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Children's Travel: Patterns and Influences

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Abstract

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Childhood obesity has doubled in the last thirty years. At the same time, youth travel patterns have changed greatly. In 1969 42% of students walked or biked to school; now 13% do. These two trends have caught the attention of policymakers who have identified walking to school as a way to reintroduce physical activity into children's lives. However, these policies have been made without much knowledge of children's travel – an area which has been understudied by transportation researchers. This dissertation seeks to fill this knowledge gap and provide information to design better policies by asking three questions: 1) What are the current patterns of children's travel? 2) What factors have the greatest influence on children's mode choice for school trips, particularly for walk trips? and 3) How can land use planning affect walking to school?

All analyses identify the spatial distribution of students and schools as the primary reason for the low rates of walking to school. For example, in 1969 45% of elementary school students lived less than a mile from their school; today fewer than 24% live within this distance. The simple fact is that most children do not live within a walkable distance of their schools. When children do live close to school, substantial numbers walk. However, current policies aimed at increasing walking to school focus on improving trip safety rather than changing distance to school.

To encourage large numbers of children to walk to school, planners will need to coordinate land use and school planning. Including children's distance from school as a planning criterion could be an effective way to change community design and encourage

walking.  This coordination is most necessary in moderate and high density areas where neighborhood schools are a possibility.  However, even in low-density areas, planners can optimize school and housing placement so that a large portion of students live within a walkable distance of their school.

# DEDICATION

*To Kurt, Sarah and Mom*

*Thank you.*

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# CHAPTER 1: INTRODUCTION AND RESEARCH QUESTIONS

Concern about rising levels of obesity in children and adults has led the U.S. Surgeon General to recommend "regular, moderate physical activity" as an important component of a healthy lifestyle (Jackson 2003, U.S. Department of Health and Human Services 1996). Research has shown that many children are not attaining the physical activity recommended by the Surgeon General. Rates of overweight (defined as at or above the 95th percentile of the sex-specific body mass index) increased from 6% in 1971-1974 for ages 12-19 to 16% in 1999-2000; similar increases were seen in other age categories (Ogden et al 2002). A 1997 survey of U.S. students found that only 20% walked or biked enough to gain health benefits (Kann et al 1998). These low rates of exercise are believed to contribute to the increasing rates of obesity among children (Koplan and Dietz 1999). Many researchers believe that if more children walked or biked to school, it might be possible to lower children's health risks (Killingsworth and Lamming 2001). The Department of Health and Human Services (2000) has made it a national health goal to increase the proportion of children that use active modes to get to school.

The rise in childhood obesity has occurred at the same time children have radically changed how they get to school. In 1969, 42% of students walked or biked to school; now 13% do. The share of school trips made by auto has gone from 16% in 1969 to 55% today. Changes in the school trip are important, because 50% of children's weekday trips during the academic year are for school. A reduction in walking and biking for this trip likely means large drops in the overall number of trips by active modes.

Concern about these two trends – the rise in obesity and the decline in walking – has focused policy attention on walking to school. Public health officials believe walking to school is a way to reintroduce regular, moderate physical activity into children's lives. The Centers for Disease Control has launched the KidsWalk program to encourage children to walk to school. Several states facilitate walking to school through their Safe Routes to School programs which fund improvements near school sites. The current federal transportation bill, as adopted by the House, contains $150 million for a national Safe Routes to School program. But these policies assume changes in pedestrian safety

and education are enough to change travel behavior.  None of these policies address the fact that more than 80% of students live more than a mile from their schools.  The reality is that distance makes it impossible for most children to walk to school.

Health concerns have focused attention on children's travel, but they are not the only – or perhaps even the most important – reason for transportation planners to be concerned about this area.  The reality is that an understanding of children's travel is necessary to understand adult travel.  For years, researchers have noted how the presence of children in a household changes travel behavior and determines travel patterns (Goodwin 1983, Kitamura 1988).   Improving understanding of these intra-household decision and travel patterns is essential to developing effective transportation policy.  Parents, particularly mothers, structure their own travel around the needs of their children; for example by coordinating school and work start times.  Responsibility for children's travel may make it difficult for parents to use travel demand management programs, such as carpooling (Rosenbloom and Burns 1993).  There is also evidence children's travel is heightening traffic in some communities.  For example, the traffic engineer for Santa Rosa, a small city in northern California, estimated that the number of cars on the road between 7:15 a.m. and 8:15 a.m. jumps 30 percent during the school year (Surface Transportation Policy Project 2003).

