COMMUNITY ENVIRONMENTS AND
WALKING-TO-SCHOOL BEHAVIORS:
MULTI-LEVEL CORRELATES AND UNDERLYING DISPARITIES

A Dissertation

by

XUEMEI ZHU

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 2008

Major Subject: Architecture

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Approved by:

Co-Chairs of Committee,	Robin F. Abrams
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ABSTRACT

Community Environments and Walking-to-School Behaviors:

Multi-Level Correlates and Underlying Disparities. (December 2008)

Xuemei Zhu, B.A., Southeast University, China

Co-Chairs of Advisory Committee: Dr. Robin F. Abrams
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Walking can be a safe, healthy, and affordable mode of school transportation. However, most students today do not use walking for their school travel. More research is needed to understand the correlates of walking to or from school and to identify effective interventions.

This is a cross-sectional study of 73 public elementary schools in the Austin Independent School District of Texas. The first phase used geographic information systems and field audits to examine school-level disparities in the environmental support for walking in schools' attendance areas. The second phase involved surveys of students' parents or guardians to identify the multi-level correlates of using walking as their children's typical school travel mode.

In the first phase, results from analyses of variance and linear regressions indicated the existence of disparities. Lower economic status of student population was associated with poorer street conditions (e.g., maintenance, visual quality, amenities, and perceived safety), shorter distances to school, and lower traffic volumes. Higher percentage of Hispanic students within a school was associated with increased danger

from traffic and crime and more sidewalks, greater population density, and mixed land uses.

The second phase used binary logistic regressions to predict walking to or from school. Among the personal and social factors, parents' education, car ownership, personal barriers, and school bus availability were negative correlates, while parents' and children's positive attitude and regular walking habit and supportive peer influences were positive correlates. Of the physical environmental factors, long distance and safety concerns were the strongest negative correlates, followed by the presence of highways or freeways, convenience stores, office buildings, and bus stops en route.

In conclusion, environmental interventions are needed to develop centrally-located neighborhood schools, barrier-free attendance areas, and well-maintained pedestrian infrastructure. Disparities and fine-grained differences are found in the environmental support for walking. A high priority for low-income, Hispanic children and interventions tailored for specific contexts and populations appear necessary. Safety improvement is indispensible in terms of both traffic and crime and should be supplemented with educational programs that target both parents and children. Finally, multi-agency collaborations are needed at the policy level to support and facilitate these multi-level interventions.

DEDICATION

To my parents

ACKNOWLEDGEMENTS

I would like to thank the co-chairs of my committee, Dr. Lee and Dr. Abrams, and my committee members, Dr. Ulrich and Dr. Varni for their guidance and support throughout the course of this research. Without their help, this dissertation would not have been possible.

Thanks also go to my friends and colleagues for making my time at Texas A&M University a great experience. I also want to extend my gratitude to the Robert Wood Johnson Foundation Active Living Research Program, which provided financial support for this study, and to the personnel in City of Austin and the Austin Independent School District who provided tremendous support for my data collection.

Finally, thanks to my beloved parents and husband for their encouragement, trust, patience, and love.

NOMENCLATURE

AISD	Austin Independent School District
CDC	Centers for Disease Control and Prevention
GIS	Geographic Information Systems
SRTS	Safe Routes to School

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1. INTRODUCTION*

1.1 BACKGROUND AND SIGNIFICANCE

In the United States, the percentage of students (5- to 18-year-olds) walking or biking to school has declined dramatically from 41% in 1969 to 13% in 2001, and this decline was most acute among minority and elementary school children (McDonald, 2007a). Even for those children who live within one mile of school, only 31% of school trips were made by walking or biking in 1999 (Dellinger & Staunton, 2002). Meanwhile, the prevalence of overweight among 6- to 11-year-olds has more than quadrupled over the last four decades (from 4.2% in 1963-1965 to 18.8% in 2003-2004), with even higher rates for minority children (CDC, 2008b; Ogden, Flegal, Carroll, & Johnson, 2002). In other countries such as the United Kingdom, New Zealand, Australia, and Canada, similar trends have also attracted attention (Chinn & Rona, 2001; Collins & Kearns, 2005; Hillman, 1993; Magarey, Daniels, & Boulton, 2001; Tremblay, Katzmarzyk, & Willms, 2002; U.K. Department for Transport, 2003; U.K. Department of Transportation, 2005; van der Ploeg, Merom, Corpuz, & Bauman, 2008).

Recently, it has been recognized that walking to or from school can increase school children's physical activity (Cooper, Andersen, Wedderkopp, Page, & Froberg, 2005; Cooper, Page, Foster, & Qahwaji, 2003; Dollman & Lewis, 2007; Landsberg et al., 2008; Mackett, Lucas, Paskins, & Turbin, 2005; Saksvig et al., 2007; Sirard, Riner,

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This dissertation follows the style of *Environment and Behavior*.

* Part of this section is currently under review for possible publication in a February 2009 issue of the *Journal of Public Health Policy*, which, if accepting the paper, will be the place of first publication and the copyright holder for this content.

McIver, & Pate, 2005; Tudor-Locke, Neff, Ainsworth, Addy, & Popkin, 2002) and energy expenditure (Booth et al., 2007; Tudor-Locke, Ainsworth, Adair, & Popkin, 2003), although one study showed no such impact among 5-year-olds (Metcalf, Voss, Jeffery, Perkins, & Wilkin, 2004). A few studies also noted that those children who use active school commute modes (walking or biking) may have higher overall physical activity throughout the day, as compared with non-active travelers (Alexander et al., 2005; Cooper et al., 2003; Sjolie & Thuen, 2002). The impact of active school commute in reducing children's body mass index (an indicator of overweight or obesity status) is less clear, with a few available studies showing limited support (Evenson, Huston, McMillen, Bors, & Ward, 2003; Rosenberg, Sallis, Conway, Cain, & McKenzie, 2006) or non-significant results (Heelan et al., 2005).

Parallel with this emerging evidence on the health benefits of walking to or from school, existing physical activity guidelines suggest that children and young people engage in physical activity of at least moderate intensity for one hour per day (Biddle, Sallis, & Cavill, 1998; U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2005). In its report on preventing childhood obesity, the Institute of Medicine (2005) recommended that communities provide safe routes for walking to school, and encouraged children to use them for their school travel. The Healthy People 2010 report has identified increasing the rate of students who walk to school as a national health objective (U.S. Department of Health and Human Services, 2000).

In addition, walking is an affordable transportation mode that can improve environmental sustainability by reducing automobile traffic, fuel consumption, and air pollution (Environmental Protection Agency, 2003). Traffic congestion around schools can be relieved by replacing automobile school trips with walking trips (Tsai, Cranford, & Lee, 2004). If safe walking environments were provided at the same time, such a relief may also reduce automobile-related death or injury and curbside air pollution to children. It is also possible that children's mental and social health would be enhanced through exposure to nature and social interactions while walking (Gilhooly & Low, 2005; Jackson & Tester, 2008). Further, having more children and parents walking in the neighborhood may help to foster the sense of community (Leyden, 2003).

Encouraged by these recognized benefits, some policy changes have been initiated in recent years to encourage walking to or from school. In California, state transportation funding has been made available for the Safe Routes to School (SRTS) program since 1999 (Boarnet, Anderson, Day, McMillan, & Alfonzo, 2005a). In 2005, the U.S. federal transportation bill "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users" (SAFETEA-LU) authorized federal funding in the amount of $612 million for the five-year period (2005-2009) of the national SRTS program (U.S. Department of Transportation Federal Highway Administration, 2005). The SRTS concept addresses four "E"s, including the "encouragement", "education", and "enforcement" aspects that attempt to lift personal and social barriers of walking to or from school, as well as the "engineering" improvement for physical environment.

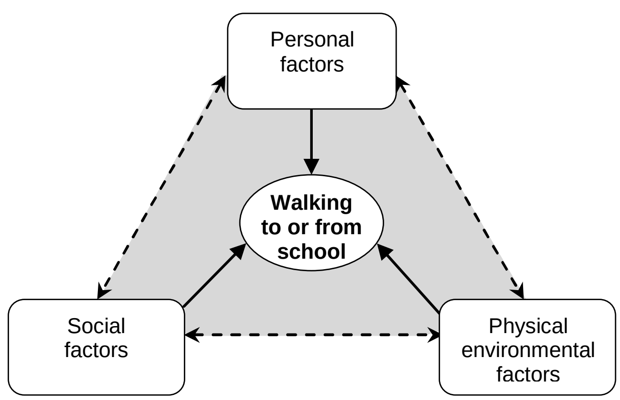
Grass-root programs have also been developed to encourage the use of walking for school travel. "Walking School Bus" was a small-scale program starting in Canada and later developed in several other countries such as the United States and New Zealand (Kingham & Ussher, 2007). In this program, one or more adults volunteer to escort a group of students to walk to or from school together. In the United States, the Nutrition and Physical Activity Program of the CDC initiated a community-based program called "Kids Walk-to-School" (CDC, 2008a) in 2000. In addition, the "International Walk to School Month" (2008) is an international event where children, parents, school teachers, and communities gather and celebrate the benefits of walking.

1.2 THE KNOWLEDGE GAP

Despite the recognized benefits and the growing demand and effort to promote walking to or from school, there is limited understanding in terms of the correlates of this active school commute mode. A growing body of literature has been developed around this topic in recent years, but the existing knowledge is still insufficient to ensure effective interventions. Current programs are mostly based on what was intuitively considered to be important for promoting walking to or from school, and more empirical evidence is needed for knowledge-based decision-making (Davison, Werder, & Lawson, 2008).

Based on social ecological theory (McLeroy, Bibeau, Steckler, & Glanz, 1988; Stokols, 1992; U.S. Department of Health and Human Services, 1996) and limited existing literature, three tenets of correlates can be identified for walking to or from school, including personal, social, and physical environmental factors, which also interact with each other (Figure 1). Previous interventions in promoting physical activity (including walking) have mainly focused on individual factors (Stokols, 1992) and showed limited impact due to the small scale of target populations and the difficulty in sustaining behavior changes over the long term. Recent efforts have recognized the potential of environmental interventions, especially of those targeting physical environment, as promising strategies to encourage population-level changes for current residents as well as for generations to come (Hoehner, Brennan, Brownson, Handy, & Killingsworth, 2003; Stokols, 1992; U.S. Department of Health and Human Services, 1996).

Figure 1
Socio-Ecological Framework for the Correlates of Walking to or from School



However, the physical environment in many U.S. neighborhoods is not supportive for walking to or from school. The sidewalk network is often incomplete, and in some cases, poorly maintained. The streets are filled with high-speed automobile traffic that makes walking dangerous for pedestrians, especially for children. Safety concerns about crime also keep children from going outdoors and walking or playing in the neighborhood.

In addition, trends in school development have shifted to larger schools located in remote areas near high-capacity roads, which facilitate automobile access at the expense of walking or biking (Environmental Protection Agency, 2003; Wilson, Wilson, & Krizek, 2007). Public policies have played an important role in this shift by encouraging school consolidation with the hope of increasing economic efficiency (Andrews, Duncombe, & Yinger, 2002; Langdon, 2007). Many states have implemented strict minimum acreage requirements for new schools and funding formulas and building codes that favor the development of new schools over the renovation of existing neighborhood schools (Environmental Protection Agency, 2003; Kouri, 1999). Also, the lack of collaborations among different stakeholders (e.g., state, county, and local governments, school districts, transportation and planning departments, etc.) often limits the consideration of multi-faceted impacts, including those on school transportation, in the process of school development (Kouri, 1999; Lees, Salvesen, & Shay, 2008).

In summary, promotion of walking to or from school is facing multiple barriers. A better understanding of these barriers and potential motivators is a prerequisite for a successful intervention effort.

1.3 STRUCTURE OF THE DISSERTATION

This dissertation attempted to fill this gap of knowledge by examining the comprehensive correlates of walking to or from school and by exploring disparities in the environmental support for walking. After a brief introduction about the background and significance of this topic in Section 1, the Section 2 reviews the limited but growing body of literature that examined the correlates of walking to or from school among school-aged children. Theories from multiple relevant disciplines are examined for their relevance to the study of active commute to school in Section 3. Then two tailored conceptual frameworks and a series of research questions are proposed, followed by an introduction of the study setting and population. Two phases of study are then introduced. Section 4 covers the first phase, school-level analysis, which used geographic information systems (GIS) and filed audits to examine economic and ethnic disparities in the environmental support for walking. Section 5 introduces the second phase, individual-level analysis, where survey results from parents or guardians of school children are analyzed to identify the correlates of using walking as a child's typical school travel mode. For each phase, the research design, methods, results, and limitations are introduced. The last section discusses the contributions to the literature and the implications for future environmental and policy interventions in the area of promoting walking to or from school.

2. LITERATURE REVIEW*

Walking to or from school is a relatively new area of research, with most empirical studies appearing in or after 2003. The researcher conducted an extensive keyword search using the online databases such as PubMed, ISI Web of Knowledge, National Transportation Library, and Google Scholar. Keywords used in the search included *walking*, *school*, *children*, *active commute*, and *active transport*. The inclusion criteria include (1) the study examined the correlates of walking to or from school among 5- to 18-year-olds using empirical methods and (2) the study was written in English and was published as a peer-reviewed journal paper, a government document, or a dissertation. In addition, the references of identified studies were reviewed to locate additional relevant literature.

By January 2008, a total of 30 empirical studies were identified, including 28 journal articles, one government document (Environmental Protection Agency, 2003), and one dissertation (McMillan, 2003). In addition, two review articles (Davison et al., 2008; McMillan, 2005) were examined as they provided comprehensive information about the state of knowledge in this area at their times of publication.

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2. "School environment and 'green' transportation", by Zhu, X. 2007. Paper presented at the Architectural Research Centers Consortium (ARCC) Annual Spring Research Conference: Green Challenges in Research, Practice, and Design Education, Eugene, Oregon, Copyright [2007] by ARCC.

2.1 RESEARCH DESIGN AND METHODS OF PREVIOUS STUDIES

Previous studies differed from each other in terms of the research design, study setting, study population, data collection, and analysis, making it difficult to synthesize their findings. For *research design*, 26 of 30 empirical studies used a cross-sectional design to examine the relationship between walking to or from school and certain personal, social, and/or physical environmental factors. Four other studies examined the impact of physical environmental interventions (Boarnet et al., 2005a; Boarnet, Day, Anderson, McMillan, & Alfonzo, 2005b) or educational interventions (Gilhooly & Low, 2005; McKee, Mutrie, Crawford, & Green, 2007) using a pre-post comparison, among which one study had a control group (McKee et al., 2007). In general, intervention studies using experimental or quasi-experimental design are able to provide stronger evidence and tackle the causality issues, but such studies were relatively rare in the existing literature. The lack of experimental or quasi-experimental studies stems from many challenges, including difficulty in systematically varying the real physical environment in research, inability to randomly sassing free living individuals to different environmental settings, and limited funding and resources for multi-year longitudinal studies.

Most identified studies were conducted in the United States, while a few were carried out in Australia (Merom, Tudor-Locke, Bauman, & Rissel, 2006; Timperio et al., 2006; Ziviani, Scott, & Wadley, 2004), the United Kingdom (Gilhooly & Low, 2005; McKee et al., 2007), Portugal (Mota et al., 2007), and Norway (Sjolie & Thuen, 2002).

The *study settings* ranged from central urban areas to suburban and rural locations, and featured various characteristics in terms of density, land-use mix, and road conditions, etc. The *study populations* were 5- to 18-year-old students and their parents or guardians, with the sample size ranging from 53 (Greves et al., 2007) to 7433 (Martin, Lee, & Lowry, 2007). Most studies focused on certain grades within elementary schools, middle schools, or high schools, while a few others covered a wider range (e.g., from elementary schools to high schools) (Environmental Protection Agency, 2003; Ewing, Forinash, & Schroeer, 2005; Ewing, Schroeer, & Greene, 2004; Kerr et al., 2006; Kouri, 1999; Martin & Carlson, 2005; McDonald, 2007b). Although most studies are case studies on specific schools in specific areas, four studies reported survey findings from either national samples (Fulton, Shisler, Yore, & Caspersen, 2005; Martin & Carlson, 2005; Martin et al., 2007) or state samples (Evenson et al., 2003).

The *dependent variable* was the use of walking or the use of either walking or biking as a travel mode for the entire or part of the trip between home and school. For the *independent and confounding variables*, most studies considered the multi-level correlates of walking to or from school, including personal, social, and physical environmental factors (Timperio et al., 2006), although the considered variables within each level were often far from complete. Three studies also considered the interaction among multi-level factors (Kerr et al., 2006; McDonald & Howlett, 2007; Timperio et al., 2006).

Data collection in most studies relied on paper surveys with children or their parents or guardians, but a few other methods have also been used. The outcome variable—walking to or from school—was captured by various methods, including paper surveys with parents, children, or school principals, in-classroom surveys by asking children to raise their hands, or field observations and counting. Most personal and social factors were captured using paper surveys. The physical environment has been measured both objectively (using GIS measurements or field audits) and subjectively (using surveys). These two types of measurements have shown related yet different results in terms of their impact on school travel.

