestrian Route Directness (the ratio of the network distance to the Euclidean (straight-line) distance between two points).

Indicator 1: Street Density is used as an indicator to provide a quantitative measure of the number of available pathways (available miles of streets) a child might be able to travel between home and school. This study will utilize the street network as the surrogate pathway for measuring these connections. These pathways are identified by a calculation measuring the distance along the centerline of each street. A greater street density within the proximity of a school site presumably means that there are more roads available thus increasing the potential for a child to walk or bicycle to school. Street density is a calculation derived from dividing the total number of street miles by the total area (square miles) within a specified range.

Indicator 2: Intersection Density is correlated to street patterns in that intersections rely on the presence of street networks. Intersection density is also used to provide information of connectivity by illustrating nodes of intersection (junction between streets and roadways). A higher degree of intersection density presumably indicates higher levels of connectivity, thus providing environments that support a greater potential for walkability. Intersection density is calculated by dividing the total number of intersections by the linear miles of street within a specified range. Again this calculation will be conducted using the half- and one-mile analysis zones as boundaries.

Indicator 3: Pedestrian Route Directness(PRD) is a value representing the directness of travel between two points. More specifically, it is a ratio between the straight-line distance of two points divided by the network distance between those same two points (an origin and a destination). In this study, PRD is measured using schools as destination points and using individual residential dwelling units as origin points. PRD is then tallied for each analysis zone using the average network and straight-line distances between residential dwelling units to the corresponding school they are zoned. Although a formative indicator of connectivity, PRD is not always representative of walkable environments (Dill, 2004).

Residential Density Indicators

Residential density is also measured, using three indicators: (1) Gross Residential Density (total number of dwelling units per gross acre); (2) Net Residential Density (total number of dwelling units per residential parcel acre). (3) Students Residential Ratio. Residential density information used for this study was provided from data prepared in previous research (Steiner, et al., 2008; Bejleri, et al., 2008). Three of them are calculated by assigning dwelling unit counts to residential parcels within each study zone. This information was created using land use codes acquired by the Department of Revenue, dwelling unit counts for multifamily parcels using data from the 2006 American Community Survey, and additional information provided by the Bureau of Economic and Business Research, and county apartment complex records (Steiner, et al., 2008; Bejleri, et al., 2008).

Indicator 1: Gross Residential Density provides a value representing the total number of dwelling units per gross acre. Gross acreage includes all land use designations (e.g.: residential, commercial, industrial, etc.).

Indicator 2: Net Residential Density provides a value representing the total number of dwelling units per residential parcel acre. The residential parcel acre is the acreage containing only residential land uses, excluding such land uses as mentioned in the calculation of gross residential densities (e.g.: commercial). Net residential density will be compared to acceptable standards of net residential density to determine levels of walkability within the established half- and one-mile analysis zones.

Indicator 3: Student Residential Ratio is a value representing the number of students per residential unit. It is calculated as students number within analysis zone divided by total residential units within analysis zone. Compared to the gross residential density and net residential density, student residential ratio reveals the generation of students population in study zone. A higher value indicates a greater children's potential walkability.

Regression Model

"Regression analysis allows you to model, examine, and explore spatial relationships, and can help explain the factors behind observed spatial patterns. Regression analysis is also used for prediction".(ArcGIS Desk Help 9.1).

Ordinary Least Squares(OLS) is the best known of all regression techniques. It is also the proper starting point for all spatial regression analyses. It provides a global model of the variable or process you are trying to understand or predict (early death/rainfall).(ArcGIS Desk Help9.1) it creates a single regression equation to represent that process. In this study, a single regression equation is created to represent how urban form factors correlate with the school children's walkability.

According to ArcGIS Desk Help 9.1, a mathematical formula of regression model could be expressed as Figure 3-5.

Y is the dependent variable, the X's are the explanatory variables, and the β's are regression coefficients. In this research, Y is students' density within study zone, the X's are all indicators representing urban form factors described above, and the β's are regression coefficient produced by OLS. Thus, the equation applying to this study could be expressed as:

$$\text{Students' Density within Study Zone} = \beta_0+\beta_1(\text{DSSP}) + \beta_2(\text{DSSZ}) + \beta_3(\text{DSPSZ}) + \beta_4(\text{Street Density}) + \beta_5(\text{Intersection Density}) + \beta_6(\text{PRD}) + \beta_7(\text{Gross Residential Density}) + \beta_8(\text{Net Residential Density})+ \beta_9(\text{Student Residential Ratio})+\varepsilon$$

Applying this equation to the Ordinary Least Squares Tools in ArcGIS (Figure 3-6) will produce the results demonstrated in the Chapter 4. The interpretation of OLS results is represented on APPENDIX.

Summary

The methodology described in this chapter provides a quantitative way to measure the urban form pattern that has effects on children's walking/biking between school and home. Dependent variable is valued by students' density within study zone, assuming that all children living within study zone could walk and bicycle to school. The total of nine indicators created in this chapter represents three urban form factors: school attendance zone geometry, street connectivity and residential density. OLS regression model gives a quantitative look into the relationship between children's walkability to school and urban form factors, which helps to understand the effect of urban form on children's walkability more precisely.