For all of these reasons, the study of children's travel is a necessary and timely topic.  Right now, policy is being made without a solid understanding of key factors influencing children's travel and their relative impacts on travel patterns.  This dissertation seeks to address this knowledge gap by providing a fact base on children's travel and to identify factors which influence walking to school.  This research focuses on three questions to develop a knowledge base about children's travel and identify policy options for increasing walking to school.  The research questions are:

**Question 1:**  What are the current patterns of children's travel?

**Question 2:** What are the relative influences of child, household, and neighborhood characteristics on children's mode choice for school trips, particularly for walk trips?

**Question 3:** How can land use planning affect walking to school?

The first question provides descriptive background on children's travel and serves as a basis for more informed analysis of the remaining questions.  The core of the

analysis revolves around the second question which will identify factors that have strong influence on how children walk to school and discuss how these patterns have changed in recent decades. The emphasis on the school trip is justified because it accounts for the majority of children's travel. The final question looks at how land use planning may influence children's travel behavior. The primary focus is on evaluating the potential for land use policy to influence walking to school, and the need for coordinating school and land use planning. The following section provides more detail on the analytic approach to each of the research questions.

*Question 1: What are the current patterns of children's travel?*

To answer the primary research question, the research will focus on a set of more detailed questions. These are:

- How much are children traveling?
- Why are children traveling, i.e. what are the primary trip purposes?
- Who are children traveling with?
- How do trip patterns vary with socio-demographic characteristics, e.g. age, household income, auto availability?

Much of this analysis will present descriptive statistics that highlight the patterns of children's travel and show how they vary; for example by weekday vs. weekend. Differences in behavior between groups, e.g. low-income vs. high-income, will be tested using t-tests and ANOVA.

*Question 2: What factors influence mode choice to school?*

Three sub-questions will be addressed by the research design:

- How has children's school travel changed in the past 30 years?
- What factors explain the observed changes?
- What factors have the most influence on current mode choice, particularly for walking?

Unfortunately longitudinal analysis of school travel has been limited by data availability at the national level. The one exception to this is the availability of national data on school travel collected in 1969. This information provides an interesting counterpoint to our current situation and allows analysis of how larger demographic shifts, such as

mothers' increased labor force participation rates, have influenced the observed changes. To identify which factors currently influence mode choice, I will construct a multinomial logit model to assess how characteristics of the trip, child, household, and neighborhood affect travel choice, particularly walking.

### *Question 3: How can land use planning affect walking to school?*

Several strategies, including neighborhood schools, grid street patterns, and increased density, have been proposed as land use planning strategies to combat a multitude of ills including the low rates of walking to school. Using the multinomial logit developed previously, I will test the potential effects of each of these strategies on walking to school. The findings will identify the land use strategies that are most likely to result in increased walking.

### *Structure of the Dissertation*

Chapter 2 provides an introduction to the analytical framework and previous research underlying this analysis. Although there is very little previous work on children's travel, this research is informed by the literature on travel behavior – particularly for families and mothers – and by research into neighborhood effects. Much of this research, particularly the sociology literature related to neighborhood effects, emphasizes the need for an ecological model to consider how different layers of factors affect behavior. The analytical framework recognizes the need to consider how factors at multiple levels, e.g. child, household, and neighborhood, affect how children get to school.

The third chapter provides an overview of the data used in the analyses. The primary data source is the 2001 National Household Travel Survey which contains travel diaries for 34,000 children eighteen and under. Census descriptors of the household block group and tract supplement the NHTS data.

The fourth chapter examines the current patterns of children's travel, addressing four research questions: 1) how much are children traveling? 2) why are children traveling and, in particular, what are they doing afterschool? 3) who are children traveling with? and 4) how do the observed travel patterns vary with demographic characteristics such as age, race, sex, and income? The analysis shows that children's

travel resembles adults' in many ways. Youth travel is dominated by the automobile, with nearly 75% of trips being made in a private vehicle. Children's travel patterns are also complex; kids chain trips to reach needed afterschool activities. But in important ways, children's travel is different. In addition, children from low-income, minority households without cars consistently travel less than their peers.