2.2 PERSONAL AND SOCIAL CORRELATES OF WALKING TO OR FROM SCHOOL

Personal and social correlates of walking to or from school are many. Personal factors include children's and parents' socio-demographic characteristics, personal attitudes, and behaviors. Social factors consist of the influences from children's and parents' peers, schools, and neighborhoods.

Children's socio-demographic characteristics have been identified as significant correlates, although the empirical findings are not always consistent. Overall, boys are more likely to walk or bike to school than are girls (Evenson et al., 2003; Fulton et al., 2005; McMillan, Day, Boarnet, Alfonzo, & Anderson, 2006; Merom et al., 2006), but some studies reported non-significant findings (Gilhooly & Low, 2005; Martin et al., 2007). The impact of age is even less consistent. An Australian study (Merom et al., 2006) and a Scotland study (Gilhooly & Low, 2005) showed that older elementary or primary school children walked more often than younger children, while two U.S.

studies (Fulton et al., 2005; McMillan et al., 2006) reported reversed associations. Two other studies reported that within a wider age range, older students were more likely to walk to or from school (Martin et al., 2007; McDonald, 2007b), but non-significant results have also been reported (Evenson et al., 2003; Kerr et al., 2006; Schlossberg, Greene, Phillips, Johnson, & Parker, 2006). One important confounding factor related to the impact of age is that middle schools or high schools are usually located much farther from children's homes compared with elementary schools. In terms of ethnicity, it appears that Hispanic, African, or non-white children walk more often for their school travel (Braza, Shoemaker, & Seeley, 2004; Evenson et al., 2003; Falb, Kanny, Powell, & Giarrusso, 2007; McDonald, 2007b), but some studies reported non-significant results (Martin et al., 2007; Schlossberg et al., 2006).

Children's attitudes, behaviors, and other personal characteristics have shown significant impact in a few studies. Regular participation in physical education, organized physical activity, or school groups has been identified as positive correlates (Evenson et al., 2003). In contrast, child's preference for being driven to school was a negative factor (Salmon, Salmon, Crawford, Hume, & Timperio, 2007). Another study found that body mass index of middle school students was negatively associated with walking to or from school (Evenson et al., 2003).

In addition to children's characteristics, *parents' socio-demographic factors* also appear important in the use of walking for children's school travel. Parents' (family's) socioeconomic status was a negative correlate in most cases (Environmental Protection Agency, 2003; Ewing et al., 2004, 2005; Falb et al., 2007; McMillan, 2006; Mota, Almeida, Santos, & Ribeiro, 2005), but was not significant in a few other studies (Martin et al., 2007; McDonald, 2007b; Schlossberg et al., 2006). Parents' education level can be considered as a proxy of the family's socioeconomic status and has shown negative impact (Evenson et al., 2003; Martin et al., 2007; Mota et al., 2007) as well as non-significant results (Fulton et al., 2005; Kerr et al., 2006; McMillan et al., 2006). Caregiver born in the United States has been reported as a negative correlate (McMillan, 2006), while parents being divorced was a positive correlate in one study (Martin et al., 2007). Car ownership or driver license ownership was not significant in a few studies (McDonald, 2007b; Merom et al., 2006; Schlossberg et al., 2006).

Compared with children's attitudes and behaviors, *parents' attitudes and behaviors* appear to be more important. Parents' perceived importance of physical activity or active commute (for physical activity purposes or for social interaction purposes), parents' personal history of active commute to school, parents' own participation in physical activity, and the level of independence given to children are positive correlates (McMillan, 2006; Merom et al., 2006; Ziviani et al., 2004). In contrast, parents' lack of time to supervise walking and perceived convenience of driving are negative factors (Greves et al., 2007; McMillan, 2006; Salmon et al., 2007). It is also noticed that if the family supported the caregiver's idea of letting the child walk to or from school, the child is more likely to walk (Evenson, Neelon, Ball, Vaughn, & Ward, 2005; McMillan, 2006).

Some other *factors related to the family structure* have also been studied, but results are inconsistent. The number of children has been identified as a negative

(Greves et al., 2007), non-significant (Martin et al., 2007), and positive (McDonald, 2007b; McMillan, 2006) correlate, leaving questions for future research. Having the father as the responsible parent (Merom et al., 2006) and never having adults at home immediately after school are positive correlates (Evenson et al., 2003).

In addition to personal factors, *social influences* from parents' and children's peers, schools, and neighborhoods have shown significant impact on walking to or from school. Social support from friends and family and perceived positive school climate are positive correlates (Evenson et al., 2005). Not having many other children around (Timperio et al., 2006) or no other children to walk with (Salmon et al., 2007) have negative impact. Social control and cohesion was found to be a positive or non-significant factor, depending the distance between home and school (McDonald, 2007b).

2.3 PHYSICAL ENVIRONMENTAL CORRELATES OF WALKING TO OR FROM SCHOOL

A growing number of studies have shed light on the physical environmental attributes that may encourage or deter walking to or from school among school-aged children (Table 1). These variables cover both walkability and safety of physical environment at both the neighborhood level and the street level.

Table 1

Summary of Physical Environmental Correlates of Walking to or from School

Class	**Variable**	**Measure-ment Type[a]**	**Associ-ation[b]**	**Source**
Travel distance	Travel distance or travel time	CP, O, PP	(–)	EPA 2003, Ewing 2004 & 2005, Gilhooly 2005, Greves 2007, Martin 2005, McDonald 2007, McMillan 2006, Merom 2006, Schlossber 2006, Timperio 2006, Zivani 2004
	Distance for trips >1 mile	O	(×)	McDonald 2007
Safety	Traffic and crime safety	PP	(–)	Greves 2007, Kerr 2006, Martin 2005, McMillan 2006, Merom 2006
		PP, CP	(×)	Fulton 2005, McMillan 2003, Timperio 2006
Non-motorized infra-structure	Sidewalk completeness	O, PP	(+)	Boarnet 2005a & 2005b, EPA 2003, Ewing 2004 & 2005, Kerr 2006, McMillan 2003
		O	(×)	McMillan 2003
	Development of bicycle facilities	O	(×)	Boarnet 2005b
	Sidewalk gap closures	O	(+)	Boarnet 2005a & 2005b
	Replacement of four-way stops with traffic signals	O	(+)	Boarnet 2005a & 2005b
	Pedestrian or bicycle crossing improvement	O	(×)	Boarnet 2005a & 2005b
Motorized infra-structure	Roads with speed >30 miles per hour	PP	(–)	McMillan 2003 & 2006
	Major roads	O	(×)	Schlossberg 2006
	Busy roads	O	(–)	Timperio 2006
	Railroad tracks	O	(–)	Schlossberg 2006
	Steep roads for 5-6 year olds	O	(–)	Timperio 2006
	Steep roads for 9-12 year olds	O	(×)	Timperio 2006
	No traffic lights or crossings	PP	(–)	Timperio 2006
	Need to cross several roads	PP	(×)	Timperio 2006
	Average street width	O	(×)	McMillan 2003
	Average block length	O	(×)	McMillan 2003
	Speed humps	O	(×)	McMillan 2003
	Street lighting	O	(×)	McMillan 2003
	Street tree coverage	O	(×)	Ewing 2004 & 2005
	Limited public transport	PP	(×)	Timperio 2006

Table 1 (continued)

Class	**Variable**	**Measurement Type**[a]	**Association**[b]	**Source**
School	School size (enrollment)	O	(–)	Braza 2004, Falb 2007
		O	(×)	EPA 2003, Ewing 2004 & 2005
	Age of school	O	(+)	Kouri 1999
			(×)	EPA 2003, Ewing 2004 & 2005
Street pattern	Street density	O	(+)	Falb 2007
	Street Intersection density	CP, O	(+)	Mota 2007, Schlossberg 2006
		O	(×)	Braza 2004
	Dead end density	O	(–)	Schlossberg 2006
	Ratio of street network area to radial buffer area	O	(+)	Falb 2007
	Route directness	O	(×)	Schlossberg 2006
		PP	(+)	Salmon 2007
	Route directness for 5-6 year olds	O	(×)	Timperio 2006
	Route directness for 10-12 year olds	O	(–)	Timperio 2006
Neighborhood environment	Highly urbanized locations versus relatively un-urbanized locations	CP, PP	(+)	Fulton 2005, Martin 2007
		O	(×)	Sirard 2005, McMillan 2003
		O	(–)	Falb 2007
	Located in the southern region	CP, PP	(–)	Martin 2007
	Population density	O	(+)	Braza 2004, Falb 2007
		O	(×)	EPA 2003, Ewing 2004 & 2005
	Residential unit density for trips <1 mile	O	(×)	McDonald 2007
	Residential unit density for trips >1 mile	O	(+)	McDonald 2007
	(Residents + jobs) density	O	(×)	EPA 2003, Ewing 2004 & 2005
	Land-use mix	O	(×)	EPA 2003, Ewing 2004 & 2005, McMillan 2003
		O, PP	(+)	Kerr 2006, McMillan 2006
	Comprehensive walkability measure in high-income neighborhoods	O	(+)	Kerr 2006
	Comprehensive walkability measure in low-income neighborhoods	O	(×)	Kerr 2006
	Block size for trips <1 mile	O	(+)	McDonald 2007
	Block size for trips >1 mile	O	(×)	McDonald 2007
	Abandoned buildings	O	(–)	McMillan 2003
	Houses with windows facing streets	O	(×)	McMillan 2003
		O	(+)	McMillan 2006
	Houses built before 1950	O	(–)	Falb 2007
	Neighborhood aesthetics	PP	(+)	Kerr 2006

[a] CP, children's perceptions; O, objective measures; PP, parents' perceptions.
[b] (+), positive association; (–), negative association; (×), non-significant association.
EPA, Environmental Protection Agency.

Distance between home and school is one of the most significant correlates in previous literature. Its objective and subjective measures all showed negative impact on walking to or from school (Environmental Protection Agency, 2003; Ewing et al., 2004, 2005; Gilhooly & Low, 2005; Greves et al., 2007; Martin & Carlson, 2005; McMillan, 2006; Merom et al., 2006; Schlossberg et al., 2006; Timperio et al., 2006; Ziviani et al., 2004). The only exception is that one study found distance to be no longer significant when it is farther than 1.6 miles (McDonald, 2007b). From a national representative sample in a CDC survey, long distance was identified as a topmost barrier to walking to school by 61.5% of the parents (Martin & Carlson, 2005). Some studies have attempted to identify a threshold for walkable distance and reported 0.5 mile (0.8 kilometer) or one mile (1.6 kilometers) between home and school to be the maximum threshold for walking to school (McDonald, 2007b; McMillan et al., 2006; Merom et al., 2006; Schlossberg et al., 2006; Timperio et al., 2006). But this value will likely vary depending on the children's personal characteristics and the environmental conditions.

Safety concerns about traffic and crime is another significant barrier for walking to or from school, and parents' perceptions play an especially significant role (Greves et al., 2007; Kerr et al., 2006; Martin & Carlson, 2005; McMillan, 2006; Merom et al., 2006). Although the actual crash rates have declined over the years, the perceived fear of traffic crashes has not. The CDC survey found that 30.4% of the parents reported traffic danger to be a barrier to walking to school, while the fear of crime was reported by

11.7% of the parents (Martin & Carlson, 2005). However, a few studies found safety factors to be non-significant (Fulton et al., 2005; McMillan, 2003; Timperio et al., 2006).

Characteristics of non-motorized infrastructure have shown significant impact in several articles, including two intervention studies, although non-significant results have also been reported. Objective or perceived sidewalk completeness was a positive correlate in most studies (Boarnet et al., 2005a, 2005b; Environmental Protection Agency, 2003; Ewing et al., 2004, 2005; Kerr et al., 2006). One study found the perceived measure to be significant, while the objective sidewalk ratio within a quarter mile of school was not significant (McMillan, 2003). Although the majority of previous studies are cross-sectional, a small number of intervention studies have been carried out and identified certain environmental improvements to be effective. These interventions include the development of new sidewalks, sidewalk gap closures at locations with moderate or heavy pre-existing walking or biking traffic, and the replacement of four-way stops with traffic signals (Boarnet et al., 2005a, 2005b). Other interventions such as the development of bicycle facilities and the improvement of pedestrian and bicycle crossing showed no significant impact (Boarnet et al., 2005a, 2005b).

Motorized infrastructure has also shown certain influences on walking to or from school. Most features related to traffic danger have negative impact, including the need to cross roads with busy or high-speed traffic (e.g., speed limit greater than 30 miles per hour), rail tracks, steep roads (for 5- to 6-year-olds only), and roads that lack traffic lights, crossings, or street lighting (McMillan, 2003; McMillan, 2006; Schlossberg et al., 2006; Timperio et al., 2006). However, non-significant results have been reported in a study for the need to cross major roads and several roads (Schlossberg et al., 2006). Some other characteristics of motorized infrastructure and its surroundings have also been studied, but showed non-significant results. These factors are street width, block length, speed humps, street lighting, tree coverage, and limited public transport (Ewing et al., 2004, 2005; McMillan, 2003; Timperio et al., 2006). More studies are needed to further examine the impact of these factors in well-designed studies.

School characteristics have been studied for their impact. The size (enrollment) of school appeared to be a negative correlate of walking to or from school in two studies (Braza et al., 2004; Falb et al., 2007), but was not significant in some other cases (Environmental Protection Agency, 2003; Ewing et al., 2004, 2005). The age of the school was a positive correlate in Kouri's study (1999), but not significant in others (Environmental Protection Agency, 2003; Ewing et al., 2004, 2005). It is important to note that the size or age of the school may actually serve as a proxy of the surrounding environment in these studies.

Compared with the role of distance, safety, and infrastructure conditions, the influence of *street patterns and other neighborhood characteristics* such as locations, density, land uses, and housing characteristics appeared somewhat weaker with less consistent results, despite their relatively consistent results among adults.

Different measures of s*treet patterns, especially street connectivity*, have been examined for their impact on walking to or from school. Street density showed positive impact in one study (Falb et al., 2007). Street intersection density appeared to be positive correlates in two studies (Mota et al., 2007; Schlossberg et al., 2006), but was not significant in another study (Braza et al., 2004). Dead end density is a negative correlate (Schlossberg et al., 2006), implying that lack of street connectivity deters children from walking to or from school. This finding is also supported by another study, where a higher ratio of street network area to radial buffer area (indicating better street connectivity) showed positive impact (Falb et al., 2007). Results for the impact of route directness are inconsistent, including positive, negative, as well as non-significant findings (Salmon et al., 2007; Schlossberg et al., 2006; Timperio et al., 2006).

Other neighborhood characteristics have also shown inconsistent findings. *Locations* in highly urbanized areas appear to be a positive correlate in several studies (Fulton et al., 2005; Martin et al., 2007), but reversed (Falb et al., 2007) and non-significant results (McMillan, 2003; Sirard, Ainsworth, McIver, & Pate, 2005) have also been reported. Neighborhood location in the south geographic region is a negative correlate (Martin et al., 2007), likely due to the hot weather in the southern region. *Density* has been measured in different ways, including population density, residential unit density, and residential and job density; results are also inconsistent (Braza et al., 2004; Environmental Protection Agency, 2003; Ewing et al., 2005; Ewing et al., 2004; Falb et al., 2007; McDonald, 2007b). *Land-use mix* is generally considered as a positive correlate for adults' daily walking behaviors, and showed positive (Kerr et al., 2006; McMillan, 2006) or non-significant impact (Environmental Protection Agency, 2003; Ewing et al., 2004, 2005; McMillan, 2003) for children's active school commute. A comprehensive index of neighborhood walkability (including residential density, retail density, intersection density, and land-use mix) showed positive impact in high-income neighborhoods and non-significant impact in low-income neighborhoods (Kerr et al., 2006). Other neighborhood characteristics being studied include block size (positive or non-significant), abandoned buildings (non-significant), windows facing streets (positive or non-significant), age of house (negative), and neighborhood aesthetics (positive).

2.4 INTERACTIONS AMONG MULTI-LEVEL FACTORS

Interactions among multi-level correlates of active school commute are important factors for both research and practice, but have not been studied in most previous studies. One exception is Kerr and colleagues' study (2006), which demonstrated an interaction between objectively measured neighborhood walkability and neighborhood income level: walkability was a positive correlate in high-income neighborhoods, but was not significant in low-income neighborhoods. It is likely that parents in low-income neighborhoods are highly concerned about safety issues so that the objective walkability does not make a difference.

Another study examined the interactions between home-to-school distance and other physical or social environmental characteristics (McDonald, 2007b). Results showed that residential unit density, block size, and social cohesion have positive or non-significant impact, depending on the length of the trip between home and school (farther or closer than one mile). In addition, Timperio and colleagues (2006) considered the interactions between child's age and physical environment. Results revealed that the impact of route directness or steep road barrier on active commute to school varies depending on the child's age.

