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IRVINE

Walking and Urban Form:
Modeling and Testing Parental Decisions about Children's Travel

DISSERTATION

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by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT OF THE DISSERTATION

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Doctor of Philosophy in Urban and Regional Planning

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Over the past several years, the private vehicle has become the predominant mode of travel to school while walking and bicycling rates have decreased. Some suggest that this change in travel behavior contributes to negative health outcomes in children, including increased rates of 1) overweight/obesity through inactivity and 2) pedestrian and bicyclist fatality and injury. A series of recent policies and programs directly attribute the change in travel behavior to school to the urban form of communities. Limited research exists to support this hypothesis, however. The fundamental questions of whether and how urban form impacts a child's trip to school must to be answered in order to develop effective interventions aimed at increasing rates of walking and bicycling activity and safety.

This research proposes a conceptual framework to examine the nature and shape of the relationships between urban form; interpersonal, demographic and social/cultural factors; parental decision-making and a child's travel to school. Using parent survey data on children's travel to school and urban design assessments from twelve elementary school neighborhoods, the relative influence of urban form on the mode choice to school was first determined. Results indicate that urban form elements such as street lights and street widths do affect the probability of a child walking or bicycling to school; however, the affect of these elements is modest compared to other influential variables such as the perceived convenience of driving, country of birth, family support of walking behavior, reported traffic conditions in the neighborhood and perceived distances between home and school.

A second analysis examined how urban form and children's travel behavior relate by testing the hypothesis of an indirect relationship. The findings show that parent's feelings of neighborhood safety, traffic safety and/or household transportation options do not intervene in the relationship between urban form and children's travel behavior. Socio-demographic characteristics and parent's attitudes toward travel, however, may modify the strength of the relationship between urban form and children's travel behavior.

The results of this study advance the discussion on relationships between urban form, transportation and health and inform policy and practice of the best targets for future planning interventions.

Chapter 1

Introduction: Children's safe and active travel

Over the past several years, the journey to school for children has undergone significant change. The private vehicle has become the predominant mode of travel, even for distances of less than a mile (Dellinger and Staunton, 2002; Nationwide Personal Transportation Survey, 1997). Bicycling and walking to school have decreased. Yet despite this decrease, walking and bicycling have the highest rates of injury and fatality on a per-mile basis (Killingsworth and Lamming, 2001; Transportation Research Board, 2002). While the true causes of these changes in travel behavior are not yet known, proponents of concepts like smart growth and livable communities have developed a persuasive hypothesis attributing the change in travel to school to the urban form[1] of our communities. This hypothesis suggests that elements such as increased block lengths and street widths and decreased presence of sidewalks in communities have led to the decrease in walking and bicycling in children, with long-term negative impacts on transportation and public health. Policies and programs are rapidly being created at the local, state and national level in response to the hypothesized link between urban form and a child's trip to school (Transportation Alternatives, 2002; Transportation Research Board, 2002). For example, in California the Safe Routes to School construction program (SR2S) provides over $20 million per year to modify the urban form around schools to increase pedestrian and bicyclist safety and activity (California Department of Transportation, 2000). The investments are relatively uninformed by research, however, because the mechanisms of the relationship between urban form and a child's trip to school are largely unknown.

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[1] Urban form is defined as a composite of characteristics related to land use patterns, transportation systems and urban design (Handy, 1996c).

Many of the created programs and policies assume a fairly direct relationship between urban form and children's travel behavior. These programs suggest that an intervention focused on changing urban form, such as constructing a sidewalk or marking a bicycle lane, will in and of itself increase walking and bicycling activity and safety. Limited research exists to support this hypothesis. Research conducted in fields that study walking and bicycling behavior, such as planning and public health, suggests that factors other than urban form, such as parental decision-making, neighborhood safety or household transportation options, may have stronger, more direct relationships with children's travel behavior (see, for example, DiGuiseppi et al., 1998; Eichelberger et al., 1990; Bradshaw, 1995). Urban form may influence some of *these factors*, and therefore may remain as an explanatory factor in a child's trip to school, albeit through a less direct path than has been proposed in the aforementioned programs and interventions. In order to develop effective interventions aimed at increasing rates of walking and bicycling activity and safety, the fundamental questions of whether and how urban form impacts a child's trip to school must to be answered.

This research presents a new and broader conceptual framework of the urban form/travel behavior relationship for children than previously discussed. The research explores how urban form impacts children's travel behavior by examining the nature and shape of the relationships between urban form; interpersonal, demographic and social/cultural factors; parental decision-making and a child's travel to school. This research adds to the literature on individual and household travel behavior and walking correlates, especially from the perspective of more dependent users of the transportation system, by dissecting how variables relate to one another to affect behavior.

A multidisciplinary issue

Children's travel behavior is a topic poorly understood by planning and health academics and practitioners alike, as indicated by the dearth of literature on the topic and the lack of planning for children's travel, or specifically for their travel to school. Yet the importance of this issue spans beyond the traditional disciplinary boundaries of planning. While children's travel is obviously a transportation issue, it is also a health issue. Research indicates that transportation decisions may have links to health outcomes such as pedestrian and bicyclist accidents and obesity (Frank and Engelke, 2001; Koplan and Dietz, 1999; Leaf and Preusser, 1999). This snowball effect makes the question of how urban form impacts a child's trip to school both complex and important, with strong links to policy levers. Examining the topic with a multidisciplinary lens helps to define its significance and guide policy action, and can inform the development of a broad conceptual framework to examine how urban form affects a child's trip to school.

Transportation

Children are a user group poorly served by today's transportation system in most locations in the United States. Like adults, children need transportation for activities such as education, social events and health care; however, unlike most adults, children are largely dependent on others to provide this transportation. In the United States, children's transportation is greatly limited to private automobile travel. The 1995 Nationwide Personal Transportation Survey (NPTS) indicated that 69% of all trips made by children aged 5-15 were by private vehicle. School travel, constituting approximately 26% of trips made by 5-9 year olds, is an important opportunity for non-motorized travel, given the neighborhood location of many primary schools. Yet only 10.5% of children aged 5-9 walked to school, while 52.8% traveled by private vehicle, 30.2% by school bus and 6.5% by other modes

(NPTS, 1997). Parents cite long distances and traffic danger as the primary barriers to their children traveling to school by walking or bicycling (Dellinger and Staunton, 2002). Parents also suggest that the streets closest to the school are some of the most dangerous locations for children who travel to school on foot due to the high period-specific traffic volumes and erratic driving behavior of car-bound parents (Anderson, et al., 2002; Bradshaw, 2001).

This travel pattern not only affects school traffic but can also impact overall household quality of life by adding trips or limiting the work schedule or job opportunities of a caregiver. While both mothers and fathers make a significant number of trips solely for children, mothers tend to make the majority of these trips up to age 17 (Rosenbloom, 1987) In a trip-chaining analysis of the 1995 NPTS data, women made a significantly greater percentage of trips serving passengers, as compared to men. This analysis also showed that women in households with children (regardless of marital status) also trip-chained more than did women in households without children and more than men (McGuckin and Murakami, 1999).

Finally, it has been suggested that habits formed early are hard to break. Children that do the majority of their traveling by car while growing up may continue that behavior into adulthood and may be more reluctant to travel by alternative transportation modes (Bradshaw, 2001). While there is a growing body of literature testing the hypothesis of habitual travel mode choice in adults (see special issue in *Transportation* , volume 30 (2003); Bamberg and Schmidt, 2003; Verplanken et al., 1994), there is little literature to support this hypothesis in children.

Existing research on adult walking behavior and urban design suggests that the accessibility[2] of the pedestrian infrastructure (focusing on the presence, quality, travel distances and route options) are associated with walking behavior (Corti, et al., 1996; Handy, 1996a; Hess, et al., 1999; Kitamura, 1997; Moudon, et al., 1997; Shriver, 1997). In the case of children's travel to school, it is possible that the sheer distance from home to school could be one of the biggest barriers to walking or bicycling (Bradshaw, 1995; DiGuiseppi et. al., 1998). A survey conducted in 1999 by the Centers for Disease Control and Prevention (CDC) found that long distances were the primary barrier to walking and bicycling to school. Walking and bicycling accounted for only 2% of trips made by children aged 5-15 living within two miles of school. Rates remained low even for children living within one mile of school, however, where only 31% of trips were walk/bicycle trips (Dellinger and Staunton, 2002). These results suggest that factors other than distance may influence the decision about travel mode to school.

Health

Collisions

Child pedestrian and bicycle death and injury have a major impact on society. More than one-fifth of all children aged 5-9 who were killed in traffic crashes in 2001 were pedestrians and a total of 361 pedestrians aged 5-15 were killed (National Center for Statistics and Analysis, 2003). Pedestrian injuries are the second leading cause of unintentional injury-related death among children and adolescents between the ages of 5 and 14 (National Safe Kids Campaign, 2002). Fatalities are few compared to child and adolescent pedestrian injuries, however. In 2001, approximately 20,000 children aged 5-15

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[2] Hansen (1959) defined accessibility as "the intensity of the possibility of interaction," which Handy (1996a) states is determined by "the pattern of activities; their quantity, quality, variety, and proximity; and the connectivity between them as provided by the transportation system."

were injured as pedestrians in traffic crashes. Motor vehicle traffic crashes are the second leading contributor to total unintentional injury costs among children (includes occupant, pedestrian and bicyclist injuries), with costs per victim equaling $20,500 for motor vehicle-pedestrian incidents and $17,600 for motor vehicle-pedalcycle incidents (Miller et al., 2000).

Statistics also show that pedestrian and bicycle injury death rates among children have declined in the past two decades, indicating perhaps that progress is being made in making streets safer for these users; however, these numbers should be examined in light of the fact that children's walking and bicycling rates have also declined during this time period (DiGuiseppi, Roberts and Li, 1997; Kann, Kinchen, Williams, et. al, 1997; Killingsworth and Lamming, 2001)[3]. Death rate is typically measured in terms of total population, not the population that is exposed to the danger (Adams, 1988). Therefore, a reduction in death rates that suggests roadways are safer for pedestrians and bicyclists may mask the larger problem of the removal of these users from the transportation system.

Widening and straightening roads and creating a smoother pavement surface are techniques that may enhance travel efficiency and safety for the automobile driver, but may serve as a costly deterrent to non-motorized transportation users, due in part to the increased speeds the roadways can support (Adams, 1988). Numerous studies have shown that vehicle speed is a crucial risk factor for pedestrian injuries and a major determinant of the severity of these injuries (see review by Leaf and Preusser, 1999). The risk of injury (or death) in both adult and child pedestrians increases dramatically with increased vehicle speeds (Roberts et al., 1995; Pasanen, 1993; Mueller et al., 1990; Pitt et al., 1990). Pasanen

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[3] Most notably, in an analysis of national travel surveys and death records in England and Wales, DiGuiseppi, Roberts and Li (1997) found a decline in child pedestrian and bicycling deaths per capita. A much less substantial decline was seen when deaths were analyzed on a per-mile basis, however, reflecting the decline in the annual distance traveled by walking and bicycling in children aged 0-14 between 1985 and 1992.

estimated that while approximately 5% of pedestrians would die when struck by a vehicle traveling 20 mph, this percentage increased to 40% for vehicles traveling 30 mph, 80% at 40 mph, and nearly 100% for vehicle speeds over 50 mph (Pasanen, 1993). While many communities have reduced speed limits (e.g., 15 mph) within school zones during school hours, vehicle speeds often exceed this limit, placing young children at greater risk of injury or death (Anderson et al., 2002; Pasanen, 1993).

Physical Inactivity/Obesity

The reduction in travel to school by walking and bicycling may contribute to a reduction in overall physical activity and health in youth today. Data from the 1997 Youth Risk Behavior Survey (YRBS), a school-based survey conducted by the Centers for Disease Control and Prevention in partnership with state health agencies, showed that only one fifth of students nationwide walked or bicycled for the amount of time necessary for associated health benefits (Kann, Kinchen, Williams, et. al, 1998). Since 1963-65, the age-adjusted prevalence of overweight in U.S. children has increased from 4% for both boys and girls ages 6-11 years (and 5% for both boys and girls ages 12-17 years in 1966-70) to 11% among boys and 10% among girls in both age ranges in 1988-94 (Flegal, 1999). This trend has continued, with the prevalence of overweight in children aged 6-11 increasing to 15.3% in 1999 (Ogden et al, 2002). In adolescents aged 12-19, the prevalence jumped to 15.5% and occurred most significantly among Mexican-American and non-Hispanic black adolescents (Ogden et al, 2002).

The trend in children and adolescents mirrors an equivalent trend in U.S. adults. The prevalence of overweight in adults increased from 46% in 1980 to 65% in 1999-2000 (Flegal et al., 2002; Flegal, 1999; Koplan and Dietz, 1999). Similarly, the age-adjusted prevalence of obesity in adults increased from 14.5 percent in 1980 to 22.9 percent in 1994 to 30.5% in 1999-2000 (Flegal et al., 2002; Flegal, 1999). A recent report by the Centers for Disease Control and Prevention found that one in four American adults engaged in little or no regular physical activity in the year 2000 (Barnes and Schoenborn, 2003). Research on obesity indicates that while genetics and reductions in leisure-time activity are contributors to society's weight gain, it is the reduction in energy expenditure from our *everyday* activities that is largely contributing to the increase in rates of overweight and obesity (see Hill and Melanson, 1999, for a detailed quantification of energy intake and expenditure related to environmental factors; Koplan and Dietz, 1999).

There are serious long-term health outcomes due to this reduction in activity in both children and adults. At least four of the top ten leading causes of death in the United States are directly related to physical inactivity: heart disease (#1 cause of death), cancer, stroke, and diabetes mellitus. These conditions accounted for over half of the deaths in 1998 (U.S. Department of Health and Human Services, 1998). Research shows that chronic diseases such as coronary heart disease, Type II diabetes and osteoporosis, for which physical inactivity and weight are risk factors, can begin in childhood (Sallis and Owen, 1999).

The causal relationship between physical activity and health has been clearly established by the health research community, including the dose-response relationship between these variables (Pate, et al., 1995; U.S. Department of Health and Human Services, 1996). Several studies indicate that the health benefits associated with physical activity accrue proportionate to the amount of activity that is done, measured as either minutes of activity or caloric expenditure. Stated another way, these studies show that the relative risk of death from cardiovascular disease is significantly related to the amount of activity performed (Blair et al, 1989; Ekelund et al., 1988; Hakim et al., 1998; Leon et al, 1987; Morris et al., 1990; Paffenbarger et al., 1986; Sandvik et al., 1993). Therefore, to attain the health benefits associated with physical activity, the *accumulation* of 30 minutes of moderate activity throughout the day for most days of the week is necessary. This activity can be conducted in as little as 10-minute bouts three times a day—the equivalent of a walk to and from school plus running around at recess.

Policies to promote children's safe and active travel

Major public investments are currently being made both nationally and internationally to alter the physical infrastructure of communities to encourage walking and bicycling, under the assumption that urban form is a major barrier to non-motorized activity. Safe Routes to School (SR2S) is a direct policy reaction to this hypothesized relationship. SR2S is an international transportation and public health movement that directly addresses the child's trip to school. Conceived in Denmark, SR2S aims to positively impact a child's travel route to and from school by making the route safer and walkable through (1) *education* (of both the child and the driver) on road safety; (2) *enforcement* of traffic laws around schools; and/or (3) *engineering* of the street environment along the routes to school in an attempt to control traffic and to enhance pedestrian and bicycling facilities (elements known as the three E's in transportation engineering) (Transportation Alternatives, 2002).

California's Safe Routes to School Program

California created the first state-level SR2S construction program in the United States in October 1999, with the signing of California Assembly Bill 1475 (AB1475). The program, which was supported by a broad coalition of transportation, physical activity, injury and urban design advocates, allows "the use of federal transportation funds for construction of bicycle and pedestrian safety and traffic calming projects" (California Department of Transportation, 2000, 1). Specifically, the Bill authorized the allocation of $40 million in federal transportation funds over two years to fund projects that would, in theory, increase the safety and physical activity of child pedestrians and bicyclists on routes to school by altering traffic conditions for vehicles, pedestrians and bicyclists. Since the fall of 2000, over 200 projects have been awarded to incorporated cities or counties in California. The program was re-authorized in 2001 for another $75 million for three more years under California Senate Bill 10.

Projects are awarded to incorporated cities or counties in California and are administered through Caltrans, the California Department of Transportation. Caltrans awarded the first round of projects in the fall of 2000, with 85 projects receiving a total of $20 million in federal funds. The most common types of projects awarded in the first cycle of SR2S projects were sidewalk improvements (e.g., installation of sidewalks), pedestrian/bicycle improvements (e.g., installation or widening of bicycle lanes, marking crosswalks) and traffic control improvements (e.g., installation of flashing beacons, traffic signals and/or left-turn phase of traffic signal). Eight projects proposed to use traffic calming techniques such as speed humps or curb bulb-outs.[4] A total of 101 projects were awarded in the second cycle of SR2S projects announced in fall 2001. Table 1.1 contains a breakdown of the projects by improvement type awarded in the first two rounds of SR2S funding.

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[4] 85 overall projects were awarded, with some projects containing multiple improvements and/or multiple school sites. The classification of all proposed improvements is given here, totaling 115.

TABLE 1.1 Summary of California SR2S projects by type of improvement

Type of improvement	Round 1, Fall 2000 N = 85	Round 2, Fall 2001 N=101	Group Classification
Sidewalk improvements	47	61	Separation and behavioral control of all road users
Pedestrian/bicycle improvements	30	62	Separation and behavioral control of all road users
Traffic control improvements	30	41	Separation and behavioral control of all road users
Traffic calming interventions	8	15	Control of motor vehicle behavior and integration of all users

Using a scheme suggested by Leaf and Preusser (1999) to classify traffic engineering efforts in speed management, the SR2S projects fall into two distinct groups: 1) those that work to separate road users (either temporally or physically) to control their behavior in the hopes of achieving safety and providing efficient transport of motor vehicles (the first three categories of improvement types in Table 1.1), and 2) those that work to control the behavior of one user (motor vehicles) in the hopes of creating a safer and more pleasant environment that is integrated for all users (the last improvement type in Table 1.1). In their analysis of the literature on vehicle travel speeds and pedestrian safety, Leaf and Preusser point out that engineering efforts that focus on the first group of improvements have often achieved safety at the expense of activity due to the added inconvenience, delay and discomfort that may be associated with these improvements. This most typically occurs when pedestrians and bicyclists are not thought of as users of a transportation system for the purpose of transport (typically, no matter what the travel mode, the goal of efficiency is the same). For this same reason, these efforts may not achieve safety if the pedestrian and bicycle users of the road continue to use the road in the way that is most efficient, yet not accommodating or safe, for them. In contrast, engineering efforts focused on traffic calming have been moderately successful at reducing the rates of pedestrian and bicycle injury *and* motor vehicle collisions (Bared, 1997; Mundell and Grigsby, 1997; Portland, 1997; Schoon and van Minnen, 1993).

Other programs and policy actions

California's SR2S program, based on legislation to support engineering changes, has spawned similar programs in other states, including Oregon, Washington, Texas and Delaware. Still other localities, such as Tallahassee and Clearview, Florida; Atlanta, Georgia; Chicago, Illinois; and Arlington, Virginia are investing funds in the education of children, parents and communities on walking and bicycling safety or in enforcement of traffic laws around schools (Transportation Alternatives, 2002). The National Highway and Traffic Safety Agency (NHTSA) and the CDC have invested resources in the area of safer and more pedestrian and bicycle-oriented routes to school, in the form of both internal and external program dollars. National organizations such as the Surface Transportation Policy Project, the American Planning Association, and the American Public Health Association currently advocate for national legislation to support the concept of safe walking and bicycling routes to school.

Programs such as SR2S are part of the greater Walkable/Livable Communities, Smart Growth and New Urbanism movements. These movements support the idea that community resources such as schools should be built (or in many cases, remain) within walking or bicycling distance of the majority of the population they are meant to serve, reducing the need for resources such as school buses or parent's time and private vehicles to shuttle children to and from school (Calthorpe, 1993; Katz, 1994; Smart Growth America, 2003).

The findings of this research, on the shape and nature of the relationship between urban form and a child's trip to school, can impact outcomes and policies related to health, transportation and land use. As the literature review in the following section discusses, there is still much to learn about the relationships between these three elements.

Chapter 2

Current research related to urban form, children's travel behavior and activity

Research conducted on walking and bicycling activity in both planning and public health suggests there are several factors that contribute to a relationship between urban form and a child's trip to school. Still, existing research on travel behavior, urban design, and physical activity provides limited evidence on the complexity of the relationship because of: 1) the relatively narrow focus on variables typically studied within a given discipline; 2) a lack of focus on children, walking and school; and 3) the absence of a framework that suggests how variables relate to one another to affect behavior. The current literature cannot answer the question of how urban form impacts a child's trip to school; however, it provides a good starting point for the development of a new framework for studying this relationship.

Planning—transportation/urban design

Traditional travel behavior models are principally limited to the examination or prediction of adult travel behavior, primarily that which is automobile-dependent. The study of travel behavior in transportation and urban design research has generally followed two paths: model-building to forecast travel demand and empirical research to identify elements that affect travel behavior. While different in purpose, most of the research is similar in its focus on adult and auto-oriented travel (e.g., McNally, 2000; Boarnet and Crane, 2001; Boarnet and Sarmiento, 1998; Crane and Crepeau, 1998; Boarnet and Greenwald, 2000).

The first generation of travel behavior models (e.g., four-step model) were really trip generation models, in the sense that they were statistical equations designed to predict trip outcomes and not the behavioral processes that went into deciding about a trip (McNally, 2000, ch.3; Domencich and McFadden, 1975). The four-step model that is traditionally used by transportation agencies in the forecasting of travel demand contains, predictably, four stages: trip generation, trip distribution, mode choice and route choice, primarily executed in sequence, although feedback loops do exist in some versions of the model (McNally, 2000, ch.3). A major limitation of this model is that since it is primarily a forecasting tool devoid of true behavioral theory, temporal and spatial constraints are largely absent in the model building process, in conflict with how those factors actually play into an individual's decision about a trip (Goodwin and Hensher, 1978). In addition, the model is designed to examine trips as individual events rather than interconnected activities, making it difficult to outline the complexity of trip making (McNally, 2000, ch.3; Jones, 1978). Adult trips are those that are typically modeled, since these are automobile trips. Walking and bicycling are rarely considered in the four-step models unless they provide a connection to transit and are typically only considered utilitarian trips, not trips that may be generated for recreational purposes (the same is also true for auto travel "for the fun of it"—see Mokhtarian, 1999). Because of these limitations, the four-step model generally cannot explain why travel happened, just where and how much of it may occur (McNally, 2000, ch.3; Domencich and McFadden, 1975).

The activity-based framework to travel behavior developed in part out of the limitations of the four-step model. The framework attempts to improve the understanding and prediction of travel behavior by recognizing its complexity and the need to develop a model that is more relevant for policy applications (Goodwin and Hensher, 1978; Stoner and Milione, 1978; McNally, 2000, ch.4). The framework suggests that an understanding of travel behavior cannot only be based on an examination of travel attributes (e.g., time and cost of travel). Rather, it must consider the affect of individual preferences and constraints on choice, as well as the attributes of the destination, to understand travel behavior (Goodwin and Hensher, 1978; Jones, 1978). Therefore, travel is recognized as a derived demand (trips are made for a purpose)—and is a composite of overall household demand for activities rather than one individual's trips. Given this demand, travel decisions involve a course of action wherein the "what, when, where, how and why" of household activity patterns are considered to determine behavior (Stoner and Milione, 1978).

Through the recognition of the impact of the household on overall travel patterns, the activity-based framework implicitly includes the transportation needs of children. Travel is seen as a sequence of events (not isolated trips) that are influenced by elements such as the opening hour and location of a child's school in relation to the parent's workplace—examples of temporal, spatial and interpersonal constraints on trip decisions that are neglected in the traditional four-step model (Chapin, 1974; Fried et al., 1977; Jones, 1978; Stoner and Milione, 1978; Jones et al., 1983; McNally, 2000).

The activity-based framework's focus on the affect of preferences, constraints and destination attributes on travel behavior is also well-suited to the understanding of walking and bicycling behavior. While optimizing the time and cost of travel are important factors in deciding to travel by these modes (as in the automobile), elements such as enjoyment, good for personal health and the environment, discomfort, and no knowledge of bike paths are other factors that weigh on decision-making that the activity approach can identify.

Moving the activity-based approach from the point of being a framework to a model for the study of travel behavior has been problematic. The approach is better suited to localized use than to regional travel behavior studies since data collection requires detailed activity-based surveys that are often expensive and labor-intensive(McNally, 2000, ch.4). This has made the model unappealing to researchers and practitioners alike, causing many to default to collecting conventional trip-based data rather than the more behaviorally-based data such as spatial, temporal and interpersonal constraints on households and individuals and destination attributes (McNally, 2000; ch.4). While the activity-based approach would likely support the hypothesis that other factors besides urban form influence a child's trip to school, the lack of critical urban form data makes it difficult to address the overall question of how urban form relates to a child's trip to school using this framework.

Despite their limitations, both the four-step model and the activity-based framework provide valuable guidance in that they explicitly suggest how variables relate through a path of decision-making and behavior. In particular, the activity-based framework has advanced the discussions and research on the complexity of travel behavior by highlighting the interplay of various factors on travel decisions.

The complexities of the activity-based approach to travel behavior have spurred others to search for other theoretically-based behavioral frameworks that empirically test hypothesized transportation-land use links. In recent years, Boarnet and Crane, both collectively and with various authors, have contributed to the discussion on the relationship between land use and travel behavior by expanding upon the behavioral framework introduced by Domenich and McFadden (1975) of an econometric model of travel demand, using utility maximization as the primary behavioral goal of each individual (Boarnet & Crane, 2001; Boarnet & Greenwald, 2000; Boarnet & Sarmiento, 1998; Crane, 1996a; Crane, 1996b; Crane & Crepeau, 1998; Greenwald & Boarnet, 2001). Central to their argument is that the impact of land use on travel behavior is its affect on the generalized price of travel (i.e., travel cost and time), not its relationship to more subjective variables such as quality of life or sense of community. When examining land uses that are considered "New Urbanist," results from several of these studies indicate that street configurations (thereby land use) may optimize the economics of travel behavior by increasing the efficiency of the trip through shorter trip distances and decreased travel times—for the automobile as well as the pedestrian (Cervero and Kockleman, 1997; Crane and Crepeau, 1998; Boarnet and Crane, 2001). These results would suggest that land use policies that place residences and schools closer together could still promote traffic around the school because of the ease with which parents who live close could drop their child off by automobile.

This research cannot answer the question of how urban form impacts a child's trip to school, however, because of its limited focus on adult travel, automobile trips and easily measured disaggregate variables of behavior and land use. Since the research is based on the concept of utility maximization, which assumes full knowledge of choice sets and does not take into account spatial and temporal constraints (Jones, 1978), it ignores the behavioral complexity of a trip decision for a non-motorized user of the transportation system and the household dynamics that go into travel decisions. The utility maximization framework also ignores "non-derived" trips—those without a specific purpose—causing these trips (and the environments that support them) to be undervalued.

Travel behavior studies that include an analysis of non-motorized travel have increased significantly in the past decade (e.g., see Cervero and Kockelman, 1997; Greenwald and Boarnet, 2001; Handy, 1996a; Handy, 1996b; Handy and Clifton, 2001; and Kitamura et al., 1997). This literature is important since the experiences and needs of a pedestrian, especially a child pedestrian, differ greatly from that of an adult automobile driver. Additionally, since walking and bicycling happen on a smaller- and finer-grained scale of the transportation system than automobile travel, urban form elements that affect the decision to bicycle or walk for various purposes (travel or non-travel related) may be different than those affecting an automobile trip.

In a comparison of four Bay Area neighborhoods, Handy (1996a) found that an increased number of walking trips to destinations was positively associated with shorter distances and street design elements that may affect perceived levels of accessibility (e.g., narrow streets, shaded sidewalks, front porches). The study found that the average frequency of walks and the percentage of individuals who walked to commercial areas in the past month were higher in traditionally-designed (turn-of-the-century) neighborhoods as compared to modern (post-WWII) neighborhoods. Notably, the study did not find any effect on strolling activity by neighborhood type, suggesting that accessibility in terms of distance may be an activity-specific factor in the relationship between walking and urban design.

Handy and colleagues (Handy and Clifton, 2001; Handy, Clifton and Fisher, 1998) also examined the factors that influence walking trips based on trip purpose in a study of six Austin, Texas neighborhoods. The neighborhoods were divided equally into traditional (built early in the 1900s near the city center), early-modern (built soon after World War II near the city center) and late-modern (built in the past two decades near the urban fringe). When looking at the impact of local shopping on travel mode choice, Handy and Clifton (2001) found that distance to a store was a stronger predictor of walking trip frequency, with each mile of distance equating to a reduction of four trips per month (or as the authors state, one trip per quarter mile of distance). Other studies have also found that the proximity of commercial and/or mixed use development to residences affects walking activity, with higher walking trips to stores found in neighborhoods near commercial development (Frank and Pivo, 1995; Corti et al., 1996; Shriver, 1997).

Several studies that examined walking and urban form at the neighborhood level found correlations between the presence of a sidewalk or footpath system and adult walking behavior (Hess et al., 1999; Moudon et al., 1997; Corti et al, 1996). In particular, Moudon et al. (1997) and Hess et al. (1999), in a study of twelve neighborhoods sites in the Puget Sound region, found that site design (a measure of the completeness of pedestrian facilities, particularly block size and sidewalk length) and route directness (an accessibility measure) significantly affected the number of pedestrian trips to commercial areas.

The quality of the pedestrian environment also plays a role in the decision to walk. In several studies (Handy, 1996a; Handy, 1996b; Handy, Clifton and Fisher, 1998; Handy and Clifton, 2001), elements such as busy streets and the general safety of the walking environment between residential neighborhoods and shopping areas were found to affect walking trips for shopping. Focus groups reported that design elements such as expansive parking lots made it easier to envision traveling to stores by automobile and were intimidating features to pedestrians.