The school trip is the most common and regular of all children's trips. It has also been the recent focus of policymakers and advocates who believe walking to school is an effective means to re-introduce physical activity into children's lives to fight childhood obesity. The trip is important because it structures children's travel in much the same way that the work trip structures adult trips, but, also because a better understanding of the trip is needed to make effective policy. Because of the important policy questions in this area, the fifth and sixth chapters are devoted to the study of school travel. Chapter 5 considers how school travel changed between 1969 and 2001. During this time, the share of trips made by auto went from 16% of all school trips in 1969 to 55% today; biking and walking have slipped from 42% to 13%. These changes are huge and may have important health implications.

The analysis reveals that a large portion of the decline in walking to school can be explained by increasing distance between home and school, particularly for elementary school children. In 1969, 45% of elementary school students lived less than a mile from their school; today fewer than 24% live within this distance. This same pattern occurs at the middle and high school levels. The simple fact is that most children do not live within a walkable distance of their schools. When children do live close to school, substantial numbers walk. For example, 69% of students living within a half mile of school choose to walk.

However, changing distances between home and school cannot fully explain the decline in active travel to school. In 1969, 87% of students living less than one mile of their schools walked; in 2001, this number was 54%. Larger societal forces such as increased auto ownership, mothers' labor force participation and changing social norms have also affected the proportion of students walking to school. Finally, the chapter considers what these changes mean for planners.

The sixth chapter focuses on children's school travel in 2001 to identify the factors with the most impact on mode choice, particularly for walk trips. I use a multinomial logit model to identify the relative influences of trip, child, household, and location characteristics on trips to school. The data reveal that distance to school is the primary barrier to walking. Children are extremely sensitive to walk travel time, which makes them unlikely to walk long distances. The large impact of walk travel time on mode choice suggests that the policies most likely to increase walking to school will be those that focus on where schools are sited. Characteristics of the trip – travel time – are highly influential. Other factors such as density are significant, but their influence is more muted. The models also identified other important factors such as age, number of siblings. Equally important is the finding that gender and race did not influence mode choice. Previous research had suggested that they would.

All analyses identify the spatial distribution of students and schools as the primary reason for the low rates of walking to school. However, current policies aimed at increasing walking to school focus on improving trip safety rather than changing distance to school. The final chapter considers how school travel might change if land use and educational facility planners coordinated their efforts and made it possible for more students to live near their school. Three land-use planning policies – neighborhood schools, street connectivity, and densification – might affect the number of children that walk to school. Using the previously developed mode choice model, I evaluate how each policy might affect walking rates. The results show that large increases in walk mode share could be achieved if most students lived within one mile of their school. But there are some important caveats. First, neighborhood schools are only possible at moderate to high densities where there are enough students living in small geographic areas to fill classrooms. In addition, the neighborhood school model is best suited for elementary education because these schools are smaller and are better-suited to smaller areas. Finally, advocates for neighborhood schools have not discussed the potential equity impacts of this policy. In areas with high levels of residential segregation, neighborhood schools could increase school segregation.

At the very least, these findings show the need for better integration of land use and school planning. Including children's distance from school as a planning criterion

could be an effective way to change community design and encourage walking. This coordination is most necessary in moderate and high density areas and when planning large-scale developments. However, even in low-density areas, planners can optimize school and development placement so that a large portion of students live within a walkable distance of their school.

## CHAPTER 2: ANALYTICAL FRAMEWORK AND PREVIOUS RESEARCH

This research places the child at the center of multiple behavioral influences – individual attributes, family, and neighborhood. This social ecology perspective, borrowed from developmental psychology and urban sociology, contrasts with the microeconomic framework employed in much of transportation research. Fundamental questions about how children make travel decisions (is it the parents or the child making the decision?) and the ability of children to rationally organize preferences undermine the basic tenets of utility maximization theory. This requires a new perspective to study youth travel. Social ecology explicitly recognizes the multiple sources of influence on children's behavior and provides a useful analytical framework.