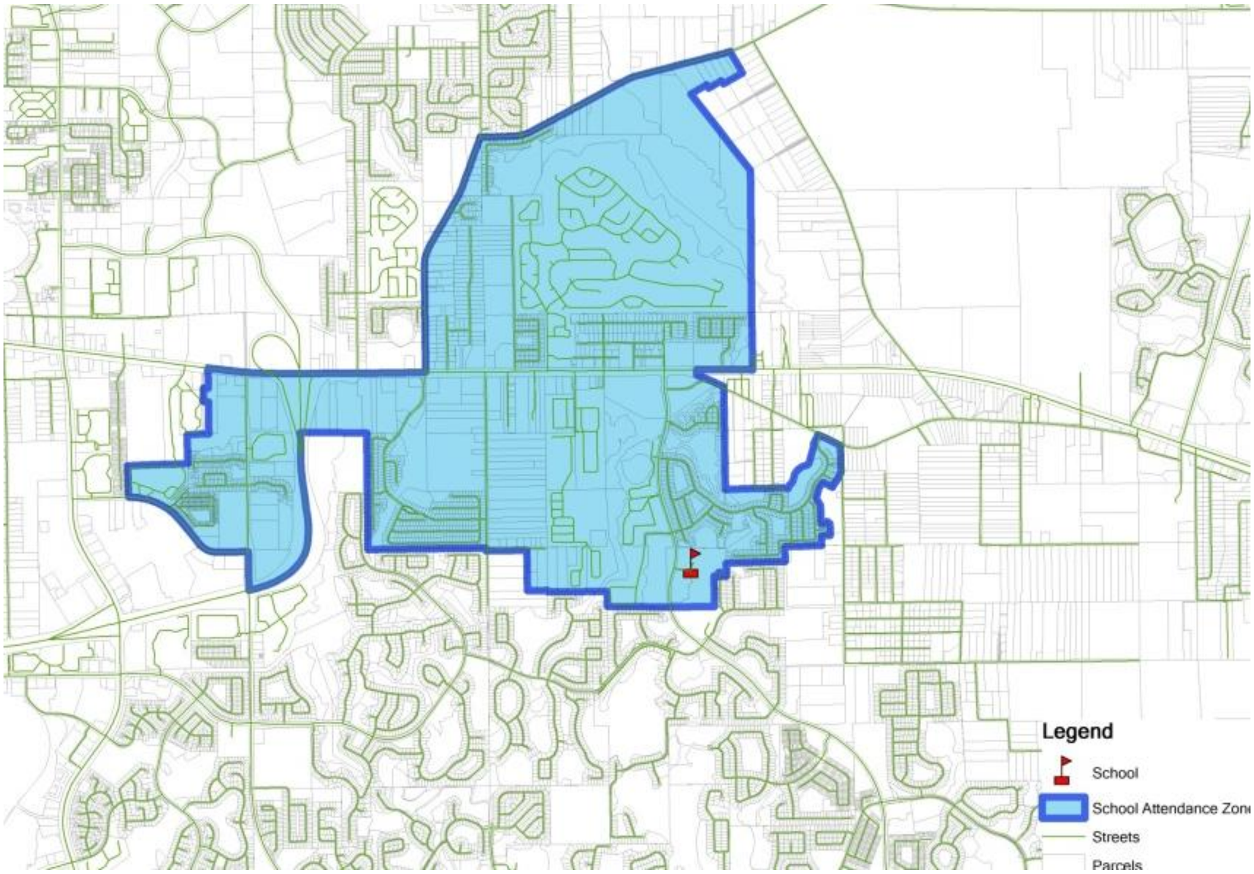


Figure 3-1. Illustration of School Attendance Zone

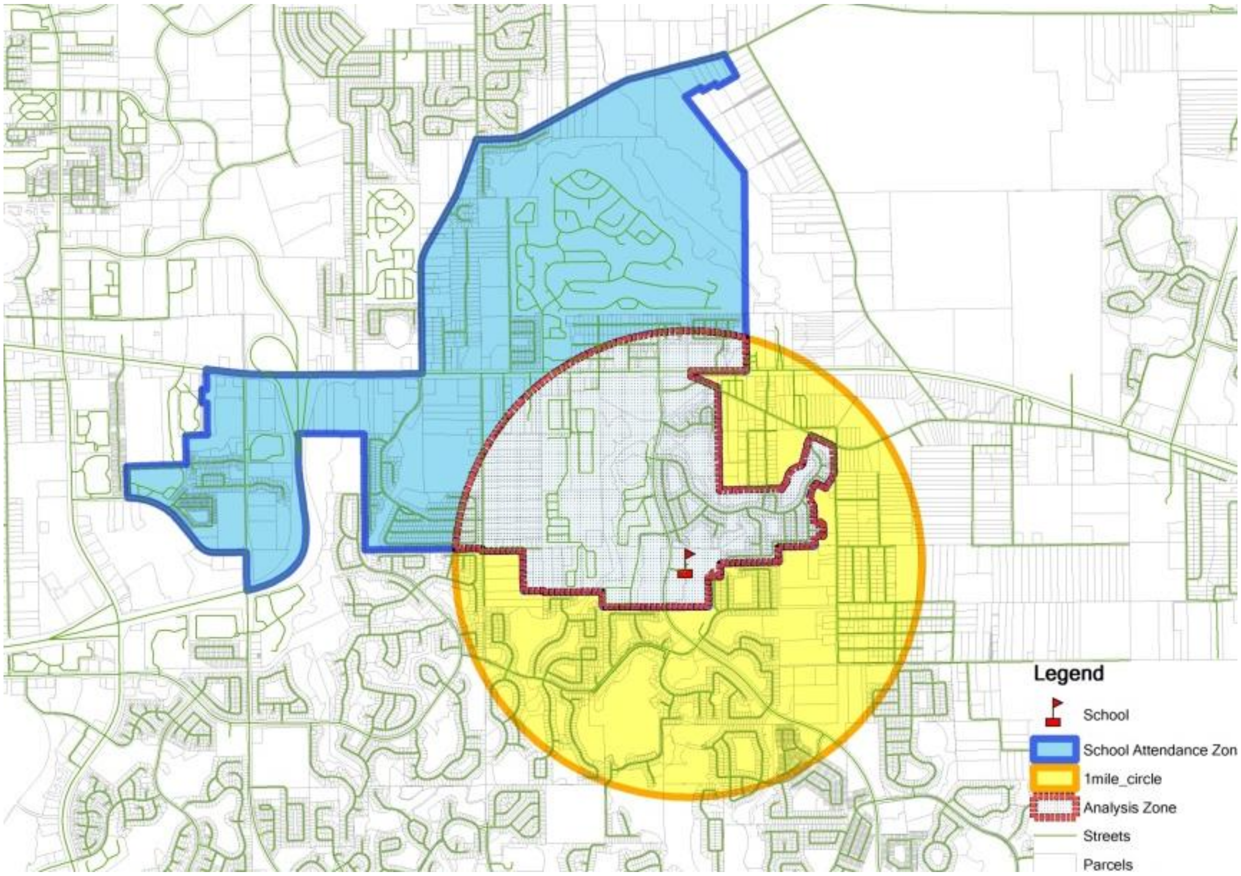


Figure 3-2. Illustration of Study Zone

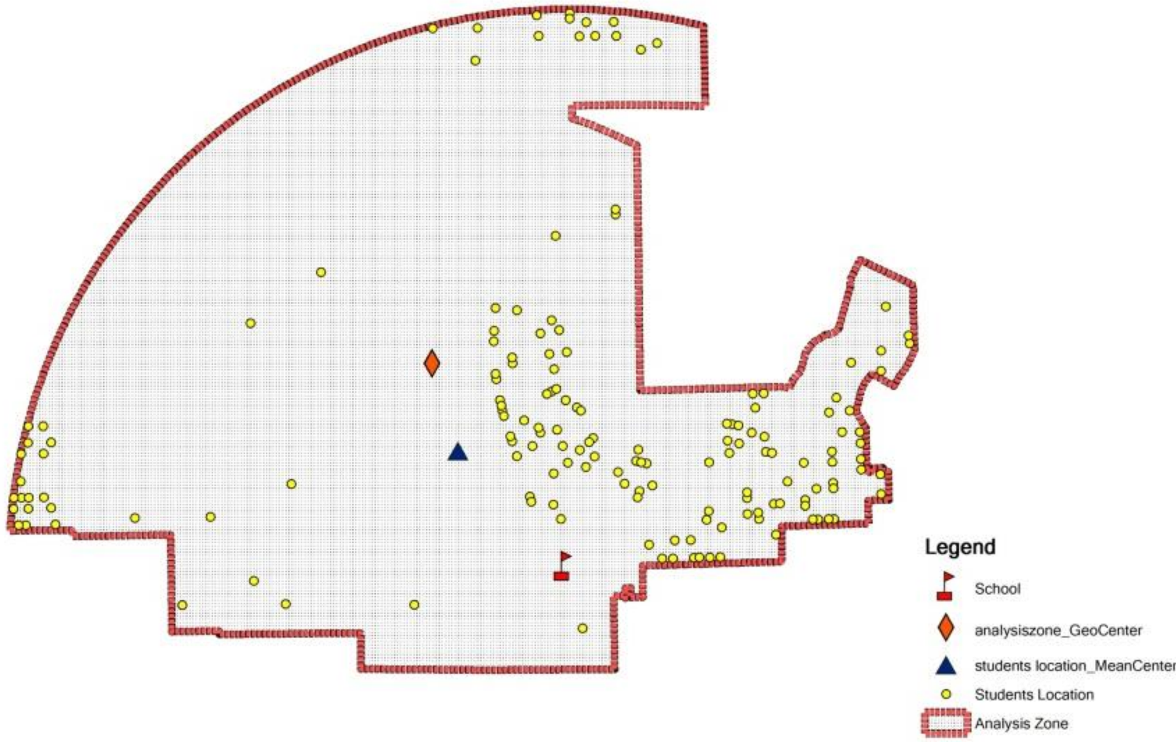


Figure 3-3. Illustration of Dependent Variable

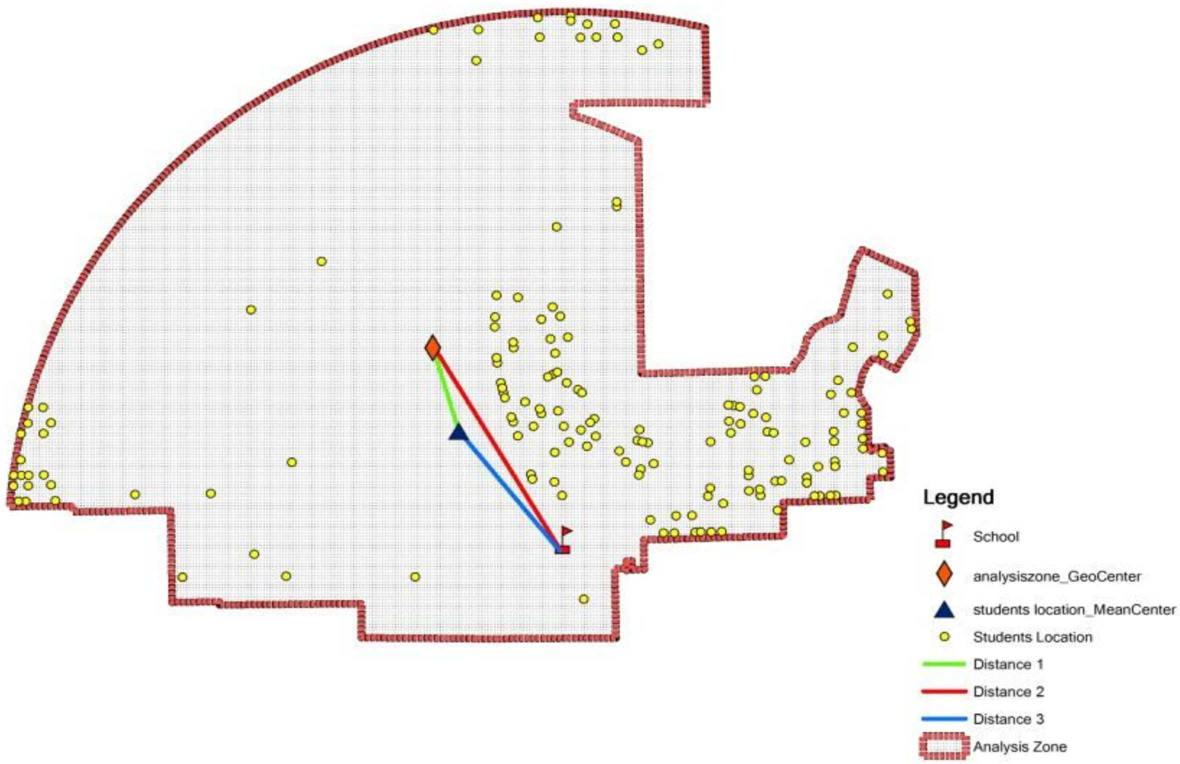


Figure 3-4. Illustration of School Attendance Zone Geometry

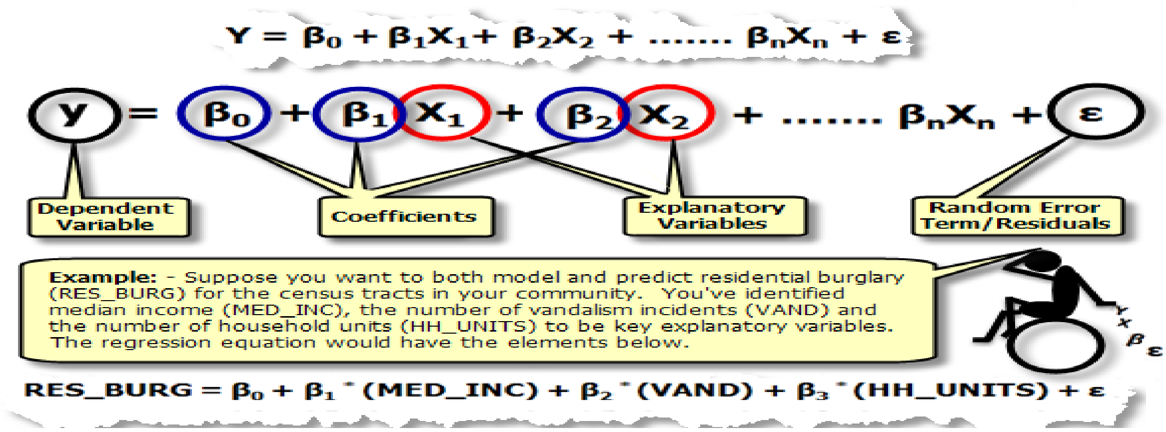


Figure 3-5. Mathematical Formula of Regression Model (ArcGIS Desktop Help 9.1)