The studies discussed above provide information on elements of urban form correlated to walking activity. To better understand the complex behavioral relationships between urban form and travel behavior, however, information is needed on the relative influence of urban form variables on motorized versus non-motorzied travel. Recent travel behavior model studies by Cervero and Kockelman (1997), Kitamura et al. (1997), Greenwald and Boarnet (2001) and Rodriguez and Joonwon, (2003) show differences in the relationships between land use variables and travel behavior based on travel mode.

In a study of five San Francisco Bay Area neighborhoods, Kitamura et al. (1997) found the presence of sidewalks to be positively associated with the number of non-motorized trips. In addition, the distance to the nearest bus stop and the nearest park were negatively associated with the fraction of non-motorized trips and positively associated with the fraction of auto trips, highlighting the effect urban form (in this case, travel distance) features have on travel mode. Variables such as sidewalk presence, percentage of grid streets, walking quality and distance to transit had greater explanatory power for non-motorized trips than auto trips. Cervero and Kockelman (1997) also found walking quality to be a strong predictor of non personal-vehicle travel (which includes transit trips, walking and bicycling), along with intensity of land uses, when examining the effects of density, diversity and design on travel demand in fifty San Francisco Bay Area neighborhoods.

Using median trip distance as a measure of trip costs in a study of Portland area neighborhoods, Greenwald and Boarnet (2001) found that, as in automobile travel, trip distance was a strong predictor of non-work walking behavior. Finally, in a study of commuter behavior at the University of North Carolina, Chapel Hill, Rodriguez and Joonwon (2003) found that the likelihood to travel by foot was positively associated with an increase in the percentage of sidewalk available on the shortest route to a destination. This study also found that the appeal of walking and bicycling was affected by sloping terrain.

While none of the aforementioned studies examined children's travel behavior, the inclusion or explicit assessment of non-motorized travel advances the discussion on the relationship between travel behavior and urban form that provides a starting point for further research. What is still largely absent from this literature is an understanding of the structural relationships between variables, which requires a deeper examination of direct and indirect relationships, interactions, and hypothesized paths of causality.[5] The four-step model and the activity-based framework discussed at the beginning of this review may provide guidance in outlining these relationships.

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[5] Causality is obviously a difficult phenomenon to determine but this review suggests it is the direction the research must move toward through hypothesis building and research design to advance our understanding of the relationships between urban form and travel behavior.

Public health—physical activity

Other disciplines that study walking behavior for purposes other than transport have also examined factors that may affect the relationship between urban form and a child's trip to school. These disciplines, such as public health, focus less on examining the utility in walking and more on the psychosocial factors that influence the activity itself, both in adults and children.

Until recently, the majority of research on walking, and physical activity in general, has been guided by theories that examine intrapersonal and social variables of influence (e.g., health belief model, transtheoretical model and theories of reasoned action and planned behavior) (Sallis and Owen, 1999; King et al., 2002). Variables such as self-efficacy ("one's confidence to engage in physical activity despite encountering barriers") (Lewis et al., 2002, 28), self-motivation, enjoyment, perceived health or fitness and social support from a spouse, family, peers or friends were positively associated with overall physical activity in adults (Calfas et al., 1994; McAuley, 1993; McAuley, 1992; Sallis et al., 1992b; Hovell et al., 1991; Kendzierski and DeCarlo, 1991; Sallis, 1989). Barriers to physical activity including stress, work and school, child care and inconvenience, had high negative associations with overall physical activity in adults (Calfas et al., 1994; Johnson et al., 1990). Variables such as knowledge of the benefits of activity and being physically active as a youth showed no relation to activity as an adult (Sallis and Owen, 1999). For children, self-efficacy was positively correlated with physical activity and perceived barriers (such as lack of time and lack of interest) were negatively correlated with activity. In addition, supportive social environments (e.g., parents who encourage and play with children, transport children to activities and/or are physically active themselves) were also positively associated with activity, suggesting the influential role parents play in guiding children's behavior (Trost et al., 1997; Zakarian et al., 1994; Sallis et al., 1993; Stucky-Ropp and DiLorenzo, 1993; Sallis et al., 1992a; Klesges et al., 1990; Tappe et al., 1989).

The field of physical activity research is now moving toward theories that emphasize variables across multiple levels of influence. The social ecological model and social cognitive theory suggest that behavior is affected by intrapersonal, social and environmental variables that "function interactively" (King et al., 2002, 17), highlighting the complexity of behavior that the research is trying to explain. In the limited research that has begun to look at the effect of environmental factors on physical activity in adults, access to facilities that support physical activity (walking paths, local stores and parks) was positively associated with activity, while the impact of perceived safety and heavy traffic on activity showed mixed results (Carnegie, et al., 2002; Booth et al., 2000; King et al., 1999; Corti et al., 1996; Hovell et al., 1992). In a recent study that focused specifically on walking activity, Giles-Corti and Donovan (2003) found that the odds of attaining the scientifically recommended amount of walking for health benefits were higher for respondents who 1) had the greatest access to public open space (compared to those with the lowest); 2) lived on streets with minor traffic and/or some trees (compared to those who lived on streets with major traffic and no trees); and 3) lived on streets with footpaths (i.e., sidewalks) and/or shops (compared to those who lived on streets with no footpaths or shops). In one of the few studies explicitly examining bicycle use, Troped et al. (2001) looked at the association between objective physical environment factors and use of a community rail trail. The authors found that steep hills and greater distance from home to trail were associated with non-use of the rail trail.

Little research has looked at environmental variables that influence children's activity. Several studies found that time spent outdoors was a strong positive correlate for physical activity (Baranowski et al., 1993; Sallis et al., 1993; Klesges et al., 1990) and one study found that children with more outdoor places near home were more physically active (Sallis et al., 1993).

The focus of physical activity research on activity for a purpose other than transport (i.e., general leisure-time physical activity) provides more detailed information on what may affect individuals' decisions to walk. This singular focus must also be recognized as a limitation in the research, however. Since most of the research addresses leisure-time physical activity generally and not walking per se, it is not clear whether the variables that affect the decision to walk are the same as those affecting bicycling, running or playing soccer; or if walking for a purpose, such as the walk to school, is influenced differently than is walking for recreation. Work by Handy (1996b) on the role of urban form in the motivation to walk indicated that urban form played a greater role in the decision to walk to a destination than to walk for recreation.

In addition, like much of the research in transportation and urban design, the majority of these studies were cross-sectional correlation research or intervention studies that oftentimes lacked an explanatory framework. Model-building is inadequate in physical activity research and is recognized as a limitation in advancing knowledge of what influences physically active behavior such as the walk to school (Baranowski et al., 1998; Lewis et al., 2002). However, research on physical activity contributes to the development of a framework on urban form and a child's trip to school because, unlike many travel behavior models, it highlights the non-economic variables that can influence a decision to walk.

Chapter 3

A conceptual framework to examine children's travel behavior

The question of how urban form impacts a child's trip to school is complex. Existing research and models of travel behavior and physical activity fail to answer the question because of the limited focus on children and non-motorized transportation and more importantly, because of the lack of complexity in explaining behavior. A framework is needed that 1) addresses the question of children's walking behavior directly rather than encompassing it in adult and auto travel behavior (Hillman et al., 1973); and 2) explicitly addresses the complex structure and direction of the relationships that exist in the decision-making about a child's trip to school.

As previously mentioned, current policies and programs such as SR2S operate off of the premise of a fairly direct relationship between urban form and a child's trip to school (Figure 3.1). This is an untested, relatively simplistic picture of the relationship and one that risks program/policy failure because of the factors not accounted for that may influence the relationship between urban form and a child's trip to school.

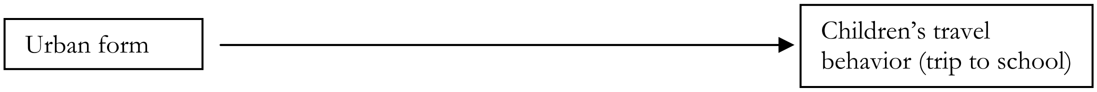

Figure 3.1 Diagram of the relationship between urban form and children's travel behavior, as suggested by SR2S program. Solid arrow indicates hypothesized direct relationship.

The following conceptual framework (Figure 3.2) draws out the complexity of the relationship between urban form and a child's trip to school. The framework moves the research on travel behavior forward by: 1) identifying the key decision-maker of children's travel behavior; 2) highlighting factors that may be considered when making decisions about a child's trip to school; and 3) outlining how these factors influence the relationship between urban form and the child's trip to school.

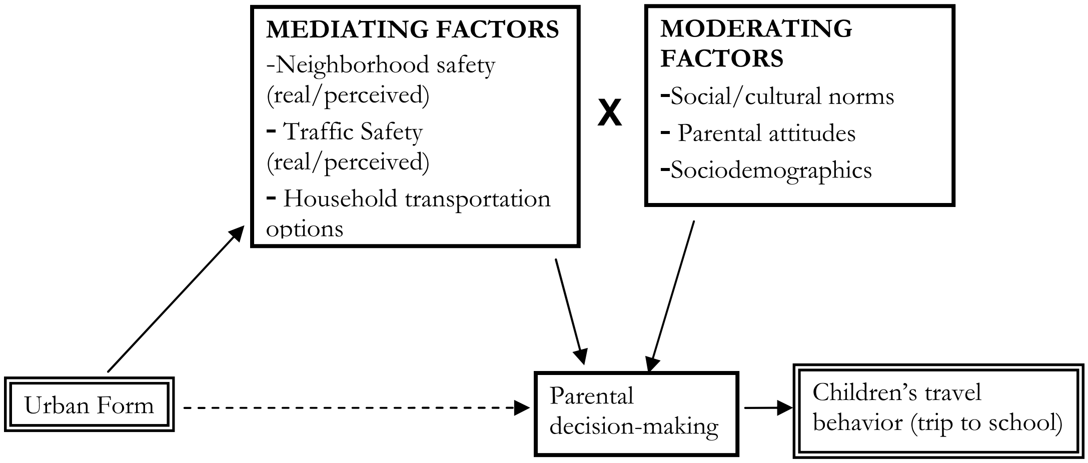

Figure 3.2 Diagram of the conceptual framework of an elementary-aged child's travel behavior. Solid arrows indicate hypothesized direct relationships; dotted arrows highlight hypothesized indirect relationships; X indicates interaction between mediating and moderating factors.

This conceptual framework of a child's trip to school assumes an elementary-aged school population (children aged 6-12) because: 1) in many instances, the geographic scale that elementary schools serve (neighborhood-based) may support walking and bicycling for a greater proportion of the school population, as compared to middle or high schools; and 2) the alarming pedestrian/bicycle injury and physical inactivity/obesity statistics for younger children indicate a need for further understanding of their behaviors and earlier intervention into their physical activity and travel patterns (Flegal,1999; Ozanne-Smith, 1992).

The framework assumes that up to a certain age, the final decision about the trip to school is most often made by the parents or caregivers in the household, not the child.

Therefore, that decision is not limited to the schedule, constraints or thoughts of the child, but is influenced in large measure by those of the parents or caregivers. In this sense, parental decision-making can be seen as an intervening causal variable, or mediator[6], of a child's travel behavior; meaning, it is a variable on the hypothesized causal pathway between urban form and a child's trip to school (Baron and Kenny, 1986; Bauman et al., 2002).

Parental decision-making itself may be a consequence of other intervening variables, however. Elements of urban form such as block length or street lighting may influence psychosocial factors (perceptions of safety and/or traffic) and/or socio-economic factors (household transportation options), which may in turn influence parental decision-making about how a child may travel to school (creating "a series of cascading mediators that intervene and are causally related in sequence" between urban form and a child's travel behavior to school) (Baumann, 2002, 7). It is these factors that bring out the nature and shape of the relationship of *how* urban form impacts a child's trip to school.

This portion of the framework is similar to Handy's model on the relationship between motivation to walk and urban form (1996b) except that the order of the suggested causal path is reversed. Handy's model suggests that given the motivation to walk, urban form is an external factor that can enable or hinder the actual walk. The conceptual framework presented here suggests instead that, given particular elements of urban form, a parent forms opinions about the ability of the physical environment to support different modes of travel for their child's trip to school and these opinions dictate the decision of how the child gets to school. As an example, the model suggests that it may not be the design of a street that directly affects a parents' decision about a child's travel; rather, the street design

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[6] "A given variable is said to function as a mediator to the extent that it accounts for the relation between the predictor and the criterion" (Baron and Kenny, 1986, p.1176). In this instance, urban form (e.g., sidewalks) is the predictor variable and a child's travel behavior is the criterion variable.

has a real and/or perceived impact on traffic, crime or household transportation options, which influences parents' decision about the trip to school. Therefore, a sidewalk may not be the panacea for low walking rates unless it addresses the underlying concerns parents have about a child's travel to school (e.g., traffic safety). An intervention focusing on changes in urban form to increase walking/biking to school may be best served by targeting elements known to affect the mediating factors identified along the decision-making path.

There may also be factors that have no apparent relationship to urban form and are not seen as intervening causal variables, yet affect parental decision-making about the trip to school (e.g., household income, number and age of children in family, cultural norms). Such variables may be moderators[7], meaning that the strength of the relationship between an intermediate variable and parental decision-making may vary for different levels of a variable (such as age or gender).

The rationale for the structure of the mediating and moderating factors in the relationship between urban form and a child's trip to school is outlined in the literature below.

Mediating factors

Neighborhood safety (real/perceived)

Elements of the urban form help to create a fear of criminal danger in parents that restricts their child's travel and play boundaries (Valentine, 1997; Moore 1986). Streets that are rundown in appearance and have low surveillance may promote a sense of danger to a pedestrian (Wilson and Kelling, 1982; Appleyard, 1981; Jacobs, 1961).

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[7] "…a moderator is a qualitative or quantitative variable that affects the direction and/or strength of the relation between an independent or predictor variable and a dependent or criterion variable" (Baron and Kenny, 1986, p.1174).

Two different surveys of parents revealed that parents were more worried that children may be abducted or harmed by a stranger than that the children would sustain a physical injury; this fear of abduction was a strong predictor of car travel to school (DiGuiseppi et al., 1998; Eichelberger et al., 1990). The fear of safety for children does not always translate into the same fear for adult's safety: results across several studies are mixed concerning the relationship between fear of safety and adult walking activity (Booth, 2000; Ross, 2000; King et al, 1999; Weinstein et al., 1999; Corti et al., 1996).

While the question of safety is typically asked at the neighborhood level, studies rarely dig deeper into this question to identify specific neighborhood factors associated with fear for children, or to determine if factors outside of the neighborhood environment have a greater influence on behavior (i.e., media). Actual levels of crime in an area may not correlate to the levels of fear that may exist in the population; therefore, interventions should address elements that relate to both real and perceived safety.

Traffic safety (real/perceived)

Streets with high traffic volumes and speeds put child pedestrians at greater risk of injury and death and lead to a reduction in walking behavior (Leaf & Preusser, 1999; Roberts et al., 1995; Mueller et al., 1990; Appleyard, 1981). This may be particularly true on streets directly adjacent to schools, with parents who drive their children to school contributing to the danger for those on foot or bike (Bradshaw, 2001). This real measure of danger or a parent's fear of traffic does not always predict whether a child will travel to school by car, however (DiGuiseppi et al., 1998). Perceptions of heavy traffic also have mixed effects on adult walking behavior, with some research identifying perceptions of heavy traffic as a major deterrent to walking (Corti et al., 1996) and other studies finding its impact on walking behavior to be less significant (King et al., 1999; Shriver, 1997). The influence of perceived and actual traffic safety on parent's decision-making may vary depending on the perception of control that parents feel they have over the child's behavior (e.g., through the presence of other individuals walking to school with the child or education on walking safety).

Household transportation options

Physical access, or proximity to destinations, creates an enabling environment that allows walking to be an option for travel in particular settings. Research shows that environments that support walking as a travel mode—by providing shorter distances to commercial areas, transit stops and recreational services— are associated with an increase in the number of walking trips or fraction of non-motorized trips by adults to these locations (Corti et al., 1996; Greenwald and Boarnet, 2001; Handy, 1996a; Handy 1996b; Kitamura et al., 1997). The presence and continuity of sidewalks also facilitates walking activity to destinations (Corti et al., 1996; Giles-Corti and Donovan, 2003; Hess et al., 1999; Kitamura et al., 1997; Moudon et al., 1997). Physical access works in the opposite direction as well, with increased trip distance and speed being associated with non-work car use (Cervero and Kockleman, 1997; Crane and Crepeau, 1998; Boarnet and Crane, 2001). Research indicates that access affects parents' decisions about their children's travel to school as well. The physical distance between home and school limits the transportation options available to a household, and was a large determinant in a parent's decision on how children travel to school (Bradshaw, 1995; DiGuiseppi et al., 1998). Decisions about school siting within a community could place real limits on the transportation options of a household by placing children out of walking or bicycling distance of a school or outside the limits of a transit route.

Other measures of household transportation options, such as access to an automobile, may also affect travel decisions. Possession of a driver's license, cars per persons in household and/or number of vehicles in the household have been found to be positively associated with auto trips and negatively associated with transit trips (Crane & Crepeau, 1998; Kitamura et al., 1997). Kitamura et al. (1997) also found that the association between the number of vehicles in the household and transit trips was greater than that between the distance to the nearest rail station and transit trips, suggesting that other factors besides a supportive physical infrastructure influence trip-making decisions.

Moderating factors

Attitudes

Parents' general attitudes and opinions may influence the decisions that are made about a child's travel mode to school. In a unique study that looked at the association between land use, transportation and attitudes, Kitamura et al. (1997) found that an individual's attitude (e.g., pro-environment, pro-transit, workaholic, automotive mobility) was a strong predictor of travel behavior, perhaps stronger than land use characteristics. While this study did not examine children's travel behavior directly, the findings suggest that a parent's attitude may potentially influence not only their own travel decision but also that of their child. A pro-environment parent may be more likely to make a decision to allow a child to walk, or to live in a setting that is physically supportive of walking, as compared to a workaholic parent. Though it has not been examined directly by researchers, children's attitudes may also potentially affect parents' decision-making—if a child does not want to walk to school, parents may be more inclined to decide to drive the child to school.

Social/cultural norms

As discussed earlier, research in the area of physical activity has shown that peer support is positively associated with activity in both adults and children (Giles-Corti and

Donovan, 2003; Hovell et al., 1991; Klesges et al., 1990; Sallis et al., 1992a; Sallis et al., 1992b; Sallis et al., 1989; Sallis et al., 1993; Stucky-Ropp and DiLorenzo., 1993; Zakarian et al., 1994). Such peer support could encourage walking to school as well, with a parent or child feeling more confident about the walk to school because of other children doing it, or other parents allowing it (Valentine, 1997).

A recent study presenting preliminary descriptive statistics from the 2001 Nationwide Household Transportation Survey (NHTS) found that automobile usage was highest among Whites, although the differences were not large [Whites-autos equal 87.6% of all trips, as compared to Asians and Hispanics (83.1%) and African Americans (78.9%]. Whites made less walking trips (8.6%) than the other three groups (12-13% of trips made by walking) and bicycling was highest among Whites and Hispanics (0.9% of all trips). Transit use showed the largest differences among racial and ethnic groups (Whites-0.9% of all trips, African Americans-5.3%, Hispanics-2.4%), with variations also existing across the various types of transit use (e.g., bus, commuter rail, metro) (Pucher and Renne, 2003).

It is well known that striking differences exist in modal distributions between the United States and many parts of the world (Cervero, 2003; Pucher and Dijkstra, 2003). Bicycling and walking account for less than 10% of all trips made in the United States. In many European countries these modes account for more than 25% of trips (Pucher and Dijkstra, 2003). Whether these cultural differences, which are partly explained by urban form (e.g., shorter travel distances, more accommodation for non-motorized travel), would remain if an individual moved to the United States is an interesting question.

Sociodemographic characteristics

Variables such as age, gender and number of children may influence parents' decisions about children's travel. Both the age and number of children in the household and household size have an effect on household auto trips, with larger households, households with children under 16, households with preschoolers and/or more children positively associated with the frequency of non-work auto trips (Boarnet & Sarmiento, 1998; Crane & Crepeau, 1998; Kitamura et al., 1997; Cervero and Kockelman, 1997). These results, along with earlier work by Rosenbloom (1987) and Rosenbloom and Burns (1993a, 1993b), indicate that many work and non-work car trips are generated by household and children's needs, whether it is for school, recreational activities or medical concerns. These studies showed that both mothers and fathers make a significant number of trips solely for children, with mothers making the majority of these trips for children up to age 17. In relation to this, over 60% of parents reported mothers as a child's most frequent source of travel (for both children under six and children 6-12 years of age), presumably by car, with more independent modes of travel (walking, bicycling, school bus) reporting less than 10% for each mode in both age groups. Studies also showed that parents' decisions about children's travel and outside independent play vary by gender, with boys having more freedom at an earlier age than girls (Valentine, 1997; Moore, 1986; van Vliet, 1983).

The analysis of the 2001 NHTS survey showed that while walking rates were highest among the lowest income group, the rates dropped quickly as income increased. Auto ownership was high even among the poorest households and was still the primary mode of travel (~75% own at least one car and cars account for ~75% of trips). Bicycle use did not vary across income levels (0.9%) (Pucher and Renne, 2003).

Testing the conceptual framework

The conceptual framework outlines the structure of the relationship between urban form and travel behavior, including the identification and role of other influencing factors on the path toward a travel decision. Like the activity-based framework, the conceptual framework suggests that there are multiple factors of influence on the decision of how to make a trip to school and that understanding how these factors are sequenced (or if they are) will assist in the development of more effective planning programs and policies.

This study focused on testing the framework by asking the following questions:

(1) What factors, including urban form, influence parental decision-making about an elementary-aged child's trip to school?

(2) Do neighborhood safety, traffic safety and/or household transportation options mediate the relationship between urban form and parental decision-making about a child's trip to school?

(3) Do social/cultural norms, parental attitudes, and/or socio-demographics modify the relationship between urban form and parental decision-making about a child's trip to school? and

(4) Do the identified relationships suggest that urban form indirectly, rather than directly, affects a child's trip to school?

Chapter 4

Methods

This study strives to be both exploratory and explanatory. The study provides much needed descriptive information on how schoolchildren travel to and from school, along with detailed information on what influences parents' decisions about the trip to school. Yet the study also begins to unravel the relationship between urban form and children's walking by testing an explanatory model that examines factors hypothesized to be related to parental decision-making about the trip to school, including key features of urban form.

A survey of parents was used to identify the key variables influencing the decision about a child's trip to school and an urban design assessment tool was used to measure characteristics of urban form in the neighborhoods near schools. The dissertation research drew data from a larger UCI study evaluating the California SR2S program. The principal investigator of this larger study is Marlon Boarnet. Tracy McMillan was the study coordinator of this study and was responsible for the development and administration of the parent survey to all study sites in the larger study. Details on research design and methods for both the larger UCI study and the dissertation study follow.

Research Design

The UCI SR2S study, funded by the University of California Transportation Centers, is a before and after evaluation of California's SR2S program. Using a quasi-experimental design, the study examines the effectiveness of different neighborhood and traffic construction improvements in increasing the safety and feasibility of children's non-motorized travel near schools. Data is collected at two time points (before and after neighborhood and traffic improvements) at a sample of 16 school sites awarded an SR2S study by Caltrans. Data collection for the larger UCI SR2S study includes traffic observations (motorized and non-motorized) at the point of the improvement, urban design observations and parent surveys.

As discussed earlier, one of the foundations of the California SR2S program is the premise that urban form impacts a child's travel to school; therefore, an improvement making walking and bicycling more feasible will increase the frequency and safety of these modes of travel to school. However, this premise is relatively untested. While the larger UCI SR2S study examines the effectiveness of the interventions used, the dissertation study sought to gain a greater understanding of the mechanisms of the relationship between urban form and the trip to school so that future traffic improvements can be better informed by research.

To accomplish this goal, the dissertation study used a cross-sectional design to examine time 1 data from twelve school sites taking part in the larger UCI SR2S study. While the data comes from twelve different groups (i.e., schools/neighborhood sites), the unit of analysis is the individual (i.e., parent). The parent survey and the neighborhood urban design observations served as the main data sources for the dissertation research. The traffic observations were not used in the dissertation research because they were representative of traffic at only one location along a route to school (i.e., at the point of the improvement), rather than of general traffic near the school (e.g., from a sample of streets along multiple routes to school).

Research sites

Twelve SR2S school sites recruited for the larger UCI study served as the study sample for the dissertation study. As mentioned in the conceptual model chapter, elementary schools were the focus of the dissertation research and the larger UCI study because of their neighborhood orientation and the more prominent role of the parent in travel decisions for elementary-aged children.

Elementary schools were recruited to participate in the study based on the approval of the municipality awarded the Caltrans SR2S grant. Approval was also received at the school district level when necessary. The criteria used for SR2S study recruitment in the larger UCI study are outlined below:

1. traffic/neighborhood improvements beginning in late spring/early summer 2002 to allow for baseline (pre-construction) data collection for the larger SR2S study;

2. traffic/neighborhood improvements targeting elementary schools;

3. overall sample of study sites must represent the range of 6 improvement types that Caltrans funds through the SR2S program; and

4. a primary focus on Southern California sites, due to budget issues.

While the recruitment of sites for the dissertation study was subject to the constraints of the larger study, all attempts were made to have the distribution of recruited sites reflect the population of California in terms of race/ethnicity, income and residential form (urban, suburban, rural). Nine of the twelve schools in the dissertation study had a census classification of being on the "urban fringe of a large city." One school was on the "urban fringe of a mid-sized city" while another was classified as a "mid-sized city." Only one site is classified as "rural area (metropolitan)." The schools varied in the percent ethnicities/races represented at each location. Five schools were predominantly Hispanic (over 90% of student body), but the remainder of schools were fairly heterogeneous in their make-up. More descriptive statistics on the twelve participating school sites and the study population follow this description of the research sites.

The UCI study worked with the Caltrans headquarters SR2S project manager, Randy Ronning, and Caltrans District SR2S coordinators to develop a list of eligible SR2S projects for recruitment. Based on the construction timeline information given by the Caltrans District SR2S coordinators, municipalities that began SR2S construction in the spring, summer or fall of 2002 were contacted about participation in the larger UCI SR2S study. Municipalities were contacted from the first two years of funding provided by Caltrans for SR2S (2000 and 2001 awardees). The contact name on the SR2S Caltrans application was phoned or a call was placed to the public works or planning department of the municipality if a contact was not listed. Only six projects out of 110 were not reached after repeated attempts. Thirty-four SR2S projects fell out of the construction timeline window, and nine projects targeted preschool, middle or high schools, leaving 61 sites as possible study participants. Once municipalities were informed of the UCI study, permission was asked to contact the elementary schools that their particular SR2S project focused on. Permission was granted in all cases.

Schools were the more difficult entity to contact and recruit. Of the 61 eligible projects, approximately 36 schools were not reached after repeated phone calls. There is nothing to indicate that these schools were any different than those recruited. All schools were clear in the demands placed on their time and it was oftentimes just luck in catching a principal on a good day. Most of the schools contacted had little awareness of the SR2S project that their school was a part of, possibly due to the long lead time between grant writing and project construction (over 2 years in many cases). Also, many schools had experienced administrative personnel change during that time. The larger UCI study was sensitive to the time constraints of school personnel and the re-education on SR2S that was likely needed in the materials sent to the school.

When contact was made and interest was expressed, the SR2S contact at each elementary school was sent a packet of materials that included a description of the study; a sample consent letter and survey; and a copy of the research protocol. Follow-up phone calls were made to the principal or vice principal to discuss the study and to obtain approval to participate. Once approval was granted, information on school hours, academic calendar and classroom numbers and sizes were collected to guide data collection scheduling. All formal procedures for research within each school and school district were followed, along with the formal research requirements of UCI. The larger UCI study received The University of California, Irvine Institutional Review Board expedited research approval as no identifiers of individuals were recorded during data collection. The dissertation study was included under this expedited research approval.

Data collection

Data for the dissertation study consisted of parent surveys and neighborhood urban design characteristics. Details on each of these data elements are outlined below.

Survey

The sample for the parent survey consisted of all parents with children in grades 3-5 attending the elementary school. This sample was originally estimated to be approximately 120-180 parents per school, based on 4-6 total classrooms of 30 children each (one parent per household). However, average sample size across the twelve schools was actually 367 parents (min. 222, max. 571). The original estimate was inaccurate because the number of classrooms at each school was greater than anticipated. In total, 4,405 surveys were distributed across twelve school sites (see Appendix A for parent survey).

Data collection began in the spring of 2002. Parent surveys were distributed to all children in grades 3-5 at the recruited schools to bring home to their parents for completion. Parents returned the completed survey to school via their child. With the school's permission, a small incentive (i.e., a ruler) was given to the child to thank them for their parent's participation. The surveys had no identifiers (e.g., parent names, addresses, Social Security numbers) other than a code for the school. An attached cover letter explained the purpose of the study, indicating Caltrans' and the school district's support of the study and asked for the parent's participation in the survey component of the study. The letter included contact information for the UCI SR2S study and UCI human subjects administrators. The letter asked the adult in the household most responsible for the care and upbringing of the individual child who brought the survey home to complete the survey. If two individuals were equally responsible for childcare, the letter asked one of these individuals to complete the survey. The parent was asked to complete the survey only in relation to the child who brought the survey home. No follow-up was conducted to capture non-respondents.

The survey was designed for a completion time of approximately 15 minutes. When possible, validated survey questions from existing instruments were used to develop this multi-component survey. The pedestrian safety, physical activity, urban design and transportation/travel behavior literature was reviewed to assess the presence and validity of instruments and was used to create new questions as needed (DiGuiseppi et al., 1998; Forward, 1998). In addition, a survey developed by this author for an earlier study on pedestrian safety and quality of life provided a helpful foundation.

The survey was developed in both English and Spanish in order to capture the Spanish-speaking, non-English speaking portions of the population in California (see Appendix 1 for survey instrument). Surveys were prepared in English, translated to Spanish, back translated to English, and edited to assure equivalence of the two versions. Surveys in both languages were designed for approximately a sixth-grade reading level. The English and Spanish versions of the survey were pilot tested to assess the construct validity of the instrument as well as its reasonableness in garnering responses. The surveys were evaluated in regards to: 1) readability, 2) length and 3) ability to measure the key variables of interest.