The social ecology perspective recognizes that all environments which children are exposed to influence their behavior (Bronfenbrenner 1979, Earls and Carlson 2001). Most researchers have acknowledged the importance of the family for understanding children's behavior. However, social ecology requires the consideration of more distant influences as well such as the neighborhood, school, and community institutions. Social ecology represents a shift from individualistic paradigms, where one's behavior is determined from a set of individual factors, to a model where multiple sets of factors operating at different levels, e.g. individual, family, neighborhood, affect behavior (Earls and Carlson 2001, King et al 2002). Earls and Carlson (2001) suggest that "nested Chinese boxes, representing hierarchical ecological systems from the molecular to the societal level" provide an apt metaphor for this model.

### *Analytical Framework*

Applying the social ecology framework, I propose to study the effects of three 'ecologies' on children's travel: the individual, household, and neighborhood. The most difficult aspect of modeling children's travel behavior is that their travel "choices" rely heavily on their parents' beliefs about what modes are appropriate. Figure 1 presents a model that directly acknowledges that the parent's beliefs have an impact on the mode chosen for the school trip. Specifically, I believe the parent's comfort with the child's use of independent travel modes influences the overall mode choice. Figure 1reflects this model of behavior. However, it is impossible with large-scale surveys to measure how

parents feel about their child's independent travel.  Even with an attitudinal survey, it may be difficult to gauge parent's true feelings about this issue rather than their 'after the fact' rationalizations.  Therefore, I propose to use a second, simplified model to guide this research (see Figure 2) which considers the characteristics of neighborhoods, households, and children and measures their relative influence on children's mode choice.