2.5 SUMMARY

Overall, research on correlates of walking to or from school is a work in progress, with inconsistent findings and missing variables. Also lacking are systematic comparisons between objective and subjective measures, and investigation into the interrelations between different environmental factors as well as between environmental and personal and social factors. It is also important to note that a tailored and well-developed conceptual framework is needed for more rigorous research and more effective interventions on walking to or from school among school-aged children. The following section will examine theories from multiple relevant disciplines and propose a tailored conceptual framework to guide the study on correlates of walking to or from school.

3. RESEARCH IDEOLOGY, QUESTIONS, AND DESIGN*

3.1 Conceptual Framework

Physical environment in related to walking to or from school is a newly developed area that requires expertise and collaboration from multiple disciplines, including physical activity and health promotion, environment-behavior research, transportation, urban design and planning, and architecture. Previous theories and knowledge in various disciplines have provided a helpful basis for this new area, but a single discipline is insufficient due to limited variables and methods in their traditional areas. For active school commute, the unique population (children) and the unique behavior (walking to or from school) require a tailored and well-developed conceptual framework to direct more focused research and more effective interventions. Guided by McMillan's previous review (2005), this study examined relevant theories in two areas—the broader area of physical activity research and the specialized area of walking research. Two tailored frameworks were then proposed for walking to or from school among school-aged children.

An important recent change in physical activity research is the application of an ecological perspective that considers multi-level correlates of behaviors (McLeroy et al., 1988; Stokols, 1992). In the past, behavioral and social science research on physical activity has focused more on intrapersonal and social factors, based on theories such as

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learning theories, health belief model, transtheoretical model, relapse prevention, and theories of planned behavior (King, Stokols, Talen, Brassington, & Killingsworth, 2002; Sallis & Owen, 1999; U.S. Department of Health and Human Services, 1996). Several important correlates have been identified, including both motivators (e.g., self-efficacy, self-motivation, enjoyment, perceived health or fitness, and social support from a spouse, family, peers, or friends) and barriers (e.g., stress, work or school load, time constrinat, and inconvenience) (McMillan, 2005).

Recently, ecological approaches are being increasingly used in physical activity research because of their considerations of interactive multi-level factors, including personal, social, and physical environmental elements (King et al., 2002). It is also believed that most effective interventions occur when multiple strategies are employed at multiple levels simultaneously, and such interventions can lead to sustainable changes in behaviors and lifestyles (U.S. Department of Health and Human Services, 1996).

As one type of healthful physical activity, walking can serve multiple purposes such as transportation, recreation, and exercise. It has potential benefit to improve physical health through increased physical activity, and at the same time reduce automobiles use, fuel consumption, and environmental pollution.

Based on the ecological perspective and previous physical activity research, scholars have given more attention to the potential of physical environment in promoting and sustaining healthy and routine walking behaviors (Stokols, 1992; Stokols, Grzywacz, McMahan, & Phillips, 2003). In addition to public health researchers, scholars from fields related to built environment (e.g., urban design and planning, transportation, and architecture) have also joined this growing effort of walking research. Active Living Research (Robert Wood Johnson Foundation Active Living Research, 2008) is a leading program in this field, and has contributed to build the collaboration among multiple disciplines and to advance the state of knowledge.

However, theories and methods in traditional areas of transportation, urban design and planning, and architecture research appear insufficient for the field of walking research, especially for active commute to school among school-aged children (McMillan, 2005).

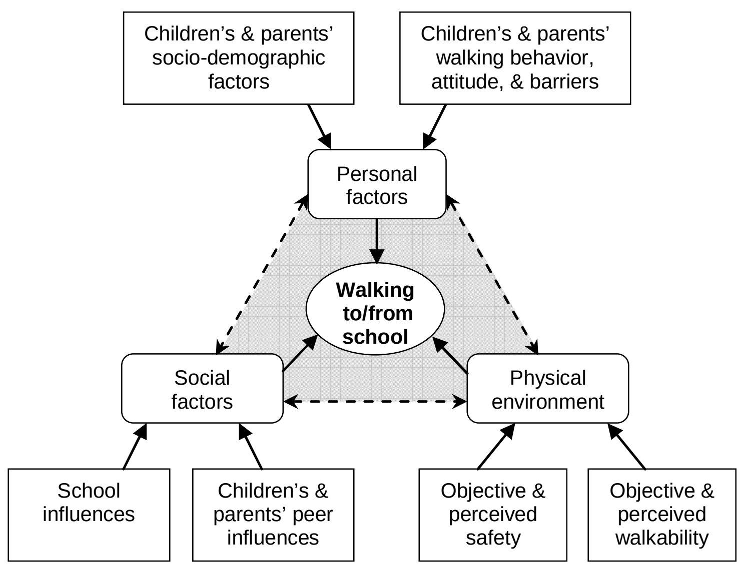
Traditional travel study and urban research mainly focus on adult populations and automobile trips, and are not directly applicable to children's active school commute. As proposed by McMillan (2005), these theories and research generally fall into two categories: (1) statistical models that forecast travel demand and (2) activity-based frameworks that attempt to identify complex elements affecting travel behaviors. The four-step model is a typical example of the first type—trip forecasting models. It uses statistical equations to forecast travel demand (where and how much automobile trips) by four stages, including trip generation, trip distribution, mode choice, and route choice (McMillan, 2005; McNally, 2000b). Such a model is not appropriate to understand active commute to school because it only predicts trip outcomes and does not consider the complex decision-making process for the travel behavior (McNally, 2000b). For example, it often ignores the potentially important impact of temporal and spatial constraints (Goodwin & Hensher, 1978; McMillan, 2005), as well as parents' strong focus on children's safety. As a result, such models often fail to answer the question of "why" in an effective way. In addition, data collection and analysis for these forecasting models often use large-scale units of analysis such as Traffic Analysis Zones. The collected data are too coarse for walking research due to the relatively shorter distance covered by walking, and to the more intimate interactions between walkers and environment, as compared with those between drivers and physical environment.

The second type of travel behavior models—the activity-based framework—focuses on the impact of broader elements such as personal preferences, constraints, and characteristics of destinations (McMillan, 2005; McNally, 2000a). As a result, it generates a better understanding of "what, when, where, how, and why" of travel behaviors (McMillan, 2005; Stoner & Milone, 1978). However, its theoretical strength also leads to the difficulty in collecting data for complex individual and local information on a relatively large scale, which makes it somewhat less feasible from the practical perspective (McMillan, 2005; McNally, 2000a).

One important difference between walking research and traditional transportation research is the increased importance of small-scale physical environment. As mentioned above, walking involves a moving speed that is much lower than that of automobile vehicles, and thereby consists of more intimate interactions between travelers and the environment. As a response to this difference, recent walking research in transportation, urban design and architecture fields also considers those physical environmental features at smaller scale. Examples include street width, tree shade, façade of buildings, buffers between sidewalks and roads, site design, visual quality, as well as the maintenance of sidewalks and road-side buildings and gardens (Handy, 1996; Shriver, 1997; Zimring, Joseph, Nicoll, & Tsepas, 2005). Although the evidence is still limited at this moment, some important findings have emerged, and warrant further investigations in this area.

A review of relevant theories further indicates the need to develop a well-defined conceptual framework to reflect characteristics of the specific problem as related to active commute to school among school-aged children. Based on the basic framework of social ecological theory (Figure 1) and literature review (Section 2), this study proposed a problem-oriented conceptual framework (Robinson & Sirard, 2005) that is tailored for the target population (elementary school children) and the specific behavior (walking to or from school) of this study (Figure 2).

Figure 2
Problem-Oriented Conceptual Framework for Walking to or from School among Elementary School Children



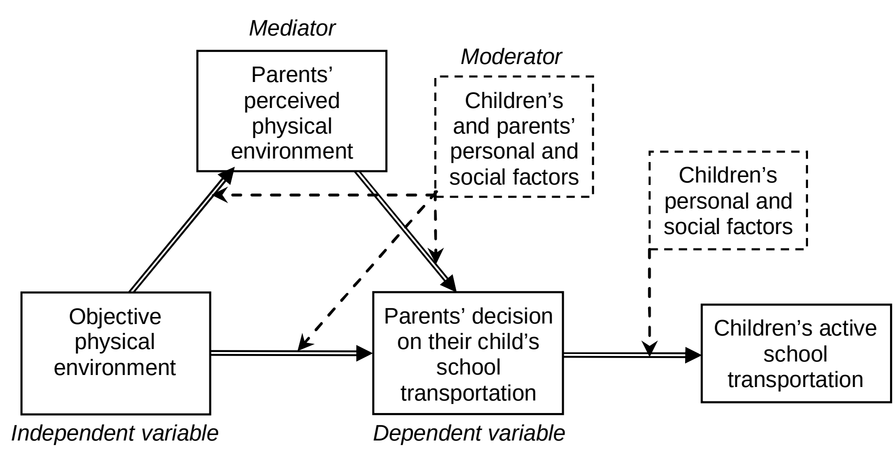
This framework considers specific factors related to walking to or from school among elementary school children. First, parents play an important role in children's school travel, and therefore their personal and social factors should also be considered. Second, school influences, especially the provision of school bus service, will have an important impact on the use of walking for school travel. Third, in addition to walkability of the physical environment, the safety issue is also of paramount importance to children. Fourth, objective and subjective measures of physical environment are related, but may have different roles in encouraging or deterring walking to or from school.

Despite its relevance to the research problem, this framework does not explicitly consider the complex relationships (e.g., mediating roles and moderating roles) between objective and subjective measures of physical environment, or among personal, social, and physical environmental factors. Since immediate interventions are needed at this moment, when empirical knowledge is still insufficient, a solution-oriented approach is needed on top of this problem-oriented framework to guide interventions and direct more intervention-relevant research at the same time (Robinson & Sirard, 2005).

McMillan (2005) has proposed a conceptual framework for elementary school children's travel behaviors, which serves such a solution-oriented purpose. It assumes that parents are the primary decision-makers for school-aged children's school travel and attempts to understand the complex multi-level factors involved in this decision-making process. However, it does not explicitly consider the relationship between objective and subjective measures of physical environment, which have significant implications for the study of causal relationships and the development of effective interventions.

Based on social ecological theory, literature review, and McMillan's previous framework (2005), this study proposed a solution-oriented conceptual framework (Figure 3) for active school commute among elementary school children. It specifies the mediating effects of perceived physical environment and moderating effects of personal and social factors, in the hope that such fine-grained relationships can direct more solution-oriented research and more effective interventions.

Figure 3
Solution-Oriented Conceptual Framework for Walking to or from School among Elementary School Children



3.2 RESEARCH QUESTIONS AND AIMS

This study examines part of the relationships in this proposed framework (Figure 3) as a step to understand this complex decision-making process and environment-behavior relationship. Based on current state of knowledge, a set of research questions were identified as high-priority issues. (1) How can the environmental support for walking to or from school be quantified in a comprehensive way that is tailored to children's school travel? (2) Is there any disparity in such environmental support across neighborhoods with difference economic status and ethnic composition? (3) What are the personal, social, and physical environmental correlates for parents' decision-making in choosing walking as a typical school travel mode for their elementary school children? (4) Do children from lower-income families have any specific characteristics and needs in their school travel compared with their affluent peers?

In order to answer these questions, the following aims were identified: (1) to develop a set of tailored and comprehensive measurement tools that can capture both walkability and safety of the physical environment, on both the neighborhood level and the street level, using both objective and subjective measures; (2) to examine if there was any economic and ethnic disparity in the walkability and safety for walking to or from school; (3) to identify the multi-level correlates of using walking as a typical school commute mode and their implications for relevant environmental and policy interventions; and (4) to examine the characteristics of lower-economic status children in terms of the prevalence, feasibility, and safety of walking to or from school.

3.3 RESEARCH DESIGN

3.3.1 Study Setting and Population

This study was carried out in the Austin Independent School District (AISD) in the city of Austin, Texas. As the state's capital city, Austin had an estimated population of 678,457 in 2005, among which about 24.1% was under the age of 18 (U.S. Census Bureau, 2006a). Like many other Texas cities, Austin features a high percentage of Hispanics or Latinos (32.9% in 2005). The median household income was $43,731 in 2005, with about 13.8% of families and 18.1% of individuals living below the poverty level (U.S. Census Bureau, 2006a).

In the 2005–2006 school year, AISD had a total student population of 81,003, including Hispanics (55.4%), whites (27.9%), African Americans (13.5%), Asians or Pacific Islanders (2.9%), and Native Americans (0.2%) (Texas Education Agency, 2007). About 60.3% of the students were economically disadvantaged (i.e., eligible for free or reduced-price lunch based on household income and size) (Texas Education Agency, 2007).

In terms of physical environment, AISD consists of neighborhoods with diverse locations (from inner city areas to suburban locations) and various development patterns (from grid-like, high-density street networks with small parcels to low-density, cul-de-sac street networks with large parcels). Other physical environmental features such as land-use mix, sidewalk completeness, and traffic and crime safety also vary across neighborhoods. Relevant details will be introduced in the following sections.

Overall, this school district provides a unique setting to test the impact of physical environment on walking to or from school, as well as the influence of personal and social factors and the underlying disparity issues. The high percentage of Hispanic students offers a unique opportunity to explore the characteristics of their school travel.

3.3.2 Two Phases: School-Level and Individual-Level Analyses

Two phases were carried out in this study. The first phase was a school-level analysis of the 73 public elementary schools in AISD using geographic information systems (GIS) and field audits. It fulfilled part of the first aim by developing *objective* measures on the walkability and safety for walking to or from school, for both the neighborhood level (schools' attendance areas) and the street level (street segments). Results of the measurements were used to examine disparities in such objective measures of physical environment based on economic status and ethnic composition, which was part of the second aim.

In the second phase, individual-level analyses were conducted using surveys of parents or guardians from 19 sampled elementary schools in AISD. As part of the first aim, a survey instrument was developed to capture the *subjective* measures of physical environment together with children's and parents' personal and social factors, as well as the child's school travel mode. Results from the survey were used to further examine the question raised in the second aim—disparities in the environmental support for walking to or from school. More important, the analyses helped to fulfill the third aim—identifying the multi-level correlates of using walking as a child's typical school travel mode—and the fourth aim—understanding characteristics of school travel among lower-economic status children.

4. SCHOOL-LEVEL ANALYSIS:

DISPARITIES IN THE ENVIRONMENTAL SUPPORT FOR WALKING*

4.1 RESEARCH DESIGN

This phase is a cross-sectional study that examined different aspects of environmental support for walking to or from school, including both walkability and safety at both neighborhood level and street level. It also explored disparities in such environmental support based on the student population's economic status and ethnic composition.

The study site consists of the attendance areas of 73 public elementary schools in AISD; the unit of analysis was the school's attendance area. This school district covers 230 square miles (59,560 hectares) and features a unique mix of socio-demographic and physical environmental characteristics. Its high percentage of Hispanic students (54.7% during the 2004–2005 school year) (Texas Education Agency, 2006) represents an important trend in the Texas population (35.9% Hispanic in 2006) (U.S. Census Bureau, 2007). Non-Hispanic white students and other ethnic groups accounted for 20.0% and 16.3% of the total students in the district, respectively (Texas Education Agency, 2006).

In this study, a school's "poverty rate" was defined as the percentage of students eligible for free or reduced-price lunch based on household income and size, and ranged from 2.0% to 98.9% across schools (Texas Education Agency, 2006). Geographically,

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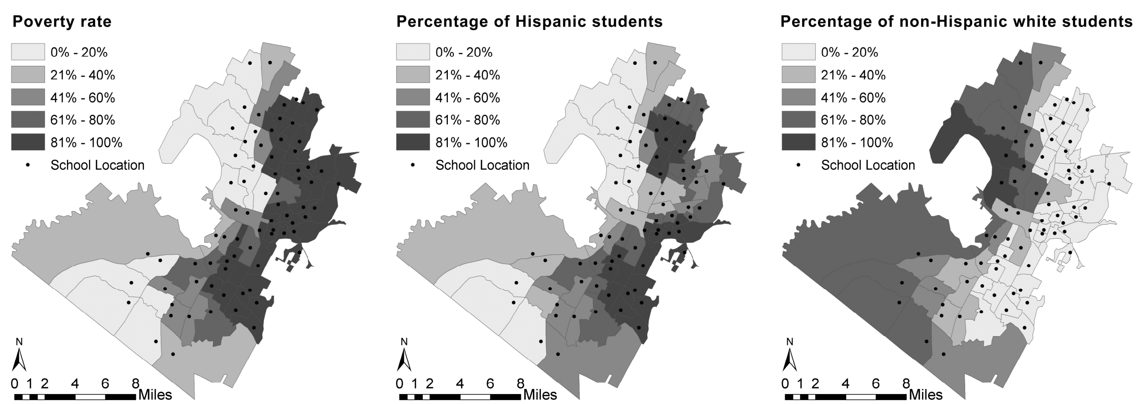
low-income Hispanic students were concentrated in the eastern district, while affluent, non-Hispanic white students lived primarily in the western area (Figure 4).