The parent survey was designed to elicit the factors that affect parental decision-making about travel behavior for children. As the conceptual model stated, an assumption was made that the final decision about travel to school is most often made by the parent or caregiver in the household, not the child. Therefore, the travel decision is likely not limited to the schedule, constraints or preferences of the child, but rather that of the parent or caregiver. In addition, travel choice is not only influenced by the rational thought that is outlined in the four-step model—"Do I need to make a trip?"; "Where will I go?"; "By what mode will I get there?"; and "By which route will I go?"—but also by beliefs, perceptions and attitudes about travel at each of these decision points (Ajzen, 1991; Ajzen, 1988; Bamberg and Schmidt, 2003; Handy, 1996c; McNally, 2000; Kitamura, 1997; Verplanken et al., 1994). For these reasons, the survey of parents[8] in this study focused primarily on:

> 1) parent's self-report of their child's travel to and from school and their own travel pattern related to the trip to school;

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[8] Note that no assumptions were made on the structure of households participating in this study. Therefore, for the purpose of this study "parent" is defined as that adult 18 and older most responsible for the care and upbringing of the child attending the school participating in the study. "Parent surveys" will be used to solicit information from an individual in this household that fits this description.

2) parent's perception of safety (crime and traffic) for their children while walking/bicycling to school;

3) parent's perception of the degree to which neighborhood design features influence their and their children's walking/bicycling behavior (e.g., traffic calming treatments, traffic speed);

4) parent's perceptions of driving behavior in the neighborhood around the school;

5) parent's attitudes towards walking, bicycling and the trip to school;

6) parent's feelings about the social and/or cultural norms about walking, bicycling and the trip to school;

7) parent's self-report of their own walking and bicycling activity; and

8) demographic questions about the household.

A total of 2,128 surveys were returned out of the 4,405 distributed--an overall survey response rate of 48%. While the overall response rate was within the anticipated range, the response rates by school varied from a low of 23% to a high of 72%. The same survey distribution procedures were used at each school. In the recruitment phase some principals expressed more confidence about the potential response from their parent population than others did, based on past experience with the parents. This may account for some of the variations in response rates across schools.

School bus-riders are another possible source of non-respondents. School bus-riders made up only 9.3% of survey respondents, a figure much lower than the approximately 16% of public school students who ride school buses in the state of California (Ed-Data, 2003; School Bus Fleet, 2003). At least one school in the sample did not offer school bus service. At four schools where school bus service was available, bus-riding made up less than one percent of the mode split. Since the survey focused heavily on the choice between walking and bicycling or driving, those parents whose children ride school buses may have felt the survey was not intended for them. The descriptive data presented in this chapter includes the school bus population. This population is removed from the sample in the analysis in chapters 5 and 6 because of the aforementioned concerns about the non-respondents being non-random.

Surveys were returned almost equally across grade levels sampled (3rd grade-36.8%, 4th grade-31.4%, 5th grade-25.9%), with 5th grade being slightly underrepresented because two schools only enrolled children in kindergarten-4th grade (Figure 4.1). The sample of children represented by their parents' responses was also almost equally split across sex (42.7% female, 37.8% male, 19.5% sex not indicated). The large amount of missing data for this particular demographic is due to the fact that the question was inadvertently left off the survey at the first two schools. The average age of the child bringing the survey home was 9.2 years old (standard deviation=0.966, interquartile range=2).

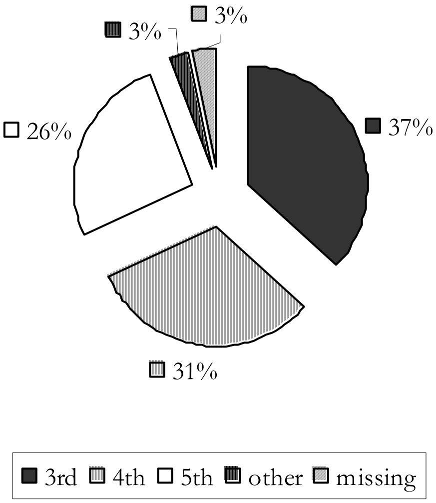

Figure 4.1 Grade distributions of children of survey respondents

Parents who returned the survey were of modest income, with over 45% of the sample having an average annual household income under $35,000 (Figure 4.2). This household income is significantly lower than the population living within each schools' census tracts, which had an average median household income of $44,638; and the California population as a whole (California median household income=$47,493) (U.S. Census, 2000).

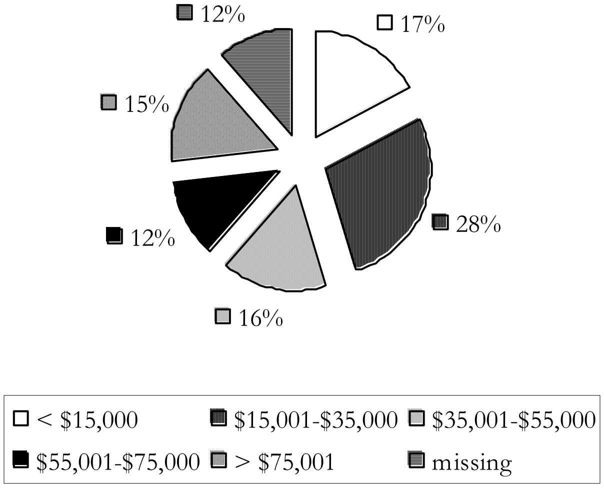

Figure 4.2 Average annual household income distributions of survey respondents

The average years of education of the parent filling out the survey was 10.9 (standard deviation=3.78, interquartile range=5). Education information was only collected on the parent completing the survey. Many houses may have a spouse with education beyond high school. Over 75% of parents were married or living with someone (Figure 4.3). The majority of households had more than one child under age 16 (89%). Children under the age of 5 were present in 33.4% of all households.

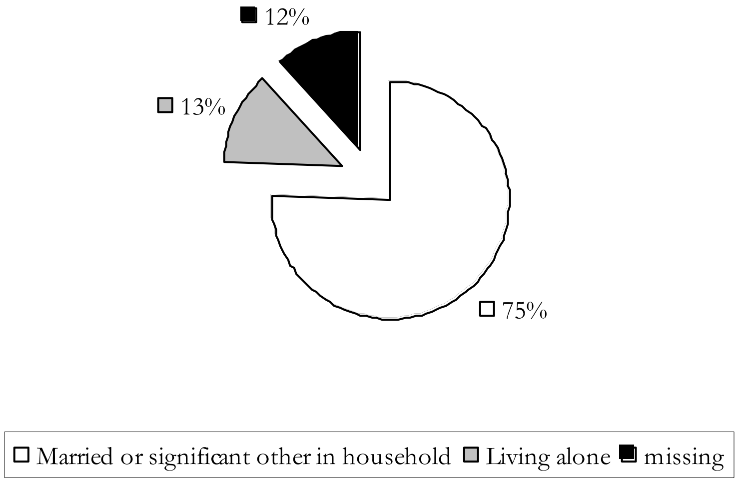

Figure 4.3 Marital status of survey respondents

Parents were asked a series of questions designed to address issues of cultural norms and residential longevity. Fifty-one percent of the sample population was born outside of the United States, with approximately 45% listing Mexico/Central/South America as their birthplace. Parents born in the U.S. made up about 44% of the respondents, while parents born in Asia (3%), the Middle East/India (2%) and Europe (1%) making up the remaining 11% (5% of respondents did not report a place of birth) (Figure 4.4).

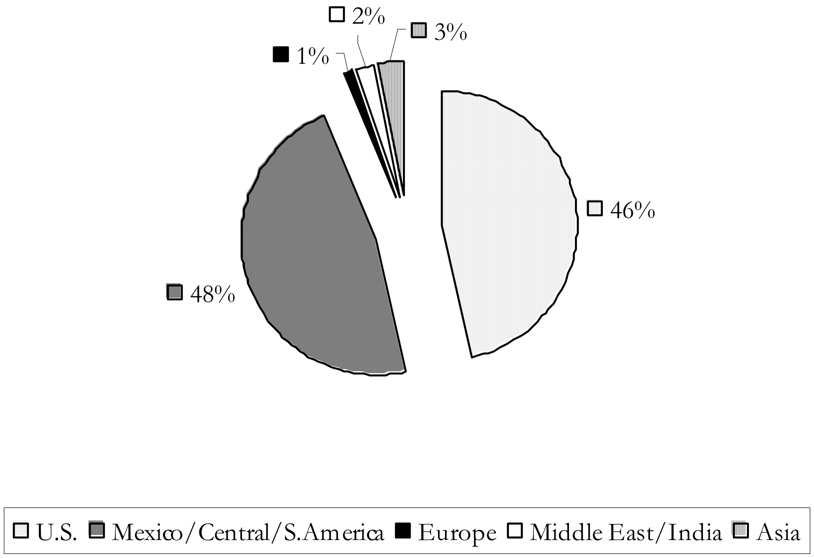

Figure 4.4 Survey respondents' country of birth

Over 86% of respondents have lived in the United States for more than ten years (Figure 4.5). Approximately 45% of respondents have lived in their neighborhood for over 6 years, with 11% being in residence for less than one year (Figure 4.6).

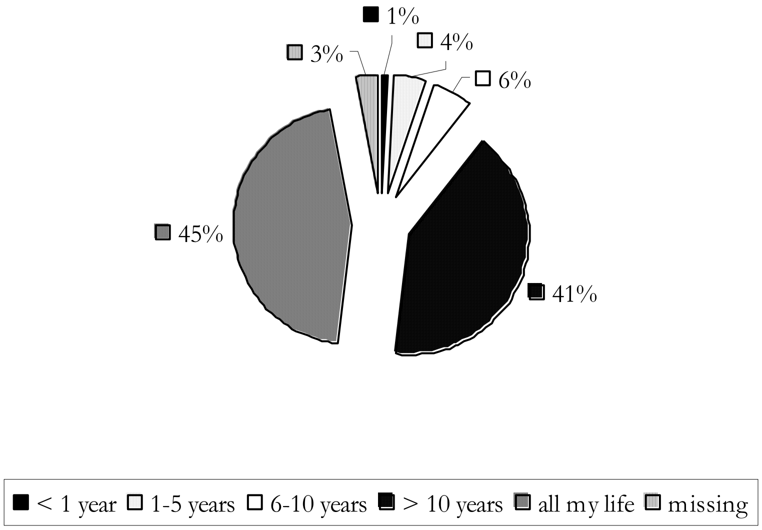

Figure 4.5 Survey respondents' reported length of time living in U.S.

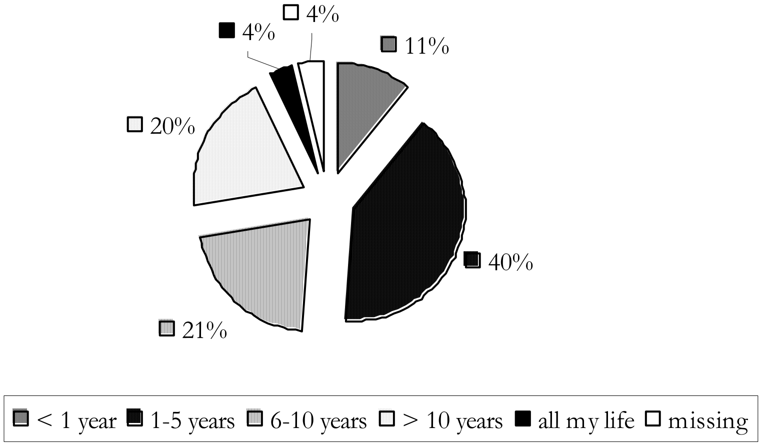

Figure 4.6 Survey respondents' reported length of time living in current neighborhood

Traveling to school by private vehicle was the primary mode for the trip to school (Table 4.1). When asked about how their child travels to school on a normal day, approximately 61% of the total sample indicated private vehicle as the primary mode (includes driven alone and in a carpool). Over 25% of the total sample population reported that on a normal day their children travels to school by walking or bicycling, while approximately 9% reported children traveling by school bus, transit or private bussing services (e.g., before-school day care van). Traveling by private vehicle was the predominant mode at each of the individual schools as well. Three of the more urban schools in the sample had walking/bicycling rates of over 40%. The lowest walking/bicycling rate to school was 5.4% at an elementary school in a rural-turning-suburban community in Riverside County (Figure 4.7).

Table 4.1 Normal mode of travel of child for the trip to school

Mode	Frequency	Percent	Cumulative percent
Walk/bike	551	25.9	25.9
Private vehicle (alone or carpool)	1,297	61.0	86.8
School bus, transit or daycare van	197	9.3	96.1
Missing	83	3.9	100.0

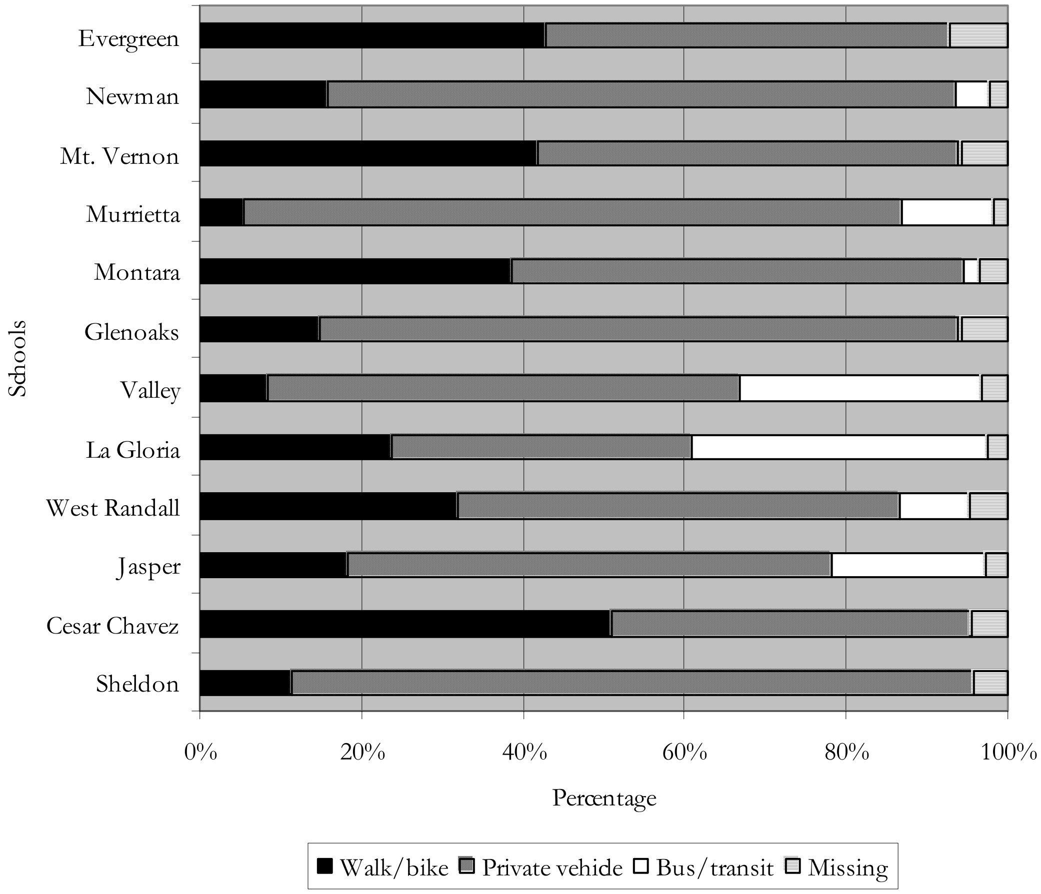

Figure 4.7 Normal mode of travel of child for the trip to school for each school

Children walked/biked and took the bus at slightly higher rates on the trip home from school (29.61% and 11.37%, respectively) (Table 4.2). This trend also existed at most of the individual schools as well (Figure 4.8). This increase presumably occurred because parent's work schedules made it more difficult to pick children up from school midafternoon than to drop them off at school in the morning on the trip to work. It might also reflect that children are slow to start in the mornings, which causes them to run late and need a ride to school!

Table 4.2 Normal mode of travel of child for the trip from school

Mode	Frequency	Percent	Cumulative percent
Walk/bike	630	29.6	29.6
Private vehicle (alone or carpool)	1,103	51.8	81.4
School bus, transit or daycare van	242	11.4	92.8
Missing	153	7.2	100.0

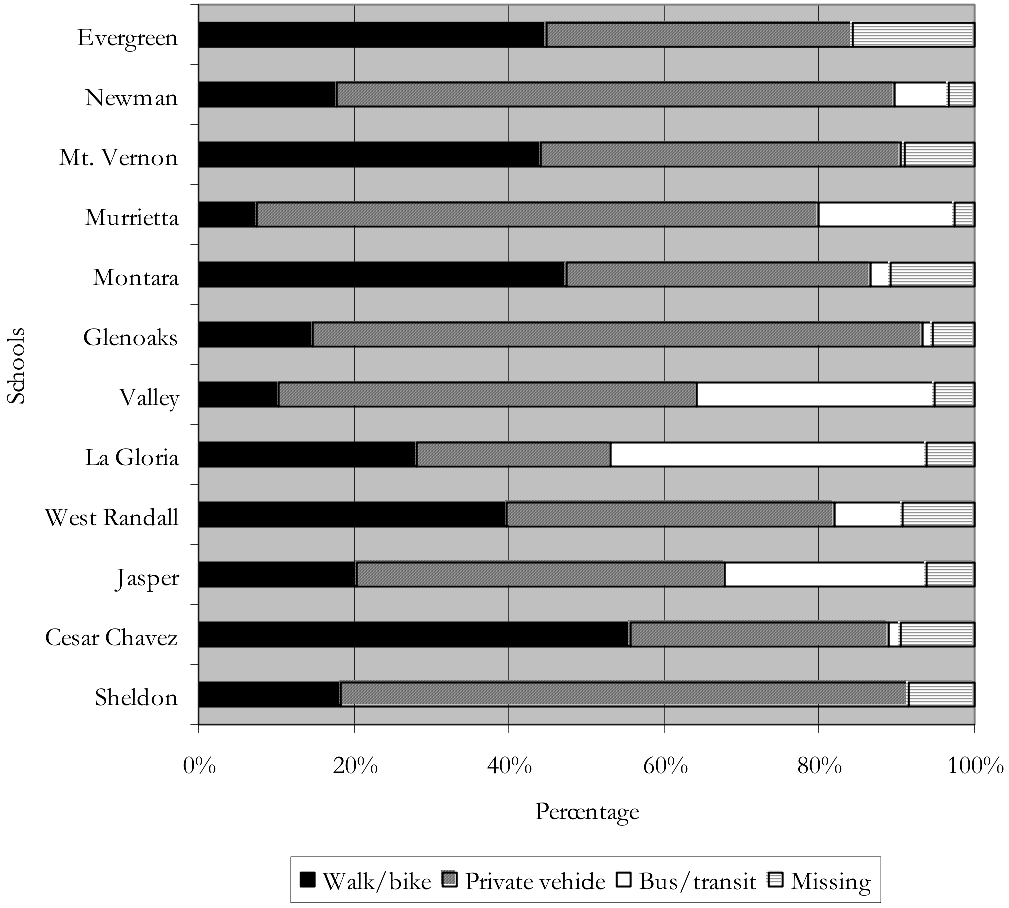

Figure 4.8 Normal mode of travel of child for the trip from school for each school

The majority of children were escorted to school by an adult (Table 4.3). Most children traveled to school with adults, with mothers being the primary escort (52% of children) and fathers about 9%. Approximately 8% of children were escorted by another adult within the household (e.g., grandparent) and 7% were escorted by an adult not from the household (e.g., school bus drivers, neighbor, day care services). A little over 11% of children traveled to school without an adult. On the way home from school, mothers were again the primary escort (44.6%). A slightly greater amount of children traveled without an adult (12.6%) or with an adult not from the household (10.4%). This result is consistent with the higher rates of children walking/bicycling or traveling by bus in the afternoon.

Table 4.3 Typical adult escort for child when traveling to and from school

	To school			From school		
	Frequency	**Percent**	**Cumulative percent**	**Frequency**	**Percent**	**Cumulative percent**
Mother	1107	52.0	52.0	945	44.6	44.6
Father	191	9.0	61.0	123	5.8	50.3
Other adult from household	170	8.0	69.0	175	8.2	58.6
Other adult not from household	150	7.1	76.0	221	10.4	68.9
Other	14	0.7	76.7	12	0.6	69.5
None; child travels alone	237	11.1	87.8	269	12.6	82.1
Missing	259	12.2	100.0	380	17.7	100.0

The trip to school was more commonly a single-purpose trip than part of a trip-chain. Table 4.4 provides information on where the parent went after dropping the child off at school. Over 53% of parents returned home. Approximately 22% traveled on to work or school, and about 6% ran errands (e.g., serving other family member's travel needs or shopping). In the afternoon the majority of parents went home after picking up their child

(64.3%). No information was gathered on where the parent was prior to picking the child up, so the afternoon travel pattern is less clear.

Table 4.4 Where do the parents go after dropping off/picking up their child?

	Dropping off			Picking up		
	Frequency	**Percent**	**Cumulative percent**	**Frequency**	**Percent**	**Cumulative percent**
Returns home	1,128	53.0	53.0	1,369	64.3	64.3
To work (not at home)	475	22.3	75.3	112	5.3	69.6
Shopping or other errands	70	3.3	78.6	48	2.3	71.9
Drop off/pick up other children or household members	50	2.4	81.0	75	3.5	75.4
Other	26	1.2	82.2	38	1.8	77.2
Missing *	379	17.8	100.0	486	22.8	100.0

* Includes those who were directed to not answer question because child traveled to school without an adult (237 children, see preceding table)

Short travel distances did not guarantee that the trip to school would be on foot. Approximately 55% of parents reported living within 1 mile of school, with about 21% of those parents stating they live with ¼ mile of the school (Table 4.5). Only 21.4% lived more than a mile away from school (9.5% of parents did not know the distance and 13.9% did not report distance). When this data is examined in relation to travel mode to school, 45.5% of those children living within a quarter mile of school walked/bicycled to school. Over 48% were driven in a private vehicle (Table 4.6). The percent of students walking/bicycling fell off precipitously for those living a quarter mile to a half mile from school: only 28.5% walked/bicycled compared to 68.5% being driven. For distances over ½ mile, walking/bicycling rates continued to drop, private vehicle rates stayed fairly constant and bus rates increased.

Table 4.5 Parent's reported travel distance from home to school for all modes

	Frequency	Percent	Cumulative percent
Less than ¼ mile	446	21.0	21.0
¼ mile – ½ mile	355	16.7	37.6
½ mile – 1 mile	372	17.5	55.1
Greater than 1 mile	456	21.4	76.6
Don't know	203	9.5	86.1
Missing	296	13.9	100.0

Table 4.6 Cross tabulation of the normal mode of travel for the trip to school by distance from home to school

	<1/4 mile	**1/4-1/2 mi.**	**½-1mi.**	**> 1 mi.**	**Not sure**	**Missing**	**Total**
Walk/ bike	202 36.7 45.3	101 18.3 28.5	65 11.8 17.5	16 2.9 3.5	69 12.3 33.5	99 18.0 33.5	551 100.0 25.9
Private vehicle	216 16.7 48.4	243 18.7 68.5	256 19.7 68.8	328 25.3 71.9	99 7.6 48.8	155 12.0 52.4	1297 100.0 61.0
Bus/ transit	9 4.6 2.0	6 3.1 1.7	39 19.8 10.5	98 49.8 21.5	25 12.7 12.3	20 10.2 6.8	197 100.0 9.3
Missing	19 22.9 4.3	5 6.0 1.4	12 14.5 3.2	14 16.9 3.1	11 13.3 5.4	22 26.5 7.4	83 100.0 3.9
Total	446 21.0 100.0	355 16.7 100.0	372 17.5 100.0	456 21.4 100.0	203 9.5 100.0	296 13.9 100.0	2128 100.0 100.0

For each mode: the first row represents the frequency, the second row represents the row percentages and the third row represents the column percentages.

Short travel times also did not equate to a walking trip to school. Over 75% of children live within ten minutes of school (all modes), with approximately 35% living within five minutes of school (Table 4.7). Like distance, however, a short travel time does not necessarily mean a walking trip. Eighty-one percent of trips to school of less than five minutes were made by private vehicle—only 14.7% were made by walking (Table 4.8). The majority of walking trips took ten minutes or less (66%); however, so did the majority of private vehicle trips (88.4%).

Table 4.7 Parent's reported travel time from home to school for all modes

	Frequency	Percent	Cumulative percent
Less than 5 minutes	736	34.59	34.59
5-10 minutes	890	41.82	76.41
11-20 minutes	337	15.84	92.25
More than 20 minutes	102	4.79	97.04
Not sure	26	1.22	98.26
Missing	37	1.74	100.00

Table 4.8 Cross tabulation of the normal mode of travel for the trip to school by travel time from home to school

	< 5 min.	**5-10 min.**	**11-20 min.**	**> 20 min.**	**Don't know**	**Missing**	**Total**
Walk/	108	259	154	21	3	6	551
bike	19.60	47.01	27.95	3.81	0.54	1.09	100.00
	14.67	29.10	45.70	20.59	11.54	16.22	25.89
Private	597	549	111	26	5	9	1297
vehicle	46.03	42.33	8.56	2.00	0.39	0.69	100.00
	81.11	61.69	32.94	25.49	19.23	24.32	60.95
Bus/	15	48	61	51	18	4	197
transit	7.61	24.37	30.96	25.89	9.14	2.03	100.00
	2.04	5.39	18.10	50.00	69.23	10.81	9.26
Missing	16	34	11	4	0	18	83
	19.28	40.96	13.25	4.82	0.00	21.69	100.00
	2.17	3.82	3.26	3.92	0.00	48.65	3.90
Total	736	890	337	102	26	37	2128
	34.59	41.82	15.84	4.79	1.22	1.74	100.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

For each mode: the first row represents the frequency, the second row represents the row percentages and the third row represents the column percentages.

Increasing traffic safety is a primary goal of programs like Safe Routes to School. Parents were asked a series of questions about potential traffic barriers their child may encounter if they were to walk or bike to school (or already did travel by these modes) (Table 4.9). Twenty-two percent of parents reported that their children would have to cross a road with more than four lanes of traffic along the route to school. Approximately 31.5% of children would cross a street at an intersection with an uncontrolled stop and about 35% of children would cross a street without a painted crosswalk. Almost 39% of parents said their children would have to walk in the road or on the edge of the road because of the lack of a sidewalk along the route. Finally, 43% reported the route to school was along roads with traffic speeds greater than 30 miles per hour.

Table 4.9 Potential traffic barriers on the way to school

"If **your child were to walk/bike to/from school (or already does), would they have to do any of the following on their way to/from school?"**	**YES**	**NO**	**Missing**
a. Cross a road with more than 4 lanes of traffic?	22.09% (470)	66.64% (1,418)	11.28% (240)
b. Cross a road at an intersection that doesn't have a street signal or a stop sign to stop traffic?	31.48% (670)	56.11% (1,194)	12.41% (264)
c. Cross a road at an intersection without a painted crosswalk?	34.73% (739)	52.63% (1,120)	12.64% (269)
d. Walk in the road or on the edge of the road because there is no sidewalk?	38.96% (829)	49.06% (1,044)	11.98% (255)
e. Walk or bicycle along a road or sidewalk that has traffic going more than 30 miles an hour?	43.14% (918)	44.83% (954)	12.03% (256)

Frequencies are in parentheses

Urban design

Data was collected on the urban design characteristics for the neighborhood surrounding each school site (see Appendix B for measurement tool and code book). A quarter mile was selected as the reasonable walking radius around each school based on the literature on American's willingness to walk (Untermann, 1984). On the two days that data was collected in the field at each site (i.e., traffic and urban design observations), two individuals walked each street segment (i.e., block)[9] as a team to record elements of the urban design hypothesized in the literature to be related to walking activity. In total, 410 street segments were measured across the twelve study sites, an average of 34.2 segments per study site. The minimum number of segments observed at a site was 13 (a rural-turning-suburban location) and the maximum was 55 (an urban site). Urban design data collection at each site took approximately 3 hours.

Table 4.10 summarizes the urban design characteristics assessed across the twelve study sites, while Table 4.11 presents summary urban design data for each individual school site. The proportion of blocks with a given characteristic was calculated for each study site and then d averaged across the twelve study sites was determined. The urban design data collection instrument included four sections—perceived traffic safety, perceived crime safety, actual traffic safety and aesthetics, based on how different elements of the urban design are suggested in the literature to impact walking/bicycling activity.

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[9] A block or street segment was defined as that portion of the street between two intersection points, or an intersection and dead-end for cul-de-sacs. Block and street segment are used interchangeably.

Table 4.10 Percentage of blocks within a ¼ mile radius of school with urban design characteristics*

	Average	Minimum	Maximum
Perceived Traffic Safety			
Blocks with complete sidewalk network	61%	8%	100%
Blocks with complete, buffered sidewalk network	54%	0%	87%
Blocks with bike lanes	0.1%	0%	2%
Blocks with bike lanes separated from the street	0%	0%	0%
Perceived Crime Safety			
Blocks with first floor windows facing the street	83%	46%	96%
Blocks with street lighting	81%	0%	100%
Blocks with no abandoned buildings	95%	83%	100%
Blocks with no rundown buildings	92%	75%	100%
Blocks with no vacant lots	83%	42%	95%
Blocks with no graffitti	83%	9%	100%
Blocks with no undesirable land uses	94%	86%	100%
Actual Traffic Safety			
Average # of traffic lanes	2	2	3
Average street width (ft.)	41	33	48
Average block length (ft.)	545	426	879
Average sidewalk width (ft.)	5	4	6
Blocks with traffic circles	0.3%	0%	2%
Blocks with bulbouts	0.6%	0%	3%
Blocks with speed humps	4%	0%	19%
Blocks with cul-de-sacs	15%	0%	39%
Blocks with medians	2%	0%	12%
Blocks with paving treatments	1%	0%	9%
Aesthetics			
Blocks with street trees	52%	0%	96%
Blocks with mixed use	31%	0%	72%
Blocks with public space	5%	0%	23%
Blocks with street furniture	4%	0%	10%

* Values summarized across 12 study sites; Average # blocks assessed across 12 schools=34.2, maximum=55, minimum=13.