**Figure 1:  Conceptual Framework: Complex Model**

*Neighborhood*
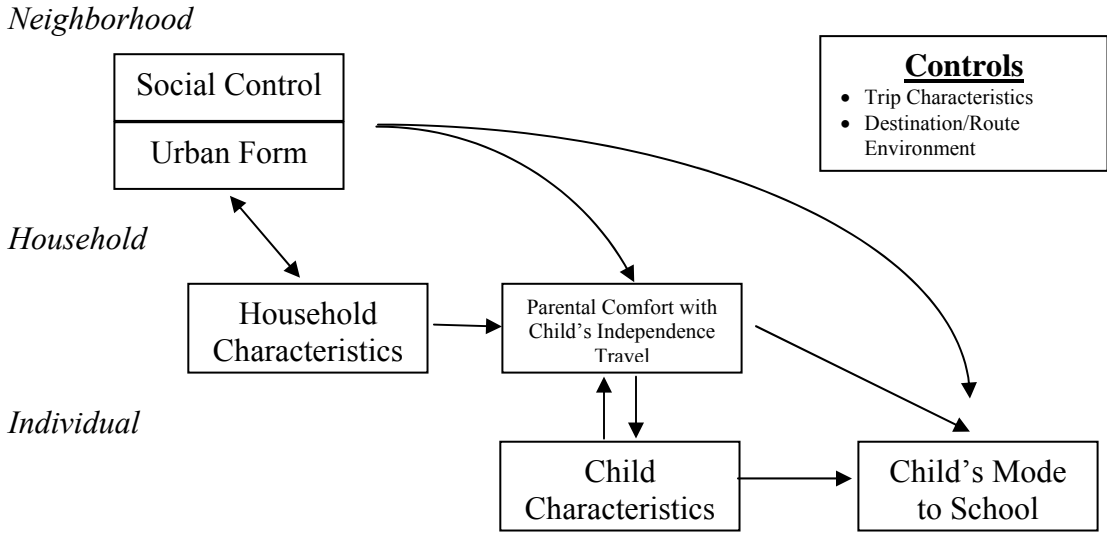


**Figure 2:  Conceptual Framework: Simple Model**
**Data Level**
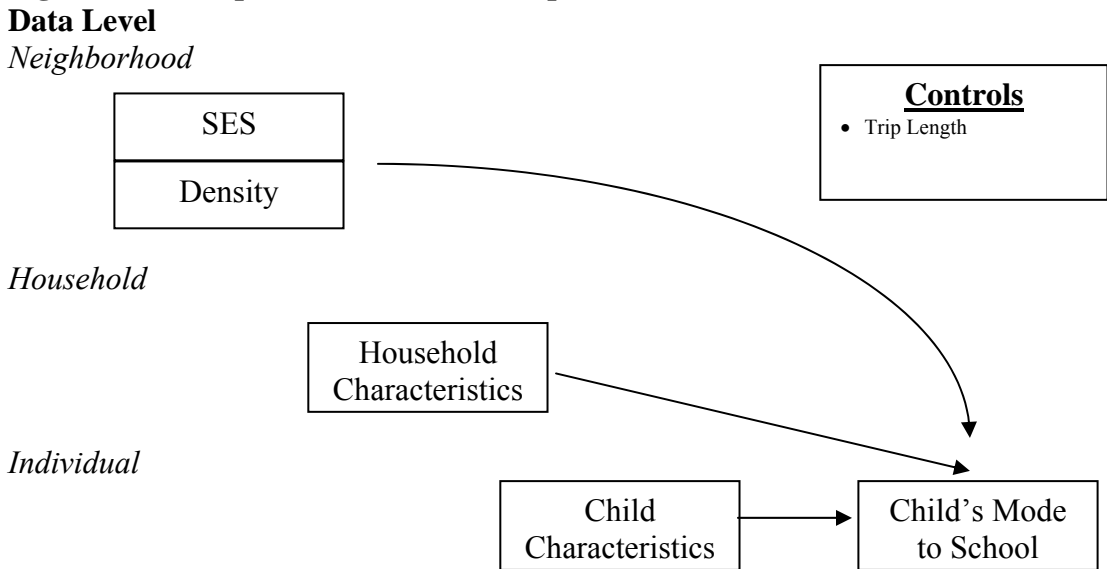
*Neighborhood*

*Previous Research*

Although there is little literature directly on the topic of children's travel, this dissertation draws from previous work on travel behavior, the relationship between travel and the built environment, neighborhood effects, and physical activity. Following the analytical framework, the remainder of this chapter describes what previous research suggests will be important factors at the child, household, and neighborhood levels.

**Child**

Researchers have identified several factors that influence mode choice for children: distance to school, urban form, age, gender, household car availability, safety, and children's travel preferences. However, little statistical analysis of the relative importance of various factors has been done (McMillan (2003) is an exception). Several authors identify the distance to school as an important factor (McMillan 2003, Bradshaw and Atkins 1996, STPP 2003, Beuret and Camara 1998, Bradshaw 1995, Hillman et al 1990, DiGuiseppi et al 1998, Dellinger 2002, Sjolie and Thuen 2002).

Age and gender are also important in determining children's travel. Hillman et al (1990) showed that "boys six to eleven are twice as likely as the girls to make the school journey on their own or with someone of their own age." A study of Toronto children showed that suburban boys were allowed to travel farther than girls (Vliet 1983). Interestingly, this relationship only held in the suburbs. City children exhibited no difference in geographic range. This may be symptomatic of the fact that desired destinations are generally closer in cities than in suburbs so there were fewer occasions for parents to curtail girls' travel in the city. More recent studies continue to show gender differences, particularly among younger children (Evenson et al 2003).

Research on the travel behavior of low-income middle and high school students suggests ethnicity is a mediating variable in the link between age, gender, and travel freedom (McDonald et al 2004). Focus group discussions revealed that Latinas and Asian girls had limited travel freedom, particularly the ability to travel by themselves on public transit.

One factor which is not well understood is how children's own travel preferences influence their travel patterns. The small amount of research that exists suggests that travel represents important socializing time for many youth and that this influences their

travel preferences (Gurin 1974, Weston 2002). Some trips appear to be undertaken purely on their merits, e.g. joyriding and cruising. In other cases, it appears that the ability to socialize, e.g. with friends on the school bus, or the desire to avoid schoolmates, e.g. a child that who is picked on, influences mode preferences for youth. This finding is at odds with the axiom that travel is a derived demand, but may relate to findings that even adults have a preferred travel time, which is not zero, and are not simply looking to minimize general travel cost (Mokhtarian and Salomon 2001).