Figure 4
Spatial Patterns of Socio-Demographic Characteristics in Austin Independent School District, by Attendance Area



4.2 RESEARCH METHOD

Two objective measurement methods were used in this phase. GIS was used to measure the neighborhood-level walkability and safety from traffic and crime for schools' attendance areas. Field audits were conducted to assess the street-level walkability and safety for street segments that were sampled from the attendance areas. Variables for walkability and safety were identified based on the literature review.

4.2.1 GIS Measures

ArcGIS 9.0 was used for all GIS measures, utilizing the secondary data collected from the city of Austin (City of Austin, 2006), the Capital Area Metropolitan Planning

Organization, the Texas Department of Transportation, and the U.S. Census Bureau (U.S. Census Bureau, 2006b). Because the size and shape of the attendance areas varied across schools, all variables were captured by normalized measurements (density or percentage) (Table 2). Measures for the neighborhood-level walkability included the estimate of potential walkers (based on the percentage of students living within a half mile from school), pedestrian facilities (sidewalk completeness and traffic-signal density), residential density, street connectivity (street density and intersection density), and land-use mix. Neighborhood-level safety was captured by crime rates and traffic dangers such as traffic volumes, percentages of high-speed streets (> 30 miles per hour), and crash rates.

The land-use mix measure was adopted from the Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality study (Frank, Schmid, Sallis, Chapman, & Saelens, 2005). It had a value range from 0 to 1. Higher values indicated more even distributions of residential, commercial, and office land uses, which were assumed to be more supportive of walking. The crash rate was measured using geo-coded point data for all crashes between 2002 and 2006, including automobile–automobile, automobile–bike, and automobile–pedestrian crashes. The crime rate was based on geo-coded Part-I crime data (2005–2006) consisting of eight major index crimes, including criminal homicide, forcible rape, robbery, aggravated assault, burglary, larceny–theft, motor vehicle theft, and arson.

Table 2
Definitions, Equations, and Descriptive Statistics of the Neighborhood-Level Walkability and Safety Variables[a]

Variable	Definition	Equation	Mean	SD
Neighborhood-level walkability				
Estimate of potential walkers	Percentage of students living near school	Number of students living within half a mile from school/total number of students within school	0.240	0.156
Pedestrian facilities	Sidewalk completeness	Total miles of sidewalks/(total miles of streets × 2)	0.267	0.137
	Traffic-signal density	Number of traffic signals/total miles of streets	0.266	0.198
Residential density	Gross population density	Total population/total acres of the area	6.815	3.717
Street connectivity	Street density	Total footage of streets/total acres of the area	136.067	48.678
	Street-intersection density	Number of street intersections (≥3-way)/total acres of the area	0.197	0.113
Land-use mix[b]	Evenness of distribution based on square footage of R, C, and O	(−1) × [(area of R/total area of R, C, and O) × ln (area of R/total area of R, C, and O) + (area of C/total area of R, C, and O) × ln (area of C/total area of R, C, and O) + (area of O/total area of R, C, and O) × ln (area of O/total area of R, C, and O)]/ln (number of land uses present)	0.450	0.241
Neighborhood-level Safety				
Traffic danger	Average traffic volume	Average daily traffic count of sampled locations	8552.384	3872.626
	Percentage of high-speed streets	Total footage of streets with speed limit >30 miles per hour/total footage of all streets	0.208	0.078
	Yearly crash rate	(Number of crashes between year 2002 and 2006)/(total miles of streets × 5)	4.673	2.733
Crime	Yearly crime rate	(Number of Part-I crimes[c] in year 2004 and 2005 × 100)/(total acres of the area ×2)	52.102	38.705

[a]All neighborhood-level variables were measured using ArcGIS. The unit of analysis was the school's attendance area.

[b]The land-use mix measure was adopted from the Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality study (Frank et al., 2005).

[c]Part-I crimes consist of eight major index crimes, including criminal homicide, forcible rape, robbery, aggravated assault, burglary, larceny-theft, motor-vehicle theft, and arson.

C = commercial land use; O = office land use; R = residential land use; SD = standard deviation.

4.2.2 Field Audits

Field audits were conducted to assess the street-level walkability and safety. Due to resource limitations, only one 200-meter street segment was sampled from each attendance area. The initial exploratory observation of the street-level features showed little variation within the same attendance area, while presenting clear differences across schools. Therefore, this approach allowed the capture of a fairly representative street condition of the attendance area.

The street segment was sampled using the following criteria: (1) proximity to the geographic center of the attendance area; (2) posted speed limit of 30 miles per hour; (3) a majority (>80%) of roadside parcels being residential developments; (4) sidewalks on at least one side of the street; and (5) not a dead-end street. These criteria ensured consistency among sample segments in terms of the overall characteristics of the street networks such as street connectivity, pedestrian facilities, and adjacent land uses, which were already captured as part of the neighborhood-level walkability. By these means, the audit was restricted to street-level walkability, focusing on the urban design and architectural qualities. The speed limit of 30 miles per hour was used as a sampling criterion, because streets with higher speed limits have shown negative impact on walking to or from school. Meanwhile, 30 miles per hour was the most frequently encountered speed limit in the study area, accounting for 75% of total streets excluding highways and freeways. High-resolution aerial photographs and GIS datasets including street centerlines, land uses, and sidewalks were utilized for sampling.

The audit instrument (Appendix A) was adopted from the previously validated Pedestrian Environment Data Scan Tool (Clifton, Smith, & Rodriguez, 2007), and was revised to account for this particular study's design and setting and to incorporate additional findings from the recent literature. Audit measures included various attributes of sidewalks, roads, and roadside buildings, as well as perceptions of the overall walking environment (Table 3). All subjective variables were measured on a 5-point Likert-type scale, covering the maintenance, visual quality, physical amenities, safety, and other aspects. Objective variables were captured by either absolute values (e.g., width, distance, or count) or dichotomous measures (e.g., presence or absence).

The audit was conducted independently but simultaneously by two researchers in May and June 2006. The inter-rater reliability was tested by the average measure intraclass correlation coefficients (ICCs). Except for a few items, including the degree of enclosure and surveillance along sidewalks, air quality, and quietness, all variables showed moderate-to-high reliability (ICCs ranging from 0.698 to 0.871) (Table 3). The final analysis used the average value of the two auditors' ratings.

Table 3
Intraclass Correlation Coefficients (ICCs) and Descriptive Statistics for the Street-Level Walkability and Safety Variables[a]

Street-level walkability and safety variables	ICC	Mean or %	SD
SUBJECTIVE VARIABLES MEASURED ON A 5-POINT LIKERT SCALE			
Maintenance			
Sidewalk maintenance	0.764	2.676	0.728
Road maintenance	0.717	3.179	0.581
Building maintenance	0.870	2.556	0.777
Overall maintenance	0.839	2.487	0.783
Visual quality			
Visual quality of buildings	0.851	2.460	0.742
Overall visual quality	0.794	2.621	0.695
Physical amenities			
Degree of tree shade along sidewalks	0.810	2.684	0.813
Degree of enclosure along sidewalks	0.487	2.705	0.599
Overall physical amenities	0.769	2.461	0.718
Safety			
Degree of surveillance from windows along sidewalks	0.577	2.775	0.533
Overall perceived safety	0.698	2.916	0.635
Others			
Air quality	0.294	3.397	0.499
Quietness	0.547	3.020	0.767
Overall convenience of walking	0.731	2.921	0.680
OBJECTIVE VARIABLES MEASURED WITH ABSOLUTE VALUES			
Sidewalk distance from the curb (unit: feet)	—	2.726	1.850
Sidewalk width (unit: feet)	—	4.137	0.502
Building setback from the road (unit: feet)	0.871	32.185	12.101
OBJECTIVE VARIABLES MEASURED WITH BINARY VALUES (0=NO; 1=YES)			
Presence of discernable slopes while walking (% Yes)	—	58	—
Presence of sidewalk obstructions (% Yes)	—	45	—
Presence of buffers between sidewalks and roads (% Yes)	—	74	—
Presence of on-street parking (% Yes)	—	95	—
Presence of power lines along streets (% Yes)	—	40	—

[a]All street-level variables were measured by field audits, and the unit of analysis was a 200-meter street segment sampled from each school's attendance area. Several additional variables were measured, yet revealed no variation among the sampled segments. These variables were sidewalk material (concrete); presence of pedestrian-oriented lighting (no); presence of off-street parking lots (no); the need to walk through parking lots in order to access buildings (no); number of lanes (2); and presence of street furniture (no).

SD = standard deviation.

4.2.3 Data Analysis

A series of GIS maps were developed to visually examine spatial disparities of environmental variables. Moran's *I* indices and Gini coefficients were also calculated for continuous variables to measure their spatial autocorrelations and disparities, respectively.

Spatial autocorrelation describes the spatial dependency (influence of spatial proximity) of measurements for a single variable at different locations. The expected value of Moran's *I* is $E(I) = -(n-1)^{-1}$ under a randomization hypothesis (Barbujani, 1987). Generally, its value ranges from –1 to 1 (Barbujani, 1987). More departure from E(*I*) in either direction suggests stronger spatial dependency. Significant, positive *I* values imply the existence of spatial clustering, meaning similarities of nearby measurements, while negative values reflect dissimilarities. In this study, ArcGIS was used to calculate the Moran's *I*.

Gini coefficient is a measure of disparities widely used in the field of economics for variables such as income. It evaluates how close a variable's actual distribution is to an ideal distribution with perfect equity (Keppel et al., 2005). It has a value range from 0 (perfect equity) to 1 (perfect disparity), and higher values indicate greater disparities. This study used the Gini coefficient as an exploratory measure to evaluate the spatial distribution of walkable environmental features or safety concerns as compared with the distribution with perfect equity (i.e., each attendance area having the same value). Calculations were made with the Free Statistics Software (Wessa, 2007).

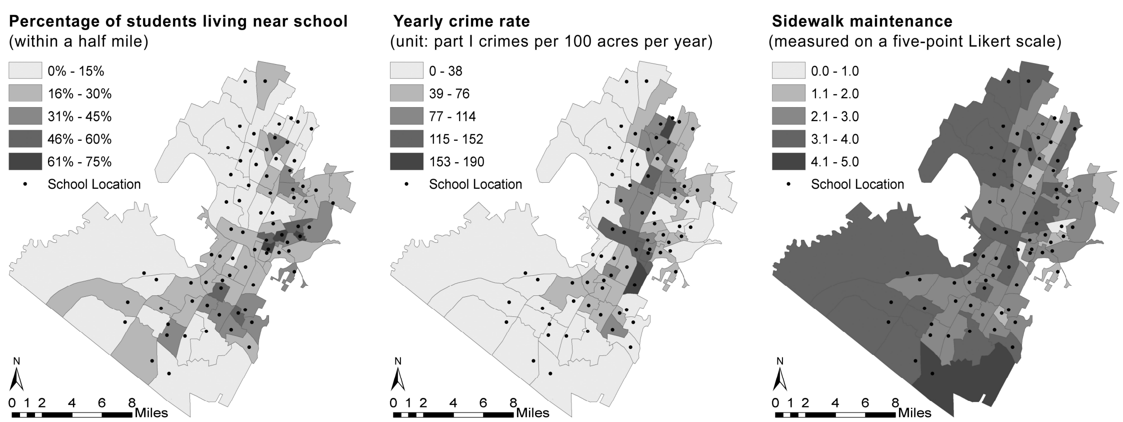
Regression analyses and analyses of variance (ANOVAs) were conducted to examine economic and ethnic disparities in walkability and safety, using the statistics software SPPS 15.0. First, ANOVAs were used to compare the top quartile schools (poverty rate ≥ 92.3%, or percentage of Hispanic students ≥ 82.1%) with the bottom quartile (poverty rate <45.1%, or percentage of Hispanic students <37.6%) based on economic status or ethnic composition. Next, three sets of regression models were estimated to predict each environmental variable, using (1) only the poverty rate, (2) only the percentage of Hispanic students, and (3) both variables. Because of non-normal distributions, the poverty and Hispanic student rate variables were transformed into five ordinal categories based on percentiles and were treated as continuous variables in the regression analyses. Linear and binary logistic regression analyses were used for continuous and dichotomous outcome variables, respectively.

4.3 RESULTS

4.3.1 GIS Maps, Moran's *I* Indices, and Gini Coefficients

According to GIS maps (see Figure 5 for examples), schools with higher poverty or Hispanic student rates had greater neighborhood-level walkability in their attendance areas: more students living near school, more completed sidewalk networks, and greater residential density and land-use mix. However, they also had increased dangers from traffic and crime and lower street-level walkability such as poor visual quality, lack of physical amenities, and poor maintenance.

Figure 5
Spatial Patterns of Walkability and Safety Variables in Austin Independent School District, by Attendance Area



Based on Moran's *I*, most socio-demographic (Table 4) and environmental variables (Table 5) showed small yet significant effects of spatial clustering. The exceptions were two traffic safety variables (traffic volume and percentage of high-speed streets) and a few street-level variables, including sidewalk width and distance from the curb, and the degrees of tree shade, enclosure, and surveillance along sidewalks.

Gini coefficients are new measures to be used in walkability studies, and there is no recommended threshold for determining high versus low levels of disparities. However, it is useful to compare the values across the study variables. For socio-demographic factors (Table 4), the distribution of non-Hispanic white students showed a greater disparity (Gini coefficient = 0.597) than did the poverty rate and the percentage of Hispanic students. This implies that white students were more likely to be segregated from other ethnic groups in their residential locations and school attendance. For continuous environmental variables (Table 5), crime rate showed the most serious disparity (Gini coefficient = 0.401), followed by traffic-signal density (0.361), sidewalk distance from the curb (0.361), percentage of students living near school (0.343), crash rate (0.317), residential density (0.305), and land-use mix (0.305).

Table 4
Descriptive Statistics, Moran's *I* indices, and Gini Coefficients of Schools' Socio-Demographic Characteristics

Variable	Mean	SD	Moran's *I*	Gini coefficient
Poverty rate (percentage of students eligible for free or reduced-price lunch)	0.679	0.326	0.145***	0.248
Percentage of Hispanic students	0.591	0.267	0.114***	0.252
Percentage of non-Hispanic white students	0.240	0.277	0.138***	0.597

SD = standard deviation; ***$p < 0.001$.

Table 5
Moran's *I* indices, Gini Coefficients, and Estimated Mean Differences (EMDs) of Physical Environmental Variables[a]

Outcome variable	Moran's *I*	Gini co-efficient	EMD based on poverty rate	EMD based on Hispanic student rate
NEIGHBORHOOD-LEVEL WALKABILITY				
Students living near school (unit: %)	0.113***	0.343	20.9**	19.6***
Sidewalk completeness (unit: %)	0.050***	0.286	13.2**	15.0***
Traffic signal density (unit: signals per mile street)	0.052***	0.361	0.044	0.035
Gross population density (unit: persons per acre)	0.077***	0.305	2.992**	4.268***
Street density (unit: feet per acre)	0.122***	0.195	27.358	30.213
Street intersection density (unit: intersections per acre)	0.138***	0.287	0.040	0.047
Land-use mix (range: 0–1)	0.084***	0.305	0.130	0.165*
NEIGHBORHOOD-LEVEL SAFETY				
Average traffic volume (unit: cars per day)	0.018	0.250	–1302.208	–90.310
Percentage of high-speed streets (unit: %)	–0.011	0.211	–0.3	–0.5
Crash rate (units: crashes per mile street per year)	0.109***	0.317	2.453**	3.648***
Crime rate (unit: Part-I crimes per 100 acres per year)	0.114***	0.401	44.680***	45.478***

Table 5 (continued)

Outcome variable	Moran's *I*	Gini co-efficient	EMD based on poverty rate	EMD based on Hispanic student rate
STREET-LEVEL WALKABILITY AND SAFETY				
Subjective variables measured on a 5-point Likert scale				
Maintenance				
Sidewalk maintenance	0.045***	0.152	–0.991***	–0.879***
Road maintenance	0.024*	0.101	–0.380*	–0.366
Building maintenance	0.096***	0.170	–1.196***	–1.206***
Overall maintenance	0.086***	0.176	–1.248***	–1.127***
Visual quality				
Visual quality of buildings	0.084***	0.163	–1.151***	–1.156***
Overall visual quality	0.072***	0.146	–1.077***	–1.035***
Physical amenities				
Degree of tree shade along sidewalks	0.014	0.158	–0.507	–0.436
Degree of enclosure along sidewalks	0.013	0.115	–0.361	–0.425*
Overall physical amenities	0.081***	0.162	–1.163***	–1.137***
Safety				
Degree of surveillance along sidewalks	0.006	0.107	–0.016	0.101
Overall perceived safety	0.069***	0.123	–1.012***	–0.866***
Others				
Air quality	0.053***	0.078	–0.552***	–0.408*
Quietness	0.019*	0.140	–0.540*	–0.590*
Overall convenience of walking	0.064***	0.130	–0.733***	–0.518*
Objective variables measured with absolute values				
Sidewalk distance from the curb (unit: feet)	–0.003	0.361	–0.094	0.436
Sidewalk width (unit: feet)	–0.035	0.056	–0.209	–0.171
Building setback from the road (unit: feet)	0.076***	0.170	–6.725	–10.374**
Objective binary variables (0 =no, 1=yes)				
Presence of discernable slopes while walking	—	—	–0.181	–0.462**
Presence of sidewalk obstructions	—	—	0.345*	0.246
Presence of buffers between sidewalks and roads	—	—	–0.020	0.181
Presence of on-street parking	—	—	0.211**	0.167*
Presence of power lines along streets	—	—	0.289	0.304

[a]Estimated mean differences were calculated between the top- and bottom-quartile schools.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

4.3.2 Mean Differences Based on Poverty and Hispanic Student Percentages

ANOVAs were used to calculate the estimated mean differences between the top-quartile and the bottom-quartile schools based on the poverty rate and the percentage of Hispanic students (Table 5).