Table 4.11 Percentage of blocks within a ¼ mile radius of school with urban design characteristics by school*

	Sheldon	Cesar Chavez	Evergreen	Glenoaks	Jasper	La Gloria	Montara	Mt. Vernon	Murrieta	Newman	Valley	West Randall
Perceived Traffic Safety												
Blocks with complete sidewalk network	53%	94%	49%	36%	57%	91%	100%	63%	8%	86%	22%	36%
Blocks with complete, buffered sidewalk network	10%	77%	42%	15%	57%	87%	84%	72%	8%	80%	0%	34%
Blocks with bike lanes	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%
Blocks with bike lanes separated from the street	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Perceived Crime Safety												
Blocks with first floor windows facing the street	81%	94%	79%	73%	91%	94%	82%	82%	46%	83%	94%	96%
Blocks with street lighting	88%	100%	53%	93%	100%	84%	92%	90%	0%	91%	50%	94%
Blocks with no abandoned buildings	98%	100%	98%	96%	93%	94%	96%	83%	100%	100%	100%	91%
Blocks with no rundown buildings	75%	89%	94%	96%	93%	97%	98%	82%	100%	94%	100%	91%
Blocks with no vacant lots	80%	94%	94%	95%	93%	94%	93%	48%	42%	94%	83%	71%
Blocks with no graffitti	95%	46%	55%	93%	93%	97%	9%	14%	100%	83%	100%	35%
Blocks with no undesirable land uses	98%	86%	98%	91%	94%	99%	91%	97%	100%	100%	94%	87%
Actual Traffic Safety												
Average # of traffic lanes	2	2	3	2	2	2	3	3	2	2	2	2
Average street width (ft.)	39	48	44	40	38	45	39	44	33	41	37	39
Average block length (ft.)	477	684	426	467	636	434	492	547	879	439	526	528
Average sidewalk width (ft.)	4	4	5	5	5	4	6	5	6	5	6	5
Blocks with traffic circles	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	2%
Blocks with bulbouts	0%	0%	0%	0%	3%	1%	0%	0%	0%	0%	0%	2%
Blocks with speed humps	3%	0%	2%	4%	2%	19%	4%	0%	0%	0%	0%	2%
Blocks with cul-de-sacs	20%	0%	9%	13%	32%	10%	0%	7%	0%	37%	39%	25%
Blocks with medians	12%	0%	11%	0%	2%	0%	0%	0%	0%	0%	3%	2%
Blocks with paving treatments	0%	2%	0%	0%	2%	9%	0%	0%	0%	0%	0%	2%
Aesthetics												
Blocks with street trees	7%	96%	67%	54%	59%	94%	81%	56%	0%	17%	0%	22%
Blocks with mixed use	10%	65%	44%	5%	6%	39%	45%	51%	72%	14%	0%	13%
Blocks with public space	0%	2%	0%	4%	0%	15%	1%	14%	23%	0%	0%	2%
Blocks with street furniture	0%	8%	2%	9%	0%	10%	9%	6%	0%	0%	0%	0%

*All values represent percentages except for average number of traffic lanes, average street width, average block length and average sidewalk width.

Perceived traffic safety

Perceptions of danger from traffic caused by the lack of pedestrian or bicyclist facilities may cause reductions in walking and bicycling activity on neighborhood streets. A study in Western Australia showed that the presence or absence of facilities for pedestrians affected individual's perception of traffic safety (Corti et al., 1996). Street segments were assessed for the presence of sidewalks and bike lanes and how much protection was available from automobile traffic for users of these facilities. Approximately 61% of the blocks assessed had a complete sidewalk network (i.e., sidewalks on both sides of the street). One study site had a relatively absent sidewalk network (minimum across schools=8%). Of those with a complete sidewalk network, 54% of those segments had a buffer present between the sidewalk and the roadway (buffers were defined as elements that separated the sidewalk user from the roadway; grassy strips and parking were the two primary buffers seen). Almost none of the blocks assessed had on-street, marked bike lanes or bike lanes that were separated from the street.

Perceived crime safety

Parent's comfort level about allowing children to walk to school may be affected by elements of urban design that relate to safety and security. Donald Appleyard's work showed that pedestrian activity is affected by the level of personal safety and security that an individual feels within their neighborhood and the cleanliness of the neighborhood (Appleyard, 1981). The "broken window theory" also supports the idea that a well-kept neighborhood is a more active neighborhood, socially and physically (Wilson and Kelling, 1982). Elements such as poor lighting and fewer eyes on the street can inhibit pedestrian activity (Demetsky, 1975; Jacobs, 1961; Shriver, 1997). Over 80% of the measured blocks had first floor windows visible from the street and street lighting, and lacked vacant lots.

The most rural site in the study sample completely lacked street lighting. The majority of street segments also lacked abandoned or rundown buildings and undesirable land uses (e.g., liquor stores, motels, pawn shops). Approximately 63% of the blocks lacked graffiti. However, at one school site only 9% of the blocks lacked graffiti.

Actual traffic safety

Walking activity to school may be affected by traffic conditions on neighborhood streets. Actual traffic safety was assessed by focusing on physical characteristics of the street environment that would affect traffic speeds and volumes, two variables related to pedestrian collisions (Appleyard, 1981; Mueller et al., 1990; Leaf & Preusser, 1999; Roberts et al., 1995). Since the majority of the segments assessed were residential streets, the average number of traffic lanes was two. Average street width across the school sites was 41 feet, average block length was 545 feet and sidewalk width averaged 5 feet. Traffic calming elements were largely absent from the study sites. Less than one percent of blocks had traffic circles or bulbouts, and only 4% had speed humps. Medians and paving treatments were present on only 2% and 1% of the segments, respectively. Cul-de-sacs were the most prevalent "traffic calming" feature, though while this feature controls traffic volumes on a street; it does not necessarily promote walking activity unless it contains a pedestrian outlet at the dead end of the cul-de-sac. Without this outlet walking distances become longer and more circuitous.

Aesthetics

General aesthetics of the neighborhood may affect walking activity. The aforementioned study in Western Australia showed that aesthetic features such as street trees, greenery and park space facilitated walking (Corti et al., 1996). A study by Booth et al. (2000), also in Australia, found that access to a local parking was positively associated with increased walking activity in older adults. Studies by Frank and Pivo (1995) and Kitamura et al. (1997) determined that the presence of mixed use was also associated with walking or non-motorized trips. In this current study, over 50% of the blocks contained street trees; however, only 5% of blocks had public space. Mixed use (any development other than residential within the ¼ mile radius of the school) was present on 31% of the blocks. Only four percent of blocks had street furniture.

The next two chapters present the results of the study. Chapter 5 tests the underlying assumption of SR2S programs of a direct relationship between urban form and children's travel behavior and presents other factors that influence the trip decision. Chapter 6 offers suggestions on how these factors actually relate to one another to determine the true relationship between urban form and travel behavior.

Chapter 5

The relative influence of urban form on a child's trip to school

The descriptive data in the previous chapter suggests that the trip to school is not easily explained by just examining urban form. Short distances did not guarantee a walk trip and neighborhood environments with characteristics thought to detract from walking such as long blocks had high walking rates to school. As previous studies have shown (Dellinger and Staunton, 2002; DiGuiseppi et al., 1998; Eichelberger et al., 1990), other factors besides urban form appear to affect school travel decisions.

The purpose of this chapter was twofold: 1) to provide information on what factors influence parental decision-making about an elementary-aged child's trip to school, focusing on the choice between walking/bicycling and private vehicle travel; and 2) to begin to determine the influence of urban form on the trip to school, relative to these identified factors. The general hypothesis was that urban form is an important contributing factor in a parent's decision about a child's trip to school, yet it is not the only factor. Specifically, the analysis focused on the role of the following factors in children's travel to school: neighborhood safety, traffic safety, household transportation options, parental attitudes, social/cultural norms, socio-demographics and urban form. The analysis informs the discussion about the journey to school and its relationship to urban form and provides insight into children's travel behavior and needs. It also advances the debate on walking and urban form by examining the relative influence of urban form in relation to other factors that may affect human behavior.

Analytical methods

Logit probability models were used to examine the likelihood of a child walking/bicycling to school. Travel that was not done by walking/bicycling was limited to that done by private vehicle or neighborhood carpool. Bus travel was not included in this analysis due to the aforementioned concerns with this portion of the survey sample.

The conceptual model proposed that the probability that an elementary-aged child walks or bikes to school is a function of parental decision-making. Parental decision-making itself was hypothesized to be a function of several factors: neighborhood safety (NS), traffic safety (TS), household transportation options (HTO), social/cultural norms (SC), attitudes (A), socio-demographics (SD), and as suggested in policies like Safe Routes to School, urban form (UF). In this analysis, since the parent reported the mode of travel to school, the trip to school variable was used as a proxy for parental decision-making.

Pr (walk to school)=f (parent decision)

Parent decision=f (**NS, TS, HTO, SC, SD, A, UF**)

therefore, Pr(walk to school)= f(**NS, TS, HTO, SC, SD, A, UF**)

Binary logit models were used to predict the likelihood of a child walking/bicycling to school versus traveling to school by private vehicle:

Pr(y=1|**x**)=exp(**xß**)/1+exp(**xß**),

where **x** is a vector of values and **ß** is a vector of parameters representing the independent variables included in the probability models. Variables were selected from the parent survey and urban design instrument to represent each of the factors outlined in the conceptual model. As discussed in the conceptual model and methods chapter, the factors and survey questions are based on relationships evaluated in the physical activity and travel behavior literature. Variables were included if they showed significant associations with the dependent variable in preliminary cross-tabulations and added significantly to the model in preliminary model estimation. Variables were also included in the model if they were theoretically and empirically relevant even if they did not add significantly to model fit (i.e., HSHLDINC, KIDS) (Giles-Corti and Donovan, 2002).

Two models were estimated to identify the key factors affecting the parent's decision about the trip to school, relative to urban form. The first model (factors model) contained variables from the parent survey that represented each of the factors highlighted in the conceptual model, excluding the urban form variables. A second model (urban form model) was then estimated that included the same variables as the first model and urban form variables from the objective measurement of urban design in order to assess the relative influence of urban form when controlling for other factors of influence. Variables were selected based on hypothesized relationships between characteristics of urban form and walking in the literature on travel behavior, physical activity, as discussed in Chapters 2, 3 and 4. The variables considered in the analyses are listed in Table 5.1. Their hypothesized associations with the probability to walk to school are listed in Table 5.2.

Table 5.1 Parent survey and urban design instrument variables examined for association with the probability of a child walking/bicycling to school

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Dependent variable—parent survey

MODE--mode of travel to school (1-walk/bike; 0-private vehicle or neighborhood carpool)

Independent variables

Neighborhood safety—parent survey

NOTSAFE—neighborhood is not safe for child to walk/bike to/from school alone (5 point scale, not true at all to very true)

Traffic safety—parent survey

DRVAWARE—likelihood of allowing child to walk/bike if people drove with more awareness (5 point scale, not very likely to very likely)

TRAFMPH—if child were to walk/bike, would they have to travel on road w/traffic >30mph (1=yes, 0=no)

WLKNOSDW—if child were to walk/bike, would they have to walk in road or shoulder because no sidewalk (1=yes, 0=no)

Household transportation options—parent survey

DRVLIC—number of licensed drivers in household

HSHLDCRS—number of cars in household

MITOSC—distance from home to school less than or equal to 1 mile (1=yes, 0=no)

TRVLTIME—travel time from home to school less than or equal to 10 minutes (1=yes, 0=no)

Social/cultural norms—parent survey

APRVFAM—how would family feel about parent's decision to allow child to walk to school (5 point scale, strongly disapprove to strongly approve)

BORNUS—was parent born in United States (1=yes, 0=no)

Attitudes—parent survey

INTERACT —importance of child interacting with other kids while going to/from school (5 point scale from not very important to very important)

SCLCLOSE—school is close enough to walk/bike (5 point scale, not true at all to very true)

DRVCONV—driving is more convenient/fits parent's schedule better (5 point scale from not true at all to very true)

Socio-demographics—parent survey

KIDS—number of children in household 16 & under

HSHLDINC—average annual household income (5 categories, acting like interval)

YRSEDUC—number of years of education of parent filling out survey

PCTHISP—percent of Hispanic students at school

Urban form variables—urban design instrument*

PR_SDW (neighborhood), QSDWALK (quadrant)—proportion of street segments within ¼ mile radius of school with sidewalks

PR_WIN (neighborhood), QWINDOWS (quadrant)--proportion of street segments within ¼ mile radius of school with < 50% of houses with windows facing street

PR_STLGHT (neighborhood), QSTLIGHT (quadrant)—proportion of street segments within ¼ mile radius of school with street lighting

PR_NOABBLD (neighborhood), QNOABBLD (quadrant)--proportion of street segments within ¼ mile radius of school with no abandoned buildings

STWIDTH (neighborhood), QSTWDTH (quadrant)--average street width of street segments within ¼ mile radius of school

BLKLNGTH (neighborhood), QBLKLNGTH (quadrant)—average block length of street segments within ¼ mile radius of school

PR_SPDHMP (neighborhood), QSPDHUMP (quadrant)-- proportion of street segments within ¼ mile radius of school with speed humps

PR_MU (neighborhood), QMU (quadrant)—proportion of street segments within ¼ mile radius of school with mixed use
URBAN—urban or suburban city? (1-urban, 0=suburban)

*Neighborhood indicates that the urban form variable is the proportion of all street segments within the ¼ mile radius of the school; quadrant indicates that the urban form variable is the proportion of street segments within the ¼ mile radius of the school disaggregated into four quadrants

Table 5.2 Hypothesized association between independent variables and the probability of a child walking/bicycling to school

Independent variables	Associations
Neighborhood safety	
NOTSAFE	-
Traffic safety	
DRVAWARE	+
TRAFMPH	-
WLKNOSDW	-
Household transportation options	
DRVLIC	-
MITOSC	+
TRVLTIME	- +
HSHLDCRS	-
Social/cultural norms	
APRVFAM	+
BORNUS	-
Attitudes	
INTERACT	+
SCLCLOSE	+
DRVCONV	-
Socio-demographics	
KIDS	-
HSHLDINC	-
YRSEDUC	-
PCTHISP	+
Urban form	
PR_SDW	+
PR_WIN	+
PR_STLGHT	+
PR_NOABBLD	+
STWIDTH	-
BLKLNGTH	-
PR_SPDHMP	+
PR_MU	+
URBAN	+

+ equals positive association; - equals negative association; +- equals an association that may be either positive or negative.

Regression results were examined to identify which variables affected the probability of walking/bicycling to school, relative to not walking (i.e., private vehicle travel), including the effect of urban form variables. A model improvement test was then performed to determine if the inclusion of urban form variables significantly improved the prediction of the likelihood of children walking/bicycling to school (Cervero, 2002). Finally, odds ratios were calculated for the statistically significant variables to determine the magnitude of effect a variable had on predicting travel to school by walking/bicycling. The odds ratios were examined to see the relative influence of each variable on the trip to school within a given model and to determine how the magnitude of effect for significant variables in the factors model changed with the addition of the urban form variables to the urban form model.

Results

The logit models summarized in Table 5.3 indicate that the probability of a child walking/bicycling to school is affected by several different factors, including urban form. Results from the factors model are presented first, followed by the expanded urban form model.

Table 5.3 Logit model comparison of factors that influence the probability of walking/bicycling to school

Independent		Factors model			Urban form model	
Variables	**Coeff.**	**Std. error**	**P> |z|**	**Coeff.**	**Std. error**	**P> |z|**
Neighborhood safety						
NOTSAFE	**-0.2055**	**0.0891**	**0.021**	**-0.2020**	**0.0948**	**0.033**
Traffic safety						
DRVAWARE	-0.0877	0.0958	0.360	-0.1345	0.1009	0.182
TRAFMPH	**-0.6099**	**0.2784**	**0.028**	**-0.7385**	**0.2944**	**0.012**
WLKNOSDW	***-1.1945***	***0.3066***	***0.000***	***-1.6154***	***0.3769***	***0.000***
Household transportation options						
DRVLIC	***-0.5552***	***0.2031***	***0.006***	***-0.5649***	***0.2127***	***0.008***
MITOSC	***1.4382***	***0.3664***	***0.000***	***1.3760***	***0.3742***	***0.000***
TRVLTIME	***-2.7127***	***0.4054***	***0.000***	***-2.8888***	***0.4309***	***0.000***
HSHLDCRS	-0.0461	0.1830	0.801	-0.1036	0.1906	0.587
Social/cultural norms						
APRVFAM	***0.3557***	***0.0865***	***0.000***	***0.3402***	***0.0909***	***0.000***
BORNUS	***-0.8273***	***0.3026***	***0.006***	***-1.1356***	***0.3392***	***0.001***
Attitudes						
INTERACT	***0.2892***	***0.0974***	***0.003***	***0.3298***	***0.0987***	***0.001***
SCLCLOSE	***0.2877***	***0.0977***	***0.003***	***0.2915***	***0.0991***	***0.003***
DRVCONV	***-1.0373***	***0.0986***	***0.000***	***-1.1004***	***0.1046***	***0.000***
Socio-demographics						
KIDS	0.1388	0.1068	0.194	0.1604	0.1127	0.155
HSHLDINC	-0.1965	0.1335	0.141	-0.1583	0.1432	0.269
YRSEDUC	***-0.1221***	***0.0459***	***0.008***	**-0.0982**	**0.0473**	**0.038**
PCTHISP	0.0068	0.0047	0.150	0.0624	0.0420	0.138
Urban form						
PR_SDW				0.0441	0.0342	0.197
PR_WIN				-0.0770	0.0784	0.326
PR_STLGHT				*-0.8064*	*0.0514*	*0.093*
PR_NOABBLD				*-0.1242*	*0.0668*	*0.063*
STWIDTH				*0.4047*	*0.2319*	*0.081*
BLKLNGTH				0.0166	0.0119	0.166
PR_SPDHMP				-0.0355	0.0387	0.360
PR_MU				-0.1816	0.1238	0.142
URBAN				0.2624	0.8286	0.751
Constant	***4.4553***	***1.2057***	***0.000***	4.1265	3.8653	0.286
Summary statistics						
Number of cases			904			904
Pseudo R^2			0.5681			0.5903
-2L (c): log likelihood function value, constant-only model			-512.698			-512.698
-2L (B): log likelihood function value, parameterized model			-221.460			-210.033
Model χ^2 (probability): -2[L(c)-L(B)]			582.48(0.000)			605.33(0.000)
Model improvement test: -2[L(factors model)- L(urban from model)]		χ^2=22.95	df=9	p=0.0065		

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

Factors model

In the comparison of traveling to school by walking/bicycling versus not walking in the factors model, parents reported that concerns about neighborhood safety (NOTSAFE) decreased the probability of a child walking/bicycling to school, supporting the hypothesis that parent's perception of danger in the neighborhood constrains children's freedom of movement.

Concerns about traffic safety also affected decision-making about child's travel behavior. Parents reported that traffic speeds greater than 30 miles per hour along the route to school (TRAFMPH) and the absence of a sidewalk on the route to school (WLKNOSDW) decreased the likelihood of walking/bicycling, providing some support for the general traffic safety premise that is part of SR2S policies.

As the conceptual model suggests, having options for transportation within the household may also affect decision-making about the trip to school. The results indicate that a reported distance from home and school of less than one mile (MITOSC) increased the probability of walking/bicycling. This is consistent with findings in other studies that identified distance (typically perceived distance, as reported here) as a barrier to walking to school (Dellinger and Staunton, 2002). However, an increased number of drivers in the household (DRVLIC) and a travel time of less than 10 minutes (irrespective of mode choice) between home and school (TRVLTIME) decreased the likelihood of walking/bicycling, suggesting that the mobility of automobile travel may outweigh the accessibility to school for walking. The number of cars in the household (HSHLDCRS) had no effect on walking/bicycling behavior.

Two variables designed to examine the impact of social/cultural norms on travel mode to school produced contrasting, yet anticipated results. A family's approval of the child walking to school (APRVFAM) increased the likelihood of walking/bicycling to school, while being born in the United States (BORNUS) decreased the likelihood of walking/bicycling to school, controlling for other variables in the model. Social support, as through the family network, has been studied extensively in the physical activity literature and, as found here, is positively associated with increased levels of activity (Giles-Corti and Donovan, 2003; Hovell et al., 1991; Klesges et al., 1990; Sallis et al., 1992a; Sallis et al., 1992b; Sallis et al., 1989; Sallis et al., 1993; Stucky-Ropp and DiLorenzo., 1993; Zakarian et al., 1994). The result that being born in the United States decreases the likelihood of walking/bicycling to school tests the hypothesis that societal/cultural differences may exist related to accepted/preferred modes of travel, in a sense validating the popular image of the U.S. car-dominated culture.

When parents perceived that the school was close enough for walking or bicycling (SCLCLOSE) and when they placed greater importance on the interaction with other children during the trip to school (INTERACT), the likelihood of walking/bicycling increased. However, when parents believed that driving was more convenient or fit their own schedule better (DRVCONV), the likelihood of walking/bicycling decreased. These variables highlight the underlying attitudes and values parents have about the trip to school and its place in the overall household travel pattern.

The years of education of the parent completing the survey (YRSEDUC) was the only socio-demographic variable included in the regression that affected the likelihood walking/bicycling to school, with an increase in education decreasing the likelihood of walking/bicycling. Household income (HSHLDINC), number of children in the household (KIDS), and percent Hispanic at the school (PCTHISP) had no influence on the likelihood of walking/bicycling to school.

Urban form model

The model was then expanded to include urban form variables. The inclusion of these variables did not change any of the relationships that appeared in the factors model, aside from minor changes in the magnitude of the coefficients and/or level of significance.

Only three urban form variables were significant in the urban form model. The results indicate that as the proportion of street segments within a quarter mile radius of the school that contained no abandoned buildings (PR_NOABBLD) increased, the likelihood of walking/bicycling decreased. The same result was also found for street lights (PR_STLGHT), with an increased amount of street segments with street lights decreasing the likelihood of walking/bicycling. The street width of street segments (STWIDTH) had the opposite effect, with increased widths increasing the likelihood of walking/bicycling. All three of these results are counterintuitive to popular movements such as the New Urbanism or Livable Communities, which suggest that walking is facilitated by narrower streets (helping to calm traffic and make a more pedestrian amenable environment) and a less threatening and aesthetically pleasing environment (in terms of personal safety and comfort).

While the results may be genuine, there are two possible methodological explanations for the outcome as well. First, the urban design measurement tool was developed from the literature and theories on walking activity. This information base, while helpful, is not without its biases, which may not have been accounted for in the measurement tool or the analysis. Current theories on walking and walkability measurement instruments tend to favor more urbanized areas as being more "walkable," partially because of the more advanced infrastructure development that exist in these locations. Elements that may inhibit walking in a more urban setting may have a different meaning or reason for being (or not being) in suburban or "rural becoming suburban" locations, like some of the sites in this study sample. For example, abandoned buildings are often less prevalent in these types of locations, partly because there is less development and is newer development when it does exist. Yet distances between origin and destination are typically further in these settings than in urban locations, making the automobile often the only feasible option. So, a decreasing rate of abandoned buildings may very well be associated with a decrease in the likelihood of walking/bicycling but it is probable that the lack of abandoned buildings represents something else about the setting. This measurement issue can be corrected for in future versions of the urban design measurement instrument through more context-sensitive variables of urban design.

Secondly, the results may also be due to the lack of variation in the urban form variables due to the small neighborhood sample size. While the overall survey sample size was quite large (N=2,128) the number of neighborhoods from which urban form data was collected was small (N=12). Therefore, the number of observations over which urban form may vary was quite limited, making any one data point potentially influential in the analysis. For example, the school with the highest walking/bicycling rate also had the widest streets. This particular issue can be partly addressed analytically and is discussed in more detail in a later section of the chapter.

Model Improvement Test

A model improvement test was performed to determine if the inclusion of urban form variables in the model significantly improved the model's ability to predict the probability of school travel by walking/bicycling. The model that contained all of the variables (in this case, the urban form model) was compared to the nested model (containing a subset of variables; in this case, the factors model variables) using the general test statistic for nested maximum-likelihood models:

$$X^2=-2(\ln L_1-\ln L_0)$$

The results at the bottom of Table 5.3 indicate that the urban form variables significantly improved the overall fit of the model, supporting the hypothesis that urban form is a contributing factor in parental decision-making about children's travel mode to school. However, the level of influence that individual urban form variables have on mode choice was fairly modest, as the odds ratios described next illustrate.

Odds ratios

In the comparison of walking/bicycling versus private vehicle travel, variables that were significant in the factors model tended to remain significant in the urban form model, with some variation in the magnitude of the coefficients and the level of significance. However, the coefficients and the levels of significance only highlight associations and do not provide much guidance on what were the most influential factors in parents' decisions about the trip to school. Therefore, odds ratios were calculated to see the magnitude of effect each variable has on the decision-making about the travel mode to school and to see the change in the magnitude of effect once urban form variables are included in the predictive model (Table 5.4).

Table 5.4 Odds ratios of factors that influence the probability of walking/bicycling to school (percent change in odds)

	Factor model % change in odds	Urban form model % change in odds
Neighborhood safety		
NOTSAFE	**-18.6**	**-18.3**
Traffic safety		
DRVAWARE	-8.4	-12.6
TRAFMPH	**-45.7**	***-52.2***
WLKNOSDW	***-69.7***	***-80.1***
Household transportation options		
DRVLIC	***-42.6***	***-43.2***
MITOSC	***321.3***	***295.9***
TRVLTIME	***-93.4***	***-94.4***
HSHLDCRS	-4.5	-9.8
Social/cultural norms		
APRVFAM	***42.7***	***40.5***
BORNUS	***-56.3***	***-67.9***
Attitudes		
INTERACT	***33.5***	***39.1***
SCLCLOSE	***33.3***	***33.8***
DRVCONV	***-64.6***	***-66.7***
Socio-demographics		
KIDS	14.9	17.4
HSHLDINC	-17.8	-14.6
YRSEDUC	***-11.5***	**-9.4**
PCTHISP	0.7	6.4
Urban form		
PR_SDW		4.5
PR_WIN		-7.4
PR_STLGHT		*-8.3*
PR_NOABBLD		*-11.7*
STWIDTH		*49.9*
BLKLNGTH		1.7
PR_SPDHMP		-3.5
PR_MU		-16.6
URBAN		30.0

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

In the factors model, the odds ratios indicated that several variables strongly influenced parents to drive their child to school rather than allow them to walk. The odds of walking/bicycling to school decreased by over 50% with each unit increase in the convenience of driving for the parent, being born in the United States, the lack of sidewalk on the route to school, and most significantly, a travel time from home to school of less than 10 minutes. Conversely, living within a mile of school provided the greatest impetus to allow a child to walk to school, while family support of walking, the importance of interaction with other children and school perceived to be close enough for walking/bicycling also influenced parents' decision-making (increasing the odds of walking/bicycling by over 30%). The magnitude of effect of living within a mile of school—making it over three times more likely that a child would walk to school rather than being driven, holding all other variables constant—was clearly the variable with the most influence. Interestingly, while there is much press about issues of personal safety dictating parents' decisions to drive children to school, the neighborhood safety variable had a relatively modest effect compared to others factors of influence.

Urban form variables entered into the urban form model did not significantly change the magnitude of effect of the aforementioned variables. More important to note is that the urban form variables themselves had a relatively modest influence over parental decision-making about the trip to school, compared to variables from the factors model. The odds of walking decreased by only 12% for each unit increase in the absence of abandoned buildings on street segments within a quarter mile of school, holding all other variables constant. Street lights had even less influence, only decreasing walking by 8% for each unit increase in street segments with street lights. However, the effect of street widths was more significant—for each unit increase in street width, the odds of walking/bicycling to school increased by approximately 50%. While the direction of these variables was not necessarily anticipated, the odds ratio results provide evidence that elements of urban form have varying degrees of influence on travel behavior.

An alternative model analysis

To address the problem of the lack of variation in the urban form variables, the urban form data was disaggregated down to the quadrant level using a question from the parent survey that asked individuals to identify on a map of the school neighborhood the quadrant that contained their house (Figure 5.1).

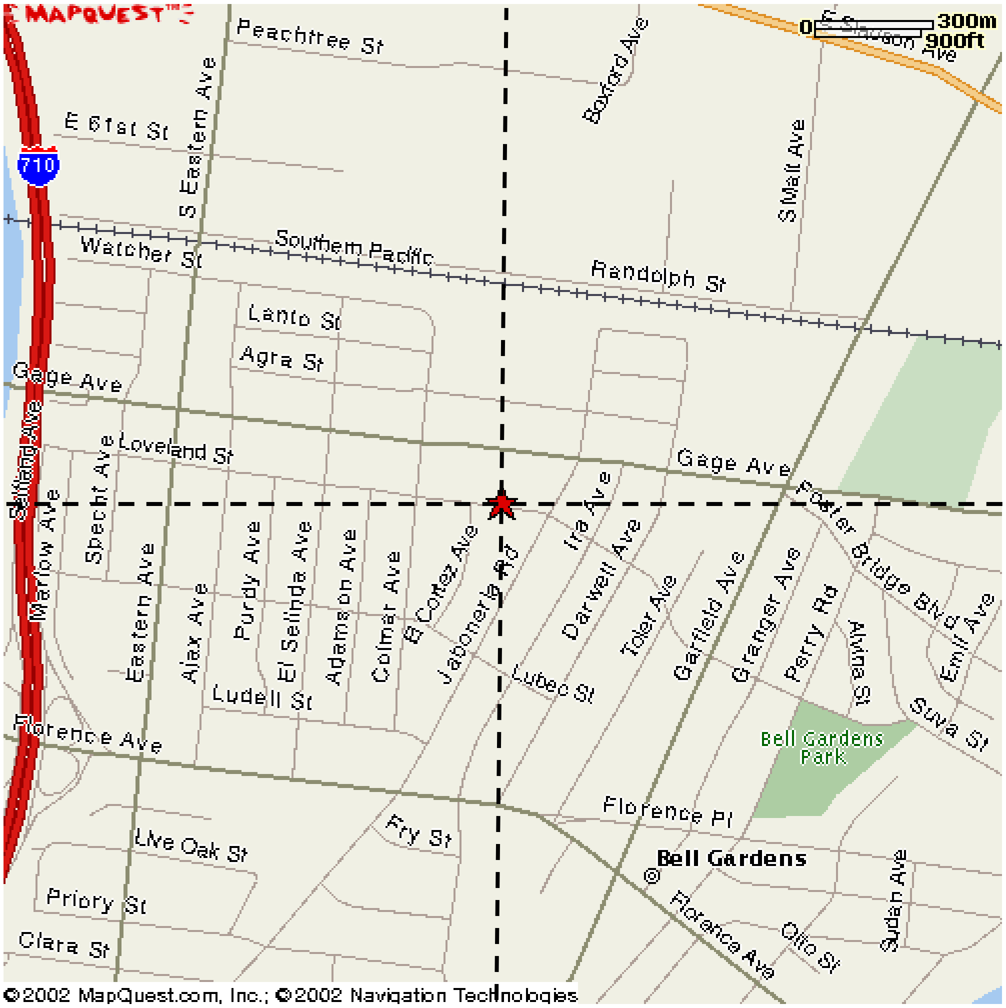

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Figure 5.1 An example of the map used on the parent survey to indicate neighborhood quadrant near the school. The location of the school is represented by the star at the center of the map. Parents were asked to place an "X" in the box that contained their home.