Very little research has looked directly at the question of how walking to school relates to total physical activity, and what research there is has shown contradictory results. Cooper et al (2003) examined how walking to school impact overall physical activity for primary school children in the UK. Their data showed that boys who walked to school were significantly more active overall, but that this pattern was not observed in girls. In contrast, Metcalf et al (2004) found that walking to school was not associated with an overall increase in physical activity for 5 year old at 53 primary schools in the UK. Specifically, they found that walking to school only accounted for 2% of children's total weekly activity. These differences highlight the need for more research on this topic.

**Household**

Parents are critical to understanding children's travel because they may directly determine youth trip patterns by acting as the chauffeur or the permission-giver. Rosenbloom's (1987, 1989a, 1989b) analyses suggested that parents' schedules, particularly work commitments, make them more or less available to transport children. Therefore parental availability may affect the number of trips that children make. Similarly, parents have some control over when children begin to use independent travel modes and the types of trips they are allowed to use them for.

Not only are individual characteristics important to explaining travel patterns, the resources available to and total composition of the household also matter. Most previous studies of adult travel look at the monetary resources of the household, usually income. Income is an important constraint variable because it is correlated with the number of household vehicles which directly determine the travel options available to the

household.  But income also works indirectly to shape travel needs and choices.  Higher income households tend to live in better neighborhoods, many of which are suburban.  In addition, having higher incomes may make parents more likely to enroll their children in private schools.  It is possible that these private schools are more distant than neighborhood schools.

Increasing levels of car ownership make it easier for parents to drop off children at school (DiGuiseppi et al 1998, Bradshaw and Atkins 1996).  For example 1994 U.K. travel survey data showed that 87% of students in carless households walked to school compared with 36% for students in households with 2 or more cars (Bradshaw and Atkins 1996).  While there are obviously other factors influencing this, e.g. socio-economic status, the variation is quite substantial.

Previous research also suggests that parents are likely to combine their travel with their children's.  In Leeds, 60% of parents who drove students to school combined this trip with their work travel (Bradshaw and Atkins 1996).  Research in Sydney, Australia showed that the presence of children in the household made parents' trip chains more complex and encouraged the use of the car as opposed to public transport for those trips (Hensher and Reyes 2000).   Mothers, in particular, are likely to travel with children and chain trips (McGuckin and Murakami 1999, McDonald 2004).  For example, national U.S. travel survey data shows that mothers with young children make a large number of serve-passenger trips which they combine with the work trip (McGuckin and Murakami 1999).  All of these findings suggest that maternal availability, work status, and auto access will affect children's travel behavior.

There is also reason to believe that being in a single-headed household will affect children's behavior.  Rosenbloom (1989a) found that the travel patterns of single mothers are "less responsive to the needs of children or household than those of married mothers, perhaps because they face more constraints with fewer alternatives."  She concludes that the "children of single parents may make some trips independently and they may be foregoing other trips – and both situations may have far reaching social consequences."

It is also likely that the number of children in the household affects decisions around mode and travel coordination.  While it might be convenient to drop off one child at school, it might be a much more time consuming proposition with three children.

However, if all three children are going to the same destination, parents may be more likely to drive them, all else being equal.  These simple examples show that the composition of the household is likely to strongly influence observed travel patterns.  The precise nature of this influence will be addressed throughout the research.  However, no previous research has looked at this question directly.

**Neighborhood**

Although the study of neighborhood effects on behavior has recently been accused of being a cottage industry in urban sociology and transportation research (Sampson et al 2002, Cervero 2002), both fields have had a long occupation with how place affects behavior.  Starting with the Chicago School in the 1920s and 30s, researchers have emphasized the relationship between space and behavior.  Jacobs (1961) explored the links between community relationships, safety, and design.  She highlighted the importance of people – the eyes on the street – who were willing to monitor the street and maintain the social order.  Appleyard (1981) and Whyte (2000) both emphasized how the design of streets and cities affected the behavior of residents and visitors.