Based on poverty rate, the top-quartile, high-poverty (≥ 92.3%) schools showed higher neighborhood-level walkability than did the bottom-quartile schools. This was demonstrated by three conditions: 20.9% more students living within a half mile from school, 13.2% higher sidewalk completeness, and a higher density with about three more people per acre. Meanwhile, the top-quartile schools were less safe, having about 2.5 more crashes per mile of street per year (Mean = 4.7) and about 44.7 more Part-I crimes per 100 acres per year (Mean = 52.1) in their attendance areas. The top-quartile schools' surroundings showed poor street-level walkability with lower ratings for maintenance, visual quality, physical amenities, perceived safety, air quality, quietness, and convenience of walking. In addition, the top-quartile schools were more likely to have sidewalk obstructions and on-street parking in their surroundings.

From another set of ANOVAs based on the percentage of Hispanic students, very similar patterns were observed between the top-quartile (≥ 82.1%) and the bottom-quartile (<37.6%) schools (Table 5). However, a few additional variables became significant: the top quartile showed greater land-use mix on the neighborhood level and less enclosure along sidewalks, shorter distances between buildings and roads, and fewer slopes on the street level. In contrast, road maintenance and the presence of sidewalk obstructions became insignificant.

4.3.3 Correlates of Walkability and Safety

Results from the three sets of regression models are presented in Table 6. The first set used only the poverty rate to predict each environmental variable. For the neighborhood-level walkability, poverty showed positive associations with the percentage of students living near school, sidewalk completeness, and population density, which imply more supportive walking conditions. For safety, however, higher poverty rates were correlated with higher crash and crime rates, indicating more dangers in lower-income neighborhoods. For the street-level variables, higher poverty rates predicted poorer maintenance and visual quality, fewer physical amenities, and lower perceived safety, as well as more sidewalk obstructions and power lines along sidewalks.

Table 6
Beta Coefficients from Three Sets of Regression Models Predicting Walkability and Safety[a]

Outcome variable	Regressions including poverty rate only	Regressions including Hispanic student rate only	Regressions including both poverty and Hispanic student rates	
			Poverty rate	Hispanic student rate
NEIGHBORHOOD-LEVEL WALKABILITY				
Percentage of students living near school	0.515**	0.417***	0.446**	0.096
Sidewalk completeness	0.344**	0.422***	0.084	0.361*
Traffic signal density	0.023	0.165	–0.200	0.309
Gross population density	0.328**	0.452***	0.005	0.448**
Street density	0.199	0.243*	0.050	0.207
Street intersection density	0.143	0.163	0.054	0.124
Land-use mix	0.160	0.328**	–0.160	0.444**
NEIGHBORHOOD-LEVEL SAFETY				
Average traffic volume	–0.178	0.109	–0.533**	0.493**
Percentage of high-speed streets	0.028	0.058	–0.029	0.079
Yearly crash rate	0.364**	0.577***	–0.107	0.654***
Yearly crime rate	0.375**	0.527***	–0.010	0.535***

Table 6 (continued)

Outcome variable	Regressions including poverty rate only	Regressions including Hispanic student rate only	Regressions including both poverty and Hispanic student rates	
			Poverty rate	Hispanic student rate
STREET-LEVEL WALKABILITY AND SAFETY				
Subjective variables measured on a 5-point Likert scale				
Maintenance				
Sidewalk maintenance	–0.477***	–0.375**	–0.431**	–0.064
Road maintenance	–0.260*	–0.189	–0.258	–0.003
Building maintenance	–0.575***	–0.522***	–0.414**	–0.224
Overall maintenance	–0.554***	–0.510***	–0.388**	–0.230
Visual quality				
Visual quality of buildings	–0.571***	–0.520***	–0.407**	–0.227
Overall visual quality	–0.565***	–0.501***	–0.424**	–0.195
Physical amenities				
Degree of tree shade along sidewalks	–0.290*	–0.168	–0.351*	0.085
Degree of enclosure along sidewalks	–0.279*	–0.205	–0.274	–0.008
Overall physical amenities	–0.601***	–0.516***	–0.475**	–0.174
Safety				
Degree of surveillance along sidewalks	–0.008	0.051	–0.094	0.119
Overall perceived safety	–0.567***	–0.476***	–0.466**	–0.140
Others				
Air quality	–0.357**	–0.311**	–0.278	–0.111
Quietness	–0.277*	–0.311**	–0.110	–0.232
Overall convenience of walking	–0.406***	–0.239*	–0.468**	0.111
Objective variables measured with absolute values				
Sidewalk distance from the curb	–0.029	0.051	–0.136	0.149
Sidewalk width	–0.125	–0.084	–0.135	0.013
Building setback from the road	–0.241*	–0.281*	–0.081	–0.222
Objective binary variables (0=no, 1=yes)				
Presence of discernable slopes while walking	–0.253	–0.658**	0.462	–0.997**
Presence of sidewalk obstructions	0.368*	0.290	0.321	0.066
Presence of buffers between sidewalks and roads	0.000	0.131	–0.192	0.274
Presence of on-street parking	1.709	1.725	0.804	0.914
Presence of power lines along streets	0.351*	0.299	0.274	0.111

[a]The originally continuous poverty and Hispanic student rate variables were transformed into five ordinal categories based on percentiles, and were treated as continuous variables. Linear and binary logistic regressions were used for continuous and dichotomous outcome variables, respectively. For linear regressions, standardized beta coefficients are reported in this table.

* $p<0.05$; ** $p<0.01$; *** $p<0.001$.

In the second set of regression analyses, only the percentage of Hispanic students was used to predict the environmental condition, and the overall results were similar to those for poverty. However, several variables became significant, including street density (positive), land-use mix (positive), and presence of slopes (negative). Meanwhile, road maintenance, degree of tree shade and enclosure along sidewalks, and the presence of sidewalk obstructions and power lines became insignificant.

Finally, the poverty rate and the percentage of Hispanic students were used together to predict each environmental variable. The multicollinearity was not a serious problem (variance inflation factor = 2.080) despite the predictors' strong bivariate correlations (coefficient = 0.721, $p < 0.01$). Interesting patterns of associations emerged from the findings, revealing the contrasting relationships between the neighborhood-level and the street-level walkability and between the neighborhood-level walkability and safety.

After controlling for the percentage of Hispanic students, poverty was associated with many adverse conditions on the street level (negative for maintenance, visual quality, physical amenities, perceived safety, and convenience of walking) but with only two favorable situations on the neighborhood level, including more students living near school and lower traffic volumes. In contrast, after adjusting for poverty, the percentage of Hispanic students was no longer associated with the street-level variables except the presence of slopes (negative). In other words, the street-level walkability was predicted primarily by poverty instead of by the percentage of Hispanic students. Meanwhile, on the neighborhood level, higher Hispanic student rates were associated with increased crimes, traffic volumes, and crashes from the safety perspective, and with greater sidewalk completeness, population density, and land-use mix from the walkability aspect.

4.4 LIMITATIONS

Several limitations of this study should be noted. First, GIS data were collected at different times from 2000 to 2007, and had different levels of accuracy from precise points to census blocks. However, the utility of GIS data for this type of research seems promising, because of their increasing availability, precision, and coverage.

Second, different units of analyses were used for the neighborhood-level and the street-level walkability measures. In the assessment of street-level conditions, only one street segment was sampled for each attendance area. Although more-extensive assessments could have strengthened this study, this was considered a reasonable approach because of (1) the homogeneity in the street environments within the individual attendance area, (2) resource limitations, and (3) the simultaneous consideration of the neighborhood-level walkability in this study. The explicit consideration of the neighborhood-level and street-level walkability was important, as demonstrated by their potentially different roles across the neighborhoods.

Third, while the field audits by researchers ensured higher internal validity, their assessment of the physical environment may be different from the residents' assessment, especially for perceptual variables. This potential difference requires further attention in future research.

Further, this study examined only the urban and suburban settings. Rural environments will likely present different issues to be addressed for enhancing walkability and safety.

Finally, walkability of the built environment was inferred by researchers based on the previous literature instead of tested through empirical data on walking behaviors. In order to overcome this limitation, the second phase of this dissertation study examined the impact of parents' or guardians' perceived physical environment on children's actual school travel modes.

Despite these limitations, this study has supplemented the walkability literature and has several implications for research, practice, and public policy. Details about these contributions and implications will be discussed later after introducing the second phase of this study.

5. INDIVIDUAL-LEVEL ANALYSIS:

CORRELATES OF WALKING TO OR FROM SCHOOL*

5.1 RESEARCH DESIGN

In the previous phase, the environmental support for walking was inferred based on the existing literature, and has not been tested by empirical evidence. The measurement was carried out in an *objective* manner using GIS measures or field audits by researchers, and was conducted only on the *school* level. These limitations call for further research with different measurement methods and different units of analysis.

The second phase moved to the i*ndividual* level and examined the impact of *subjective* measures of physical environment, as perceived by parents or guardians, on their decision-making on choosing walking as their children's typical school travel modes. The impact of parents' and children's personal and social factors was also considered. Surveys with parents or guardians were used to collect empirical data for this individual-level analysis.

A two-phase survey was carried out in collaboration with the city's Child Safety Program and AISD, as part of the city's efforts to apply for the Texas SRTS funding. For the first phase in April 2007, a convenience sample of nine lower socioeconomic status

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The major part of this section is currently under review for possible publication in a special issue (February 2009) of the *Journal of Public Health Policy*, which, if accepting the paper, will be the place of first publication for this content.

(SES) elementary schools was selected by the city, based on the percentages of students receiving free or reduced-price lunch. For the second phase in November 2007, a stratified random sampling was used to cover the full range of SES.

The final sample from both phases consisted of 19 schools with a total of 11,880 students. The selected schools and their attendance areas covered a wide range of physical environmental conditions such as distance to school, sidewalk completeness, traffic crash rate, and crime rate (Figure 6 and Table 7). Meanwhile, the students in these schools and their parents or guardians represent various socio-demographic characteristics in terms of ethnic composition and SES.

Figure 6
Socioeconomic Status (SES) of Elementary Schools in the Austin Independent School District and Locations of Sampled Schools

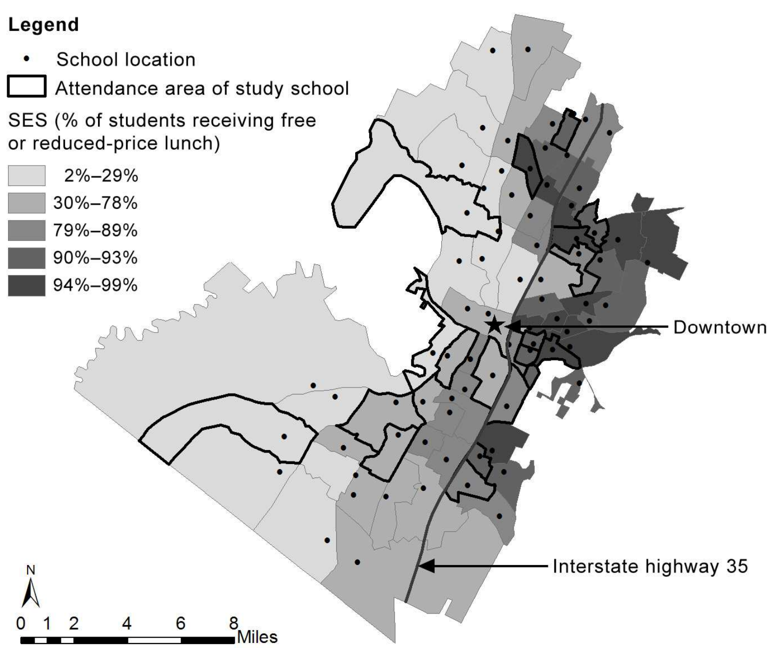

Table 7
Socio-Demographic and Physical Environmental Characteristics of 19 Study Schools, Compared to the Mean of All Elementary Schools in the Austin Independent School District (AISD)[a]

	Total enroll-ment	Hispanic students (%)	Students receiving free or reduced-price lunch (%)	Yearly crash rate per street mile	Yearly crime rate per 100 acres	Students living within half a mile from school (%)	Sidewalk complete-ness (%)
Mean	639	67.2	74.1	6.1	71.5	27.2	30.4
Standard deviation	187	26.1	31.3	3.5	50.3	15.0	16.6
Minimum	353	10.7	5.7	0.8	5.1	8.0	7.9
Maximum	1007	96.5	97.8	13.2	185.5	73.3	66.4
Mean of all AISD elementary schools	*642*	*66.2*	*75.1*	*6.0*	*70.0*	*26.9*	26.7

[a]Data sources included Texas Education Agency, AISD, Austin Police Department, and city of Austin GIS datasets.

5.2 RESEARCH METHOD

5.2.1 Study Variables and Survey Instrument

The selection of study variables was based on social-ecological theory (McLeroy et al., 1988) and conceptualized using the three tenets of personal, social, and physical environmental factors. The problem-oriented framework introduced earlier has visually illustrated these variables (Figure 2 on page 28).

The main behavioral outcome variable was whether the child used walking as a typical commute mode to get to or from school. It was captured by asking the parent or guardian “on a normal day, how does your child travel from home to school (from school to home).” Seven possible options were provided for respondents to choose from, including (1) walk alone, (2) walk with friends, (3) walk with a parent or adult, (4) bike, (5) school bus, (6) public bus, and (7) private cars including carpool.

Parents' and children's socio-demographic characteristics and attitudes and behaviors related to walking comprised personal factors (Figure 2). Social factors consisted of school and peer influences such as school bus availability and other children's and parents' walking behaviors. Physical environmental factors were captured as parents' or guardians' perceptions about safety (from traffic and crime) and walkability (e.g., travel distance, sidewalk quality, overall walking environments, physical barriers, and land uses) en route to school.

A three-page questionnaire (Appendix B) was developed based on the literature review and three previously validated instruments. Items about socio-demographic information were taken from the PedsQL Family Information Form, which has adequate reliability and validity (Varni, Seid, & Kurtin, 2001). Items for personal attitude and behavior, social, and physical environmental factors were either adapted from two validated questionnaires with moderate-to-high reliability—the University of California at Irvine's SRTS Survey (T. E. McMillan, 2003) and the Parental Survey from the "Active Where" project (Forman et al., 2008)—or developed by the researcher. The psychometric properties of those newly developed items are unknown. Except for a few binary or categorical variables, most items in this instrument were measured on a 5-point Likert scale by asking to what extent the respondent agreed or disagreed with each statement, and were treated as continuous variables during the analysis.

5.2.2 Survey Administration

This survey was approved by the Institutional Review Board at Texas A&M University (Appendix C). A total of 11,880 bilingual questionnaires (English and Spanish) were sent out to parents or guardians of all students in the sampled schools. School teachers helped to insert the questionnaire into the school's weekly folio that each student took home and to collect the returned surveys after one week. The cover letter (Appendix D) describes the city's effort to apply for the SRTS funding and an upcoming prize drawing in each school for the students who returned surveys.

5.2.3 Data Analysis

Survey results were analyzed using SPSS 15.0. Descriptive analyses examined the mode share and travel time for the trips to and from school. Data reduction was conducted using bivariate and factor analyses. Each independent variable was tested for its bivariate correlation with the outcome variable, and non-significant variables ($P>0.1$) were excluded from further analyses. However, exceptions were made for several non-significant socio-demographic variables because of their theoretical importance.

For the retained continuous variables, missing values accounted for 4.1% to 12.0% of total responses, and were imputed using the mean of the corresponding school. For the remaining binary variables, the missing values (<4.0%) were imputed using either the value from another respondent living nearby (for physical environmental variables) or a random imputation based on the percentage within each school (for other variables).

Most continuous variables (measured using a 5-point Likert scale) in this study were intended to measure parents' or guardians' perceptions, attitudes, and behaviors, and can be more effectively and efficiently captured through latent factors. Therefore, an exploratory factor analysis was performed for these 32 variables using a varimax rotation and a correlation matrix.