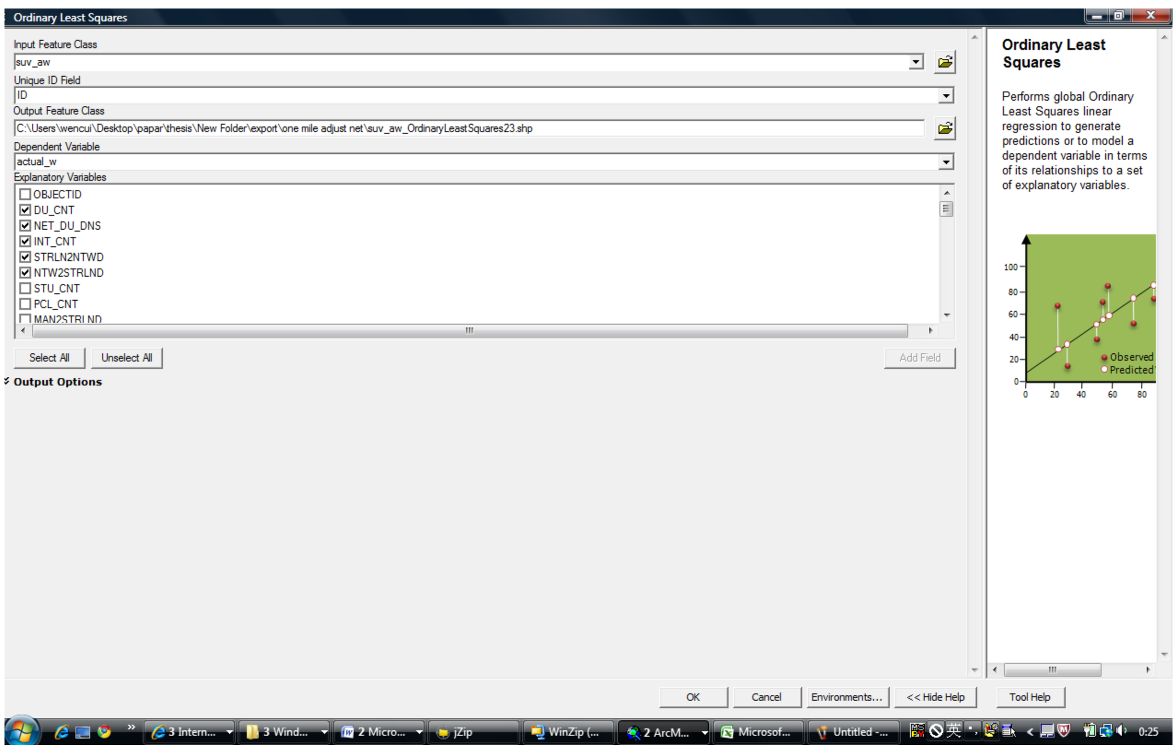


Figure 3-6. Ordinary Least Squares Tools in ArcGIS

CHAPTER 4
RESULTS AND FINDINGS

This chapter demonstrates the results and findings from the regression model based on the methodology described in Chapter 3. The whole chapter consists of 3 sections. The first section presents the results for the half-mile study zone. The second section presents the results for the one-mile study zone. In last section, the results are summarized based on the interpretation of variables and indicators described in the methodology, and compared between two different scales of study zone.

Results from Regression Model of Half-mile Study Zone

Figure 4-1 shows those indicators of half-mile study zone containing one dependent variable and nine explanatory variable indicators from all 40 school study zones.

Pre-running of OLS regression model(Figure 4-2) reveals that explanatory variable redundancy exists between street density and intersection density.(value of VIF > 7.5, see the interpretation of OLS results at APPENDIX A)Therefore intersection density is removed to refine the model.

After refining the model, the results from OLS regression model shows in Figure 4-3.

The Adjusted R-Squared value of 0.71309 indicates that regression model in this research explains approximately 71.3% of the variation in the dependent variable, or said another way: the model of half-mile study zone tells approximately 71.3% of the school children's walkability "story". 'Probability' shows that both Gross Residential Density and Student Residential Ratio are statistically significant. 'Coefficient' shows that both Gross Residential Density and Student Residential Ratio are positively correlated to dependent variable (school children's potential walkability).(Table 4-1.)

Results from Regression Model of One-mile Study Zone

Figure 4-4 shows data of One-mile study zone containing one dependent variable and nine explanatory variables from all 40 school study zones.

Pre-running of OLS regression model gives rise to the same issue of explanatory variable redundancy as half-mile model does. (Figure 4-5) Therefore intersection Density is removed for the purpose of refining the model. After refining the model, the results from OLS regression model shows in Figure 4-6.

The Adjusted R-Squared value of 0.757944 indicates that the model of one-mile study zone explains approximately 75.79% of school children's walkability in the one-mile study zone. Probability values present that four independent variables are statistically significant: PRD, Gross Residential Density, Street Density and Student Residential Ratio. Based on Coefficient values PRD is negatively correlated to dependent variable while other three independent variables are positively correlated to dependent variable. (Table 4-2)

Summary

In both models, the majority of findings from OLS reveal that there are correlations between dependent variable and some independent variables. In half-mile model, it is apparent that Gross Residential Density and Student Residential Ratio are statistically correlated to school children's potential walkability. Unlike half-mile model, one-mile model presents that PRD and Street Density are also statistically correlated to dependent variable except both Gross Residential Density and Student Residential Ratio. It is worthy noted that neither of model produces the statistic significance on school attendance zone location indicators. Besides, the result that explanatory variable redundancy exists between street density and intersection density implies that these two indicators explain the same characteristics of street connectivity.

Although two models returned different results, the value of Adjusted R-Squares, 0.713019 and 0.757944 respectively, has proved that the selections of explanatory variables and indicators are effective. Findings did not reveal any contradictions, making it reasonable to explain the results.

The next chapter provides discussion of the findings presented here, especially interpreting the difference in the results from both models. Chapter 5 also includes the limitations of this study and provides recommendations for future research.

NAME	NET_DU_DNS	STRLN2NTWD	GRS_DU_DNS	INT_DNSTY	STU_DNSTY	RD_DNS	STU_GEN	DIST_1	DIST_2	DIST_3
BRYAN PC	6.455477	0.676638	1.236317	166.849088	187.490213	20.614447	0.236957	378.68701	853.31201	836.07098
DOBY	5.700993	0.551769	2.246446	58.578724	286.526367	12.180786	0.199291	0.001396	401.104	401.189
DOVER	1.534422	0.654131	0.431779	34.383164	165.548568	7.32734	0.599078	0.00134	1039.27	1039.45
FOREST HILLS	5.032361	0.663724	1.977828	138.806107	217.760039	18.784491	0.172032	0.001383	258.59799	258.65701
GIBSONTON	1.29608	0.683511	0.772081	42.735703	140.226526	10.198507	0.283784	50.149799	623.02502	658.10901
HERITAGE	1.606882	0.250197	0.648664	28.015911	78.953932	5.854551	0.190184	0.001231	1218.03	1218.25
LAKE MAGDALENE	3.069797	0.697587	1.890236	111.649095	151.054658	15.783815	0.124864	73.941101	297.33099	313.88101
MENDENHALL	5.625061	0.654816	2.41846	132.669823	178.275075	19.317976	0.115179	189.10899	491.431	303.117
NELSON	0.766239	0.620018	0.352607	20.659784	55.622494	5.096561	0.246479	449.31601	816.58502	509.41599
PRIDE	5.1914	0.26637	1.971833	70.465521	416.387172	12.804959	0.329949	1319.52	414.73499	1517.66
RIVERVIEW	2.453787	0.631714	1.177946	93.351681	87.694003	14.491518	0.116323	62.386101	181.082	166.493
ROBLES	6.981558	0.594247	3.872308	137.682061	639.35118	19.283493	0.257982	450.49899	259.66501	442.02802
TAMPA BAY BOULEVARD	6.369255	0.697851	2.988629	138.806107	338.737839	22.980833	0.177097	0.001348	830.40399	830.599
TURNER	4.722334	0.423734	1.059855	48.767197	156.646148	9.16868	0.230937	325.242	925.40802	1064.77
ADAMS MIDDLE	4.516937	0.675329	2.099204	140.079557	165.548568	20.570714	0.123223	0.001233	459.255	459.36099
GIUNTA MIDDLE	3.889741	0.510151	1.118249	53.484922	57.305273	10.797353	0.080071	0.001119	943.13501	943.33002
MULRENNAN MIDDLE	3.760955	0.579997	2.511085	118.430898	247.049401	18.996292	0.153724	0.001261	377.39001	377.45499
BLANKNER	5.83469	0.548205	3.382283	134.059152	258.918166	19.905404	0.119604	252.39999	338.64999	101.431
CASTLE CREEK	4.071347	0.472036	2.190043	61.035108	505.719464	12.982992	0.360753	785.94397	353.13199	434.08899
CATALINA	4.717496	0.651077	1.991756	76.407031	191.017578	13.831501	0.149835	0.000095	252.188	252.183
JOHN YOUNG	5.170428	0.507082	2.339965	75.133581	485.184648	15.497932	0.323952	0.00007	427.311	427.30399
LOVELL	6.267572	0.524181	2.80192	46.056409	144.111988	9.507862	0.080358	369.76801	182.403	239.70399
MAXEY	7.999106	0.663709	1.337124	44.955448	146.105206	7.7439	0.1707	467.271	1581.12	1371.16
PINELOCH	9.512182	0.692569	4.356644	124.978477	116.177176	19.40358	0.041664	629.59601	899.50299	890.375
RIVERDALE	3.072398	0.480238	1.213758	43.297318	86.594635	7.466134	0.111457	7.61245	396.90201	390.74301
SHENANDOAH	4.106966	0.488388	2.435474	73.86013	254.690104	13.593141	0.163385	0.000059	161.177	161.17101
STONE LAKES	2.534959	0.524468	1.074971	49.376664	283.092872	9.242754	0.411385	329.95001	986.63501	1278.58
WYNDAM LAKES	1.930378	0.490879	1.42957	35.679515	361.892227	8.214774	0.395488	24.226999	341.479	317.24399
AVALON MIDDLE	2.327691	0.604681	1.295202	50.441963	126.104908	8.68265	0.152099	856.90002	689.987	1442.79
MEMORIAL MIDDLE	7.97013	0.573587	3.458214	98.05569	192.291029	15.544842	0.086876	0.000108	108.914	108.912
CHASCO	6.913348	0.506794	2.239936	82.230905	115.123267	13.194783	0.080306	1064.53	1035.3199	1882.0699
RICHEY	5.518632	0.595593	2.8388	211.392786	177.009622	23.031781	0.097428	0.000136	426.474	426.59799
SEVEN SPRINGS	5.025798	0.525944	2.814641	92.83376	355.533549	15.674162	0.197368	798.409	201.912	1000.43
CHASCO MIDDLE	5.438424	0.435047	2.602615	109.516745	120.977799	15.225105	0.072624	0	471.93201	471.93201
BEAR LAKE	3.548993	0.390287	2.051664	121.326949	317.842429	18.063858	0.24203	579.05103	403.314	842.323
CARILLON	3.751078	0.545387	1.460232	56.827171	343.546077	11.596002	0.367556	34.677898	300.91199	298.53799
LONGWOOD	5.976887	0.681919	2.83029	132.034335	344.232374	20.201167	0.190022	439.74301	525.552	863.03601
STERLING PARK	5.855226	0.493318	2.764598	94.026219	224.34326	15.027046	0.126783	492.75601	405.67401	419.70901
SOUTH SEMINOLE MIDDLE	3.262791	0.435733	1.843714	80.227213	155.360634	13.469829	0.13165	0	886.42999	886.42999
TEAGUE MIDDLE	3.366171	0.504015	2.109944	75.133421	243.228534	16.038658	0.180104	0	397.67401	397.67401