Street segments from the urban design measurements were then matched to the map from the survey. This increased the number of observations for the urban form variables from N=12 to N=48. However, as the results show, the trade-off with this analysis was the loss of regression sample size (N=594 versus N=904 for first analysis) since the survey quadrant question had a low response rate (68%).

The logit regressions outlined earlier in this chapter were re-analyzed using a sample that included only those who answered the quadrant question. Three models are presented: the factors model, the urban form model with the neighborhood-level urban form variables, and the urban form model with the quadrant-level urban form variables (Table 5.3).

Table 5.5 Alternative logit model comparison of factors that influence the probability of walking/bicycling to school, smaller sample

Variables	**Factors model**			**Urban form model, neighborhood level**			**Urban form model, quadrant level**		
	Coeff.	**Std. error**	**P<|z|**	**Coeff.**	**Std. error**	**P<|z|**	**Coeff.**	**Std. error**	**P<|z|**
Neighborhood safety									
NOTSAFE	**-0.2299**	**0.1060**	**0.030**	*-0.1936*	*0.1146*	*0.091*	*-0.2026*	*0.1140*	*0.076*
Traffic safety									
DRVAWARE	0.0016	0.1181	0.989	-0.0706	0.1229	0.566	-0.0509	0.1237	0.681
TRAFMPH	*-0.6049*	*0.3246*	*0.062*	*-0.5791*	*0.3438*	*0.092*	*-0.5940*	*0.3375*	*0.078*
WLKNOSDW	***-0.9809***	***0.3588***	***0.006***	**-0.9436**	**0.4433**	**0.033**	***-1.1742***	***0.4422***	***0.008***
Household transportation options									
DRVLIC	-0.3444	0.2223	0.121	-0.3570	0.2322	0.124	-0.3121	0.2303	0.175
MITOSC	***1.2272***	***0.4500***	***0.006***	***1.2153***	***0.4651***	***0.009***	***1.2170***	***0.4625***	***0.009***
TRVLTIME	***-2.2566***	***0.4484***	***0.000***	***-2.3292***	***0.4790***	***0.000***	***-2.4009***	***0.4776***	***0.000***
HSHLDCRS	-0.0096	0.2138	0.964	-0.1076	0.2269	0.635	-0.1012	0.2252	0.653
Social/cultural norms									
APRVFAM	***0.4303***	***0.1022***	***0.000***	***0.4348***	***0.1075***	***0.000***	***0.4220***	***0.1066***	***0.000***
BORNUS	**-0.7830**	**0.3423**	**0.022**	***-1.0476***	***0.3821***	***0.006***	**-0.9099**	**0.3671**	**0.013**
Attitudes									
INTERACT	0.1548	0.1160	0.182	0.1833	0.1185	0.122	0.1640	0.1187	0.167
SCLCLOSE	**0.2668**	**0.1168**	**0.022**	**0.2692**	**0.1185**	**0.023**	**0.2664**	**0.1197**	**0.026**
DRVCONV	***-1.0396***	***0.1139***	***0.000***	***-1.0661***	***0.1172***	***0.000***	***-1.0740***	***0.1182***	***0.000***
Socio-demographics									
KIDS	0.1211	0.1225	0.323	0.1254	0.1304	0.336	0.1218	0.1283	0.342
HSHLDINC	-0.2619	0.1610	0.104	-0.2483	0.1729	0.151	*-0.2820*	*0.1686*	*0.094*
YRSEDUC	***-0.1779***	***0.0576***	***0.002***	***-0.1539***	***0.0599***	***0.010***	***-0.1581***	***0.0602***	***0.009***
PCTHISP	0.0031	0.0056	0.586	0.0712	0.0437	0.104	-0.0018	0.0079	0.825
Urban form									
PR_SDW				*0.0638*	*0.0367*	*0.082*			
PR_WIN				-0.0970	0.0844	0.251			
PR_STLGHT				**-0.1067**	**0.0543**	**0.050**			
PR_NOABBLD				**-0.1424**	**0.0707**	**0.044**			
STWIDTH				*0.4418*	*0.2452*	*0.072*			
BLKLNGTH				*0.0212*	*0.0126*	*0.093*			
PR_SPDHMP				0.0017	0.0457	0.970			

PR_MU				*-0.2306*	*0.1299*	*0.076*			
QSDWALK							-0.0059	0.0065	0.366
QWINDOWS							0.0020	0.0098	0.841
QSTLIGHT							*0.0179*	*0.0094*	*0.056*
QNOABBLD							-0.0084	0.0096	0.383
QSTWDTH							-0.0005	0.0259	0.986
QBLKLNGTH							-0.0002	0.0009	0.809
QSPDHUMP							-0.0353	0.0220	0.109
QMU							*0.0119*	*0.0072*	*0.100*
URBAN				1.0202	0.9320	0.274	-0.5864	0.4116	0.154
Constant	***4.7240***	***1.4952***	***0.002***	4.2919	4.2756	0.315	**4.9913**	**2.1792**	**0.022**
Summary statistics									
Number of cases			594			594			594
Pseudo R^2			0.5392			0.5570			0.5543
-2L(c): log likelihood function value, constant-only model			-356.543			-356.543			-356.543
-2L(B): log likelihood function value, parameterized model			-164.290			-157.961			-158.912
Model χ^2 (probability): -2[L(c)-L(B)]			384.51(0.000)			397.17(0.000)			395.26(0.000)
Model improvement test:		χ^2=12.66	df=9	p=0.1787					
-2[L(factors model)- L(urban form neighborhood model)]									
Model improvement test:		χ^2=10.76	df=9	p=0.2928					
-2[L(factors model)- L(urban form quadrant model)]									

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

Factors model

Results of the factors model that accounts for missing quadrant data were similar to the previously-presented factors model.[10] The likelihood of children walking/bicycling to school decreases with an increase in parents' concerns about neighborhood and traffic safety (NOTSAFE, TRAFMPH and WLKNOSDW), as well as an increase in the convenience of driving for parents (DRVCONV). A travel time of less than ten minutes to school (TRVLTIME), more years of education (YRSEDUC) and the parent being born in the United States (BORNUS) also had a negative effect on the probability of walking. However, the number of licensed drivers in the household (DRVLIC) was not significant in this model.

A reported distance from home to school of less than one mile (MITOSC) increased the likelihood of walking/bicycling to school, as did family approval of the walk to school (APRVFAM) and the perception that school was close enough to home to walk/bike (SCLCLOSE). Unlike the previous factors model, the level of importance parents placed on interaction with other children during the trip to school (INTERACT) was not significant in this model.

Urban form model, neighborhood-level

Relatively little change was seen in the variables from the factors model when the neighborhood-level urban form variables were added to the model. While the variables representing parents' concerns about neighborhood and traffic safety became less significant (NOTSAFE and TRAFMPH), they remained so at the $p<0.10$ level. Being born in the U.S. (BORNUS) became more significant with the addition of the urban form variables. The percent of Hispanic students (PCTHISP) became marginally significant in this analysis,

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[10] A direct comparison between these two models is not possible as the samples used in the analyses differ. The previous model is used only as a point of reference.

suggesting that as the population of Hispanic students increased, the likelihood of walking/bicycling increased. The signs on all of the coefficients remained the same, with the exception of driver awareness (DRVAWARE), which was highly insignificant.

A greater number of urban form variables were significant in this model than the previously analyzed urban form model.[11] As in prior results, an increased proportion of street segments with no abandoned buildings (PR_NOABBLD) again decreased the likelihood of walking/bicycling to school, as did an increased presence of street lighting (PR_STLGHT). Similarly, as street width (STWIDTH) increased, the likelihood of walking/bicycling also increased. Two other urban form variables were significant and in directions that were opposite that expected based on walkability theories. The likelihood of walking decreased as the proportion of street segments with mixed use (PR_MU) increased, yet the probability of walking increased as block length (BLKLNGTH) increased. Both results were unexpected (see Table 5.2). Mixed use is generally assumed to promote neighborhood pedestrian activity by putting more destinations within a neighborhood environment (Calthorpe, 1993; Katz, 1994). In terms of block length, it is suggested that shorter walking distances are more appropriate to promote walking activity (Calthorpe, 1993; Katz, 1994). This is partially achieved by shorter block lengths, which may not actually shorten a walking distance but may give the perception of a shorter and more complex (i.e., varied) walking trip. Shorter block lengths also increase accessibility to various locations along a walking route.

Finally, one result was consistent with the walkability theories: as the proportion of street segments with a completed sidewalk network (PR_SDW) increased, the probability of

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[11] A direct comparison between these two models is not possible as the samples used in the analyses differ. The previous model is used only as a point of reference.

walking/bicycling to school increased. The next urban form model tested whether the level of aggregation in the urban form data contributed to these unanticipated results.

Urban form model, quadrant-level

The inclusion of the urban form data at a more disaggregated level caused some changes in the results of the analysis, particularly in the urban form variables. The variables from the factors model representing neighborhood safety, traffic safety, attitudes, social/cultural norms and socio-demographics shifted in the level of significance and the value of the coefficients from the previous urban form model with neighborhood-level data. In particular, household income (HSHLDINC) became significant for the first time in this model, indicating that as household income increases, the likelihood of walking/bicycling to school decreases. The percent of Hispanic students was insignificant in this analysis, however.

Significant differences were seen in the results of the urban form variables from the neighborhood-level model to the quadrant-level model. First, the variable that assesses the impact of a complete sidewalk network, QSDWALK, was no longer significant in the quadrant-level analysis, and interestingly, the sign of its coefficient also changed (from positive to negative). The impact of street lights (QSTLIGHT) on walking/bicycling to school remained significant yet now had a positive sign on the coefficient. This indicates that an increase in the presence of street lights increases the probability of walking/bicycling to school, as originally hypothesized (see Table 5.2). However, the coefficient was much smaller in this model than in the neighborhood-level model, signifying that the level of influence of this urban form variable is limited. The impact of the absence of abandoned buildings (QNOABBLD) on walking activity was no longer significant, nor was street width (QSTWDTH) or block length (QBLKLNGTH). Despite the lack of significance, it is important to note that a change is seen in the sign of the coefficient for these last two variables. These results now suggest that an increase in block length or street width would decrease the likelihood of walking/bicycling, a result more in line with walking behavior hypotheses (see Table 5.2).

Interestingly, the proportion of street segments with speed humps (QSPDHUMP) became marginally significant in this analysis with a negative coefficient, indicating a decrease in the likelihood of walking/bicycling activity with an increase in street segments with speed humps. Again, this result does not match hypotheses about urban form and walking behavior that suggest speed humps, used as a traffic calming measure, would increase the probability of walking/bicycling activity. Finally, the effect of street segments with mixed use (QMU) remained significant in the quadrant-level model and the sign became positive, suggesting that an increase in the proportion of street segments within a quarter-mile radius of the school with mixed use increases the likelihood of walking/bicycling to school.

Model improvement test

The model improvement tests at the bottom of Table 5.5 indicate that the inclusion of urban form variables in the model did not significantly improve the model's ability to predict the probability of school travel by walking/bicycling at either the neighborhood-level or the quadrant-level of urban form data. Therefore, this finding does not support the hypothesis that urban form is a contributing factor in parental decision-making about children's travel mode to school. This result differs from that found in the earlier model improvement test; however, direct comparison is not possible between these two results due to the differences in sample size. The finding is likely due to the small number of significant relationships and the low values of the coefficients found in the alternative model analysis, especially at the quadrant-level of urban form variables.

Discussion

The results of the analysis support the hypothesis that urban form is important, but not the sole factor that influences a parent's decision about a child's trip to school. Other factors may be equally important such as neighborhood safety, traffic safety, household transportation options, parent attitudes, social/cultural norms, and socio-demographics. The findings provide useful information that advances the scientific knowledge on children's travel behavior and highlights important methodological considerations in this type of research.

Each of the model comparisons found that objectively-measured urban form variables had some influence on the probability of a child walking or bicycling to school. The variables had a modest effect on travel mode choice, however, when compared to the other variables in the model. Variables that had not previously been considered in studies of travel behavior (one exception being Kitamura, et al., 1997), such as attitudes towards mode choice and place of birth, were very influential in decisions about the trip to school, even when urban form was taken into account. Variables that represented perceptions of the urban form—reported vehicle speeds and distance—also strongly influenced the trip to school. These initial results are useful to planners because it begins to suggest how elements of urban form can be used to address underlying concerns or perceptions parents have about travel. For example, a design element such as traffic calming may be useful around schools to reduce the perceived speed and convenience of driving, while perceived distance is a factor to consider in the siting of new schools, perhaps through the determination of a threshold *perceived* distance for walking. The results also lend support to the hypothesis that urban form has more of an indirect relationship to the trip to school rather than the direct relationship suggested in the current policies/programs surrounding the journey to school. This hypothesis is tested further in the next chapter.

Testing the models at different levels of geographic scale for the urban form variables was not initially intended but was a useful methodological exercise. Due to the concern that the results (or lack of results) found for the urban form variables may be partially caused by the small neighborhood sample size, new models were analyzed that disaggregated urban form to the neighborhood quadrant level, allowing characteristics of urban design to be more closely matched with the parents who lived within a given quadrant. Relatively little change was seen in the comparison between the factors model and the neighborhood-level urban form model from the primary model set examined. This was not entirely unexpected, since only sample size had changed at this point of the alternative model analysis. When the urban form data was included in the model at the quadrant level, however, several changes in the results did occur, primarily for the urban form variables. Many variables that had been significant in the neighborhood-level urban form model lost significance, while the sign on several other variables changed. New variables also became significant.

These changes highlight the effect of disaggregated data when measuring urban form, particularly for walking behavior. The variations in the urban environment, which are noticeable to pedestrians at a finer grain than in an automobile, can become diluted when data is aggregated. The characteristics of the urban environment can also become exaggerated at the aggregate level. For example, if a given school in the sample had, on average, wide streets in the neighborhood yet also many children walked, the result that wider streets increase the likelihood of walking/bicycling could be found (as it was).

Disaggregating the urban form data reduces the effect of influential data points and provides a more accurate picture of the physical environment at the individual level of analysis.

In this study, however, the effect of disaggregating the data must be weighed against the effect of a loss in sample size. A reduction in sample size causes an increase in the standard error and a more insensitive hypothesis test, thereby reducing the probability of detecting a false null hypothesis (a Type II error) (Witte and Witte, 1997). Standard errors were slightly higher with the smaller sample in the alternative model analysis as compared to the first analysis. Therefore, while the results of disaggregating the urban form data to the quadrant level were discouraging from the standpoint of a lack of significance of urban form on travel behavior, they may be viewed with anticipation that an increase in sample size with data at the quadrant level may yield different results.

It is also important to note that while the direction of some of the significant urban form variables contradicted previous hypotheses and results, this does not mean the results were incorrect or that they do not provide useful information. The significant mixed use result found in the alternative model analysis may indicate that an element suggested to promote walking in adults may not be an attractive element when parents are considering their child's walking behavior, highlighting the importance of population-specific measures. The results may also be a reflection of the need to develop a measurement tool more sensitive to the type and level of development being examined. As mentioned earlier, a neighborhood that has a more developed infrastructure may conform better (produce a more "expected" results) to current evaluation tools for walkability.

This analysis was the first step towards the complete testing of a model of children's travel behavior, specifically the trip to school. As the conceptual framework outlines and this analysis shows, urban form is a significant contributing factor in a parent's decision about how their child gets to school. There are other factors to consider, however, besides urban form. It is important for planners to determine what role each factor plays in the decision-making process to develop safe and effective interventions to get children to school in less auto-dependent ways. Modeling children's travel behavior involves not only determining how urban form relates to the mode choice to school, but how it relates to these other factors of influence. The next chapter tackles this issue by examining the nature and shape of the relationships between variables.

Chapter 6

Examining the indirect relationship between urban form and a child's trip to school

The previous chapter provided evidence that urban form plays a fairly modest role in parental decision-making about children's travel to school. Does this mean it has little influence on decision-making or rather does urban form play an important role but one that occurs indirectly? One of the primary hypotheses of the conceptual framework is that the relationship between urban form and children's travel behavior is indirect and is mediated by three factors—neighborhood safety, traffic safety and household transportation options. This chapter explains and tests the concept of mediating factors, or the indirect effect of urban form. It moves beyond the analysis presented in chapter 5 by examining a directional relationship between variables rather than a basic test of association (Hoyle, 1995). This chapter also examines whether the hypothesized relationships occur equally across segments of the population by looking at factors that may moderate the effect between the independent and dependent variables. The analysis used the larger data sample with neighborhood-level urban form variables (N=904) because of the increased power to detect small effects in larger sample sizes (MacKinnon, et al., 2002; Witte and Witte, 1997).

Mediators and moderators

A mediator is a variable that explains the relationship between an independent and dependent variable. Figure 6.1 diagrams the mediation model within this study's conceptual framework. It contains two causal pathways: (c), which is a direct path between the independent variable and the dependent variable; and (ab), which describes the indirect impact of the independent variable on the dependent variable through the mediator. As discussed in the conceptual framework chapter, in the case of the relationship between urban form and a child's travel behavior, this research suggests that it is unlikely that urban form (the independent variable) directly determines travel behavior (the dependent variable)—path *c* in the model. More likely it is internal factors (i.e., mediators) that shape the decision about travel, which may be affected by elements of urban form that exist along the route to school (paths *a* & *b*). The three factors identified in the conceptual framework as mediating the relationship between urban form and children's travel behavior are: 1) neighborhood safety; 2) traffic safety; and 3) household transportation options.

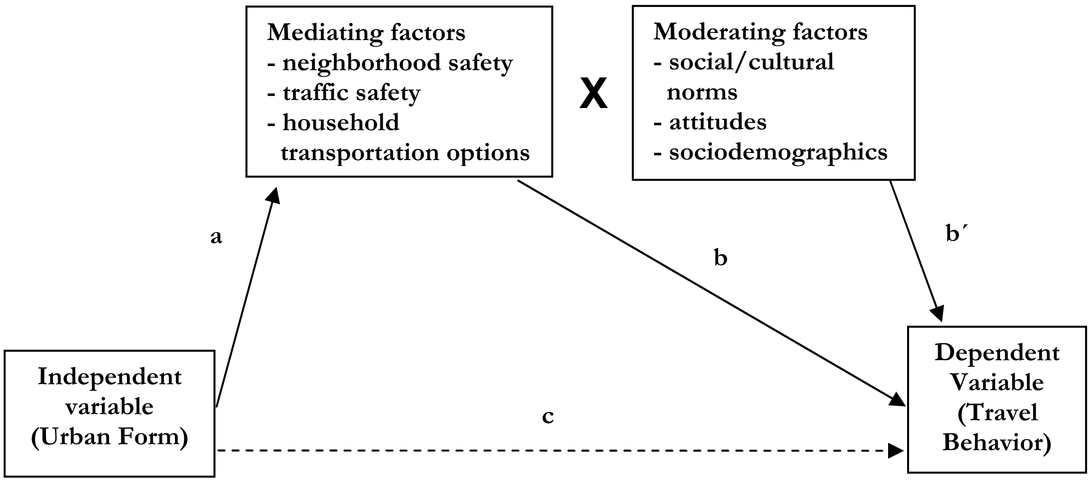

Figure 6.1. The mediation model of the conceptual framework of how urban form affects children's travel behavior. Adapted from the mediation model, by MacKinnon, Warsi and Dwyer, 1995; Baron & Kenny, 1986.

A moderator is a variable that affects the strength of the relationship between an independent variable and a dependent variable (MacKinnon, et al., 2002; Baron and Kenny, 1986). Variations may be seen in the relationship between the independent and dependent variables across different levels or categories of the moderator variable. Moderation is synonymous with interaction and is tested in many research studies. In this study, social/cultural norms, parental attitudes and sociodemographics are suggested to be moderating factors in the relationship between urban form and a child's travel behavior as measured through the mediating factor (path b´, Figure 6.1).

Knowing more about how internal factors play into travel decisions, and how the degree of influence of a given independent variable or factor may vary across segments of the population can assist in the development of more effective and equitable programs on travel behavior.

Hypotheses tested

The analyses presented in Chapter 5 indicated that several variables representing the mediating and moderating factors strongly influenced the decision about a child's trip to school, even when urban form variables were entered into the equation. While this information was useful, it did not test the hypothesis of mediation because the associations were non-directional. It also did not test whether the impact of urban form elements on travel behavior varied across different levels of other independent variables. Therefore, this chapter focuses on two general hypotheses: 1) that traffic safety, neighborhood safety and household transportation options factors mediate the relationship between urban form and travel behavior; and 2) that social/cultural norms, parental attitudes and sociodemographics factors moderate the relationship between urban form and travel behavior through the mediating variables.

Mediation hypothesis

The factors neighborhood safety, traffic safety and household transportation options are latent variables in the sense that they were not observed or measured directly in this study, but rather are represented by other measured variables (Bollen, 1989). Unlike the previous chapter where directly measured independent variables that represented the three factors were examined in relation to travel behavior, this analysis created additive indexes for each factor. Each index is defined by at least 3 items from the parent survey (i.e., variables) to better represent the latent variable (Hoyle, 1995) and to reduce the amount of measurement error in the factors (Kenny, 2001). Cronbach's alpha (α)[12] was calculated to assess the reliability of each summative index. Variables representing factors used in the previous chapter's analysis were initially used in each index. However, if these variables (or any other variables considered) lowered Cronbach's α below an acceptable level (<0.55)[13] they were removed from the index. Table 6.1 summarizes the indexes and reports Cronbach's α for each of the three factors.

Table 6.1 Summary of the indexed mediating factors and Cronbach's alpha

Neighborhood safety factor index:
NSI = ADLTWALK + NHBRSAFR + KNEWPEPL
Cronbach's α = 0.6943

Traffic safety factor index:
TSI = TRAFMPH + WLKNOSDW + XTRAFFIC + XNOSTOP + XNOXWALK
Cronbach's α = 0.6810

Household transportation options index:
HTOI = DRVLIC + HSHLDCRS + DISTANCE
Cronbach's α = 0.5514

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[12] Cronbach's α "is defined as the square of the correlation between the measured scale and the underlying factor." (StataCorp, 2001).

[13] This value is less than what is normally acceptable. Nunnally and Bernstein (1994) recommend an α of 0.70 or higher. MacKinnon et al., (2001) used an α of 0.60 or higher. 0.55 was the highest α obtained for the HTOI with three variables.

The neighborhood safety index (NSI) is the sum of three items from a question that asked parents about the conditions needed to allow a child to walk or bike to school. Answers were recorded on a five-point scale with 1 being very unlikely and 5 being very likely.

> "Would you allow your child to walk or bike to school if:
> a….you or an adult you knew could walk with him/her?
> b….the neighborhood was safer?
> c….you knew more people in the neighborhood?"

These items focus on adult supervision, general safety of the neighborhood and community awareness as elements that may affect parent's perceptions of personal safety for their children (Valentine, 1997; Moore 1986; Wilson and Kelling, 1982; Appleyard, 1981; Jacobs, 1961). The Cronbach's α for this index is 0.6943. The index value can range from 0 to 15. A higher value on the index is indicative of greater comfort about safety.

The traffic safety index (TSI) is the sum of a five-part question that asked parents about potential physical barriers their child might experience if they walked/biked to school. Answers were either yes or no.

> "If your child were to walk/bike to and from school (or if your child does already walk/bike to and from school), would they have to do any of the following:
> a. Cross a road with more than 4 lanes of traffic?
> b. Cross a road at an intersection that doesn't have a street signal or a stop sign to stop traffic?
> c. Cross a road at an intersection without a painted crosswalk?
> d. Walk in the road or on the edge of the road because there is no sidewalk?
> e. Walk or bicycle along a road or sidewalk that has traffic going more than 30 miles per hour?"

These questions target elements of street design known or suggested to be related to traffic safety—vehicle speed & volume, lack of facilities for all roadway users and the absence of safe crossing points (Leaf & Preusser, 1999; Roberts et al., 1995; Mueller et al., 1990; Appleyard, 1981). The Cronbach's α for this index is 0.681. The index value can range from 0 to 5. A higher value on this index is suggestive of more barriers to safe pedestrian travel.

The household transportation options index (HTOI) is the sum of three questions that target the feasibility of different transportation options in the household:

1) number of cars present in the household,
2) number of licensed drivers in the household
3) reported distance from home to school: 1) less than ¼ mile; 2) ¼ - ½ mile; 3) ½ mile – 1 mile; 4) greater than 1 mile.

The Cronbach's α for this index is 0.5514. Note that the index is not a direct measure of the number of *options* present in the household; therefore, a higher value for the index does not mean that there are more transportation options available. This index ranges from 0 to 17. A higher value on this index is suggestive of an increased capacity or ability to drive in the household.

The specific hypotheses for each mediating factor are:

1) Neighborhood safety (NSI) is hypothesized to mediate the effect of urban form on travel behavior;

2) Traffic safety (TSI) is hypothesized to mediate the effect of the urban form on travel behavior; and

3) Household transportation options (HTOI) is hypothesized to mediate the effect of urban form on travel behavior.

The relationship between urban form, children's travel behavior and the mediating factors was tested using three models (i.e., the effect of each indirect relationship was tested separately).

Moderation hypothesis

As previously mentioned, the three factors identified in the conceptual model as moderators are: 1) social/cultural norms; 2) parental attitudes; and 3) sociodemographics. The general hypothesis is that the mediated effect, urban form on children's travel behavior through the mediating variable, varies by levels of a moderator variable (Morgan-Lopez, et al., 2003). Given the large number of variables that could be tested for interaction, only one variable that represented each moderating factor was tested for interaction with the mediating variable: 1) BORNUS—parent born in the U.S. (mediating variable X BORNUS; 2) DRVCONV—parents feelings about the convenience of driving their child to school rather than the child walking (mediating variable X DRVCONV; 3) KIDS—number of children in the household under age 16 (mediating variable X KIDS).

Analytical methods

There are several methods to test mediation that are used in the psychology literature (MacKinnon et al., 2002). While appropriate for experimental research designs, they are less well-suited for this exploratory cross-sectional analysis due to the large number of independent variables being investigated and issues of temporality. Refining the analyses to test particular variable combinations for mediation may cause omitted variable bias, while reverse causality is possible because the mediator and outcome were measured at the same time. Therefore, the analyses will look more broadly at the affect of urban form on travel behavior, as mediated by neighborhood safety, traffic safety and household transportation options.

A series of regression equations were used to examine the impact of urban form on travel behavior through the mediating factors. The same routine was followed to test each hypothesis. The first logit regression (the mediating factors model) contained only the three indexed mediating factors and the variables representing moderating factors, as outlined in the conceptual model in Figure 3.2 and described in Table 5.1:

$$\Pr(\text{walk to school})=f(\mathbf{NSI, TSI, HTOI, SC, A, SD}) \qquad (1)$$

Equation (1) established the effect of the three mediating factors on the probability of a child walking to school without urban form in the equation.

Equation (2) contained the same variables as the equation (1) plus the urban form variables, establishing the effect of the three mediating factors on the probability of a child walking to school while controlling for urban form, and the effect of urban form on the probability of a child walking to school while controlling for the three mediating factors (the mediating urban form model).

Pr(walk to school)=f(**NSI, TSI, HTOI, SC, A, SD, UF**) (2)

These two equations were identical to that used in Chapter 5 except that the indexed mediating factors were used rather than individual independent variables to represent neighborhood safety, traffic safety and household transportation options. The equations indicate the association of the indexed factors on the probability of a child walking to school. However, as in Chapter 5, these regressions only show the non-directional association between variables. It cannot be determined if the variables affect travel behavior decisions simultaneously or along a directional path. In order to establish if the relationship between urban form and travel behavior was mediated by the three indexed mediating factors and to control the direction of the hypothesized causal path, two more regression analyses were necessary.

Using a two-step method suggested by Boarnet and Crane (2001), each mediating factor was first regressed on the urban form variables included in equation 2. This regression calculates the predicted value of the mediating factor, which identifies that portion of the mediating factor explained by urban form (in a sense, indicating how much variation in the mediating factor can be attributed to urban form, establishing the directional association between urban form and the mediating factors).

Mediating factor = f(**UF**) (3)

The predicted values of the mediating factors were then used in a fourth regression that examined the effect of urban form on the mediating factors (through the urban form variables included in equation 3) and the effect of the mediating factors on the probability of a child walking to school. The equation is identical to equation (1) with the exception of the predicted value of each mediating factor being substituted for its non-predicted value for each set of equations (e.g., predicted neighborhood safety index is substituted for neighborhood safety index; traffic safety and household transportation indexes remain the same)

Pr(walk to school)=f(**NSIhat, TSI, HTOI, SC, A, SD**) (4)

Each mediating factor was tested separately; therefore, equation (4) only contains one predicted mediating factor and the two original mediating factors for each analysis.

After the initial test for mediation, equation (4) was re-calculated with interaction terms for each mediating factor to determine whether the hypothesized indirect relationships varied across levels of the moderating factor (equation 5).

Pr(walk to school)=f(**NSIhat, TSI, HTOI, SC, A, SD, NSIhatxSC, NSIhatxA, NSIhatxSC**) (5)

Results

The series of regression equations used to look at the hypothesis of mediating and moderating factors in the relationship between urban form and a child's travel behavior supports the results found in Chapter 5 that urban form has some association with the probability of a child walking to school. However, the nature and shape of the relationship is still not entirely clear. The results for the two initial regressions used to identify general associations between variables are summarized first for all three mediating factors, followed by the two-step method to test the affect of urban form on children's travel behavior through each mediating factor. Finally, the regressions with interaction terms are presented.