After data reduction, four multivariate logistic regression models were estimated in a sequential order to predict the odds of walking to or from school. Four blocks of independent variables were added to the regression models, one at a time, cumulatively into the previous model, including 1) socio-demographic, 2) attitude and behavior, 3) social, and 4) physical environmental variables. The final model also included a dummy variable for the time of survey and 18 other dummy variables for students' school membership. These variables ensured that the impact of survey time and the clustering effect by school could be taken into account. Finally, the associations between the student's SES and environmental correlates of walking to or from school were examined to explore disparities in the perceived environmental support for walking.

5.3 RESULTS

From the 19 study schools, a total of 2,695 valid responses were returned, yielding a mean response rate of 22.7% and a range of 9.2% to 40.3% across schools. Data for several key variables (ethnicity, gender, and grade of students, and the percentage of students receiving school bus service) were available for the entire population, and were used to examine the non-response bias. No serious bias was found based on these variables. A few schools had low response rates, but were retained in the analysis because their respondents were representative of the student population.

5.3.1 Mode Share and Travel Time

For the pooled sample, walking was a typical commuting mode for 27.8% and 31.5% of the trips to and from school, respectively. From the 19 individual schools, some variations of mode shares were observed (Table 8). The total percentages of walking (alone, with friends, and with a parent or adult) ranged from 8.7% to 46.8% for the morning trips and from 6.3% to 56.3% for the afternoon trips. Biking and public transit were rarely used in all schools (mean <2%). School bus usage is largely determined by service availability and accounted for 0% to 44.2% (mean = 15.7%) of the morning trips and 0% to 49.6% (mean = 18.0%) of the afternoon trips. The school district provides bus service for students who live farther than 2 miles from school or who have to face hazardous conditions en route such as highways. Private vehicles accounted for the largest mode share, with mean values of 53.4% for the morning and 41.7% for the afternoon trips.

It is also important to note that in 75% of walking trips, the child was accompanied by a parent or another adult. The afternoon trips had a slightly higher rate of walking than the morning trips in both the pooled sample and the sub-samples of 15 individual schools. As for travel time, 76% of walking trips took less than 15 minutes, 21.1% took 15–30 minutes, and only 2.9% took longer than 30 minutes.

Table 8
Descriptive Statistics of the Mode Share from 19 Study Schools

Travel mode	Mode share for home-to-school trip				Mode share for school-to-home trip			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Walk alone	2.3%	1.8%	0.0%	7.0%	3.2%	2.6%	0.7%	9.3%
Walk with friends	3.6%	2.8%	0.0%	8.8%	5.6%	4.2%	0.0%	13.3%
Walk with a parent/adult	21.9%	9.1%	7.7%	38.5%	22.7%	10.7%	4.7%	44.3%
Bike	1.4%	1.6%	0.0%	5.4%	1.3%	1.5%	0.0%	5.2%
School bus	15.7%	16.1%	0.0%	44.2%	18.0%	17.0%	0.0%	49.6%
Public bus	1.5%	2.0%	0.0%	6.7%	2.1%	2.4%	0.0%	9.1%
Private car, including carpool	53.4%	12.8%	30.2%	76.3%	47.1%	15.0%	19.5%	71.5%

Min = minimum; Max = maximum; SD = standard deviation.

5.3.2 Bivariate and Factor Analysis

From the bivariate analysis, 49 of 57 considered independent variables were retained (Table 9). Seven factors were extracted from factor analysis, including parents' personal barriers, children's personal barriers, parents' and children's positive attitude and regular walking habit, positive peer influences, safety concerns, sidewalk availability and quality, and quality of overall walking environments. All individual items were loaded to only one primary factor with moderate (0.58 and 0.49 for two factors) or high loadings (>0.60 for five factors). Cronbach's alpha was used to examine the internal consistency: children's and parents' personal barriers showed relatively low reliability (0.50 and 0.60); but five other factors showed adequate (>0.70) or good (>0.80) reliability. In total, the seven factors accounted for 57.5% of all individual items' variances.

Table 9
Descriptive Statistics and Odds Ratios for Multi-Level Correlates of Walking to or from School (Unadjusted)[a]

Predictors (unadjusted)	Coding scheme or individual observed variables	% or M (SD)	OR
Personal Socio-Demographic Factors			
Child's gender (Male: %)	0 = female, 1 = male	46.2	0.946
Child's grade level	Pre-Kindergarten = −1, Kindergarten = 0	1.837 (1.739)	1.017
Child's ethnicity (Hispanic: %)	(0 = non-Hispanic, 1 = Hispanic)	68.9	1.386***
Parents' highest education level	1 = 6th grade or less; …; 7 = graduate or professional degree	4.084 (1.838)	0.838***
Single-parent (Yes: %)	0 = no, 1 = yes	28.9	0.919
Number of family members		4.700 (1.459)	1.185***
Household's car ownership	Number of motor vehicles in the household	1.590 (0.838)	0.812***
Personal Attitudes and Behaviors			
Parents' personal barriers *(factor)*[b]	1. "I have no time to walk with my child to/from school."	3.123 (1.387)	0.687***
	2. "It is easier for me to drive my child to/from school."	3.830 (1.321)	0.723***
	3. "Walking to school involves too much planning ahead."	2.912 (1.340)	0.645***
Child's personal barriers *(factor)*	1. "My child has too much to carry."	2.698 (1.225)	0.753***
	2. "My child gets too hot and sweaty."	3.186 (1.278)	0.897**
Parents' and children's positive attitude and regular walking habit *(factor)*	1. "Walking is a good way to interact with other people."	3.805 (1.168)	1.211***
	2. "Walking is a good way to exercise."	4.621 (0.800)	1.107[c]
	3. "My child walks quite often in his/her daily routine."	3.327 (1.306)	1.651***
	4. "My child thinks walking to school is 'cool'."	3.428 (1.214)	1.283***
	5. "I walk quite often in my daily routine."	3.658 (1.187)	1.258***
	6. "I enjoy walking with my child to/from school."	3.489 (1.229)	1.888***
	7. "My family and friends like the idea of walking to school."	3.279 (1.212)	1.363***
Social Factors: School and Peer Influences			
School bus availability (%)	0 = no, 1 = yes	33.9	0.227***
Positive peer influences *(factor)*	1. "Other kids walk quite often in their daily routines."	3.737 (1.077)	1.397***
	2. "Other parents walk quite often in their daily routines."	3.667 (1.205)	1.301***
	3. "Other kids walk to/from school."	3.942 (1.146)	1.536***

Table 9
Continued

Predictors (unadjusted)	Coding scheme or individual observed variables	% or M (SD)	OR
Physical Environmental Factors: Perceived Safety and Walkability			
Distance close enough (%)	0 = no, 1 = yes	47.3	7.601***
Safety concerns *(factor)*	1. “My child may be taken or hurt by a stranger.”	3.686 (1.332)	0.768***
	2. “My child may get bullied, teased, or harassed.”	3.317 (1.346)	0.841***
	3. “My child may be attacked by stray dogs.”	3.327 (1.351)	0.878***
	4. “My child may be hit by a car.”	3.823 (1.306)	0.789***
	5. “Exhaust fumes will harm my child’s health.”	3.100 (1.250)	0.855***
	6. “My child may get lost.”	3.037 (1.465)	0.701***
Presence of physical barriers: “Does your child have to cross the following on the route to school?”			
Highway or freeway (%)	0 = no, 1 = yes	15.9	0.315***
Busy road (%)	0 = no, 1 = yes	58.4	0.501***
Intersection without a painted crosswalk (%)	0 = no, 1 = yes	20.4	0.606***
Sidewalk quality *(factor)*	1. “Sidewalks are wide enough.”	3.443 (1.549)	1.103***
	2. “Sidewalks are well maintained and clean.”	3.253 (1.493)	1.052[c]
	3. “Sidewalks are separated from traffic by grass/trees.”	2.693 (1.540)	1.113***
	4. “Sidewalks are NOT blocked by trash cans, power poles, or cars.”	2.805 (1.515)	1.068*
	5. “People in the neighborhood will easily see and help my child in case of danger.”	3.241 (1.256)	1.220***
	6. “Are there sidewalks along your child’s way to school? 1. No; 2. Yes, on *very few* streets; 3. Yes, on *some* streets; 4. Yes, on *most* streets; 5. Yes, on *all* streets.”	3.747 (1.256)	1.144***
Quality of overall walking environment *(factor)*	1. “It is well shaded by trees.”	3.010 (1.253)	1.066[c]
	2. “It is quiet.”	2.835 (1.381)	1.335***
	3. “It is well maintained and clean.”	3.459 (1.180)	1.165***
	4. “Streets are well lit.”	3.068 (1.236)	1.120**
	5. “It is convenient to walk to school.”	3.148 (1.450)	1.759***
Presence of land uses en route			
Convenience store (%)	0 = no, 1 = yes	33.8	0.274***
Bakery/café/restaurant (%)	0 = no, 1 = yes	21.1	0.207***
Office building (%)	0 = no, 1 = yes	18.0	0.222***
Vacant lot (%)	0 = no, 1 = yes	18.4	0.597***
Large parking lot (%)	0 = no, 1 = yes	26.2	0.509***
Presence of bus stops en route (%)	0 = no, 1 = yes	50.1	0.443***

[a]This table presents odds ratios from a series of bivariate logistic regressions that use individual independent variables to predict walking to or from school, without controlling for other variables. All perception or attitude variables were measured on a 5-point Likert scale ranging from “1 = strongly disagree” to “5 = strongly agree”.
[b]Factors rather than individual items are used in the multivariate analysis presented in Table 4.
[c]Odds ratios are marginally significant at the 0.1 level.
M = mean; OR = odds ratio; SD = standard deviation; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

5.3.3 Correlates of Walking to or from School

Four multivariate logistic regressions were estimated in a sequential order to predict the odds of walking to or from school using four blocks of variables. The Nagelkerke R^2 was used as an estimate for the percentage of variance explained by each model and the comparison of four models. The first model with only socio-demographic variables explained 4.8% of the variance in walking to or from school. In the second model, attitude and behavior variables related to walking were added to the first model, and they explained an additional 23.5% of the variance. In the third and fourth models, the additions of social and physical environmental variables increased the percentages of explained variance by 10.8% and 11.1%, respectively. The final full model showed an adequate fit ($P = 0.099$) and explained 51.4% of the variance (Table 10).

From the personal factors, parents' highest education and household car ownership (proxies of SES) showed negative associations with walking to or from school (odds ratio [OR] = 0.821 and 0.712, respectively). The number of family members was a positive correlate (OR = 1.134). Children's barrier was a factor variable captured by "having too much to carry" and "getting too hot and sweaty while walking," and was not significant. However, parents' personal barrier (a factor captured by time constraint, convenience of driving the child to school, and walking requiring too much planning ahead) was a negative correlate (OR = 0.417). In addition, the factor capturing parents' and children's positive attitude (walking being good for exercise and interaction, and being "cool" and enjoyable) and regular walking habit was a positive correlate (OR = 1.525).

Table 10
Multi-Level Correlates of Walking to or from School (Adjusted)[a]

Independent variables	Coefficient	SD	OR	CI (95%)
Personal Socio-Demographic Factors (explains 4.8% of variance)				
Child's gender (0 = female, 1 = male)	–0.198	0.109	0.820	0.662 – 1.016
Child's grade level	0.023	0.032	1.023	0.961 – 1.089
Hispanic ethnicity (0 = no, 1 = yes)	–0.098	0.167	0.907	0.654 – 1.257
Parents' highest education level (range: 1 – 7)	–0.197***	0.043	0.821***	0.755 – 0.893
Single-parent status (0 = no, 1 = yes)	–0.195	0.129	0.822	0.638 – 1.059
Number of family members	0.126**	0.040	1.134**	1.048 – 1.227
Household's car ownership	–0.339***	0.071	0.712***	0.620 – 0.818
Personal Attitudes and Behaviors (explains 23.5% of variance)				
Parents' personal barriers *(factor)*	–0.875***	0.063	0.417***	0.369 – 0.471
Child's personal barriers *(factor)*	–0.059	0.054	0.943	0.848 – 1.049
Parents' and children's positive attitude and regular walking habit *(factor)*	0.422***	0.057	1.525***	1.364 – 1.706
Social Factors: School and Peer Influences (explains 10.8% of variance)				
School bus availability (0 = no, 1 = yes)	–1.201***	0.150	0.301***	0.224 – 0.404
Positive peer influence *(factor)*	0.175**	0.061	1.192**	1.057 – 1.343
Physical Environmental Factors: Perceived Safety and Walkability (explains 11.1% of variance)				
Distance close enough (0 = no, 1 = yes)	1.390***	0.127	4.014***	3.128 – 5.150
Safety concerns *(factor)*	–0.253***	0.056	0.776***	0.695 – 0.867
Presence of physical barriers (0 = no, 1 = yes):				
Highway or freeway	–0.485*	0.192	0.616*	0.422 – 0.898
Busy road	0.094	0.117	1.098	0.873 – 1.382
Intersection without a painted crosswalk	–0.268	0.149	0.765	0.572 – 1.024
Sidewalk availability and quality *(factor)*	0.044	0.059	1.045	0.930 – 1.173
Quality of overall walking environment *(factor)*	0.108	0.060	1.114	0.991 – 1.252
Presence of land uses en route (0 = no, 1 = yes):				
Convenience store	–0.548***	0.149	0.578***	0.432 – 0.774
Bakery/café/restaurant	–0.131	0.197	0.878	0.596 – 1.292
Office building	–0.536*	0.203	0.585*	0.393 – 0.872
Vacant lot	0.016	0.155	1.016	0.750 – 1.377
Large parking lot	0.072	0.143	1.074	0.812 – 1.423
Presence of bus stop en route (0 = no, 1 = yes)	–0.305*	0.122	0.737*	0.580 – 0.936
Survey Time (0 = April 2007, 1 = November 2007)	-0.398	0.529	0.672	0.238 – 1.895
School Membership				
Highland Park Elementary School	–1.152*	0.546	0.316*	0.108 – 0.921
Mills Elementary School	–1.100*	0.494	0.333*	0.127 – 0.876
Blanton Elementary School	–1.009**	0.373	0.365**	0.176 – 0.757

[a]A set of dummy variables were entered into the model to indicate the student's school membership and the time of survey. For school membership variables, only those significant ones are listed in this table.
SD = standard deviation; OR = odds ratio; CI = confidence interval; *$P < 0.05$; **$P < 0.01$, ***$P < 0.001$.

Social factors also appeared important for parents' decision-making. The child was less likely to walk (OR = 0.301) if the school provided bus service for him or her. The factor for positive peer influences (other children's and parents' regular walking behaviors) was a positive correlate (OR = 1.192).

For the physical environmental factors, the child was about four times more likely to walk to or from school if the parent perceived the distance to be close enough for the child to walk. Parents' safety concerns (range: −2.8 to 2.0) and the need to cross highways or freeways were negative correlates (OR = 0.776 and 0.616, respectively). The factor for sidewalk availability and quality (e.g., maintenance, width, buffers from traffic, and no obstructions) was not significant. Another factor for overall walking environments, captured by maintenance, tree shade, quietness, street lighting, and perceived convenience of walking, was marginally significant at the 0.1 level (OR = 1.114). Presence of bus stops (OR = 0.737) and certain land uses such as convenience stores (OR = 0.578) and office buildings (OR = 0.585) en route were negative correlates.

From the school membership variables, three schools were negatively associated with walking, after controlling for all the other variables included in the multivariate models (OR = 0.316, 0.333, and 0.365, respectively). The time of survey was not significant.

5.3.4 Disparities in Perceived Environmental Support for Walking

To explore underlying disparities, bivariate correlations between parents' highest education (a proxy of SES) and each significant environmental correlate of walking to or from school were examined (Table 11). Parents with higher education were more likely to perceive the distance to school to be close enough for their children to walk (OR = 1.078, $p<0.001$). The most-educated group (graduate or professional degree) was about 46% more likely to perceive the distance to be walkable than was the least-educated group (sixth grade or less). Parents' perception of safety was not associated with their education level. In addition, children of well-educated parents were less likely to have highways/freeways (OR = 0.916, $p<0.01$) and bus stops (OR = 0.915, $p<0.001$) and more likely to have office buildings (OR = 1.217, $p<0.001$) en route to school. The presence of convenience stores en route to school was not associated with parents' education.

Table 11
Bivariate Correlations between Socioeconomic Status[a] and Significant Physical Environmental Correlates of Walking to or from School

Physical environmental correlates of walking to or from school	Coefficient	SD	OR	CI (95%)
Distance close enough (0 = no, 1 = yes)	0.075***	0.021	1.078***	1.035–1.124
Safety concerns (factor)	–0.008	0.010	N/A	N/A
Presence of highways or freeways en route (0 = no, 1 = yes)	–0.087**	0.029	0.916**	0.866–0.970
Presence of convenience stores en route (0 = no, 1 = yes)	–0.005	0.022	0.995	0.953–1.040
Presence of office buildings en route (0 = no, 1 = yes)	0.196***	0.028	1.217***	1.152–1.285
Presence of bus stops en route (0 = no, 1 = yes)	–0.089***	0.021	0.915***	0.878–0.954

[a] Parents' highest education level was used as a proxy for the family's socioeconomic status, and was used to predict each physical environmental that showed significant association with walking to or from school.