NET_DU_DNS: Net Residential Density.
GRS_DU_DN: Gross Residential Density.
STRLN2NTWD: PRD.
INT_DNSTY: Intersection Density.
STU_DNSTY: Students density within study zone.
RD_DNS: Street Density.
STU_GEN: Student Residential Ratio.
DIST_1: Euclidean distance between school location point and the geographic center point of study zone.
DIST_2: Euclidean distance between the mean center of students' points within analysis zone and the geographic center of study zone.
DIST_3: Euclidean distance between the mean center point of students' locations within study zone and school location points.

Figure 4-1. Indicators of Half-mile Model

Summary of OLS Results

Variable	Coefficient	StdError	t-Statistic	Probability	Robust_SE	Robust_t	Robust_Pr	VIF [1]
Intercept	-56.611917	81.641897	-0.693417	0.493382	90.170809	-0.627830	0.534865	--------
NET_DU_DNS	9.023187	10.907770	0.827226	0.414642	8.800367	1.025319	0.313411	3.939163
STRLN2NTWD	-231.609388	118.348415	-1.957013	0.059708	99.905310	-2.318289	0.027437*	1.436877
GRS_DU_DNS	47.238915	28.835174	1.638239	0.111818	38.049889	1.241499	0.224041	5.912454
INT_DNSTY	-1.382621	0.888530	-1.556077	0.130176	0.836045	-1.653763	0.108602	12.413922
RD_DNS	18.714426	8.933413	2.094880	0.044729*	9.310756	2.009979	0.053501	15.886777
STU_GEN	856.260302	114.331695	7.489264	0.000000*	183.815291	4.658265	0.000060*	1.443257
DISTANCE_1	0.049871	0.055725	0.894943	0.377943	0.046433	1.074024	0.291376	3.033234
DIST_2	-0.076915	0.070428	-1.092097	0.283484	0.059637	-1.289709	0.207006	4.723754
DIST_3	-0.012816	0.062582	-0.204785	0.839124	0.044620	-0.287226	0.775914	6.352847

OLS Diagnostics

Number of Observations:	40	Number of Variables:	10
Degrees of Freedom:	30	Akaike's Information Criterion (AIC) [2]:	459.794244
Multiple R-Squared [2]:	0.788923	Adjusted R-Squared [2]:	0.725600
Joint F-Statistic [3]:	12.458714	Prob(>F), (9,30) degrees of freedom:	0.000000*
Joint Wald Statistic [4]:	198.438424	Prob(>chi-squared), (9) degrees of freedom:	0.000000*
Koenker (BP) Statistic [5]:	22.076547	Prob(>chi-squared), (9) degrees of freedom:	0.008640*
Jarque-Bera Statistic [6]:	17.094286	Prob(>chi-squared), (2) degrees of freedom:	0.000194*

Figure 4-2. Pre-running Results from Half-mile Model

Summary of OLS Results

Variable	Coefficient	StdError	t-Statistic	Probability	Robust_SE	Robust_t	Robust_Pr	VIF [1]
Intercept	-23.936948	80.683753	-0.296676	0.768692	103.068508	-0.232243	0.817876	--------
NET_DU_DNS	7.206927	11.090984	0.649801	0.520607	8.749207	0.823724	0.416390	3.894058
STRLN2NTWD	-228.734604	121.016447	-1.890112	0.068124	103.067232	-2.219276	0.033921*	1.436527
GRS_DU_DNS	60.486196	28.174317	2.146856	0.039740*	31.600485	1.914091	0.064879	5.397090
RD_DNS	5.972003	3.651546	1.635472	0.112063	2.936403	2.033782	0.050609	2.537960
STU_GEN	901.554833	113.070567	7.973382	0.000000*	176.417132	5.110359	0.000015*	1.349708
DISTANCE_1	0.040155	0.056629	0.709080	0.483574	0.051747	0.775983	0.443639	2.995152
DIST_2	-0.086072	0.071773	-1.199230	0.239525	0.059963	-1.435428	0.161178	4.690770
DIST_3	-0.004730	0.063780	-0.074161	0.941361	0.047684	-0.099193	0.921625	6.309048

OLS Diagnostics

Number of Observations:	40	Number of Variables:	9
Degrees of Freedom:	31	Akaike's Information Criterion (AIC) [2]:	460.899067
Multiple R-Squared [2]:	0.771887	Adjusted R-Squared [2]:	0.713019
Joint F-Statistic [3]:	13.112177	Prob(>F), (8,31) degrees of freedom:	0.000000*
Joint Wald Statistic [4]:	136.305927	Prob(>chi-squared), (8) degrees of freedom:	0.000000*
Koenker (BP) Statistic [5]:	22.415399	Prob(>chi-squared), (8) degrees of freedom:	0.004202*
Jarque-Bera Statistic [6]:	6.805064	Prob(>chi-squared), (2) degrees of freedom:	0.033289*

Figure 4-3. Results from Half-mile Model

Table 4-1. Summary of Results from Half-mile Model

Variables	Coefficient	Probability (95%)
Net Residential Density	7.206927	0.520606
PRD	-228.735	0.068123
Gross Residential Density	60.4862	0.039739
Street Density	5.972002	0.112063
Student Residential Ratio	901.5548	3.92E-09
DSSP	0.040154	0.483574
DSPSZ	-0.08607	0.239525
DSSZ	-0.00473	0.94136