Initial regressions

The mediating factors model indicates that two of the three mediating factors have significant associations with the probability of a child walking to school (Table 6.2). The traffic safety index (TSI) and the household transportation options index (HTOI) were both negatively associated with the probability of walking to school, indicating that as the value of the indexes increased, the likelihood of walking decreased. This result was in the anticipated direction since a higher value on the TSI reflects a greater amount of reported traffic barriers on the route to school, while a higher value on the HTOI reflects a greater capacity to drive. The neighborhood safety index (NSI) was not significant in this analysis. The remaining variables had generally the same outcomes as in Chapter 5, with the exception of the percent of Hispanic students at the school (PCTHISP). This variable was positively associated with the probability of a child walking to school, suggesting an increased number of Hispanic students at the school increased the likelihood of walking.

When the urban form variables were entered into the model in equation 2, the NSI remained insignificant and the TSI and HTOI remained negatively associated with a slight increase in their coefficients. There were no changes in the associations found in the other non-urban form variables aside from small changes in the value of the coefficients and the significance levels, particularly for the variables BORNUS and PCTHISP.

Table 6.2 Initial regressions with three mediating factors to establish the effect of independent variables on the probability of a child walking to school

Independent variables	Mediating factors model			Mediating urban form model		
	Coef.	**Std. error**	**P>|z|**	**Coef.**	**Std. error**	**P > |z|**
NSI	-0.0073126	0.0368604	0.843	-0.0272963	0.0377645	0.470
TSI	***-0.2910632***	***0.0897875***	***0.001***	***-0.3011015***	***0.0985074***	***0.002***
HTOI	***-0.3619117***	***0.0671286***	***0.000***	***-0.3881705***	***0.0691912***	***0.000***
APRVFAM	***0.4273452***	***0.0823485***	***0.000***	***0.4239814***	***0.0861***	***0.000***
BORNUS	**-0.6779355**	**0.2772223**	**0.014**	***-0.9497196***	***0.3029078***	***0.002***
INTERACT	***0.289653***	***0.088951***	***0.001***	***0.3094984***	***0.0922952***	***0.001***
SCLCLOSE	**0.1681412**	**0.0835322**	**0.044**	*0.1581082*	*0.0848251*	*0.062*
DRVCONV	***-0.9510633***	***0.0870156***	***0.000***	***-1.002138***	***0.0917252***	***0.000***
KIDS	0.1033584	0.0989952	0.296	0.1184766	0.1049432	0.259
HSHLDINC	0.0038671	0.1213878	0.975	-0.0012229	0.1298854	0.992
YRSEDUC	-0.0518097	0.04349	0.234	-0.0371403	0.0456206	0.416
PCTHISP	**0.0101338**	**0.0044114**	**0.022**	**0.1008594**	**0.0407552**	**0.013**
PR_SDW				**0.0685887**	**0.0324888**	**0.035**
PR_WIN				**-0.1544895**	**0.0748675**	**0.039**
PR_STLGHT				**-0.1178402**	**0.0498985**	**0.018**
PR_NOABBLD				***-0.166491***	***0.0635237***	***0.009***
STWIDTH				***0.6291797***	***0.2220973***	***0.005***
BLKLNGTH				**0.0283611**	**0.0115152**	**0.014**
PR_SPDHMP				0.0436386	0.035081	0.214
PR_MU				**-0.2898374**	**0.1194773**	**0.015**
URBAN				1.164299	0.789814	0.140
CONSTANT	1.519485	1.012221	0.133	*-2.319686*	*3.475356*	*0.054*
Number of cases	904			Number of cases	904	
log(L)	-255.29316			log (L)	-243.08526	

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

Several elements of urban form were significant in equation (2). The proportion of street segments within a quarter mile of school with a complete sidewalk network (PR_SDW) was positively associated with the probability of a child walking to school, as anticipated (i.e., more sidewalks, more walking). The average street width (STWIDTH) and block length (BLKLNGTH) of street segments within a quarter mile of school were also positively associated. This result, while in the opposite direction than expected, is equivalent to the results found in Chapter 5 for these two variables.

The proportion of street segments within a quarter mile of school with windows facing the street (PR_WIN), street lights (PR_STLGHT), no abandoned buildings (PR_NOABBLD) and mixed use (PR_MU) were all negatively associated with the probability of a child walking to school, suggesting that as the presence of these elements increase, the likelihood of driving to school increases (and walking decreases). As discussed in Chapter 5, each of these variables was hypothesized as positively associated with a walk trip to school. The results may be due to the effect of influential data points or may be genuine findings.

These regressions provided the baseline associations between the independent variables and the probability of a child walking to school. The following series of regressions examined the issue of directional association in the relationships between these variables.

Two-step method: neighborhood safety index

Neighborhood safety was regressed on the urban form independent variables using equation 3. The results indicate that the urban form variables explain approximately 6% of the variation in the NSI and several of the urban form variables were associated with the index, although not always in the anticipated direction (Table 6.3).

Table 6.3 Two-step method for the probability of a child walking/bicycling to school (neighborhood safety index): Step 1—get predicted neighborhood safety index

Independent variables	**Coefficient**	**Standard Error**	**P>|t|**
PR_SDW	***-0.0335649***	***0.01000076***	***0.001***
PR_WIN	***0.0495913***	***0.0159304***	***0.002***
PR_STLGHT	***0.0435629***	***0.0139864***	***0.002***
PR_NOABBLD	0.0313109	0.0340714	0.358
STWIDTH	*-0.136708*	*0.0705369*	*0.053*
BLKLNGTH	***-0.0078615***	***0.0019823***	***0.000***
PR_SPDHMP	0.0029477	0.0312756	0.925
PR_MU	***0.0748822***	***0.0164058***	***0.000***
URBAN	**-0.753332**	**0.3816883**	**0.049**
CONSTANT	***10.45875***	***3.734514***	***0.005***
N	904		
R^2	0.0643		
F statistic	F(9,894) = 6.63		

$p<0.01$ is bold and italicized; $p<0.05$ is bold; $p<0.10$ is italicized

The proportion of blocks within a quarter mile of school with windows facing the street (PR_WIN) and street lights (PR_STLGHT) were positively associated with the NSI, suggesting that as the presence of these elements increase in a neighborhood, a parent's comfort level about neighborhood safety increases. This result is consistent with the literature on crime safety (Shriver, 1997; Demetsky, 1975; Jacobs, 1961). The proportion of mixed use on blocks within a quarter mile of school (PR_MU) was also positively associated with the index. This result was not entirely anticipated. While it makes sense in terms of mixed use increasing the number of eyes on the street, undoubtedly some types of non-residential uses cause parents to be concerned about children's safety.

The average street width (STWIDTH) and block length (BLKLNGTH) on those blocks within a quarter mile of school were negatively associated with the index, as anticipated. As street widths and block lengths increase, allowing an increased volume of cars into a neighborhood, a parent's comfort level about neighborhood safety may decrease. The urban dummy variable (URBAN) is also negatively associated with the NSI, again not an unanticipated result.

The only result that was unexpected and runs counter to that suggested by New Urbanist or Smart Growth theories is the finding that the proportion of blocks with sidewalks within a quarter mile of school (PR_SDW) was negatively associated with the NSI (Calthorpe, 1993; Katz, 1994). This indicates that as the presence of sidewalks increase, a parent's comfort level about neighborhood safety decreases. Like street widths and block lengths, this is perhaps a reflection of a higher volume of people traveling through a neighborhood. It was anticipated that this variable would have no association or a positive association.

The results from equation (4) show that the predicted value of NSI—that part of NSI that is explained by urban form—was not associated with the probability of a child walking to school (NSIUF) (Table 6.4). This indicates that urban form does not affect a child's travel behavior through the mediator neighborhood safety. Given the highly insignificant results in equations (1) and (2) for NSI, and the small coefficients, relatively weak explanatory power, and counterintuitive results in equation (3), this result was not unexpected.

Table 6.4 Two-step method for the probability of a child walking/bicycling to school (neighborhood safety index-NSI): Step 2, use predicted neighborhood safety index in logit for probability of a child walking/bicycling to school

Independent variables	Coefficient	Standard error	P>|z|
NSIUF	0.4359191	0.2826184	0.123
TSI	***-0.3025901***	***0.0900688***	***0.001***
HTOI	***-0.3559228***	***0.0665231***	***0.000***
APRVFAM	***0.425956***	***0.0810641***	***0.000***
BORNUS	**-0.6853981**	**0.2772022**	**0.013**
INTERACT	***0.2922319***	***0.0879128***	***0.001***
SCLCLOSE	**0.1660108**	**0.0828418**	**0.045**
DRVCONV	***-0.9529606***	***0.0871288***	***0.000***
KIDS	0.1139737	0.1000716	0.255
HSHLDINC	0.0189331	0.1216839	0.876
YRSEDUC	-0.054381	0.0433752	0.210
PCTHISP	0.000876	0.0073849	0.906
CONSTANT	-2.913568	2.991287	0.330
Number of cases	904		
log(L)	-254.10863		

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

The remaining independent variables in Table 6.4 maintained the associations seen in the results of the earlier regressions (i.e., Table 6.2) with the exception of the percent of Hispanic students at the school (PCTHISP), which was no longer significant when controlling for the effect of urban form on travel behavior through neighborhood safety.

Two-step method: traffic safety index

Using equation 3, traffic safety was regressed on the urban form independent variables. Approximately 23% of the variation in the TSI was explained by urban form and several of the variables were associated with the index (Table 6.5).

Table 6.5 Two-step method for the probability of a child walking/bicycling to school (traffic safety index): Step 1, get predicted traffic safety index

Independent variables	Coefficient	Standard Error	P>|t|
PR_SDW	0.0005033	0.0038765	0.897
PR_WIN	***-0.0209414***	***0.0061707***	***0.001***
PR_STLGHT	**-.0110998**	**0.0054177**	**0.041**
PR_NOABBLD	-0.0105121	0.0131977	0.426
STWIDTH	0.0104746	0.0273228	0.702
BLKLNGTH	*0.001466*	*0.0007678*	*0.057*
PR_SPDHMP	**-0.027042**	**0.0121147**	**0.026**
PR_MU	***-0.0235655***	***0.0063548***	***0.000***
URBAN	***-0.3888915***	***0.1478485***	***0.009***
CONSTANT	***5.162075***	***1.446589***	***0.000***
N	904		
R^2	0.2313		
F statistic	F(9,894) = 29.89		

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

The proportion of blocks within a quarter mile of school with windows facing the street (PR_WIN) and street lights _PR_STLGHT) were negatively associated with the TSI, suggesting that as the presence of these elements increase in a neighborhood, a parent's concerns about traffic safety decrease. This result was not anticipated because these elements of urban form are not typically suggested in the literature as being related to traffic safety. The proportion of blocks within a quarter mile of school with mixed use (PR_MU) and speed humps (PR_SPDHMP) were also negatively associated with the index. These results were expected in that the presence of speed humps and mixed use are suggested as urban form elements that may slow traffic, making the pedestrian environment safer (Calthorpe, 1993; Katz, 1994; Institute of Transportation Engineers [ITE], 1999). The urban dummy variable (URBAN) was also negatively associated with the TSI, suggesting that a more urban setting decreases concerns about traffic safety. If URBAN is acting as a proxy for density this result would be consistent with the literature that suggests reduced speeds occur in denser environments (Boarnet and Crane, 2001), thereby decreasing traffic safety concerns.

The average block length on those street segments within a quarter mile of school (BLKLNGTH) was positively associated with the index, as anticipated. As block lengths increase and the number of crossing opportunities likely decrease, a parent's concerns about traffic safety increase.

The most unexpected result was the finding that the proportion of blocks with sidewalks within a quarter mile of school (PR_SDW) was not associated with the TSI. It was anticipated that this variable would have a negative association with the TSI since the literature has shown that the provision of footpaths (i.e., sidewalks) increases walking activity and reduces concerns about traffic safety (Corti et al., 1996; Giles-Corti and Donovan, 2003).

The results from equation (4) show that the part of the TSI that is explained by urban form was not associated with the probability of a child walking to school (TSIUF) (Table 6.6). This indicates that urban form does not affect a child's travel behavior through the mediator traffic safety. Unlike the NSI finding, this result was unexpected. The urban form variables had relatively high explanatory power for the TSI and several variables were significant in the anticipated directions; however, the coefficients were rather small. Since TSI was highly significant in the initial regressions, one can conclude that the portion of the TSI not explained by urban form elements is the significant portion of TSI affecting the probability of a child walking to school. This was confirmed in Table 6.7, which shows equation (4) calculated with the TSI residuals (the difference between the observed and the predicted TSI).

Table 6.6 Two-step method for the probability of a child walking/bicycling to school (traffic safety index): Step 2, use predicted traffic safety index in logit for probability of a child walking/bicycling to school

Independent variables	Coefficient	Standard error	P>|z|
NSI	-0.0102517	0.0365101	0.779
TSIUF	-0.2370061	0.2758014	0.390
HTOI	***-0.4040664***	***0.0666955***	***0.000***
APRVFAM	***0.4569512***	***0.0814671***	***0.000***
BORNUS	**-0.7010432**	**0.2776932**	**0.012**
INTERACT	***0.2754734***	***0.0876714***	***0.002***
SCLCLOSE	***0.2112771***	***0.0818586***	***0.010***
DRVCONV	***-0.9407898***	***0.0857114***	***0.000***
KIDS	0.0991048	0.0978538	0.311
HSHLDINC	0.0322358	0.1184111	0.785
YRSEDUC	-0.0610893	0.0435832	0.161
PCTHISP	0.0096539	0.0064338	0.133
CONSTANT	1.592788	1.273949	0.211
Number of cases	904		
log(L)	-260.3079		

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

Table 6.7 Two-step method for the probability of a child walking/bicycling to school (traffic safety index): Step 2, use residuals of traffic safety index in logit for probability of a child walking/bicycling to school

Independent variables	Coefficient	Standard error	P>|z|
NSI	-0.01015	0.0368163	0.783
TSIE	***-0.2920357***	***0.0943361***	***0.002***
HTOI	***-0.3707241***	***0.0668305***	***0.000***
APRVFAM	***0.4306735***	***0.082257***	***0.000***
BORNUS	***-0.7140607***	***0.2774038***	***0.010***
INTERACT	***0.2967513***	***0.0885714***	***0.001***
SCLCLOSE	**0.169405**	**0.0835312**	**0.043**
DRVCONV	***-0.95202***	***0.0870771***	***0.000***
KIDS	0.1013465	0.0985837	0.304
HSHLDINC	0.0021446	0.1211275	0.986
YRSEDUC	-0.0454189	0.0435329	0.297
PCTHISP	***0.0152019***	***0.0043455***	***0.000***
CONSTANT	0.6674269	0.9927804	0.501
Number of cases	904		
log(L)	-255.74298		

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

The remaining variables maintained the associations seen in the results of the earlier regressions (Table 6.2) with the exception of the percent of Hispanic students at the school, which is no longer significant in the predicted TSI model (PCTHISP) (Table 6.6). However, it is significant in the residual model (Table 6.7).

Two-step method: household transportation options index

Lastly, the household transportation options index was regressed on the urban form independent variables using equation 3. The results indicate that these urban form variables explain approximately 17% of the variation in the HTOI and several of the urban form variables were associated with the index, although once again not always in the anticipated direction (Table 6.8).

Table 6.8 Two-step method for the probability of a child walking/bicycling to school (household transportation options index): Step 1—get predicted household transportation options index

Independent variables	Coefficient	Standard Error	P>|t|
PR_SDW	0.0082305	0.0059441	0.166
PR_WIN	***-0.0384455***	***0.0094619***	***0.000***
PR_STLGHT	-0.0098122	0.0083072	0.238
PR_NOABBLD	*0.0348132*	*0.0202368*	*0.086*
STWIDTH	0.034434	0.0418955	0.411
BLKLNGTH	***0.0048989***	***0.0011774***	***0.000***
PR_SPDHMP	*0.0363165*	*0.0185762*	*0.051*
PR_MU	***-0.0390146***	***0.0097442***	***0.000***
URBAN	*-0.3909558*	*0.2267043*	*0.085*
CONSTANT	3.440503	2.218136	0.121
N	904		
R^2	0.1706		
F statistic	F(9,894) = 20.43		

$p<0.01$ is bold and italicized; $p<0.05$ is bold; $p<0.10$ is italicized

The average block length on those blocks within a quarter mile of school (BLKLNGTH) was positively associated with the index, suggesting that as block lengths increase, a household's capacity to drive increases. This result was expected as longer block lengths may decrease pedestrian accessibility, making driving more appealing (Calthorpe, 1993; Katz, 1994). The proportion of blocks within a quarter mile of school with speed humps (PR_SPDHMP) was also positively associated with the HTOI. However, this result was not expected as traffic calming elements are suggested to be a deterrent to driving (ITE, 1999).

The proportion of street segments within a quarter mile of school with mixed use (PR_MU) was negatively associated with the HTOI, as was the urban dummy variable (URBAN). Both were anticipated results.

The proportion of blocks within a quarter mile of school with windows (PR_WIN) facing the street was negatively associated with the HTOI, while the proportion of blocks within a quarter mile of school with no abandoned buildings (PR_NOABBLD) was positively associated with the HTOI. Neither of these urban form elements was anticipated to have any association with the HTOI, which represents a household's ability to drive.

It was surprising that the proportion of blocks with sidewalks (PR_SDW) within a quarter mile of school was not associated with the HTOI. Several results from the literature suggest that the presence of a pedestrian infrastructure increases the proportion or likelihood of non-auto trips (Cervero & Kockleman, 1997; Kitamura et al., 1997; Rodriguez & Joonwon, 2003). However, the HTOI is not a reflection of real trips, just the capacity of the household to take a motorized trip. In addition, a lower value in the index is not necessarily an indication of an increased capacity to walk, just a decreased capacity to drive. Therefore, the result only suggests that there is no association between the completeness of the sidewalk network near schools and a household's ability to drive.

The results from equation (4) show that the part of the HTOI that is explained by urban form was not associated with the probability of a child walking to school (HTOIUF) (Table 6.9). This indicates that urban form does not affect a child's travel behavior through the mediator household transportation options. As was the case with the TSI finding, this result was unexpected. The urban form variables had decent explanatory power for the HTOI and several variables were significant in the anticipated directions, although the coefficients were small. Similar to the TSI, HTOI was also highly significant in the initial regressions. Re-calculating equation (4) with the HTOI residuals shows that the portion of the HTOI that is not explained by urban form elements is the significant portion of HTOI affecting the probability of a child walking to school (Table 6.10).

Table 6.9 Two-step method for the probability of a child walking/bicycling to school (household transportation options index): Step 2, use predicted household transportation options index in logit for probability of a child walking/bicycling to school

Independent variables	Coefficient	Standard error	P>|z|
NSI	0.010266	0.0355712	0.773
TSI	***-0.3818247***	***0.0865522***	***0.000***
HTOIUF	-0.3312611	0.2419876	0.171
APRVFAM	***0.3876879***	***0.0778922***	***0.000***
BORNUS	**-0.54635**	**0.2630129**	**0.038**
INTERACT	***0.2979622***	***0.0851745***	***0.000***
SCLCLOSE	***0.2090534***	***0.079362***	***0.008***
DRVCONV	***-0.9548248***	***0.0844895***	***0.000***
KIDS	0.1069881	0.0951567	0.261
HSHLDINC	*-0.2137764*	*0.1131318*	*0.059*
YRSEDUC	**-0.0854864**	**0.0418673**	**0.041**
PCTHISP	0.0022714	0.0062351	0.716
CONSTANT	2.83244	1.923125	0.141
Number of cases	904		
log(L)	-271.15597		

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

Table 6.10 Two-step method for the probability of a child walking/bicycling to school (household transportation options index): Step 2, use residuals of household transportation options index in logit for probability of a child walking/bicycling to school

Independent variables	Coefficient	Standard error	P>|z|
NSI	-0.0066651	0.036675	0.856
TSI	***-0.3160608***	***0.089049***	***0.000***
HTOIE	***-0.3407703***	***0.0664387***	***0.000***
APRVFAM	***0.4172271***	***0.0814667***	***0.000***
BORNUS	**-0.7035239**	**0.2763135**	**0.011**
INTERACT	***0.2899632***	***0.0881501***	***0.001***
SCLCLOSE	**0.1674318**	**0.0832214**	**0.044**
DRVCONV	***-0.9528455***	***0.0870105***	***0.000***
KIDS	0.1080523	0.0980809	0.271
HSHLDINC	-0.0497527	0.1180682	0.673
YRSEDUC	-0.0496222	0.0435189	0.254
PCTHISP	***0.0167115***	***0.0046877***	***0.000***
CONSTANT	-0.8944746	1.032649	0.386
Number of cases	904		
log(L)	-257.1004		

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

Notably, household income (HSHLDINC) and the years of education (YRSEDUC) of the parent completing the survey became significant for the first time using the predicted value of the HTOI in equation (4) (Table 6.9). Both were negatively associated, suggesting that as income and education increase, the probability of a child walking to school decreases when controlling for the affect of urban form on travel behavior through household transportation options. Past results showed that neither variable was significant when controlling for urban form variables and the HTOI simultaneously (Table 6.2). Rather, it is when that portion of the HTOI that is explained by urban form is controlled for that these variables become significant. This result reinforces the need to understand the nature of relationships between variables.

The remaining variables maintained the associations seen in the results of the earlier regressions (Table 6.2) with the exception of the percent of Hispanic students at the school

(PCTHISP), which was no longer significant when controlling for the effect of urban form on travel behavior through neighborhood safety.

Interactions

The three regression equations containing interaction variables indicate there is some variation in the influence of the predicted portion of the indexed factors (that part explained by urban form) on travel behavior when examined across levels of the moderating variables.

Using equation (5), the probability of a child walking to school was regressed on the independent variables in equation (4), NSIUF and the interaction terms NSIUFUS (NSIUF x BORNUS), NSIUFDRV (NSIUF x DRVCONV) and NSIUFKD (NSIUF x KIDS). The results indicate that when the interaction terms were included in the equation, the predicted NSI (NSIUF) still had no effect on travel behavior (Table 6.11). The overall effect of being born in the U.S. (BORNUS) on the probability of a child walking to school was no longer significant but the number of children in the household (KIDS) became significant. Driving convenience (DRVCONV) remained negatively associated with the probability of walking. Interestingly, the relationship between that part of NSI explained by urban form and travel behavior was modified by both parent's reported driving convenience and the number of children in the household (NSIUFDRV and NSIUFKD), suggesting that a parent's feelings about neighborhood safety that are affected by urban form influences the decision about walking to school based on different ratings of driving convenience and the number of children in the household. The relationship was not modified by being born in the United States (NSIUFUS).

Table 6.11 Examination of the interaction effects on the relationship between urban form and a child's travel behavior through the mediating variable neighborhood safety

Independent variables	Coefficient	Standard error	P>|z|
NSIUF	0.5118061	0.5840604	0.381
TSI	***-0.3544956***	***0.0938881***	***0.000***
HTOI	***-0.3609832***	***0.0665376***	***0.000***
APRVFAM	***-.04012038***	***0.0815012***	***0.000***
BORNUS	1.666021	3.648132	0.648
INTERACT	***0.3114252***	***0.0880541***	***0.000***
SCLCLOSE	*0.1601613*	*0.0835659*	*0.055*
DRVCONV	***-4.061966***	***1.279074***	***0.001***
KIDS	**2.616805**	**1.305523**	**0.045**
HSHLDINC	-0.0439279	0.1259373	0.727
YRSEDUC	-0.0441588	0.0434627	0.310
PCTHISP	-0.0008704	0.007561	0.908
NSIUFUS	-0.2055291	0.3222266	0.524
NSIUFDRV	**0.27069**	**0.1105073**	**0.014**
NSIUFKD	*-0.2226481*	*0.1152436*	*0.053*
CONSTANT	-3.443397	6.47741	0.595

Number of cases	904
log(L)	-248.13603

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

Table 6.12 presents the results of the probability of a child walking to school regressed on the independent variables in equation (4), TSIUF and the interaction terms TSIUFUS (TSIUF x BORNUS), TSIUFDRV (TSIUF x DRVCONV) and TSIUFKD (TSIUF x KIDS). As in the previous analysis with NSI, when the interaction terms were included in the regression, that part of TSI explained by urban form (TSIUF) had no effect on travel behavior. The number of children in the household (KIDS) and driving convenience (DRVCONV) were negatively associated with the probability of a child walking to school, while born in the United States was no longer significant (BORNUS). There was no interaction between that part of TSI explained by urban form and driving convenience (TSIUFDRV) or that part of TSI explained by urban form and born in the United States (TSIUFUS). The relationship between that part of TSI explained by urban form and travel behavior was modified by the number of children in the household (TSIUFKD), indicating that a parent's feelings about neighborhood safety that are affected by urban form does influence the decision about walking to school based on the number of children in the household.

Table 6.12 Examination of the interaction effects on the relationship between urban form and a child's travel behavior through the mediating variable traffic safety

Independent variables	Coefficient	Standard error	P>|z|
NSI	-0.0126322	0.0366737	0.731
TSIUF	-0.6838387	0.6265425	0.275
HTOI	***-0.4117529***	***0.0673531***	***0.000***
APRVFAM	***0.4645925***	***0.0830579***	***0.000***
BORNUS	-0.1680128	0.704425	0.811
INTERACT	***0.2739721***	***0.0886851***	***0.002***
SCLCLOSE	**0.2073854**	**0.0824992**	**0.012**
DRVCONV	***-0.8128074***	***0.2120325***	***0.000***
KIDS	*-0.4160549*	*0.2417731*	*0.085*
HSHLDINC	-0.0015658	0.1213082	0.990
YRSEDUC	-0.0576712	0.0438294	0.188
PCTHISP	0.0088463	0.0065744	0.178
TSIUFUS	-0.2809543	0.3628707	0.439
TSIUFDRV	-0.0783669	0.1174869	0.505
TSIUFKD	**0.288367**	**0.1261714**	**0.022**
CONSTANT	2.602246	1.625441	0.109
Number of cases	904		
log(L)	-257.31079		

p<0.01 is bold and italicized; p<0.05 is bold; p<0.10 is italicized

Lastly, the probability of a child walking to school was regressed on the independent variables in equation (4), HTOIUF and the interaction terms HTOIUFUS (HTOIUF x BORNUS), HTOIUFDRV (HTOIUF x DRVCONV) and HTOIUFKD (HTOIUF x KIDS). No effect was seen for that part of HTOI explained by urban form (HTOIUF) on travel behavior when controlling for the interaction terms (Table 6.13). As in the analysis of NSI, the overall effect of place of birth (BORNUS) on the probability of a child walking to school was no longer significant but the number of children in the household (KIDS) became significant. Driving convenience (DRVCONV) was no longer associated with travel behavior. The relationship between that part of HTOI explained by urban form and travel behavior was modified by the number of children in the household (HTOIUFKD). This suggests that a parent's feelings about neighborhood safety that are affected by urban form does influence the decision about walking to school based on the number of children in the household. The relationship was not modified by being born in the United States (HTOIUFUS) or driving convenience (HTOIUFDRV).

Table 6.13 Examination of the interaction effects on the relationship between urban form and a child's travel behavior through the mediating variable household transportation options

Independent variables	Coefficient	Standard error	P>|z|
NSI	0.012662	0.035804	0.724
TSI	***-0.3887352***	***0.0879866***	***0.000***
HTOIUF	-0.6431549	0.5201718	0.216
APRVFAM	***0.3743889***	***0.0791982***	***0.000***
BORNUS	-0.4549036	1.826266	0.803
INTERACT	***0.2985382***	***0.085927***	***0.001***
SCLCLOSE	***0.2051189***	***0.0797604***	***0.010***
DRVCONV	-0.4965945	0.558002	0.373
KIDS	-0.9750593	0.5640848	0.084
HSHLDINC	**-0.2532031**	**0.1165391**	**0.030**
YRSEDUC	**-0.0822294**	**0.0419307**	**0.050**
PCTHISP	0.0012808	0.0063611	0.840
HTOIUFUS	*0.1812089*	*0.0931702*	*0.052*
HTOIUFDRV	-0.0082062	0.2958105	0.978
HTOIUFKD	-0.079203	0.0940679	0.400
CONSTANT	4.872474	3.393103	0.151
Number of cases	904		
log(L)	-268.7881		

$p<0.01$ is bold and italicized; $p<0.05$ is bold; $p<0.10$ is italicized

Discussion

The hypotheses tested in this chapter were that urban form influences travel behavior but does so through internal factors that guide parental decision-making about the trip to school, and that the effect of these mediating relationships varied across levels of modifying variables.

The results suggest that urban form does affect travel behavior, but how that relationship occurs through the mediating factors of neighborhood safety, traffic safety and household transportation options is ambiguous. Specifically, the results suggest that:

> 1) neighborhood safety, as explained by urban form, does not influence the probability of a child walking to school except when modified by levels of reported driving convenience and the number of children within a household;
>
> 2) traffic safety, as explained by urban form, does not influence the probability of a child walking to school except when modified by the number of children within a household; and
>
> 3) household transportation options, as explained by urban form, does not influence the probability of a child walking to school except when modified by the number of children within a household.

Programs like Safe Routes to School suggest that changes in urban form lead to changes in travel behavior -- a "build it and they will come" philosophy, of sorts. This is possibly true, but how does urban form influence this behavior change? The analyses in this chapter attempted to provide insight into this question. Previous research, like that found in Chapter 5, only looked at the associations between variables of urban form and travel behavior with assumptions of the direction of influence (Cervero and Kockelman, 1997; Handy 1996a; Handy, 1996b; Handy and Clifton, 2001; Kitamura et al., 1997). The purpose of this analysis was to test the hypothesized path of decision-making, or causality, from urban form to travel behavior and to identify factors that influence the relationship along the way. This framework of analysis is more common in the psychology or medical sciences literature but is a direction that the travel behavior literature should move in, especially as the field attempts to evaluate the effects of changes in urban form on travel behavior.