SD = standard deviation; OR = odds ratio; CI = confidence interval; $^{**}P < 0.01$, $^{***}P < 0.001$

5.4 LIMITATIONS

Several limitations for this phase of study should be recognized. First, this is a cross-sectional study on the association between multi-level factors and the use of walking as a typical school travel mode. It cannot lead to conclusions on any causal relationships, which will be stronger and more informative evidence for interventions. Second, the sampling process was not completely randomized, and a few schools had low response rates.

The unknown reliability of several new survey items are also limitations of this study. There is also possible non-response bias because parents or guardians of walking children may be more likely to return surveys and to report problems in the pedestrian environment than would be those of non-walkers.

Further, the impact of age and gender in this study was somewhat diluted because some parents mixed their responses for different children, who went to the same school, when filling out the questionnaire. In addition, although the clustering effect by school was partially accounted for during the analysis, Type I error may still remain due to the reduced variations resulting from this clustering.

Despite these limitations, this study has generated new knowledge and has significant implications for future environmental and policy interventions.

6. CONCLUSION AND DISCUSSION*

This dissertation research is one of the few studies that explored the issues of disparity in the area of physical environment and walking to or from school. It also generated important new knowledge about the multi-level correlates of walking to or from school, using a relatively large sample. Findings from this study have important contributions for the existing body of literature and significant implications for future interventions.

6.1 CONTRIBUTIONS TO THE LITERATURE

From the measurement perspective, this study provided timely support for the comprehensive assessment of the environmental support for walking to or from school, using both objective methods (GIS measures and field audits) and subjective measures (surveys). The complex relationships among different aspects and measures of walkability and safety still require more rigorous studies in the future.

For the objective measures used in the first phase, neighborhood-level and street-level walkability showed contrasting variations across the neighborhoods, and had reversed associations with the students' ethnic and economic conditions. Similarly,

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* Part of this section is reprinted with permission from "Walkability and safety around elementary schools: Economic and ethnic disparities", by Zhu, X., & Lee, C., 2008. *American Journal of Preventive Medicine*, 34(4), 282-209, Copyright [2008] by American Journal of Preventive Medicine.
The major part of this section is currently under review for possible publication in a special issue (February 2009) of the *Journal of Public Health Policy*, which, if accepting the paper, will be the place of first publication for this content.

neighborhood-level safety and neighborhood-level walkability appeared to have contrasting variations and thereby different impacts on walking behaviors. Street-level field audits and traffic and crime measures appear to be important in quantifying the environmental support for walking.

Subjective measures of walkability and safety for walking to school were developed in the second phase. Contrasting with previous studies, sidewalk quality and overall walking environments were not significant in the survey, possibly due to differences in the environmental awareness and perception between walkers and nonwalkers. Most walking children were accompanied by their parents. As a result, these parents would be more aware of the environmental problems (e.g., poor maintenance and sidewalk obstructions) than those who do not walk to school. These findings raised an important question about the validity and interpretability of the environmental perception measures used in walking and physical activity research, and the need to address the interactive nature of the behavior, awareness, and perception variables.

Further, the comparison between the first and second phases revealed important differences between objective and subjective measures of walkability and safety (Zhu & Lee, 2008). In terms of the distance, the first phase using the *objective* measures found that students from higher-SES neighborhoods lived farther away from their school (Zhu & Lee, 2008). However, this association was reversed in the second phase between the *perception* of walkable distance and SES (using parental education as a proxy). It is speculated that the *perception* of acceptable walking distance may be confounded by safety and maintenance conditions of the environment, and by the availability of alternative travel options such as private vehicles. In terms of safety concerns, the first phase using *objective* measures showed higher-SES schools had much lower crash and crime rates in their attendance areas. However, in the second phase, SES was not associated with parents' perceived safety. In addition to the different units of analyses (school attendance areas for the first phase versus individuals in the second phase), one possible explanation is that parents' *perception* may be exaggerated beyond the actual level of danger when it comes to their children's school transportation.

Future research should consider walkability and safety at multiple spatial scales, using both objective and subjective measures, to better understand their complex relationships and interactive roles in influencing walking. As proposed in the solution-based framework (Figure 3 on page 29), perceptions of physical environment may act as important mediators for the relationship between objective physical environment and parents' decision-making regarding children's school travel. A better understanding of these mediators is a necessary step to tackle the underlying mechanism and causal relationships.

Further, this study contributed to the understanding of disparities and fine-grained differences in the environmental support for walking. New aspects of economic and ethnic disparities were explored in terms of objective walkability and safety around public elementary schools in Austin, Texas. Schools with higher poverty rates were located closer to their students' homes but showed much worse street environments. Schools with higher percentages of Hispanic students were exposed to more dangers from traffic and crime, although their neighborhood conditions were considered more walkable based on the aggregated measures. Unsafe neighborhoods and poor street conditions may influence not only children's school travels but also their play activities and the overall physical activities of all residents. These disparities became aggravated when considering the limited access among low-income and minority populations to private automobiles and formal or paid physical activity facilities, such as parks and gyms.

The second phase of this study generated important knowledge about the patterns and correlates of walking to or from school among elementary school children in Austin, Texas. The rate of walking in this study is much higher than the result from a national survey, which reported only 17% of 5- to 18-year-old children walked to or from school at least once per week (Martin & Carlson, 2005). Possible reasons include that (1) the study site consisted of urban and suburban areas that are generally more walkable than rural areas; (2) a substantial portion of the respondents were from lower-income families with either no private vehicle (6.9%) or only one vehicle (35.6%); and (3) walking-children's parents or guardians may be more likely to return the survey. In terms of the distance, a 15-minute walk appears to be acceptable for school travels among our study children.

Consistent with several previous studies (Gilhooly & Low, 2005), the morning trips from home to school had a lower rate of walking than the afternoon trips from school to home. Possible reasons include (1) morning trips can easily fit into some parents' trips to work while in the afternoon those working parents would still be at work when the school day ends and (2) children have a more flexible schedule in the afternoon compared with the one in the morning.

Most walking trips were accompanied by a parent or another adult. This is consistent with previous findings that many parents felt that their children should be escorted to school (Gilhooly & Low, 2005).

Biking was rarely used as a school travel mode (1.4%), likely due to the lack of bike lanes and concerns about children’s safety. As identified in another study, parents may consider biking in busy traffic during peak traffic hours to be inappropriate for elementary school children (Gilhooly & Low, 2005) due to their limited physical and cognitive development.

The negative impact of convenience stores, office buildings, and bus stops in this study is contradictory to previous studies involving general adult populations, where mixed land uses showed positive influences (Saelens, Sallis, & Frank, 2003). One explanation is that school travel is driven by a predetermined destination (school) and, therefore, having other diverse yet irrelevant land uses is not likely to be attractive. Residential-only environments may impose less safety threats and be easier to navigate for children. Second, in the study area, many convenience stores are located within or next to a gas station, and typical office developments are large complexes with extensive surface parking. Such automobile-centered environments may be hostile or unsafe for pedestrians, especially children. Future research should consider not only the types of land uses, but also how they are developed at the site level and integrated into the community. An overly simplified approach may lead to misunderstanding of the environment–behavior relationships.

6.2 IMPLICATIONS FOR ENVIRONMENTAL AND POLICY INTERVENTIONS

Finding from this study also highlighted the importance of establishing priorities and developing tailored approaches toward environmental and policy interventions. The first phase identified disparities and differences in the environmental support for walking, and such findings were further explored in the second phase through surveys of parents and guardians of elementary school children. Low-income, Hispanic children in the study area appear to have greater potential and needs for walking to or from school, because they live closer to school, have more sidewalks in their neighborhoods, and may have no means to get to school other than walking. However, such potential and needs may be undermined by serious safety threats and poor street conditions, which may also compromise the potential health benefits of walking as physical activity. Therefore, a high priority is needed for these disadvantaged populations.

In addition, tailored approaches are warranted for different physical settings and populations, because fine-grained differences exist in multilevel walkability factors and traffic and crime safety. For example, although the provision of new, high-quality pedestrian infrastructure is important whenever possible, the improvement of dilapidated and unsafe existing facilities seems crucial for low-income, minority neighborhoods. In addition, the development of tailored approaches should be informed by empirical evidence. A necessary step is to identify important and feasible interventions, which could be objective or subjective aspects of physical environment and may require different interventions strategies. For example, while engineering improvement may be effective to overcome barriers in objective physical environment, educational interventions may be more effective if the major barriers were related to the perceptions of the physical environment, such as perceived safety and accessibility.

Empirical evidence from this study can be applied to the development of more effective interventions using environmental and policy approaches.

First, this study highlights the limitations of current policies related to school siting and the determination of schools' attendance areas. Centrally located, neighborhood schools can help lift barriers for walking to school, such as long distance and the need to cross highways or freeways en route to school. A 15-minute walk appeared to be acceptable for children in this study, and this can be roughly translated to 0.8 mile (1 kilometer) by using an estimated average walking speed of 4 kilometers per hour for elementary school children (McKee et al., 2007). Policy changes are needed for existing acreage requirements and school funding formulas in order to preserve or build neighborhood schools that are accessible by walking. In addition, the school consolidation policy in many states should be examined for its impact on school transportation. Since 2003, three states have eliminated minimum acreage requirements for new schools (Langdon, 2007). It is worthwhile to follow up and examine the impact of such changes on children's school travels.

Second, this study confirms the importance of safety concerns as one of the foremost action items for policy and environmental interventions in promoting walking to or from school. Traffic management and traffic-calming strategies are needed to reduce the traffic volume and speed near schools, and thereby reduce safety concerns. Stronger political support is needed to allocate sufficient funding for non-motorized transportation facilities and safety improvement projects, especially in areas around schools and in “hot spots” with high crash rates or poor infrastructure conditions. In addition, policy support is needed for programs such as the “Walking School Bus,” which involves parents or other volunteers leading a group of students walking to or from school and thereby helps overcome parental safety concerns and time constraints. The potential of this program is underscored by the finding that 75% of children who walked to school were accompanied by a parent or guardian while walking.

Third, in terms of the “big picture,” decision-making for school travels is a complex process involving multiple and interactive considerations. Policy-makers should employ multi-level interventions and collaborate with multiple agencies. School developments or renovations should involve all stakeholders, including school districts, transportation, planning, and health departments, Parent-Teacher Associations, and other neighborhood organizations. The cost of school transportation should be taken into account during the school siting and planning process through multi-agency collaborations.

Finally, the disparity issues in school transportation require immediate attention and action. Compared to the children who do not walk, those who walk to school are more likely to come from lower-SES families. These lower-SES children may be forced to walk because of their limited access to private vehicles and their parents' longer work hours with less flexible schedules. Such disparities are further exaggerated by the fact that lower-SES and minority children have disproportionate exposure to traffic (Green, Smorodinsky, Kim, McLaughlin, & Ostro, 2004), pedestrian injuries (Stevenson, Jamrozik, & Spittle, 1995), air pollution (Pastor, Sadd, & Morello-Frosch, 2002), other environmental hazards (Metzger, Delgado, & Herrell, 1995), and risk of obesity (CDC, 2008b; Ogden et al., 2002). A high priority is warranted for targeted policy and environmental interventions for low-income, minority children in the light of equity, mobility, and health. Examples include subsidized "Walking School Bus" programs and the allocation of federal and local funding for traffic-calming and pedestrian infrastructure improvements in these high-risk areas.

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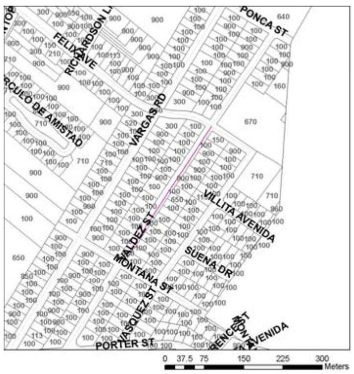
APPENDIX A

SAMPLE OF THE INSTRUMENT FOR FIELD AUDITS

Name: 02 ALLISAN ____ **Date:** ____ **Study area:** ____

Segment number: ____ **Time:** ____ **Weather:** ____

A. Map



B. Environment

1. Uses in segment *(all that apply)*

Housing – single family [ ] 1
Housing – multi-family [ ] 2
Housing – mobile homes [ ] 3
Office/ institutional [ ] 4
Restaurant/ café/ commercial [ ] 5
Industrial [ ] 6
Vacant/ undeveloped [ ] 7
Recreation [ ] 8

2. Segment intersections

Number of 3-way intersections ____.
Number of 4-way intersections ____.
Number of other intersections ____.

3. Slope

Flat [ ] 1
Slight hill [ ] 2
Steep hill [ ] 3

C. Sidewalks

4. Material *(all that apply)*

Asphalt [ ] 1
Concrete [ ] 2
Paving bricks or flat stones [ ] 3
Gravel [ ] 4
Dirt or sand [ ] 5

5. Sidewalk condition/ maintenance

Very poor — Average — Very good

Under repair [ ] 0

6. Sidewalk obstructions *(all that apply)*

Poles or signs [ ] 1
Parked cars [ ] 2
Greenery [ ] 3
Garbage cans [ ] 4
Others [ ] 5
None [ ] 6

7. Buffers between road and sidewalk

Fence [ ] 1
Trees [ ] 2
Hedges [ ] 3
Landscape [ ] 4
Grass [ ] 5
None [ ] 6

8. Sidewalk distance from curb

0 2 4 6 8feet

9. Sidewalk width

2 4 6 8 10feet

10. Number of curb cuts

None 1 2 3 4

11. Sidewalk completeness/ continuity

Very poor — Average — Very good

12. Connection to other sidewalk/crosswalks

Number of connections ____.

D. Roads

13. Road condition/ maintenance

(bumps/ cracks/ holes)

Very poor — Average — Very good

Under repair [ ] 0

14. Number of lanes

Minimum # of lanes to cross [ ] 1
Maximum # of lanes to cross [ ] 2

15. On-street parking *(if pavement is unmarked, check only if cars parked)*

Parallel or diagonal [ ] 1
None [ ] 2

16. Number of off-street parking lot spaces

None 5 10 15 20

17. Must you walk through a parking lot to get to most buildings?

Yes [ ] 1
No [ ] 2

18. Number of med-hi volume driveways

None 1 2 3 4

19. Traffic control devices *(all that apply)*

Traffic light [ ] 1
Stop sign [ ] 2
Traffic circle [ ] 3
Speed bumps [ ] 4
Chicanes or chokers [ ] 5
None [ ] 6

20. Number of crosswalks

None 1 2 3 4

21. Crossing aids *(all that apply)*

Yield to ped paddles [ ] 1
Pedestrian signal [ ] 2
Median/ traffic island [ ] 3
Curb extension [ ] 4
Pedestrian crossing warning sign [ ] 5
Flashing warning light [ ] 6
Share the road warning sign [ ] 7
None [ ] 8

22 Bicycle facilities *(all that apply)*

Bicycle route signs [ ] 1
Striped bicycle lane designation [ ] 2
Visible bicycle parking facilities [ ] 3
Bicycle crossing warning [ ] 4
No bicycle facilities [ ] 5

E. Road-side buildings

23.Visual quality of buildings

Very poor Average Very good

24. Building setbacks from sidewalk

_______ Feet.

25. Building height

Average number of stories _______.

26. Number of windows overlooking segment

None Many

27. Cleanliness and maintenance of buildings and gardens

Very poor Average Very good

F. Overall walking environment (sidewalks/ roads/ surrounding buildings)

28. Lighting

Road-oriented lighting [ ] 1
Pedestrian-scale lighting [ ] 2
Other lighting [ ] 3
No lighting [ ] 4

29. Is following signage visible?

Way-finding aids [ ] 1
Cultural/ religious message or event [ ] 2
Political message or event [ ] 3
Neighborhood/social message/event [ ] 4
Pedestrian friendly traffic sign [ ] 5
Neighborhood crime watch [ ] 6
Security warning sign [ ] 7
No trespassing/ beware of dog [ ] 8
Unreadable sign or billboard [ ] 9

30. Street furniture and amenities

Public garbage cans [ ] 1
Benches [ ] 2
Sculptures [ ] 3
Street vendors/ vending machine [ ] 4
No amenities [ ] 5

31. Number of trees shading walking area

None Many/Dense

32. Degree of enclosure

No enclosure Highly enclosed

33. Power lines along segment

Low voltage/ distribution line [ ] 1
High voltage/ transmission line [ ] 2
None [ ] 3

34. Bus stop

Bus stop with shelter [ ] 1
Bus stop with bench [ ] 2
Bus stop with signal only [ ] 3
No bus stop [ ] 4

35. How many people visible in segment?

Total number of persons ______.
Number of children ______.
Number of older adults ______.
Number of persons talking/ greeting ______.
Number of unfriendly persons ______.

36. How much air pollution in segment?

(diesel fumes, factory emissions, etc)

A lot None

37. How much noise pollution in segment?

(sounds of trains, construction, factories, etc)

A lot Average None

38. Overall convenience for walking

Very poor Average Very good

39. Overall visual quality

Very poor Average Very good

40. Overall cleanliness and maintenance

(Litter/ graffiti/ broken facility, etc.)