NAME	NET_DU_DNS	STRLN2NTWD	GRS_DU_DNS	INT_DNSTY	STU_DNSTY	RD_DNS	STU_GEN	DIST_1	DIST_2	DIST_3
BRYAN PC	4.817364	0.716331	1.117263	123.094976	261.086795	16.190207	0.365132	2064.280029	1230.219971	2927.649902
DOBY	5.123276	0.572827	0.716581	21.709442	89.212238	7.217921	0.194527	658.710999	563.744019	1007.98999
DOVER	1.106214	0.644749	0.317839	23.556891	93.909226	6.026009	0.461659	274.412994	1398.439941	1210.030029
FOREST HILLS	5.408529	0.686287	2.222671	144.819625	224.53685	20.985162	0.157846	222.442993	839.380005	800.369995
GIBSONTON	1.64028	0.710081	0.742693	58.270803	154.417629	10.301375	0.324869	1058.969971	869.612	1134.390015
HERITAGE	1.364003	0.378983	0.371411	17.07639	46.447781	5.38354	0.195402	160.029007	1592.26001	1534.819946
LAKE MAGDALENE	3.363475	0.717945	1.924042	109.585842	149.394577	16.19254	0.121322	696.184021	303.299988	906.041016
MENDENHALL	7.348746	0.662594	3.690638	135.43214	260.721785	18.495385	0.110381	920.538025	545.583984	1338.219971
NELSON	0.857229	0.705146	0.337506	19.455304	45.395708	5.078506	0.210162	776.547974	1060.329956	763.072998
PRIDE	5.80956	0.408387	2.448771	59.682321	410.039651	12.355788	0.261636	2752.51001	455.506989	2818.350098
RIVERVIEW	2.459009	0.668944	1.227463	72.079583	115.874773	12.483857	0.147503	654.067993	1163.449951	1139.599976
ROBLES	7.02774	0.623256	3.247483	115.014283	404.292632	17.106296	0.194522	1459.560059	979.612	715.198975
TAMPA BAY BOULEVARD	7.501277	0.724757	2.48417	120.742598	257.329247	19.550666	0.161856	249.472	1685.77002	1525.910034
TURNER	4.645695	0.501458	0.839955	28.243673	130.862351	6.725977	0.243433	2063.370117	1440.910034	3256.610107
ADAMS MIDDLE	4.757332	0.735339	2.00392	131.647065	162.45808	19.705814	0.126672	110.132004	619.856018	531.017029
GIUNTA MIDDLE	4.847852	0.518883	1.3243	52.093145	125.9184	11.363271	0.148567	129.311996	1398.609985	1356.02002
MULRENNAN MIDDLE	2.646085	0.601097	1.699045	77.119789	147.170263	14.009773	0.135343	586.95697	171.789993	693.565979
BLANKNER	6.652931	0.620618	3.903228	141.558931	248.289872	18.439365	0.099391	780.291992	443.710999	442.40799
CASTLE CREEK	3.950962	0.51578	1.831582	66.622164	382.023297	12.080362	0.325876	2191.870117	860.296997	1390.650024
CATALINA	4.397153	0.633854	1.739895	86.687233	312.827841	13.619912	0.280922	346.330994	1940.280029	2266.040039
JOHN YOUNG	4.073404	0.524781	2.086065	76.359858	439.190778	13.304194	0.32895	928.322021	1302.160034	1646.680054
LOVELL	4.345418	0.585078	2.297202	65.25976	275.023276	11.27882	0.187058	690.263	1707.030029	1549.839966
MAXEY	7.620674	0.652565	1.017827	43.684259	80.944361	8.377885	0.124248	829.382019	1096.040039	919.960999
PINELOCH	7.618468	0.650481	3.492871	85.73922	104.06516	13.210485	0.046551	1950	2084.709961	2381.429932
RIVERDALE	4.407447	0.519223	1.980319	40.174317	91.827011	8.766417	0.072451	273.213989	775.58197	624.734009
SHENANDOAH	3.611202	0.595571	1.810694	65.202473	245.2093	12.078651	0.211591	1372.319946	570.564026	825.049011
STONE LAKES	2.434593	0.627597	1.178536	54.57202	260.516427	10.353211	0.345362	1886.319946	625.762024	2436.280029
WYNDAM LAKES	3.108077	0.533364	1.549357	45.413098	324.141194	9.327349	0.326877	1046.109985	1036	1552.939941
AVALON MIDDLE	3.544559	0.673522	1.448537	68.760729	107.966408	9.837779	0.116453	2223.810059	846.633972	2591.080078
MEMORIAL MIDDLE	8.263214	0.626292	3.35049	97.410926	123.514507	15.377421	0.0576	450.112	1104.609985	1457.969971
CHASCO	6.983611	0.60983	3.492894	139.337125	385.701317	20.099765	0.172538	2316.659912	796.078979	2063.879883
RICHEY	5.451054	0.573059	2.666172	177.197346	195.335657	20.611086	0.114476	1173.400024	1162.910034	1000.169983
SEVEN SPRINGS	5.186775	0.59298	2.49679	84.197371	239.962508	13.752043	0.150169	1329.280029	1028.369995	1991.619995
CHASCO MIDDLE	5.49074	0.540264	2.719459	120.745067	148.637544	16.879905	0.0854	547.017029	1058.01001	1192.02002
BEAR LAKE	3.891136	0.488398	2.389069	90.707565	269.215402	14.724253	0.176066	1809.51001	404.471985	1784.160034
CARILLON	3.205075	0.539933	1.115333	45.050784	206.637895	9.19932	0.28947	584.919006	638.153015	128.744995
LONGWOOD	4.317182	0.701982	1.936564	103.356347	223.118463	16.386556	0.180013	1752.319946	585.271973	1691.890015
STERLING PARK	4.945331	0.568232	2.300981	84.061918	201.862973	13.188983	0.137071	319.36499	891.241028	1210.319946
SOUTH SEMINOLE MIDDLE	4.06107	0.548216	2.185773	84.358962	124.787597	14.262641	0.089202	0.010299	774.432007	774.442017
TEAGUE MIDDLE	3.993415	0.601252	2.152148	78.947255	150.254453	13.314017	0.109085	0.010311	264.937012	264.945007

NET_DU_DNS: Net Residential Density.
GRS_DU_DN: Gross Residential Density.
STRLN2NTWD: PRD.
INT_DNSTY: Intersection Density.
STU_DNSTY: Students density within study zone.
RD_DNS: Street Density.
STU_GEN: Student Residential Ratio.
DIST_1: Euclidean distance between school location point and the geographic center point of study zone.
DIST_2: Euclidean distance between the mean center of students' points within analysis zone and the geographic center of study zone.
DIST_3: Euclidean distance between the mean center point of students' locations within study zone and school location points.

Figure 4-4. Indicators of One-mile Model

Summary of OLS Results

Variable	Coefficient	StdError	t-Statistic	Probability	Robust_SE	Robust_t	Robust_Pr	VIF [1]
Intercept	-359.786287	68.321107	-5.266107	0.000011*	52.790917	-6.815307	0.000000*	--------
NET_DU_DNS	0.844517	7.266443	0.116222	0.908253	5.580788	0.151326	0.880733	3.031972
NTW2STRLND	35.864094	18.647745	1.923240	0.063986	14.806558	2.422176	0.021682*	1.332566
GRS_DU_DNS	68.015819	17.969214	3.785131	0.000686*	17.520832	3.881997	0.000526*	4.640835
INT_DNSTY	-2.517013	0.949169	-2.651807	0.012669*	0.582056	-4.324347	0.000154*	22.909895
RD_DNS	29.328150	9.044075	3.242803	0.002900*	6.227514	4.709447	0.000052*	25.377518
STU_GEN	826.700611	114.872999	7.196649	0.000000*	170.732838	4.842072	0.000036*	2.013054
DIS_1	0.040776	0.019196	2.124167	0.042013*	0.021758	1.874075	0.070688	3.442497
DIS_2	0.011773	0.024769	0.475314	0.638005	0.027077	0.434808	0.666812	2.102332
DIS_3	-0.020862	0.019472	-1.071411	0.292530	0.015410	-1.353840	0.185899	3.490361

OLS Diagnostics

Number of Observations:	40	Number of Variables:	10
Degrees of Freedom:	30	Akaike's Information Criterion (AIC) [2]:	432.884049
Multiple R-Squared [2]:	0.833256	Adjusted R-Squared [2]:	0.783233
Joint F-Statistic [3]:	16.657394	Prob(>F), (9,30) degrees of freedom:	0.000000*
Joint Wald Statistic [4]:	527.805271	Prob(>chi-squared), (9) degrees of freedom:	0.000000*
Koenker (BP) Statistic [5]:	24.279898	Prob(>chi-squared), (9) degrees of freedom:	0.003880*
Jarque-Bera Statistic [6]:	5.680240	Prob(>chi-squared), (2) degrees of freedom:	0.058419

Figure 4-5. Pre-running Results from One-mile Model

Summary of OLS Results

Variable	Coefficient	StdError	t-Statistic	Probability	Robust_SE	Robust_t	Robust_Pr	VIF [1]
Intercept	-25.608095	74.031110	-0.345910	0.731747	66.976001	-0.382347	0.704812	--------
NET_DU_DNS	3.884206	7.456531	0.520913	0.606127	5.092474	0.762734	0.451387	2.859123
STRLN2NTWD	-306.408966	115.182042	-2.660215	0.012255*	107.150825	-2.859604	0.007525*	1.390850
GRS_DU_DNS	59.408195	19.721767	3.012316	0.005127*	20.455611	2.904249	0.006732*	5.006189
RD_DNS	8.619387	3.507219	2.457613	0.019782*	3.809894	2.262369	0.030832*	3.417624
STU_GEN	860.749983	119.191646	7.221563	0.000000*	174.539485	4.931549	0.000026*	1.940835
DIS_1	0.027696	0.019480	1.421754	0.165080	0.021036	1.316598	0.197624	3.174640
DIS_2	-0.005163	0.025046	-0.206136	0.838033	0.024484	-0.210869	0.834371	1.924939
DIS_3	-0.012239	0.020118	-0.608378	0.547368	0.017433	-0.702064	0.487877	3.336547

OLS Diagnostics

Number of Observations:	40	Number of Variables:	9
Degrees of Freedom:	31	Akaike's Information Criterion (AIC) [2]:	436.609456
Multiple R-Squared [2]:	0.807596	Adjusted R-Squared [2]:	0.757944
Joint F-Statistic [3]:	16.264966	Prob(>F), (8,31) degrees of freedom:	0.000000*
Joint Wald Statistic [4]:	325.050526	Prob(>chi-squared), (8) degrees of freedom:	0.000000*
Koenker (BP) Statistic [5]:	21.800147	Prob(>chi-squared), (8) degrees of freedom:	0.005300*
Jarque-Bera Statistic [6]:	3.798270	Prob(>chi-squared), (2) degrees of freedom:	0.149698

Figure 4-6. Results from One-mile Model

Table 4-2. Summary of Results from One-mile Model

Variables	Coefficient	Probability (95%)
Net Residential Density.	3.884205	0.606127
PRD	-306.409	0.012255
Gross Residential Density	59.40819	0.005127
Street Density	8.619387	0.019781
Student Residential Ratio	860.75	3.31E-08
DSSP	0.027695	0.16508
DSPSZ	-0.00516	0.838033
DSSZ	-0.01224	0.547367

CHAPTER 5
DISCUSSIONS

In this chapter of this research, the author will discuss how the findings from regression models support the research question of how the urban form factors is correlated to children's walkability.