While the original hypotheses of the affect of the mediating factors neighborhood safety, traffic safety and household transportation options on the relationship between urban form and travel behavior was not validated, the significant interactions found highlight the complexity of travel behavior. For each of the mediating factors, that portion explained by urban form interacted with the number of children in the household to influence travel behavior. For example, a parent's feelings about how the urban form of the neighborhood affects the sense of security they feel for their child may vary depending on how many children there are in the household. Possible explanations for this finding are that perhaps a household with more children has more "eyes watching all," or older children in the household have "worn the parents down" in terms of their concerns or restrictions on children's travel behavior. Previous studies have found that children in the household affect trip-making (Boarnet & Sarmiento, 1998; Cervero and Kockelman, 1997; Crane & Crepeau, 1998; Kitamura et al., 1997) but did not suggest that this association relates to urban form or the effect that urban form has on an individual's or household's feelings of safety, security and mobility, as was found in this research. The interaction effect seen between that part of neighborhood safety explained by urban form and driving convenience on travel behavior may suggest that depending on a person's predilection toward driving the neighborhood environment may be more or less threatening. This is similar to the attitude-travel behavior relationship examined by Kitamura et al. (1997); however, this analysis goes further to indicate the direction of the relationships. The results of this analysis provides evidence that the design of neighborhoods affect individuals differently; therefore, while a "one size fits all" approach to planning interventions is less expensive, it may also be less effective and equitable.

The analysis of the directional path of the conceptual model could be enhanced by several improvements to the study design. Structural equation modeling (SEM) is a statistical technique that incorporates confirmatory factor analysis, path analysis and multiple regressions to test directional relationships, particularly those that contain latent constructs such as neighborhood safety, traffic safety or household transportation options. SEM is particularly helpful in that it addresses the assumption of the mediator being free of measurement error that is likely violated when using multiple regressions to test mediation. This measurement error may cause the mediator to be underestimated and the effect of the independent variable on the dependent variable to be overestimated when all coefficients are positive (Baron and Kenny, 1986).

One of the major limitations of SEM is that it does not perform well with either coarsely categorical data (i.e., less than 5 categories) and non-normal data. Both of these conditions can lead to biased chi-square tests of model fit, parameter estimates, standard errors and tests of parameter estimates (Hoyle, 1995). Since much of the data used in this analysis was categorical and likely had non-normal properties, structural equation modeling was not used.

Cluster analysis is another technique that could enhance this analysis. The benefit of cluster analysis is that it does not assume independence among observations, an assumption that can lead to increased type I error rates. Rather, it assumes that individuals within a particular group share some of the same characteristics moreso than with individuals in another group and allows for the analysis of individual and group-level effects (e.g., neighbors would share more similarities with one another than with someone across town). Unfortunately, cluster analysis is not possible when the number of independent variables exceeds the number of clustered groups (e.g., in this analysis: 12 neighborhoods, more than 12 independent variables). Therefore, cluster analysis was not used in either this chapter or chapter 5.

Finally, since this was a cross-sectional analysis, causality is not presumed. While using the two-step method suggested by Boarnet and Crane (2001) controls the direction of relationships to some degree, it is still possible that the direction of causality is reversed somewhere along the path of decision-making for travel behavior. Future testing of these hypotheses using experimental, longitudinal designs can help control the direction of causality.

The relationships examined in this analysis increase knowledge of the mechanisms of an intervention—what do we really target when making a change in urban form? Ultimately travel behavior, but is there an intermediate condition that must be met for a change in travel behavior to occur? The analysis provides support for the hypothesis that the relationship between urban form and children's travel behavior may be indirect, rather than the direct relationship assumed by programs such as Safe Routes to School. This information can assist agencies and communities in determining what the most effective use of resources is. Concurrently, the examination of whether differences in effectiveness exist within different sub-groups of the population can lead to more equitable distribution of resources.

Chapter 7

Policy implications & future research

The purpose of this research was twofold: 1) to provide much needed basic information about children's travel to school; and 2) to determine how urban form affects travel behavior by modeling the nature and shape of the relationship between multiple factors of influence on parental decision-making about a child's trip to school. As recent programs like California's SR2S suggest, urban form is hypothesized as a major barrier for walking and bicycling to school, causing a decrease in these forms of transportation and an increase in automobile travel. While the growing literature on non-motorized travel behavior indicates that urban form has some affect on transportation decisions, what is not clear is how urban form actually relates to travel behavior and the relative importance of urban form compared to other factors of influence. Programs like SR2S suggest a direct relationship between the two—build a bike path, more children will bike—but this model is somewhat naïve, excluding other elements that might affect travel behavior and how the relationship may vary in different circumstances and for different individuals. Dissecting the travel behavior decision-making process and identifying how urban form fits into this complex structure moves the discussion of urban form and travel behavior forward from associations to actual pathways of influence. Learning more about the mechanisms of behavior—and behavior change—can guide planners in developing effective and equitable transportation and land use investments, not only for children but for travelers of all ages and modes.

A summary of the research results

The research results support the general hypothesis that urban form plays a role in decision-making about how the trip to school will be made. This result is consistent with previous findings in the literature on adult non-motorized travel and urban form (Cervero and Kockelman, 1997; Greenwald and Boarnet, 2001; Handy, 1996a; Handy, 1996b; Handy and Clifton, 2001; and Kitamura et al., 1997). The present study, focusing on children's travel, found that the relationship between urban form and travel behavior was relatively modest and that several other factors increase the complexity of the relationship.

Factors not traditionally studied in travel behavior research, such as parent's attitudes toward travel (an exception being Kitamura, et al., 1997), and those more commonly studied in the physical activity literature, such as social/cultural norms (Hovell et al., 1991; Sallis, 1989; Sallis et al., 1992b) were more influential than urban form on decision-making about the mode of travel to school. Parent's self-reported measures of urban form such as travel time and distance from home to school (classified as perceptions of household transportation options) and the convenience of driving were among the variables that had the greatest effect on how children traveled to school. These results suggest that programs focusing solely on modifications in urban form to increase the number of children walking or bicycling to school will see relatively little change in travel mode splits. Programming efforts that include urban form improvements along with education on the benefits of walking and bicycling may be more successful at changing travel behavior.

Understanding whether urban form can address underlying concerns parents have about traveling to school by particular modes may lead to the development of more effective, targeted interventions. The conceptual framework suggested that neighborhood safety, traffic safety and household transportation options were three concerns/factors that influence a parent's choice of travel mode to school. The framework also suggested that these factors themselves may be shaped by urban form, proposing a structure for how urban form may influence travel behavior. In the examination of this hypothesized pathway of influence, little evidence existed to support the hypothesis that neighborhood safety, traffic safety and household transportation options mediated the relationship between urban form and travel behavior. The factors as a whole were generally associated with travel behavior. That portion of the factors explained by urban form, however, was not associated with travel behavior. These findings indicate that it is not clear that making changes to the urban form of a neighborhood to alleviate parent's concerns about neighborhood safety, traffic safety or household transportation options will affect travel behavior to school.

Finally, the conceptual framework suggested that the strength of the mediated relationship between urban form and children's travel behavior may vary depending on social/cultural norms, parental attitudes and/or sociodemographics of the child, parent or household. This hypothesis of moderating factors was supported in the analysis. Specifically, the number of children under 16 in the household interacted with that portion of neighborhood safety, traffic safety and household transportation options explained by urban form to influence travel behavior. The portion of neighborhood safety explained by urban form also interacted with parent's reported convenience of driving to influence travel behavior. These results reinforce the idea that the relationship between urban form and travel behavior is complex. The effectiveness of programs and policies aimed at changing travel behavior may vary for different segments of the population.

Overall, the results suggest that there is a weak direct association between urban form and children's travel behavior but as discussed earlier, it is likely not strong enough to have a significant effect on increasing bicycling and walking to school. While this result implies that an indirect relationship between these two variables is plausible, the overall analysis suggests that the nature and shape of an indirect relationship remains unclear.

Policy implications of the research findings

The primary focus of this research, to identify how urban form relates to travel decisions about school travel, not just whether it does, contributes to the development of better policies and programs to affect travel behavior. In a constant climate of limited resources, the importance of identifying what the problems actually are before creating solutions is paramount to the success of programs related to travel behavior.

For example, California's SR2S program focuses almost exclusively on engineering as the solution for increasing children's walking and bicycling activity and safety. Therefore, constructing a sidewalk will change travel behavior. However, the results indicate that variables such as reported convenience of driving, a family's approval of a child walking to school and the importance of children interacting on the trip to school are stronger influences on travel decisions than characteristics of urban design. This suggests that a change in urban form may not necessarily affect travel behavior, or that changes in urban form may be less cost-effective than an educational campaign targeting parent's feelings about travel to school or an organized walking group to school such as "the walking school bus."

Programs may also be successful with a multi-pronged approach, such as using the 3 E's of traffic engineering (education, enforcement and engineering) to encourage change. Some of the most influential variables in this analysis, such as perceived traffic speeds and reported distance and travel time from home to school, may be affected by changes to street design, increased enforcement of traffic speeds and/or education on the benefits of positive walking and negative impacts of driving.

Two community-based programs—the Marin County SR2S project and the San Diego Mid-City SR2S project—provide an example of successful initiatives that used a broad framework to tackle different aspects of travel around schools[14]. Community members, city staff and officials, law enforcement, schools, parents and students participated in a process that first identified specific concerns about pedestrian activity and safety and then developed solutions to address them. While making changes to the physical design of a neighborhood was one "tool in the toolbox," it was not the only solution to change travel behavior, as the findings from this and other research support (Appleyard, 2003; McMillan and Phillips, 2002). These projects were successful at not only addressing traffic issues at existing schools but also at heading off problems at future schools by advocating for increased communication and planning between school districts and cities in school siting decisions.

The research helps projects like those described above in understanding child and household travel behavior. Movements like New Urbanism and Smart Growth and programs like Safe Routes to School and the American Association of Retired Persons' (AARP) Livable Communities guidelines suggest that communities should be built that are accessible and accommodating to multiple modes and users of transportation. The research findings support the idea that planning decisions should be sensitive to how a place is used and the population it is meant to serve, particularly the more vulnerable and dependent users of the system. It also supports the idea that the "experience of place", not just the structure

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[14] These programs were not part of California's SR2S construction program. Rather, they were part of a community planning grant program administered by the California Department of Health Services. The Marin project was also a National Highway Traffic Safety Administration demonstration project for Safe Routes to School. Both projects, however, successfully applied for SR2S construction funds in part due to their community collaborations (McMillan and Phillips, 2002).

of space, affects behavior (Hiss, 1990). For example, municipalities may use the information regarding the strong influence of parent's feelings about neighborhood and traffic safety on children's travel behavior to create neighborhoods that address these concerns through programs like neighborhood watch groups. The research can inform the development process, providing insight into the impact of transportation, land use and urban design decisions on community.

Finally, the findings are important to community development as research moves forward on studying the outcomes of the hypothesized relationship between planning and physical activity/obesity. This study suggests that the effect of urban form on children's travel behavior to school is modest at best. While at face value this does not appear to bolster the hypothesis, in essence it does provide support for further investigation and program development. The social ecological model suggests that there are multiple levels of influence on an individual's activity behavior. This research provides evidence that urban form is indeed one factor that influences activity behavior and therefore is a possible intervention to target through behavior change programs and policies.

Transportation projects already consider health issues such as the reduction of accidents or air quality changes in environmental impact statements. If further evidence develops to support the link between planning and physical activity/obesity, the impacts on community development decisions may be significant. Truly quantifying the cost of development on health (e.g., potential years of life lost or saved through chronic disease) could significantly affect the way communities are designed.

Future research

The development of a framework that examines how urban form impacts children's travel behavior and that can be tested using a multivariate statistical analysis fills a conceptual gap in planning research. The complexities of the decision-making about the trip to school highlight how household travel patterns are influenced by more than attributes such as time and cost of travel. The research findings support the need to study the mechanisms of travel behavior in greater depth, as was proposed in the 1970's using the activity-based framework, to better understand household travel decisions and guide policy and planning (Goodwin and Hensher, 1978; Stoner and Milione, 1978; McNally, 2000, ch.4). Future research on what individuals consider in their choice to make a trip and how it relates to the physical environment, their lifestyle and household travel needs would assist in defining the transportation needs and preferences of communities.

The interdisciplinary focus of this research is a significant step forward in the research on travel and activity. As was discussed in Chapter 2, walking has been studied by several disciplines but each from a different methodological perspective, with a different outcome in mind, and with fairly limited success at identifying what affects activity. The complexity of the hypothesized relationship between urban form and pedestrian activity begins to appear, however, by combining the scientific contributions of transportation, urban design and health. This conglomeration of research has also brought to light possible issues, such as increased rates of pedestrian fatality and injury and risk factors for chronic disease, which may arise when trips by various modes are compromised.

While this research did not look directly at the impact of planning on health outcomes, it highlights barriers that must be surmounted to increase walking and bicycling activity to school and provides a conceptual framework to examine how planning and health may relate, particularly for children. There is a growing interest in both the research and practitioner communities to explore the relationship between these fields. The Robert Wood Johnson Foundation, through its Active Community Environments Initiative, is funding research to identify the environmental and policy variables that affect pedestrian and bicycle activity for both transportation and recreation purposes with the long-term goal of quantifying the impact of urban form on health outcomes. While the initiative focuses on all populations, the research could be particularly important in identifying environmental factors that contribute to children's health. Given the increased rates of overweight and obesity, the low rates of physical activity and the high rates of pedestrian and bicyclist injury and death in children, the societal cost of negative child health outcomes is high. Future research should examine the effect of existing urban form on children's general activity patterns, not just the trip to school, to determine if variations in activity exist related to urban form and if there is a quantifiable health benefit to activity attributable to urban form. Future research should also examine the effectiveness of various interventions such as the construction of traffic calmed space or the planting of street trees at changing activity behavior and affecting health, to determine the most cost-effective use of resources. As was discussed previously, examining these questions for multiple population groups and community settings may also lead to a more equitable distribution of resources.

Closing remarks

The results of this research confirm what many in the transportation and physical activity literature already knew—human behavior is a complex creature. In our search for similarities, we find differences. In our quest for patterns of behavior, we discover disorder. In our pursuit of rational answers, we encounter irrational behavior. These findings are informative, however, in that they challenge us to not look for the easy, "one size fits all" answer to travel behavior. While transportation investments are often made for "the common good," it is necessary to look closer at who makes up that common good and create solutions that work for the populations they are meant to serve.

As Sallis and Owen (1999) discuss, "Interventions do not directly change behavior. Interventions modify the factors that control behavior, and those changes are expected to lead to improved behavior." The issue with using urban form as a possible change agent to affect children's travel is that little research exists that indicates what factors the intervention may possibly modify to improve the targeted behavior. In other words, the question of what determines the travel behavior for the trip to school has yet to be answered. Additionally, the current policies and interventions surrounding the trip to school assumes a simple relationship—change urban form; kids walk more to school—where there is undoubtedly not one. Both of these gaps in knowledge put the interventions at high risk of failure, which may allow good but still maturing causal leads on many health and transportation outcomes to be lost. The results of this study advance the discussion on relationships between urban form, transportation and health and inform policy and practice on the best targets for future planning interventions.

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Appendix A

SAFE ROUTES TO SCHOOL

Thank you for taking the time to fill out this survey. The University of California, Irvine is partnering with local schools on a project that looks at walking and bicycling activity to and from school.

Please fill out this survey tonight and send it back to school with your child tomorrow.

If you have more than one child that attends school, please answer the questions thinking about the child who brought the survey home. If more than one child brings a survey home, please fill out and send back only one survey. Answering these questions will only take about 15 minutes of your time and anything you say in the survey will remain confidential. No one will know that these are your answers because your name and address are not written down anywhere. You can skip any questions you do not want to answer. We hope that you will take the time to fill out this brief survey on walking and bicycling to school.

Thank you very much for your help today.

Marlon Boarnet, PhD
Associate Professor, Department of Urban and Regional Planning
University of California, Irvine

RUTAS SEGURAS A LA ESCUELA

Gracias por tomar el tiempo para contestar esta encuesta. La Universidad de California, Irvine se ha asociado con las escuelas locales en un proyecto conjunto que examina la actividad de ir a la escuela y regresar a la casa, caminando y/o en bicicleta.

Por favor, llene esta encuesta esta noche y devuélvela a la escuela mañana con su niño.

Si usted tiene más de un niño o niña que asiste a la escuela, por favor conteste las preguntas pensando en quien le trajo la encuesta a la casa. Si sus niños le han traído más de una encuesta, por favor complete y devuelva sólo una. Solamente le tomará unos 15 minutos para contestar estas preguntas. Cualquier información que usted nos proporcione será confidencial. Nadie sabrá que éstas son sus respuestas, pues ni su nombre ni su dirección serán anotadas en ningún sitio. Puede dejar en blanco cualquier pregunta que usted no desee contestar. (Note que utilizamos la palabra “niño” para referirnos a ambos sexos). Agradeceremos que se tome el tiempo para contestar esta encuesta sobre caminar e ir en bicicleta a la escuela.

Muchísimas gracias por la ayuda que nos ha brindado hoy.

Dr. Marlon Boarnet
Profesor Asociado, Departmento de Planeamiento Urbana y Regional
University of California, Irvine

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SCHOOL TRAVEL

These first few questions are about how your child *normally* gets to and from school (if the routine varies, please answer based on the *most regular routine*). Please answer the questions in both columns.

	To school	**From/After school**
1. On a normal day, how does your child travel to school/from school?	a. Driven alone or with others in household b. Neighborhood carpool c. Walk d. Bike e. School bus f. Public bus or train g. Other:_________	a. Driven alone or with others in household b. Neighborhood carpool c. Walk d. Bike e. School bus f. Public bus or train g. Other:_________
2. How long does it take your child to get to school/from school?	a. Less than 5 minutes b. 5-10 minutes c. 11-20 minutes d. More than 20 minutes e. not sure	a. Less than 5 minutes b. 5-10 minutes c. 11-20 minutes d. More than 20 minutes e. not sure
3. Do any adults travel some or most of the way to school/from school with your child?	a. Mother b. Father c. Other adult from the household d. Other adult not from the household e. Other:_____________ f. None; child travels without adults → ***if you answer f, please skip the next question***	a. Mother b. Father c. Other adult from the household d. Other adult not from the household e. Other:_____________ f. None; child travels without adults → ***if you answer f, please skip the next question***
4. Where does the adult *normally* go after dropping off/picking up the child at or near school?	a. Returns home b. To work, not at home c. Shopping or other errands d. Drop off other children or household members e. Other:_________	a. Returns home b. To work, not at home c. Shopping or other errands d. Pick up/drop off children or household members at other activities e. Other:_________
5. Does your child participate in any before-or after-school activities?	a. YES b. NO	a. YES b. NO
***If yes*, do these activities happen at school or somewhere else in the community?**	a. at school b. somewhere else in the community	a. at school b. somewhere else in the community
6. In the past two months, how often has your child walked or biked to school/from school:	a. not at all b. about once a month c. about two to three times a month d. once a week e. more than once a week	a. not at all b. about once a month c. about two to three times a month d. once a week e. more than once a week

VIAJE A LA ESCUELA

Estas preguntas iniciales son sobre cómo va y vuelve *normalmente* el niño a la escuela (si la rutina varía, conteste basándose *en la más frecuente*). Por favor conteste las preguntas en ambas columnas.

	Yendo a la escuela	**Regresando / después de la escuela**
1. En un día normal, ¿cómo viaja su niño a la escuela y regresa a la casa?	a. En auto, solo o con otros miembros de la familia b. En un auto del grupo de la vecindad ("carpool") c. Caminando d. En bicicleta e. Autobús de la escuela f. Autobús de servicio público o tren g. Otro:_________	a. En auto, solo o con otros miembros de la familia b. En un auto del grupo de la vecindad ("carpool") c. Caminando d. En bicicleta e. Autobús de la escuela f. Autobús de servicio público o tren g. Otro:_________
2. ¿Cuánto tiempo se demora su niño en ir a la escuela, o regresar de ella?	a. Menos de 5 minutos b. 5-10 minutos c. 11-20 minutos d. Más de 20 minutos e. No estoy seguro	a. Menos de 5 minutos b. 5-10 minutos c. 11-20 minutos d. Más de 20 minutos e. No estoy seguro
3. Cuando su niño va a la escuela y regresa, ¿le acompaña algún adulto a su niño por todo el camino o parte de él?	a. Madre b. Padre c. Otro adulto de la familia d. Otro adulto que no es de la familia e. Otro:_____________ f. Ninguno; el niño viaja sin adultos ***→ si contesta f, por favor no conteste la próxima pregunta***	a. Madre b. Padre c. Otro adulto de la familia d. Otro adulto que no es de la familia e. Otro:_____________ f. Ninguno; el niño viaja sin adultos ***→ si contesta f, por favor no conteste la próxima pregunta***
4. Después de llevar al niño a la escuela o recogerlo de ella, ¿a dónde va *normalmente* la persona adulta?	a. Regresa a la casa b. Al trabajo, fuera de la casa c. De compras o a hacer otras diligencias d. A dejar otros niños o miembros de la familia e. Otro:_________	a. Regresa a la casa b. Al trabajo, fuera de la casa c. De compras o a hacer otras diligencias d. A recoger o dejar niños u otros miembros de la familia a otras actividades e. Otro:_________
5. ¿Participa su niño en alguna actividad antes o después de la escuela?	a. SÍ b. NO	a. SÍ b. NO
***Si participa*, ¿estas actividades toman lugar en la escuela, o en otro lugar de la comunidad?**	a. en la escuela b. en otro lugar de la comunidad	a. en la escuela b. en otro lugar de la comunidad
6. En los últimos dos meses, ¿qué tan frecuentemente ha caminado o ha ido en bicicleta su niño a la escuela y de regreso?	a. ninguna vez b. aproximadamente una vez al mes c. aproximadamente dos o tres veces al mes d. una vez por semana e. más de una vez por semana	a. ninguna vez b. aproximadamente una vez al mes c. aproximadamente dos o tres veces al mes d. una vez a por semana e. más de una vez por semana

7. About how far is it from your home to your child's elementary school?

a. less than ¼ mile

b. ¼-1/2 mile

c. 1/2-1 mile

d. greater than 1 mile

e. don't know

8. *If* your child were to walk/bike to and from school (or if your child does already walk/bike to and from school), would they have to do any of the following on their way to/from school?

a. Cross a road with more than 4 lanes of traffic?	YES	NO
b. Cross a road at an intersection that doesn't have a street signal or a stop sign to stop traffic?	YES	NO
c. Cross a road at an intersection without a painted crosswalk?	YES	NO
d. Walk in the road or on the edge of the road because there is no sidewalk?	YES	NO
e. Walk or bicycle along a road or sidewalk that has traffic going more than 30 miles an hour?	YES	NO

FEELINGS AND DECISIONS ABOUT TRAVEL TO/FROM SCHOOL

Now we would like to ask you some questions about what helps you decide how your child gets to school. Please answer these questions no matter how your child currently gets to school.

9. On a scale of 1 to 5, with 1 being not true at all and 5 being very true, circle the number that best matches your feelings about your child's travel to/from school.

	Not true at all				***Very true***
a. Walking or biking to/from school would be good for my child's health	1	2	3	4	5
b. My neighborhood is not safe enough for children to walk or bike to/from school alone	1	2	3	4	5
c. I worry about strangers or bullies in the neighborhood approaching my child if he/she is alone	1	2	3	4	5
d. The school is close enough for my child to walk or bike	1	2	3	4	5
e. Driving my child to/from school is more convenient/fits my schedule better	1	2	3	4	5
f. My child's bike will get stolen if he/she rides it to school	1	2	3	4	5
g. I don't really think about how my child should go to school	1	2	3	4	5
h. My child does not like to walk or bike to/from school	1	2	3	4	5

10. On a scale of 1 to 5, with 1 being very unimportant and 5 being very important, circle the number that tells how important it is:

	Not very important				***Very Important***
a. …for my child to get exercise while going to/from school	1	2	3	4	5
b. …for my child to interact with other children while going to/from school	1	2	3	4	5
c. …for my child's trip to/from school to be convenient for me	1	2	3	4	5

7. Aproximadamente, ¿qué lejos está su casa de la escuela elemental de su niño?

a. Menos de ¼ de milla
b. ¼-1/2 milla
c. 1/2-1 milla
d. Más de 1 milla
e. No lo sé

8. *Si* su niño caminara o fuese en bicicleta a la escuela y volviese de ella (o si ya lo está haciendo), ¿tendría que hacer alguna de las siguientes cosas de camino a la escuela o de regreso?

a. ¿Cruzar una calle con más de 4 carriles de tráfico?	SI	NO
b. ¿Cruzar una calle en una intersección que no tiene una luz de tráfico o una señal de parada que pare el tráfico?	SI	NO
c. ¿Cruzar una calle en una intersección que no tenga un cruce de calle pintado con rayas para peatones?	SI	NO
d. ¿Caminar por la calle o por el borde de la calle porque no hay acera para peatones?	SI	NO
e. ¿Caminar o ir en bicicleta por una calle o una acera donde el tráfico vaya a más de 30 millas por hora?	SI	NO

SUS SENTIMIENTOS Y SUS DECISIONES SOBRE EL VIAJE A / Y REGRESO DE LA ESCUELA

Ahora deseamos hacerle algunas preguntas sobre que toma en cuenta para decidir cómo llega su niño a la escuela. Por favor, contesta estas preguntas sin referirse a cómo está llegando ahora su niño a la escuela.

9. En una escala de 1 a 5, en la que 1 es "nada cierto" y 5 es "muy cierto", circule el número que más corresponda a sus sentimientos sobre el viaje y regreso de su niño a la escuela.

	Nada cierto				***Muy cierto***
a. Caminar o ir en bicicleta a la escuela o de regreso sería bueno para la salud de mi niño	1	2	3	4	5
b. Mi vecindad no es lo suficientemente segura para que los niños vayan solos o en bicicleta a la escuela y regresen	1	2	3	4	5
c. Me preocupa que si mi niño está solo, se le puedan acercar gente extraña o valentones del barrio	1	2	3	4	5
d. La escuela está lo suficientemente cerca para que mi niño camine o vaya en bicicleta	1	2	3	4	5
e. Llevar a mi niño en auto a la escuela y traerlo es más conveniente / encaja mejor en mi horario	1	2	3	4	5
f. Le robarán la bicicleta a mi niño si va en ella a la escuela	1	2	3	4	5
g. No pienso mucho en como mi niño debe de ir a la escuela	1	2	3	4	5
h. A mi niño no le gusta caminar o montar en bicicleta para ir o regresar de la escuela	1	2	3	4	5

10. En una escala de 1 a 5, en la que 1 es "nada importante" y 5 es "muy importante", circule el número que represente qué tan importante es:

	Nada importante				***Muy importante***
a. …que mi niño haga ejercicio mientras va o vuelve de la escuela	1	2	3	4	5
b. …que mi niño tenga contacto con otros niños mientras va o vuelve de la escuela	1	2	3	4	5

Circle the number that tells how important it is…	***Not very important***				***Very Important***
d. …for my child to learn how to get from home to school by walking or biking	1	2	3	4	5
e. ...for my child to live close to his/her school	1	2	3	4	5

Based on the following conditions, how likely would it be that you would allow your child to walk or bike to school? Please circle the number that best matches your feelings (1 being very unlikely and 5 being very likely).

11. Would you allow your child to walk or bike to school if:

	Very Unlikely				***Very Likely***
a. …you or an adult you knew could walk with him/her?	1	2	3	4	5
b. …he/she was older?	1	2	3	4	5
c. …people paid attention when they drove?	1	2	3	4	5
d. …he/she didn't have to cross a busy road?	1	2	3	4	5
e. …the neighborhood was safer?	1	2	3	4	5
f. …the weather was better?	1	2	3	4	5
g. …you knew more people in the neighborhood?	1	2	3	4	5
h. …the school was closer to home?	1	2	3	4	5
i. …there were crossing guards at busy intersections on the way to/from school?	1	2	3	4	5
j. …if it was convenient for you to drive by school on your way to/from work and/or errands?	1	2	3	4	5
k. …other children in the neighborhood walked or biked to school together?	1	2	3	4	5
l. …your child could be driven to school?	1	2	3	4	5
m. …he/she had only a light backpack to carry?	1	2	3	4	5

	Very Unlikely				***Very Likely***
12. How likely is it that your child will walk or bike to/from school in the next two months?	1	2	3	4	5

13. On a scale of 1 to 5, with 1 being strongly disapprove and 5 being strongly approve, please tell us how the following people feel (or would feel) about your decision to allow your child to walk to school:

	Strongly disapprove				***Strongly approve***
a.…your friends	1	2	3	4	5
b. …your family	1	2	3	4	5
c. …your husband/wife or boyfriend/girlfriend	1	2	3	4	5

Circule el número que representa qué tan importante es:	***Nada importante***				***Muy importante***
c. …que el viaje de mi niño para ir o volver de la escuela sea conveniente para mí	1	2	3	4	5
d. …que mi niño aprenda a llegar de la casa a la escuela caminando o en bicicleta	1	2	3	4	5
e. ...que mi niño viva cerca de su escuela	1	2	3	4	5

Basándose en las siguientes condiciones, ¿cuán probable sería que usted le permitiría a su niño caminar o ir en bicicleta a la escuela? Por favor, circule el número que representa mejor su manera de sentir (1 es "no muy probable" y 5 es "muy probable").

11. ¿Le permitiría a su niño caminar o ir en bicicleta a la escuela si:

	Muy improbable				***Muy probable***
a. …usted o un adulto que usted conoce pudieran caminar con el niño?	1	2	3	4	5
b. …el niño fuera mayor?	1	2	3	4	5
c. …la gente prestara más atención cuando maneja?	1	2	3	4	5
d. …el niño no tuviera que cruzar una calle de mucho tráfico?	1	2	3	4	5
e. …la vecindad fuera más segura?	1	2	3	4	5
f. …el tiempo (temperatura) fuera mejor?	1	2	3	4	5
g. …conociera más gente en la vecindad?	1	2	3	4	5
h. …la escuela estuviera más cerca de la casa?	1	2	3	4	5
i. …hubiera guardas de cruce en las intersecciones con mucho tráfico en el camino de la casa a la escuela y de regreso?	1	2	3	4	5
j. …fuera conveniente para usted pasar en el auto por la escuela, yendo o viniendo de su trabajo o de hacer diligencias?	1	2	3	4	5
k. …otros niños de la vecindad fueran juntos a la escuela, caminando o en bicicleta?	1	2	3	4	5
l. …Si a su niño lo pudieran llevar en auto a la escuela?	1	2	3	4	5
m. …si el niño solo tuviera que cargar una mochila/ maleta de poco peso?	1	2	3	4	5

	Muy improbable				***Muy probable***
12. ¿Qué probabilidad hay que su niño camine o vaya en bicicleta a la escuela en los próximos dos meses?	1	2	3	4	5

13. En una escala de 1 a 5, en la que 1 es "desaprueban firmemente" y 5 es "aprueban firmemente", por favor díganos cómo se sienten (o se sentirían) estas personas sobre su decisión de permitir que su niño camine a la escuela:

	Desaprueban firmemente				***Aprueban firmemente***
a.…sus amigos/as	1	2	3	4	5
b. …su familia	1	2	3	4	5
c. …su esposo/esposa o su novio/novia	1	2	3	4	5

BACKGROUND INFORMATION

These last few questions are just some general information about yourself and your family. Remember, all of this information is confidential.