Very poor Average Very good

41. Overall safety for walking

Very unsafe Average Very safe

42. Overall attractiveness for walking

Very poor Average Very good

APPENDIX B

QUESTIONNAIRE FOR SURVEYS OF PARENTS OR GUARDIANS

Safe Routes To School Survey

Directions: This survey is to be answered by the parent/guardian who is most involved in getting the child to and from school. Please be assured that everything you tell us will be kept strictly confidential (secret).

The first few questions are about how your child normally gets to and from school. Please answer the questions in both columns by checking the box that applies.

	From home to school	From school to home
1. On a normal day, how does your child travel?	❑ Walk *alone* ❑ Walk *with friends* ❑ Walk *with a parent/adult* ❑ Bike ❑ School bus ❑ Public bus ❑ Private cars, including carpool	❑ Walk *alone* ❑ Walk *with friends* ❑ Walk *with a parent/adult* ❑ Bike ❑ School bus ❑ Public bus ❑ Private cars, including carpool
2. How long does it take to travel?	❑ Less than 15 minutes ❑ 16-30 minutes ❑ More than 30 minutes	❑ Less than 15 minutes ❑ 16-30 minutes ❑ More than 30 minutes

3. Is this distance close enough for your child to walk to school?	❑ Yes	❑ No
4. Does the school provide bus service for your child?	❑ Yes	❑ No

Now we would like to ask you some questions about your child's way to and from school.

5. Which of the following are located along your child's way to school? (Check all that apply)

❑ Playground	❑ Park	❑ Walking path or trail	❑ Convenience store
❑ Bakery/café/restaurant	❑ Big box retail	❑ Bus stop	❑ Community/youth center
❑ Library	❑ Office building	❑ Industrial site	❑ Vacant lot
❑ Large parking lot	❑ Others_______________		

6. Which of the following would your child have to cross while walking to school? (Check all that apply)

❑ A highway or freeway ❑ A road with busy traffic ❑ An intersection without street signals or stop signs

❑ An intersection without a painted crosswalk ❑ None of the above

7. Are there sidewalks along your child's way to school?

❑ Yes, on *all* streets ❑ Yes, on *most* streets ❑ Yes, on *some* streets ❑ Yes, on *very few* streets

❑ No *(If you choose No, please skip the next question, and go directly to question 9.)*

8. What do you think about the sidewalks along your child's way to and from school? Please tell us how much you agree or disagree with each statement by circling your answers.	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
1). Sidewalks are well maintained and clean.	1	2	3	4	5
2). Sidewalks are wide enough for two persons walking together.	1	2	3	4	5
3). Sidewalks are separated from traffic by grass or trees.	1	2	3	4	5
4). Some sidewalks are blocked by trash cans, power poles, or cars.	1	2	3	4	5

9. What do you think about the <u>overall walking environment (including sidewalks [if available], roads, and buildings)?</u> Please tell us how much you agree or disagree with each statement by circling your answers.	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
1). It is convenient to walk to school.	1	2	3	4	5
2). It is well maintained and clean.	1	2	3	4	5
3). It is well shaded by trees.	1	2	3	4	5
4). It is quiet (without much noise from vehicles, airplanes, etc.)	1	2	3	4	5
5). There are nice things to see.	1	2	3	4	5
6). Streets are well lit.	1	2	3	4	5
7). The school zones are well enforced.	1	2	3	4	5

10. What do you think about the safety issues for your child to walk to school?	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
1). My child may get lost.	1	2	3	4	5
2). My child may *be taken or hurt by a stranger.*	1	2	3	4	5
3). My child may *get bullied, teased, or harassed.*	1	2	3	4	5
4). My child may *be attacked by stray dogs.*	1	2	3	4	5
5). My child may *be hit by a car.*	1	2	3	4	5
6). Exhaust fumes will harm my child's health.	1	2	3	4	5
7). People in the neighborhood will easily see and help my child in case of danger.	1	2	3	4	5

The following questions ask about feelings and behaviors concerning walking to and from school.

11. Please tell us how much you agree or disagree with each statement by circling your answers.	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
1). Walking to school involves too much planning ahead.	1	2	3	4	5
2). It's easier for me to drive my child to/from school on the way to/from work or errands.	1	2	3	4	5
3). My child has too much to carry.	1	2	3	4	5
4). My child gets too hot and sweaty.	1	2	3	4	5
5). My child thinks walking to school is "cool".	1	2	3	4	5
6). My child walks quite often in his/her daily routine.	1	2	3	4	5
7). Walking is a good way to exercise.	1	2	3	4	5
8). Walking is a good way to interact with other people.	1	2	3	4	5
9). I walk quite often in my daily routine.	1	2	3	4	5
10). I enjoy walking with my child to/from school.	1	2	3	4	5
11). I don't' have time to walk with my child to/from school.	1	2	3	4	5
12). My family and friends like the idea of walking to school.	1	2	3	4	5
13). Some other kids walk to/from school.	1	2	3	4	5
14). Other *kids* walk quite often in their daily routines.	1	2	3	4	5
15). Other *parents* walk quite often in their daily routines.	1	2	3	4	5

12. On a scale of 1 (very unlikely) to 5 (very likely), please tell us how likely would it be that you would allow your child to walk to and from school if:	Very unlikely	Somewhat unlikely	Neither unlikely nor likely	Somewhat likely	Very likely
1) …there were good sidewalks?	1	2	3	4	5
2) …the neighborhood was safer?	1	2	3	4	5
3) …the school was closer to home?	1	2	3	4	5
4) …you or an adult you knew could walk with the child?	1	2	3	4	5
5) …other children in the neighborhood walked to school?	1	2	3	4	5

The following questions ask about some family information. Please be assured that everything you tell us will be kept strictly <u>confidential</u> (secret).

13. Information about the Child Who Brought the Survey Home

1). *Child is:* ❑ Male ❑ Female *Grade:* ________

2). *Child's weight:* ________ pounds *Child's height:* ________ feet ________ inch

3). *Ethnic Group or Race:* ❑ Black, Non-Hispanic ❑ Hispanic ❑ Native American or Alaskan Native ❑ Asian or Pacific Islander ❑ White, Non-Hispanic ❑ Other ______________________

14.

1). Information about Mother	**2). Information about Father**
Marital Status: ❑ Single ❑ Living with partner ❑ Married ❑ Divorced ❑ Separated ❑ Widowed	*Marital Status:* ❑ Single ❑ Living with partner ❑ Married ❑ Divorced ❑ Separated ❑ Widowed
Highest Level of Education: ❑ 6^{th} grade or less ❑ 7^{th}-9^{th} grade ❑ 9^{th}-12^{th} grade ❑ High school graduate ❑ Some college or certification course ❑ College Graduate ❑ Graduate or Professional Degree	*Highest Level of Education:* ❑ 6^{th} grade or less ❑ 7^{th}-9^{th} grade ❑ 9^{th}-12^{th} grade ❑ High school graduate ❑ Some college or certification course ❑ College Graduate ❑ Graduate or Professional Degree
Occupation or Job Title: |_|_|_|_|_|_|_|_|_|_|_|_|_|	*Occupation or Job Title:* |_|_|_|_|_|_|_|_|_|_|_|_|_|

15. Information about Family Members

1). How many people (including yourself) live in your household? _______ people

2). What are the ages of all children (under 18) in your household? _____; _____; _____; _____; _____; _____

16. Information about Your Residence

1). *Your home location:* (Street) ____ (Zip Code) ____________

2). How long have you lived in your current residence? _______ years

3). What's your main reason to choose this neighborhood?

❑ Housing price ❑ Close to work ❑ Close to my child's school ❑ Quality of school

❑ Quality of neighborhood ❑ Easy to walk around ❑ Other: ______________________________

4). How many cars are there in your household? _______ cars

5). How many people in your household have a driver's license? _______ people

You're finished! <u>THANK YOU</u> for your time and effort!

<u>Please ask your child to bring the survey back to school.</u>

APPENDIX C

APPROVALS FROM THE INSTITUTIONAL REVIEW BOARD

AT TEXAS A&M UNIVERSITY

TEXAS A&M UNIVERSITY
VICE PRESIDENT FOR RESEARCH - OFFICE OF RESEARCH COMPLIANCE

1186 TAMU
College Station, TX 77843-1186
1500 Research Parkway, Suite B-150

979.458.1467
FAX 979.862.3176
http://researchcompliance.tamu.edu

Institutional Biosafety Committee | Institutional Animal Care and Use Committee | Institutional Review Board

DATE: September 28, 2006

MEMORANDUM

TO: Xuemei Zhu
Architecture MS 3137

FROM: Office of Research Compliance
Institutional Review Board

SUBJECT: Initial Review

Protocol Number: 2006 -0509

Title: Developing the School Buffer Walkability Index as an Environment Audit Tool for Safe Routes to School Programs: With a Specific Focus on Minority Children and an Exploratory Analysis of Urban Trails

Review Category: Expedited

Approval Period: September 28, 2006 to September 27, 2007

Approval determination was based on the following Code of Federal Regulations:
45 CFR 46.110(b)(1) - Some or all of the research appearing on the list and found by the reviewer(s) to involve no more than minimal risk.

Category 7: Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation or quality assurance methodologies.

Provisions:

This research project has been approved for one (1) year. As principal investigator, you assume the following responsibilities:

1) **Continuing Review**: The protocol must be renewed each year in order to continue with the research project. A Continuing Review along with required documents must be submitted 30 days before the end of the approval period. Failure to do so may result in processing delays and/or non-renewal.
2) **Completion Report**: Upon completion of the research project (including data analysis and final written papers), a Completion Report must be submitted to the IRB Office.
3) **Adverse Events**: Adverse events must be reported to the IRB Office immediately.
4) **Amendments**: Changes to the protocol must be requested by submitting an Amendment to the IRB Office for review. The Amendment must be approved by the IRB before being implemented.
5) **Informed Consent**: Information must be presented to enable persons to voluntarily decide whether or not to participate in the research project.

TEXAS A&M UNIVERSITY
VICE PRESIDENT FOR RESEARCH - OFFICE OF RESEARCH COMPLIANCE

1186 TAMU
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Institutional Biosafety Committee | Institutional Animal Care and Use Committee | Institutional Review Board

DATE: 26-Oct-2007

MEMORANDUM

TO: ZHU, XUEMEI

FROM: Office of Research Compliance
Institutional Review Board

SUBJECT: Request for Continuation

Protocol Number:	2006-0509
Title:	Developing the School Buffer Walkability Index as an Environment Audit Tool for Safe Routes to School Programs: With a Specific Focus on Minority Children and an Exploratory Analysis of Urban Trails
Review Category:	Expedited
Approval Period:	26-Oct-2007 **To** 25-Oct-2008

Approval determination was based on the following Code of Federal Regulations:

45 CFR 46.110(b)(1) - Some or all of the research appearing on the list and found by the reviewer (s) to oinvolve no more than minimal risk.
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(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation or quality assurance methodologies.

(Note: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(2) and (b) (3). This listing refers only to research that is not exempt.)

Provisions: All data collection and recruitment to be done by City of Austin and/or Austin ISD.

This research project has been approved for one (1) year. As principal investigator, you assume the following responsibilities

1. **Continuing Review:** The protocol must be renewed each year in order to continue

with the research project. A Continuing Review along with required documents must be submitted 30 days before the end of the approval period. Failure to do so may result in processing delays and/or non-renewal.

2. **Completion Report:** Upon completion of the research project (including data analysis and final written papers), a Completion Report must be submitted to the IRB Office.
3. **Adverse Events:** Adverse events must be reported to the IRB Office immediately.
4. **Amendments:** Changes to the protocol must be requested by submitting an Amendment to the IRB Office for review. The Amendment must be approved by the IRB before being implemented.
5. **Informed Consent:** Information must be presented to enable persons to voluntarily decide whether or not to participate in the research project.

This electronic document provides notification of the review results by the Institutional Review Board.

TEXAS A&M UNIVERSITY
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Institutional Biosafety Committee | Institutional Animal Care and Use Committee | Institutional Review Board

DATE: 29-Jun-2007

MEMORANDUM

TO: ZHU, XUEMEI
TAMU-ARCHITECTURE(00010)

FROM: Office of Research Compliance
Institutional Review Board

SUBJECT: Amendment

Protocol Number:	2006-0509
Title:	Developing the School Buffer Walkability Index as an Environment Audit Tool for Safe Routes to School Programs: With a Specific Focus on Minority Children and an Exploratory Analysis of Urban Trails
Review Category:	Expedited
Approval Period:	29-Jun-2007 **To** 27-Sep-2007

Approval determination was based on the following Code of Federal Regulations:

45 CFR 46.110(b)(2) - Minor changes in previously approved research during the period of (one year or less) for which approval is authorized.
----
(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation or quality assurance methodologies.

(Note: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(2) and (b) (3). This listing refers only to research that is not exempt.)

Provisions: All data collection and recruitment to be done by City of Austin and/or Austin ISD.

This research project has been approved for one (1) year. As principal investigator, you assume the following responsibilities

1. **Continuing Review:** The protocol must be renewed each year in order to continue with the research project. A Continuing Review along with required documents must be submitted 30 days before the end of the approval period. Failure to do so may result in processing delays and/or non-renewal.
2. **Completion Report:** Upon completion of the research project (including data analysis and final written papers), a Completion Report must be submitted to the IRB Office.
3. **Adverse Events:** Adverse events must be reported to the IRB Office immediately.
4. **Amendments:** Changes to the protocol must be requested by submitting an Amendment to the IRB Office for review. The Amendment must be approved by the IRB before being implemented.
5. **Informed Consent:** Information must be presented to enable persons to voluntarily decide whether or not to participate in the research project.

This electronic document provides notification of the review results by the Institutional Review Board.

APPENDIX D

COVER LETTER FOR SURVEYS OF PARENTS OR GUARDIANS

IMPORTANT

The Austin Independent School District and the City of Austin are jointly applying for a Safe Route to School grant from the Texas Department of Transportation. _________ Elementary has been selected as one of the schools to be included in the grant application. One of the requirements is to survey the parental community about:

- The current conditions of the sidewalks on your child's way to and from school
- Any situation that might be dangerous on your child's route
- Parental attitudes about walking or biking to school
- Health issues that affect your child's ability to walk or ride their bikes to school

This is your opportunity to express your concerns about your child's route to and from ________ Elementary School.

In addition, by returning the raffle ticket and the survey to your child's teacher, your child will have a chance to win one of 5 bike helmets provided by Safe Kids Austin or one of 8 Walk Safely in Austin pedometers provided by the City of Austin's Child Safety Program. Your child will be able to attach the pedometers to his or her waistband. They are easy to read and are a fun way to record how many steps he or she has taken, the calories he or she burned while walking and the miles he or she has walked.

The deadline for returning the survey and the raffle ticket is Friday, _________ *(moth and date)*. The drawing for the prizes will be Friday, _________ *(moth and date)*.

Thank you for your time and for completing the survey. AISD and the City of Austin want to encourage children to walk and/or ride their bikes to school. Working together we will have a healthier Austin!

If you any questions, please call Chris Moore, City of Austin's Child Safety Program Coordinator at 974-7273.

VITA

Name: Xuemei Zhu

Address: Department of Architecture, Texas A&M University
College Station, TX 77843-3137

Email Address: xuemeizhu@tamu.edu

Education: B.A., Architecture, Southeast University, China, 1999
Ph.D., Architecture, Texas A&M University, 2008
Certificate in Health System and Design, Texas A&M University, 2008
Certificate in Sustainable Urbanism, Texas A&M University, 2008

Work Experience: Architect, Guangsha Associates Inc., Zhejiang, China, 1999-2002
Instructor, Department of Architecture, Texas A&M University, 2004-2005
Assistant Professor, Texas A&M University, 2008-Present

Selected Awards: Edward J. Rominiec Travelling Fellowship, $8,000, Department of Architecture, Texas A&M University, 2004-2005
William W. Caudill Research Fellowship, $10,000, Department of Architecture, Texas A&M University, 2008
Active Living Research Program Dissertation Grant, $24,838, Robert Wood Johnson Foundation, 2008

Publications: Ulrich, R., & Zhu, X. (2007). Medical complications of intra-hospital patient transports: Implications for architectural design and research. *Health Environments Research and Design Journal*, *1*(1), 31-43.
Zhu, X., & Lee, C. (2008). Walkability and safety around elementary schools: Economic and ethnic disparities. *American Journal of Preventive Medicine, 34*(4), 282-290.
Lee, C., & Zhu, X. (2008). School transportation, health and equity: The role of built environments. In P. O. Inweldi (Ed.) *Transportation Research Trends* (pp. 92-117). Hauppauge, New York: Nova Science Publishers.
Ulrich, R., Zimring, C., Zhu, X., DuBose, J., Seo, H., Choi, Y., et al. (2008). A review of the research literature on evidence-based healthcare design. *Health Environments Research and Design Journal*, *1*(3), 61-125.