Discussions and Conclusions

The study chose to use school attendance zone location, street connectivity and residential density as urban form factors to investigate the children's walkability around public school sites. Based on the prior literature, it is confident to say that these three variables are best representative of children's potential walkability. However, the findings from both models of half-mile and one-mile study zone revealed that school attendance zone geometry indicators are not associated with school children's walkability, which might imply geometry of school attendance zone does not affect children's walkability within half-mile and one-mile sheds. This finding does not support the studies (Steiner,et al, 2008)claiming that school location and siting play a key role in determining the children's walkability.

In the results from the model of half-mile study zone, the fact that both statistical significant indicators respond to dependent variable positively indicates that higher residential density and percentage of residential units that have school children could produce higher children's walkability. This findings support the discussion of former literature about residential density is positively related to children's walkability. However, it is unexpected that street connectivity did not show any correlation to the dependent variable in this case.

In the results from model of one-mile study zone, the indicators of residential density responded to the dependent variable the same as half-mile model did. Apart from this, PRD presents the negative correlation to the dependent variable while street density presents the positive one, indicating that the better street connectivity shows the higher children's walkability. The results support the studies that found both residential density and street connectivity have positive correlations with children's walkability.

It is worthy noted that Students Residential Ratio and PRD have stronger effect on dependent variable based on the values of coefficient.

The fact that variables present the different relations in two models suggests that children's walkability to school is affected by the distance to school. For children who live close enough to school (within half-mile in this study), street connectivity is not a key concern for walking and biking to school. Street connectivity is taken into account by children who live within one-mile from school. However, this implication casts a contradiction with the findings that school attendance zone geometry indicators are not associated with school children's walkability. One of reason for this contrary could be that

OLS regression model is not the best tool to test geographic relationship. Further study needs to explore the geometry of school attendance zone.

Nonetheless, with the confidence, the conclusion could be made that there is a correlation between urban form factors and children's walkability to school under certain circumstances. PRD, Gross Residential Density, Students Residential Ratio and Street Density present the statistical correlation to children's potential walkability. The correlations present a difference in half-mile and one-mile models. The findings that *Students* Residential Ratio and PRD have stronger effect on children's walkability demonstrate that the improvements on residential density and street connectivity could facilitate the children's walk or bicycle to school, which in turn may decrease the childhood obesity by increasing the children's daily physical activity.

Limitations and Future Studies

Limitations

This research study is conducted based upon data from 40 elementary and middle schools. Sample of 40 schools are too small to tell the truth about children's walkability. In addition, the selected schools are not geographically weighted, which in part explains no significance on school attendance zone geometry indicators.

Secondly there is a difference of travel model between middle school students and elementary school students, which makes it different in the acceptable walk distance.(middle school students who ride bicycle can reach a distance larger than 1 mile) Besides, some research also shows urban form factors have different impact on children at different age group and different gender.

The findings cannot tell which students actually do walk or bike to school, because this research evaluated the children’s potential walkability, assuming that all children within study zone could walk to school. Whether a child would walk or bike to school could be determined by other social, economic or family factors. Although a survey was conducted on these 40 schools to collect the number of children walking or biking to school during three surveyed days, it cannot help to tell the exact child who actually walks or bikes either.

Future Studies

Due to the limitation of this research, future study could choose the larger sample that locates close to each other geographically, using Geographically Weighted Regression (GWR) after OLS to further explore the geographical relation between children’s walkability and urban form factors.

Given that the actual travel model choice of children could be determined by a number of social, economic, family and physical environment factors, future research could add dummy variables that representing other factors other than urban form to refine the study model, such as gender, family income and ethnic.

CHAPTER 6
CONCLUSIONS

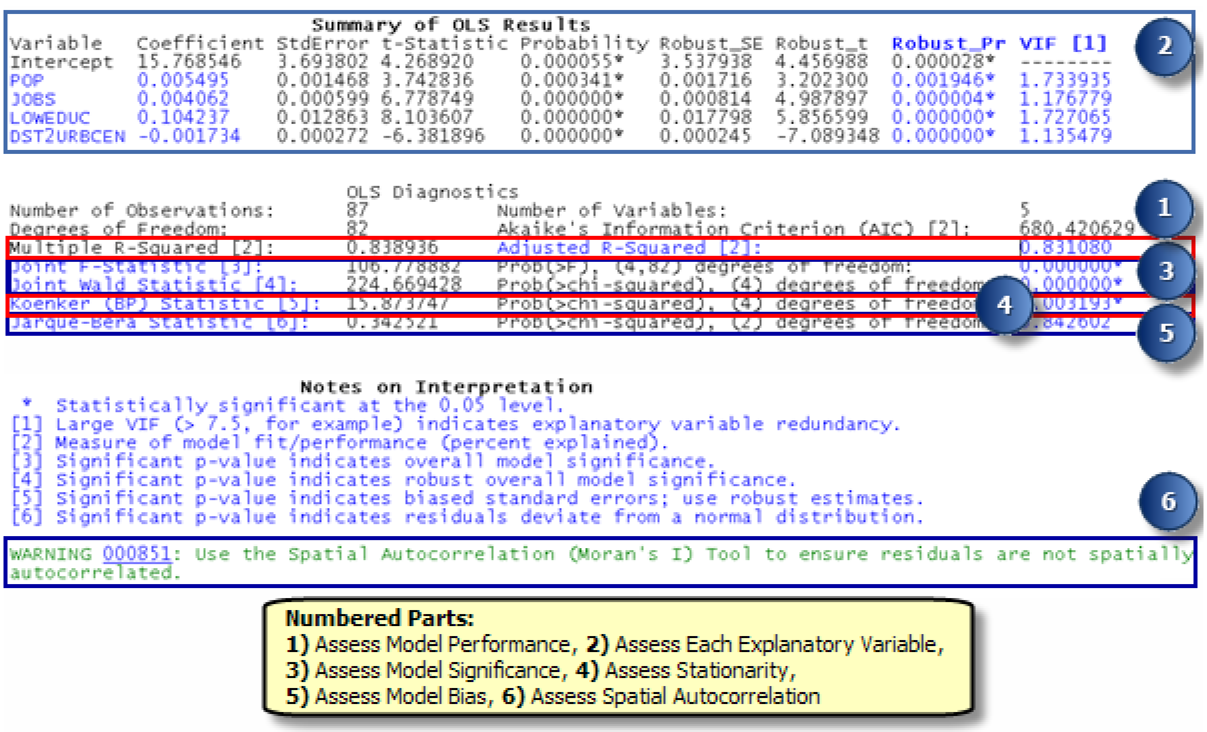
This research testified that there is a correlation between urban form factors and children's walkability under certain circumstances by using OLS regression model tool in ArcGIS. The findings support the prior theory about the impact of street connectivity and residential density on children's walkability to school.

Although the study is conducted upon a relatively small sample of forty public elementary and middle schools, the findings could help to increase children's physical activity by improving physical environment related to urban form factors, especially street connectivity and residential density, considering the findings that PRD and Students Residential Ratio have stronger relations to children's potential walkability. Due to the limitation on availability of data and research model, the findings cannot tell the actual children's walkability.

APPENDIX
INTERPRETATION OF OLS RESULTS

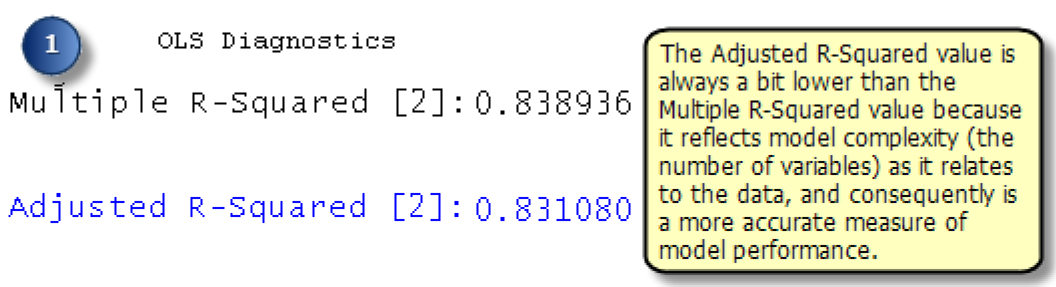
You will need to provide an input feature class with a unique ID field, the dependent variable you want to model/explain, and all of the explanatory variables. You will also need to provide a pathname for the output feature class, and optionally, pathnames for the coefficient and diagnostic output tables. As the OLS tool runs, statistical results are printed to the screen.

(B) Examine the statistical report using the numbered steps described below under "Dissecting the Statistical Report":



Dissecting the Statistical Report

Assess model performance. Both the Multiple R-Squared and Adjusted R-Squared values are measures of model performance. Possible values range from 0.0 to 1.0. The Adjusted R-Squared value is always a bit lower than the Multiple R-Squared value because it reflects model complexity (the number of variables) as it relates to the data, and consequently is a more accurate measure of model performance. Adding an additional explanatory variable to the model will likely increase the Multiple R-Squared value, but decrease the Adjusted R-Squared value. Suppose you are creating a regression model of residential burglary (the number of residential burglaries associated with each census block is your dependent variable, *y*). An Adjusted R-Squared value of 0.84 would indicate that your model (your explanatory variables modeled using linear regression) explains approximately 84% of the variation in the dependent variable, or said another way: your model tells approximately 84% of the residential burglary "story".