14. How often do you walk in your neighborhood?

a. At least once a day
b. A few times a week
c. Once a week
d. A few times a month
e. Hardly ever

15. a. How old is the child who brought home this survey?______
b. What is the sex of the child who brought home this survey? MALE FEMALE

16. What grade is the child in who brought home this survey?________

17. Which of the following categories best describes your marital status?

1. Living with someone (husband/wife or boyfriend/girlfriend)
2. Living alone (no husband/wife or boyfriend/girlfriend in the house)

18. Please indicate how many people in your household are the following ages? (include yourself)

0-5 yrs old	6-11 yrs old	12-16 yrs old	17-60 yrs old	Older than 60

19. How many people in your household have a driver's license? ______

20. On most days, how many cars are there in your household? ______

21. In the following table, please indicate the work status of all adults in the household, starting with yourself. Please indicate their relation to the child who brought this survey home (for example, father, older sister, aunt, grandfather, friend of the family)

Relation	Currently work outside of the home?		If working, average number of hours worked per week
Example: Mother	[✓ YES]	NO	25
	YES	NO	
	YES	NO	
	YES	NO	
	YES	NO	

22. How long have you lived in this neighborhood?

a. less than 1 year
b. 1-5 years
c. 6-10 years
d. more than 10 years
e. all my life

23. What country were you born in?___________

24. How many years did you go to school?_____

25. How long have you lived in the United States?

a. less than 1 year
b. 1-5 years
c. 6-10 years
d. more than 10 years
e. all my life

26. What is your average annual household income?

a. less than $15,000
b. $15,001-35,000
c. $35,001-55,000
d. $55,001-75,000
e. more than $75,001

INFORMACIÓN HISTORIAL

Estas últimas preguntas son solamente de tipo general sobre usted y su familia. Recuerde que toda esta información es confidencial.

14. ¿Cuán frecuentemente camina en su vecindad?

a. Por lo menos una vez al día
b. Unas cuantas veces por semana
c. Una vez por semana
d. Unas cuantas veces al mes
e. Casi nunca

15. a. ¿Qué edad tiene el niño que le trajo esta encuesta? ______
b. ¿Cuál es el sexo del niño que le trajo esta encuesta? MASCULINO FEMENINO

16. ¿En qué grado está el niño que le trajo esta encuesta a la casa?________

17. ¿Cuál de las siguientes situaciones describe mejor su estado matrimonial

1. Estoy viviendo con alguien (esposo/esposa o novio/novia)
2. Estoy viviendo solo/sola (no hay un esposo/esposa o novio/novia en la casa)

18. Por favor indique cuánta gente vive en la casa de las edades siguientes (inclúyase a usted)

De las edades 0-5	**De las edades 6-11**	**De las edades 12-16**	**De las edades 17-60**	**Mayor de 60 años**

19. ¿Cuántas personas de la familia tienen licencia de manejar? ______

20. ¿Cuántos autos hay en la casa casi todos los días?______

21. En la tabla siguiente, por favor indique la situación de trabajo de todos los adultos en la familia, empezando con usted. Indique qué relación tienen con el niño que trajo esta encuesta a la casa (por ejemplo, padre, hermana mayor, tía, abuelo, amigo/a de la familia)

Relación con el niño	**¿Trabaja presentemente fuera de la casa?**		**Si está trabajando, promedio de horas que trabaja a la semana**
Ejemplo: Madre	[✓ SI]	NO	25
	SI	NO	
	SI	NO	
	SI	NO	
	SI	NO	

22. ¿Cuánto tiempo hace que vive en esta vecindad?

a. Menos de 1 año
b. 1-5 años
c. 6-10 años
d. Más de 10 años
e. Toda mi vida

23. ¿En qué país nació usted?___________

24. ¿Cuántos años fue a la escuela?_____

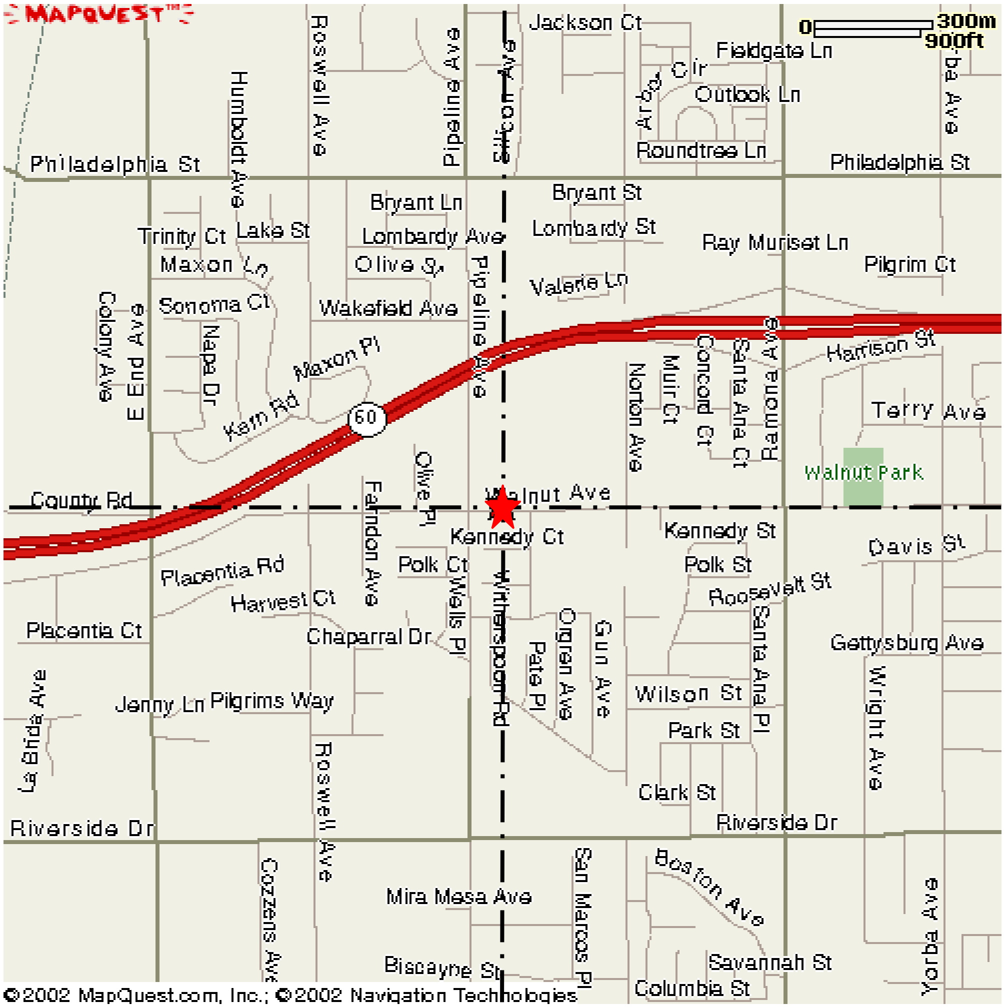
25. ¿Cuánto tiempo ha vivido en los Estados Unidos?

a. Menos de 1 año
b. 1-5 años
c. 6-10 años
d. Más de 10 años
e. Toda mi vida

26. ¿Cuál es el promedio de entradas anuales de su hogar?

a. menos de $15,000
b. $15,001-35,000
c. $35,001-55,000
d. $55,001-75,000
e. más de $75,001

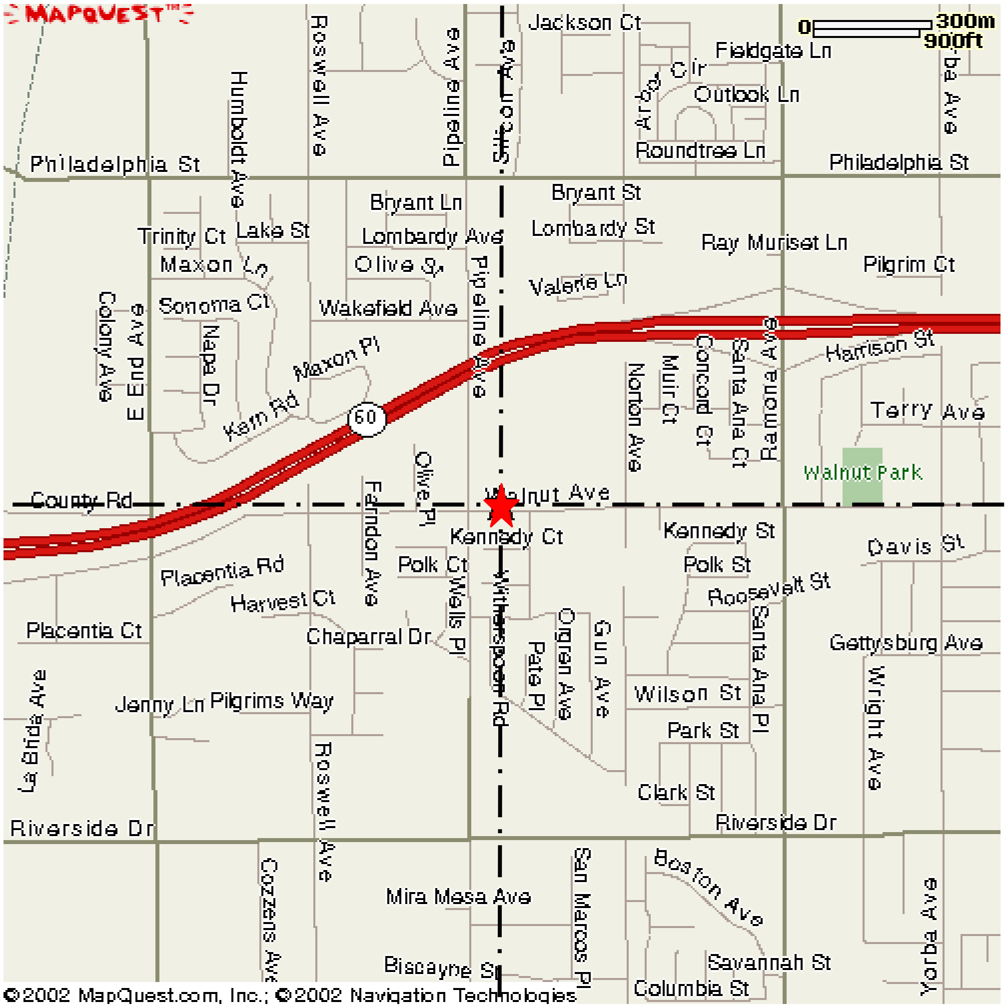
27. Your child's school is located at the star on this map. PLEASE PUT AN X IN THE SQUARE THAT CONTAINS YOUR HOUSE. *__Do not__* mark the exact location of your house if it happens to be on the map. If the street you live on is not on the map, please just write "house off map."



Thank you for your help today. Please give your completed survey to your child to return to school tomorrow. If you have any questions, please call the number listed on the letter that came with this survey.

Have a nice day.

27. La escuela de su niño está ubicada donde aparece la estrella en este mapa. Ponga una X en el cuadrado que contiene su casa. *No marque* el lugar exacto de su casa. Si la calle en donde vive no aparece en este mapa, por favor escribe "casa no está en el mapa."



Gracias por la ayuda que nos ha prestado hoy. Por favor dele la encuesta completada a su niño para que la devuelva a la escuela mañana. Si usted tiene alguna pregunta, por favor llame al número de teléfono que aparece en la carta que vino con esta encuesta.

Le deseamos que pase un buen día.

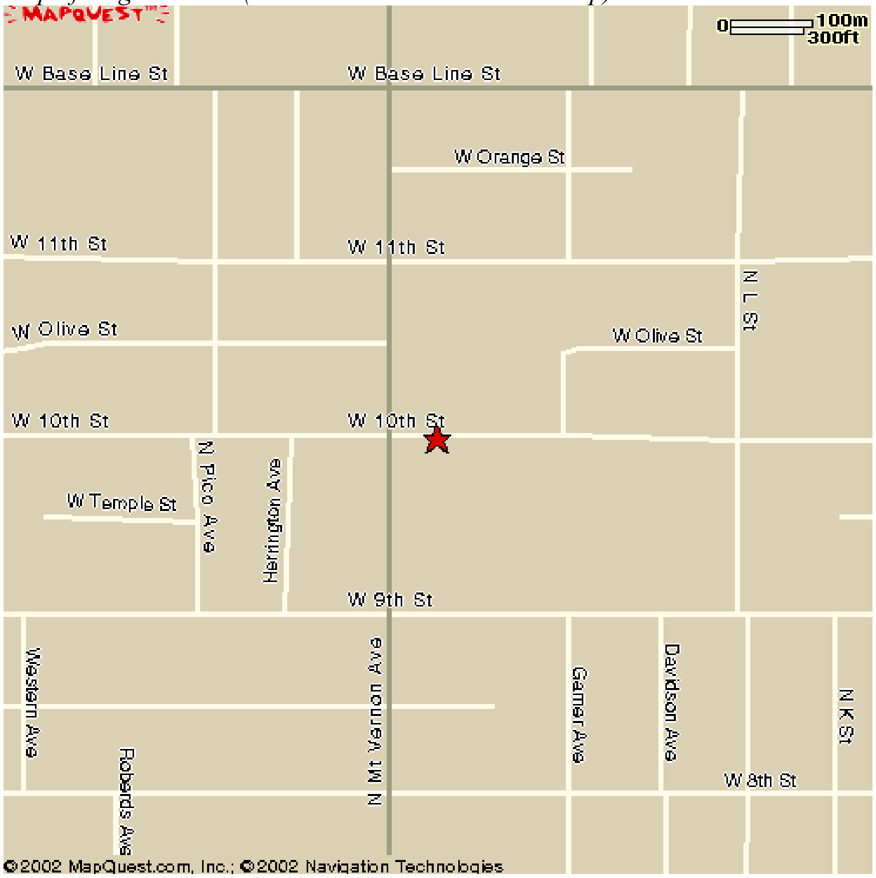
Appendix B

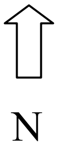
URBAN DESIGN INSTRUMENT

OBSERVER/SITE INFORMATION

(1) Observer ______________________ *(4) Segment number from master map* __________________________
(2) Date/time ______________________ *(5) Intersections that define segment* ___________________________
(3) SR2S site ______________________ *(6* ____

Map of neighborhood (school should be marked on map):





PERCEIVED TRAFFIC SAFETY (complete for each side of street)

7. **Sidewalks**
   a. Sidewalks present for entire segment Y N N/A________________
   b. Sidewalks present & separated from street by "buffer" Y N N/A________________
   (buffer includes diagonal & parallel pkg.

8. **Speed**
   a. What is speed limit? (N/A if not visible) ________________

9. **Bike lanes**
   a. Bike lanes marked for entire segment Y N N/A________________
   b. Bike lane physically separated from car lanes Y N N/A________________

Question 10 is not collected during urban design measurements

PERCEIVED CRIME SAFETY (complete for each side of street)

11. **Visibility and lighting**[1]
    a. ≥50% of bldgs. have 1st floor windows visible from street Y N N/A________________
    b. Street lighting present Y N N/A________________

12. **Maintenance**[1]
    a. Abandoned buildings are absent Y N N/A__________________
    b. Seriously run-down buildings, lots are absent Y N N/A__________________
    c. Vacant lots are absent Y N N/A__________________
    d. Visible graffiti is absent Y N N/A__________________

13. **Type of people**[1]
    a. "Undesirable" people are absent Y N N/A__________________

14. **Type of land uses**[1]
    a. "Undesirable" land uses are absent Y N N/A __________________

15. **Number of pedestrians**
    a. # of pedestrians on segment (NOT people at home) __________________

D. ACTUAL TRAFFIC SAFETY (observers do 16-20 together)

16. **Road capacity**
    a. Number of lanes of traffic (for length of segment) __________________

17. **Street width**
    a. Street width at 1st corner, in feet __________________

18. **Segment length**
    a. Length of segment from one end to the other, in feet __________________

19. **Sidewalk width**
    a. Sidewalk width at 1st corner, in feet __________________

20. **Turning radii**
    a. Turning radii at 1st corner (soft/med/hard) __________________
21. **Intersections**
    a. Number of marked crosswalks originating from segment ________ of ______
    b. (If 4 or more lanes of traffic)Traffic signal present* Y N N/A__________________
    c. Number of stop signs at intersections for segment ________ of ______

22. The following **traffic calming** features are present:
    a. traffic circles Y N N/A__________________
    b. curb bulb-outs Y N N/A__________________
    c. speed bumps, humps, or tables Y N N/A__________________
    d. cul de sac or street closing Y N N/A__________________
    e. median Y N N/A__________________
    f. paving treatment at crosswalk Y N N/A__________________

23. The following urban design features associated with **liveliness** are present:
    a. Street trees Y N N/A__________________
    b. Mixed land uses Y N N/A__________________
    c. Public space Y N N/A __________________
    d. Street furniture Y N N/A __________________

____

____

____

---

[1] Write explanation for all "No's" in this question.

URBAN DESIGN OBSERVATION CODE BOOK

BACKGROUND

Unit of analysis = neighborhood

Urban design will be characterized for the neighborhood surrounding each SR2S site

Definition of neighborhoods

Neighborhood = sum of segments contained in total or in part within 1/4 mile of primary school impacted by each SR2S site, including segment on which school located

Segment = block, including both facing sides of street, coded separately (in no case should only one side of street be included in definition of neighborhood)

Each neighborhood has different total # of segments

Observations procedures

2 independent observers

Process:

Before coding:

Team leader and assistant survey area create map for each "neighborhood" using GIS

All segments should be assigned a number on a master map for each neighborhood

Team leader and assistant survey map of neighborhood in the field, to confirm which segments to include in the neighborhood. Team leader also makes any designations about how to define segments for each neighborhood, where this is not evident.

For coding:

Use a new code sheet to code each segment

2 observers code the same segment at the same time, starting on opposite sides of the street and switching when they complete one side.

Before beginning to code new segment, observers agree on #3, 4, 5, and 6 (Observer/Site Information). Both use same responses for map marking and for #3-6.

Observers should reference notes from team leader on how to define boundaries of segment, if not obvious. Both observers should agree on these boundaries.

Observers should not consult each other for completing rest of code sheet.

Features should be coded as yes/no indicating present or absent, or inserting # where requested. (Additional urban design observations are collected for each school as part of traffic observations; see #11 a & b, above.)

Except where otherwise noted, observations pertain to features present or absent on this segment only.

Code as much as possible standing at the beginning of the segment, check responses for correctness as walk down segment. Stop at end of segment and make sure all information is complete, returning to fill in any missing information. Be sure all responses are coded before moving to opposite side of street. Be sure all responses for both sides are completed before beginning a new segment.

Both observers should independently code all data, including measurements in section D (Actual Traffic Safety).

Observers move on to a new segment together when both have observed both sides of the street.

Coding instructions

OBSERVER/SITE INFORMATION

(1) Observer	First, last name of observer
(2) Date/time	Include mo/day/year and time observations begin, including a.m./p.m.
(3) SR2S site	List by city and identifying name (e.g., Anaheim, 1st St. crosswalk)
(4) Segment number from master map	List number of segment on master map for this neighborhood
(5, 6) Intersections that define segment	List the 2 (or more) intersections that define the segment (e.g., Maple/1st St., Maple/2nd St.)

PERCEIVED TRAFFIC SAFETY

7. **Sidewalks**

a. Sidewalks present for entire segment
Y = designated (e.g., paved, marked) sidewalks present for entire segment
N = no or incomplete sidewalks, sidewalks are only dirt paths
N/A = not applicable (explain)[2]

b. Sidewalks separated from street by "buffer"
Y = sidewalks do not directly adjoin street. Separated by "buffer"(e.g., strip of lawn or landscaping, diagonal parking, etc.) of at least 2-3 feet. Buffer does not have to be landscaped
N = sidewalks are immediately adjacent to street, or no sidewalks present
N/A = not applicable (explain)

8. **Speed**

a. What is speed limit?
Write down posted speed limit for segment.
N/A = not applicable, not possible to determine posted speed limit (explain)

9. **Bike lanes**

a. Bike lanes marked for entire segment
Y = bike lane is "marked" for entire segment (e.g., by painted lines, off street path, etc.). Need not have posted signs for bike lane; posted signs not sufficient to count as "marked." Need not be off-street bike path
N = bike lane not "marked," or not marked for entire segment. May have extra space for bike use, but not marked lane
N/A = not applicable, not possible to determine whether marked bike lanes exist (explain)

b. Bike lane physically separated from car lanes
Y = bike lane is "off street" or is otherwise physically separated from car traffic for entire segment (e.g., separated by a barrier wall)
N = bike lane is not off street
N/A = no bike lane present, or not possible to determine whether bike lane is physically separated from street (explain)

(C) PERCEIVED CRIME SAFETY

11. **Visibility and lighting**[1]

a. ≥50% of buildings have 1st floor windows visible from the street
Y = More than half of the buildings have first floor windows that are visible from the street
N = No buildings OR less than half of buildings have first floor windows OR most first floor windows are not visible from the street
N/A = Not applicable (explain)

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[2] For items that require explanation, use extra lines at the bottom of page 2 of code sheet. Write neatly, include # of question being explained.

b. Street lighting present

Y = *One or more public street lighting standards present on segment*

N = *No public street lighting standards present on segment*

N/A = *Not applicable (explain)*

12. **Maintenance**

a. Abandoned buildings are absent

Y = *No obviously abandoned buildings on segment (e.g., boarded up, signs prohibiting entering, etc.) May be no buildings.*

N = *One or more obviously abandoned buildings on segment (e.g., boarded up, signs prohibiting entering, etc.) Write address & explanation of conditions that look abandoned*

N/A = *Not applicable (explain)*

b. Seriously run-down buildings and lots are absent

Y = *No buildings and/or lots with serious maintenance problems (i.e., bottom 20% of buildings—broken windows, missing porch steps, seriously overgrown vegetation, etc.)*

N = *One or more buildings and/or lots with serious maintenance problems (i.e., bottom 20% of buildings—broken windows, missing porch steps, seriously overgrown vegetation, etc.) Should be a "stand out" in the neighborhood, because of poor maintenance. Write address & explanation of conditions that look run-down*

N/A = *Not applicable (explain)*

c. Vacant lots are absent

Y = *No undeveloped lots that appear uncared for (e.g., overgrown grass or no vegetation, accumulated trash, etc.) May include a lot without development, if appears cared for.*

N = *One or more undeveloped lots that appear uncared for (e.g., overgrown grass or no vegetation, accumulated trash, etc.) Write explanation of conditions that look vacant*

N/A = *Not applicable (explain)*

d. Visible graffiti is absent

Y = *No graffiti visible. Any past graffiti painted over. May include murals (i.e., intentional wall paintings, apparently sponsored by city, community or business)*

N = *One or more pieces of graffiti visible (e.g., "tagging," gang symbols, etc.) Write address & explanation of type, extent of graffiti*

N/A = *Not applicable (explain)*

13. **Type of people**

a. "Undesirable" people are absent

Y = *no groups of people that would appear threatening to "average" pedestrians (e.g., groups of rowdy teen-agers, homeless people, men drinking, etc.) Do not consider race/ethnicity in determining.*

N = *obvious groups of people that would appear strongly threatening to "average" pedestrians (e.g., groups of rowdy teen-agers, homeless people, men drinking etc.) Write explanation of type of people*

N/A = *Not applicable (explain)*

14. **Type of land uses**

a. Undesirable land uses are absent

Y = *No liquor stores, check cashing store, pawn shop, adult movie or book stores, or bars on segment*

N = *Segment contains one or more liquor stores, check cashing store, pawn shop, adult movie or book stores, or bars. Write explanation of conditions that look undesirable*

N/A = *Not applicable (explain)*

15. **Number of pedestrians**

a. # of pedestrians on segment

Mark number of people—adults and children—walking or standing on the segment. Do not include bicyclists. Do not include people standing or walking in front of own homes or SR2S observers. N/A = Not applicable (explain)

(B) ACTUAL TRAFFIC SAFETY

16. **Road capacity**

a. Number of lanes of traffic

Mark the number of lanes of car traffic the road accommodates. Do not count turning or parking lane.

N/A = not possible to determine number of lanes of traffic (explain)

17. **Street width**

a. Street width at 1st corner, in feet

Standing at 1st corner, measure street width r from one side of the street to the other. Do not include curbs. If bulb-outs or other special features that narrow street width, do not measure that that point. Move adjacent to special features to make measurements. Use rolling tape measure; indicate in feet (round to closest number)

18. **Segment length**

a. Length of segment from one end to the other, in feet

Measure segment *length in street from one end to the other. Do not include intersections. Use rolling tape measure; indicate in feet (round to closest number)*

19. **Sidewalk width**

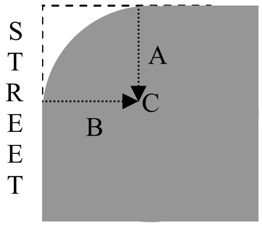
a. Sidewalk width at 1st corner, in feet

Standing at 1st corner, measure sidewalk width with rolling tape measure; indicate in feet (round to closest number)

20. **Turning radii**

a. Turning radii at 1st corner (soft/medium/hard)

Imagine the curb as the following diagram:



21. **Intersections**

a. Number of marked crosswalks & total # of intersections

List # of intersections originating from this segment, crosswalks are marked with painted crossing lanes and/or "zebra stripes." Pedestrian bridge also counts as marked crosswalk

N/A = not applicable (explain)

b. (If 4 or more lanes of traffic) traffic signal present

*Y = traffic signal present in all intersections originating from this segment involving streets that have 4 or more lanes of traffic (e.g., intersection of 2 lane street and 4 lane street has traffic light). * Mark Yes if segment does not have any streets with 4 or more lanes of traffic*

N = no traffic signal present at 1 or more intersections originating from this segment involving a street with 4 or more lanes of traffic (e.g. intersection of 2 lane street and 4 lane street does NOT have traffic light)

N/A = Not applicable (explain)

c. Stops signs at all intersections for segment

Y = stops signs present at all intersections originating from this segment. Traffic signals also count as stop signs. "Yield" signs do not count as stop signs.

N = stops signs or traffic signal absent from one or more at all intersections originating from this segment. May have Yield signs.

N/A = not applicable (explain)

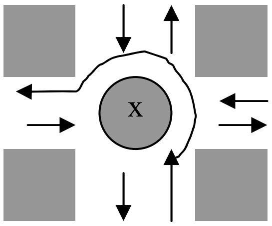
22. The following **traffic calming** features are present:

a. traffic circles

Y =One or more intersections for this segment have a round-about or traffic circle that diverts traffic in a circular pattern

N = No intersection for this segment has round-about or traffic circle

N/A = not applicable (explain)



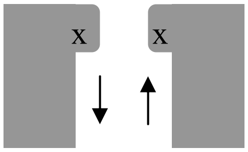
traffic circle

b. curb bulb-outs

Y = One or more intersections for this segment have a "bulb-out" or extra extension into the street to shorten the distance across the street for pedestrians and to limit lane width for cars. Bulb-out may be on one side of the street only

N = No intersections for this segment have a "bulb-out" or extra extension into the street

N/A = not applicable (explain)



curb bulb-outs

c. speed bumps, humps, or tables

Y = Street has 1 or more "bumps" or other slight intentional elevations in the road, that are explicitly intended to slow car traffic. Bump or equivalent is marked to signal drivers.

N = Street has no speed "bumps" or other slight elevations in the road

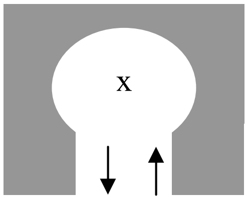
N/A = not applicable (explain)

d. cul de sac or street closing

Y =At least one end of street is closed to car traffic by a cul-de-sac or other physical closure of street.

N = No ends of street are closed to car traffic or by cul de sac

N/A = not applicable (explain)



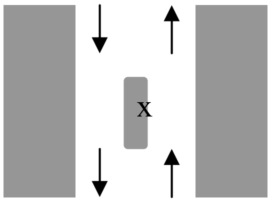
cul de sac

e. median

Y = street has one or more "islands" in the middle. Islands may or may not be landscaped, and may or may not be intended for pedestrian use

N = street has no islands in the middle

N/A = not applicable (explain)



median

f. paving treatment at crosswalk

Y = one or more crosswalks is marked with a special paving (e.g., change in color or materials). Special paving is in the street itself, not only on the sidewalk.

N = no crosswalks are marked with special paving.

N/A = not applicable (explain)

23. The following urban design features associated with **liveliness** are present:

a. Street trees

Y = 2 or more trees are planted in a regular pattern in the public portion of the roadway (e.g., in median or planting strip between the sidewalk and the street)

N = 1 or fewer trees are planted in a regular pattern in the public portion of the roadway

N/A = not applicable (explain)

b. Mixed land uses

Y = Contains <u>*residential*</u> *as well as one of the following land uses: retail//commercial, office, public, and/or industrial*

N = Contains only residential uses, or does not contain residential uses

N/A = not applicable (explain)

c. Public space

Y = Contains 1 or more open spaces that are not part of a private dwelling (e.g., park, garden, playground, plaza, etc.) Does not have to be accessible to all, may not be publicly owned.

N = Does not contain 1 or more open spaces, or only contains open spaces that are part of a private dwelling

N/A = not applicable (explain)

d. Street furniture

Y = Contains benches, chairs, or tables for use by the public. Furnishings may be part of bus shelter

N = Does not contain benches, chairs, or tables for use by the public.

N/A = not applicable (explain)