Assess each explanatory variable in the model: Coefficient, Probability or Robust Probability, and Variance Inflation Factor (VIF). The coefficient for each explanatory variable reflects both the strength and type of relationship the explanatory variable has to the dependent variable. When the sign associated with the coefficient is negative, the relationship is negative (e.g., the larger the distance from the urban core, the smaller the number of residential burglaries). When the sign is positive, the relationship is positive (e.g., the larger the population, the larger the number of residential burglaries). Coefficients are given in the same units as their associated explanatory variables (a coefficient of 0.005 associated with a variable representing population counts may be interpreted as 0.005 people). The coefficient reflects the expected change in the dependent variable for every 1 unit change in the associated explanatory variable, holding all other variables constant (e.g., a 0.005 increase in residential burglary is expected for each additional person in the census block, holding all other explanatory variables constant). The T test is used to assess whether or not an explanatory variable is statistically significant. The null hypothesis is that the coefficient is, for all intents and purposes, equal to zero (and consequently is NOT helping the model). When the probability or robust probability is very small, the chance of the coefficient being essentially zero is also small. If the Koenker test (see below) is statistically significant, use the robust probabilities to assess explanatory variable statistical significance. Statistically significant probabilities have an asterisk "*" next to them. An explanatory variable associated with a statistically significant coefficient is important to the regression model if theory/common sense supports a valid relationship with the dependent variable, if the relationship being modeled is primarily linear, and if the variable is not redundant to any other explanatory variables in the model. The variance inflation factor (VIF) measures redundancy among explanatory variables. As a rule of thumb, explanatory variables associated with VIF values larger than about 7.5 should be removed (one by one) from the regression model. If, for example, you have a population variable (the number of people) and an employment variable (the number of employed persons) in your regression model, you will likely find them to be associated with large VIF values indicating that both of these variables are telling the same "story"; one of them should be removed from your model.

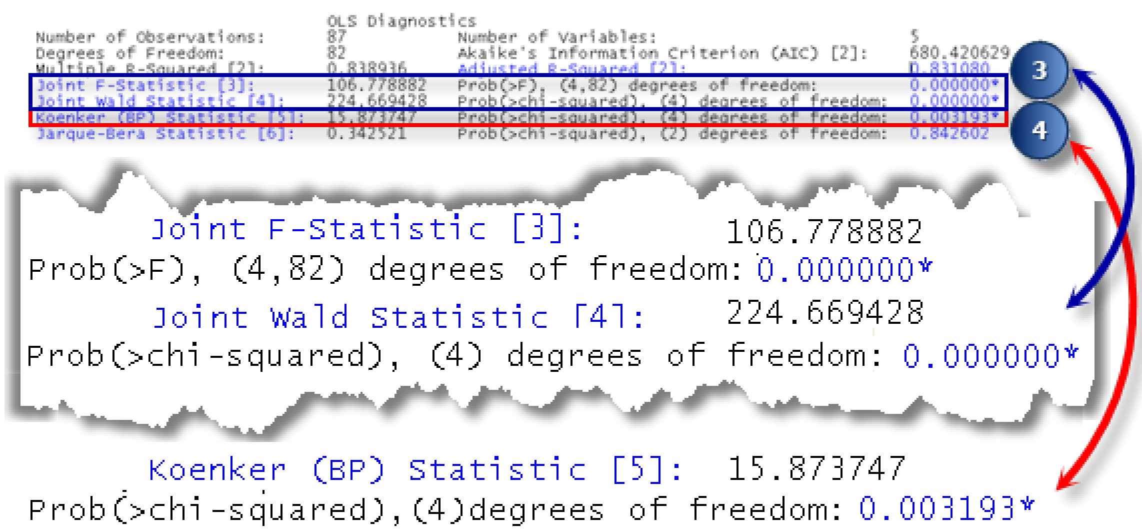
Summary of OLS Results

Variable	Coefficient	StdError	t-Statistic	Probability
Intercept	15.768546	3.693802	4.268920	0.000055*
POP	0.005495	0.001468	3.742836	0.000341*
JOBS	0.004062	0.000599	6.778749	0.000000*
LOWEDUC	0.104237	0.012863	8.103607	0.000000*
DST2URBCEN	-0.001734	0.000272	-6.381896	0.000000*

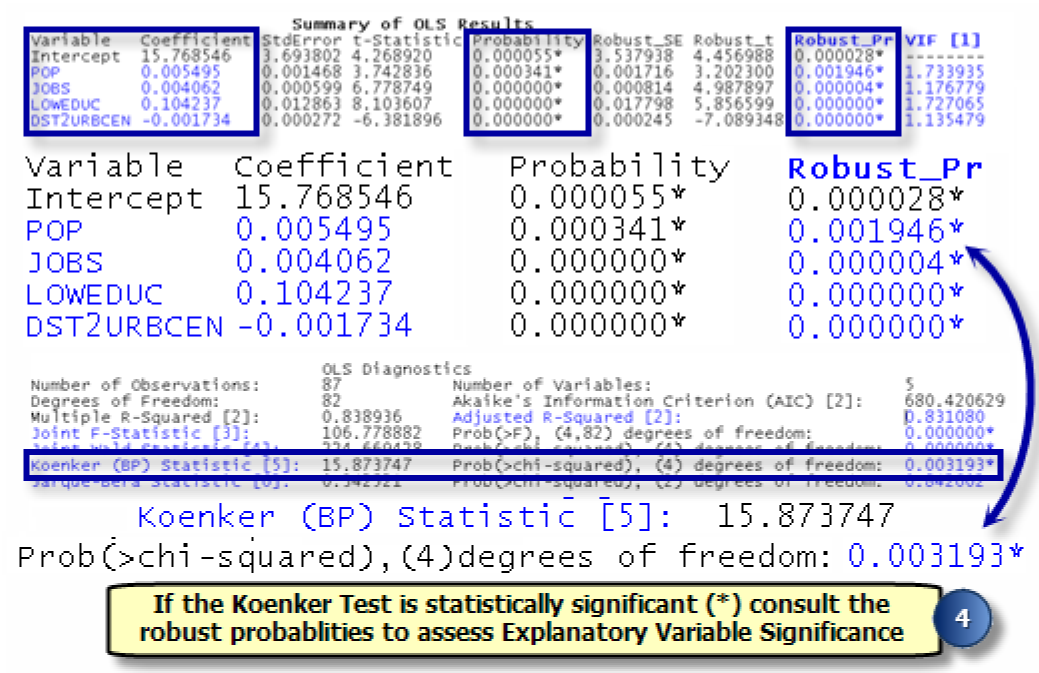
Robust_SE	Robust_t	Robust_Pr	VIF [1]
3.537938	4.456988	0.000028*	1.733935
0.001716	3.202300	0.001946*	1.176779
0.000814	4.987897	0.000004*	1.727065
0.017798	5.856599	0.000000*	1.135479
0.000245	-7.089348	0.000000*	

Assess model significance. Both the Joint F-Statistic and Joint Wald Statistic are measures of overall model statistical significance. The Joint F-Statistic is trustworthy only when the Koenker (BP) statistic (see below) is not statistically significant. If the Koenker

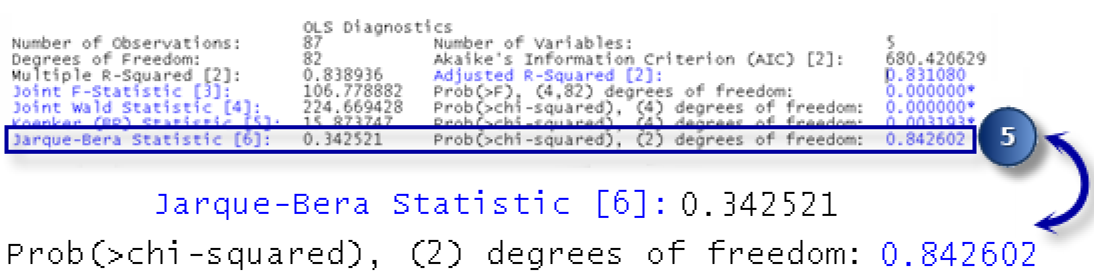
(BP) statistic is significant you should consult the Joint Wald Statistic to determine overall model significance. The null hypothesis for both of these tests is that the explanatory variables in the model are *not* effective. For a 95% confidence level, a p-value (probability) smaller than 0.05 indicates a statistically significant model.



Assess Stationarity. The Koenker (BP) Statistic (Koenker's studentized Bruesch-Pagan statistic) is a test to determine if the explanatory variables in the model have a consistent relationship to the dependent variable (what you are trying to predict/understand) both in geographic space and in data space. When the model is consistent in geographic space, the spatial processes represented by the explanatory variables behave the same everywhere in the study area (the processes are stationary). When the model is consistent in data space, the variation in the relationship between predicted values and each explanatory variable does not change with changes in explanatory variable magnitudes (there is no heteroscedasticity in the model). Suppose you want to predict crime and one of your explanatory variables in income. The model would have problematic heteroscedasticity if the predictions were more accurate for locations with small median incomes, than they were for locations with large median incomes. The null hypothesis for this test is that the model is stationary. For a 95% confidence level, a p-value (probability) smaller than 0.05 indicates statistically significant heteroscedasticity and/or non-stationarity. When results from this test are statistically significant, consult the robust coefficient standard errors and probabilities to assess the effectiveness of each explanatory variable. Regression models with statistically significant non-stationarity are especially good candidates for GWR analysis.



Assess model bias. The Jarque-Bera statistic indicates whether or not the residuals (the observed/known dependent variable values minus the predicted/estimated values) are normally distributed. The null hypothesis for this test is that the residuals are normally distributed and so if you were to construct a histogram of those residuals, they would resemble the classic bell curve, or Gaussian distribution. When the p-value (probability) for this test is small (is smaller than 0.05 for a 95% confidence level, for example), the residuals are not normally distributed, indicating model misspecification (a key variable is missing from the model). Results from a misspecified OLS model are not trustworthy.



Assess residual spatial autocorrelation. Always run the Spatial Autocorrelation (Moran's I) tool on the regression residuals to ensure they are spatially random. Statistically significant clustering of high and/or low residuals (model under and over predictions) indicates a key variable is missing from the model (misspecification). OLS results cannot be trusted when the model is misspecified.

6 Statistically significant clustering of high and/or low residuals (model under and over predictions) indicates a key variable is missing from the model (misspecification). OLS results cannot be trusted when the model is misspecified.

WARNING 000851: Use the Spatial Autocorrelation (Moran's I) Tool to ensure residuals are not spatially autocorrelated.

Finally, review the section titled "How Regression Models Go Bad" in the Regression Analysis Basics document as a check that your OLS regression model is properly specified. Notice, too, that there is a section titled "Notes on Interpretation" at the end of the OLS statistical report to help you remember the purpose of each statistical test.

```
                     Notes of Interpretation
*   Statistically significant at the 0.05 level.
[1] Large VIF (> 7.5, for example) indicates explanatory variable redundancy.
[2] Measure of model fit/performance.
[3] Significant p-value indicates overall model significance.
[4] Significant p-value indicates robust overall model significance.
[5] Significant p-value indicates biased standard errors; use robust estimates.
[6] Significant p-value indicates residuals deviate from a normal distribution.
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LIST OF REFERENCES

Atash, F. (1994). Redesigning suburbia for walking and transit: Emerging concepts. Journal of Urban Planning and Development, 120(1), 48-57.

Audirac Ivonne (1999). Stated Preference for Pedestrian Proximity: An Assessment of New Urbanist Sense of Community. Journal of Planning Education and Research. September 1999 vol. 19 no. 1 53-66.

ArcGIS Desktop Help 9.1.

Bejleri, I, Steiner, R.L., Provost, R.E., Fischman, A., & Arafat, A.A. (2008). Understanding and Mapping Elements of Urban Form that Affect Children's Ability to Walk and Bicycle to School: A Case Study of Two Tampa Bay Counties. Unpublished document, University of Florida.

Campbell, E.K. & Wang, Q. (2008). Pupil Transportation: Factors Affecting Mode Choice and the Amount of Parent-driven Trips to School, University of Vermont, Department of Community Development and Applied Economics, No: 09-3753.

Center for Design, Methods, and Analysis, US Government Accountability Office, Washington, DC 20548, USA.

Centers for Disease Control and Prevention (2005). Barriers to Children Walking to or from School --- United States, 2004. Retrieved August 7,2011, from http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5438a2.htm

Centers for Disease Control and Prevention (2011). Prevalence of Obesity Among Children and Adolescents: United States, Trends 1963-1965 Through 2007-2008 . Retrieved August 7, 2011, from http://www.cdc.gov/nchs/data/hestat/obesity_child_07_08/obesity_child_07_08.htm

Cervero, R. & Kockelman, K. (1997). Travel Demand and the 3Ds: Density, Diversity, and Design. Transportation Research Design Part D, 2(3), 199-219.

City of Raleigh, North Carolina (2008). Design Guidelines for Pedestrian-Friendly Neighborhood Schools. Retrieved June 16, 2008, from http://www.raleighnc.gov/publications/Planning/Guides,_Handbooks_and_Manuals/School_Design_Guidelines.pdf

Coffee, Neil Terence .“Constructing an objective: index of walkability.” Masters of Arts Diss., University of Adelaide, 2005.

Dellinger, A. & Staunton, C. (2002). Barriers to Children Walking and Biking to School in the United States. 1999. Morbidity and Mortality Weekly Report, 51(32), 701-704.

Dill, J. (2004). Measuring Network Connectivity for Bicycling and Walking. Presented at the Annual Transportation Research Board meeting, Washington D.C.

Duany, Andrés and Plater-Zyberk, Elizabeth. 2001. The Lexicon of the New Urbanism. Duany Plater-Zyberk & Company.

Ewing Reid, Schroeer William, and Greene William,2004. “School Location and Student Travel Analysis of Factors Affecting Mode Choice”

Forsyth, A. (2003). Measuring Density: Working Definitions for Residential Density and Building Intensity. Design Center for American Urban Landscape, College of Architecture and Landscape Architecture, University of Minnesota, Design Brief, No. 8.

Frank, L., Kerr, J., Chapman, J., & Sallis, J. (2007). Urban Form Relationships with Walk Trip Frequency and Distance Among Youth. American Journal of Health Promotion, 21(4Supp), 305-311.

Frank, L., Sallis, J., Saelens, B., Bachman, W., & Washbrook, K., (2005). Travel Behavior, Environmental, & Health Impacts of Community Design & Transportation Investment, LUTAQH: A Study of Land Use, Transportation, Air Quality, and Health, King County, Washington.

Georgina S. A. Trapp, Billie Giles-Corti, Hayley E. Christian, Max Bulsara, Anna F. Timperio, Gavin R. McCormack and 11 October 2011 Karen P. Villanueva,2010. “Increasing Children's Physical Activity: Individual, Social, and Environmental Factors Associated With Walking to and From School”. Health Educ Behav published online 11 October 2011.

Gomez, J.E., Johnson, B.A., Selva, M., Sallis, J.F., 2004. Violent crime and outdoor physical activity among inner-city youth. Prev. Med. 39, 876–881.

Hahn, R. A., S.M. Teuesch, R.B. Rothenberg, et. al. (1998). "Excess deaths from nine chronic diseases in the United States, 1986." Journal of the American Medical Association 264(20): 2554-59.

International City/County Management Association (2008). ICMA IQ Report Special Edition, Item No. E-43527 (40).

Jago,R.,Baranowski, ., Baranowski, J.C.,(2006). Observed, GIS, and self-reported environmental features and adolescent physical activity. Am. J. Health. Promot. 20, 422–428.

Kerr Jacqueline , Frank Lawrence, Sallis James F. , Chapman Jim(2007). Urban form correlates of pedestrian travel in youth: Differences by gender, race-ethnicity and household attributes. Transportation Research Part D 12 (2007) 177-182.

Kerr, J., Rosenberg, D., Sallis, J.F., Saelens, B.E., Frank, L.D., Conway, T.L., 2006. Active commuting to school: associations with environment and parental concerns. Med. Sci. Sports Exerc. 38, 787–794.

Kirsten Krahnstoever Davison , Catherine T Lawson ,2006. “Do attributes in the physical environment influence children's physical activity? A review of the literature.” International Journal of Behavioral Nutrition and Physical Activity 2006, 5868-3-19.

Kushi, L. H., R.M. Fee, A.R. Folsom, et al. (1997). "Physical activity and mortality in postmenopausal women." Journal of the American Medical Association 277: 1287-92.

Lee, C. D., S.N. Blair, A.S. Jackson (1999). "Cardiorespiratory fitness, body composition, and all-cause and cardiovascular disease mortality in men." American Journal of Clinical Nutrition 69(3): 373-80.

McGinnis, J. M., W.H. Foege (1993). "Actual causes of death in the United States." Journal of the American Medical Association 270(18): 207-12.

Norman GJ, Nutter SK, Ryan S. Community design and access to recreational facilities correlates of adolescent physical activity and body mass index. J Phys Act Health. 2006;3(suppl 1):S118–S128.

Prentice, A., Susan Jebb (1995). "Obesity in Britain: Gluttony or sloth?" British Medical Journal 311: 437-39.

Roemmich, J.N., Epstein, L.H., Raja, S., Yin, L., Robinson, J., Winiewicz, D., 2006. Association of access to parks and recreational facilities with the physical activity of young children. Prev. Med. 43, 437–441.

Romero, A.J., 2005. Low-income neighborhood barriers and resources for adolescents' physical activity. J. Adolesc. Health 36, 253–259.

Saelens, B.E., Sallis J.F., Black, J.B., & Chen, D. (2003). Neighborhood Based Differences in Physical Activity: An Environment Scale Evaluation. American Journal of Public Health, 93(9), 1552-1558.

Schlossberg, M., Greene, J., Phillips, P.P., Johnson, B., & Parker, B. (2006). School Trips: Effects of Urban Form and Distance on Travel Mode. Journal of the American Planning Association, 72(3), 337-346.

Schmucker Jeffrey M. How Does Urban Form Impact the Potential for Children to Walk and Bicycle to School: A Case Study of Orange and Seminole Counties in Central Florida. Master of Arts Thesis, University of Florida,2009.

Steiner, R.L., Bejleri, I., Wheelock, J.L., Boles, G., Cahill, M., & Perez, B.O. (2008). Understanding and Mapping Institutional Impediments to Walking and Bicycling to School: A Case Study of Hillsborough County. Transportation Research Record, 2074, 3-11.

Timperio A, Ball K, Salmon J, et al. Personal, family, social, and environmental correlates of active commuting to school. Am J Prev Med. 2006;30:45–51.

U.S. Department of Health and Human Services (2002). Physical Activity Fundamental to Preventing Disease, Office of the Assistant Secretary for Planning and Evaluation: 1-19.

US Census Bureau; 2008 American Community Survey, 1-Year Estimates; generated using American Factfinder; Retrieved October 7, 2011, from http://www.census.gov/newsroom/releases/archives/facts_for_features_special_editions/cb09-ff14.html

Wei, M., J.B. Kampert, C.E. Barlow, et al., (1999). "Relationship between low cardiorespiratory fitness and mortality in normal-weight, overweight, and obese men." Journal of the American Medical Association 282(16): 1547-53.

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