From these roots, both fields have continued to study how place affects behavior. In recent years, there have been important differences in how transportation and sociology researchers have approached the question of neighborhood effects. Transportation researchers, perhaps because of the focus on evaluating the claims of New Urbanism, have focused primarily on physical design.  In contrast, urban sociologists have conceptualized neighborhoods from a social resource perspective.  Neighborhood socioeconomic status (SES) has been seen as a critical proxy for community resources. Some sociologists have attempted to move beyond SES measures to document the underlying the social processes which affect behavior.  Most of the sociology literature has ignored questions of how the physical environment interacts with the social environment to affect behavior (Sampson et al 2002).  The following sections focus on four literatures about place and behavior – environment and travel, environment and health, SES and social processes, and safety – to better understand what factors might influence children's travel.

*Environment and Travel*

Few studies directly address how the built environment influences children's travel. Boarnet et al (2005) and Staunton et al (2003) have shown that changes in the built environment, such as sidewalk and street crossing improvements, can make students more likely to walk to school. McMillan (2003) found that the "relationship between urban form and travel behavior was relatively modest." The urban form variables which were significant – proportion of abandoned buildings, street lights and street widths – all had counterintuitive signs. The methodology she used makes it difficult to resolve whether the model accurately represents the relationships or whether the methodology (specifically the small number of locations studied) influenced the analysis.

Although there is only limited work looking at how the built environment affects children's travel, the 1990s represented an explosion of such work for adult travel (see Badoe and Miller 2000, Ewing and Cervero 2001, Crane 2000, and Boarnet and Crane 2001 for reviews). The message from a clear majority of the studies is that the built environment matters, but it may only have a marginal impact on the choice of travel mode or the rates of trip-making. However, this conclusion is still being refined as researchers develop better measures of the physical environment and study different scales, i.e. neighborhood vs. region.

Cervero and Kockelman (1997) used factor analysis to represent the density, diversity, and design of 50 neighborhoods in the San Francisco Bay Area and found that a factor representing intensity of use (composed of retail store density, activity center density, retail intensity, walking accessibility, park intensity, and population density) was associated with higher levels of non-motorized travel. Cervero (2002) found that built environment variables, such as population and employment densities, and land use diversity – all measured at the TAZ level, improve mode choice models and that the most significant built environment factor is the ratio of sidewalk to road centerline miles.

Handy (1996b) compared non-work trip frequencies for two city pairs in the San Francisco Bay Area with differing levels of local and regional shopping accessibility and found neighborhood design to be a significant factor even when accounting for socio-demographic characteristics. Studies of walking behavior in 6 Austin neighborhoods found perceived safety, shade and people on the street to be significant factors for

strolling trips; housing and scenery appeared to influence trips to the store (Handy et al 1998)

Questions of scale and regional accessibility appear to critically influence the results of studies on travel and the built environment. Cervero and Gorham (1995), using a matched-pair analysis, found that pedestrian-oriented neighborhoods (defined as being initially built along a streetcar or rail station, and having a gridded street pattern) in the Bay Area had more walking and biking trips than similar auto-oriented areas (defined as being in areas without transit, with random street patterns and high numbers of 3-way intersections). However, these results did not hold in southern California suggesting that regional accessibility is an important factor in trip making. Other research suggests that micro-level details also influence travel. Studies of 12 neighborhood commercial centers in the Puget Sound region found that site design, i.e. block size, completeness of sidewalk system, affected the amount of pedestrian travel (Hess et al 1999, Moudon et al 1997).

As researchers have begun focusing more on walking and biking, better measures of the physical environment have been developed. Cervero and Duncan (2003) modeled walking and cycling trips in the San Francisco Bay Area using traditional measures of the built environment, e.g. employment accessibility, land use diversity, as well as variables for the slope between origin and destination, rainfall, nighttime trips, and a proxy for neighborhood safety. They conclude that "density and land-use diversity exert stronger pressures than urban design on the decision to walk"; [...however,] "built environment factors exerted far weaker, although not inconsequential influences on walking and biking than control variables."

Rodriquez and Joo (2004) modeled faculty and student commutes to the University of North Carolina, Chapel Hill and found two factors, which have been ignored in much of the early work in this area – sidewalk availability and slope – to impact the decision to walk or bike to campus. In a study of mode choice in Boston, Srinivasan (2002) found that the pedestrian environment between the origin and destination (as measured by factor containing average sidewalk width, proportion of roads with level terrain, and proportion of roads with sidewalks) was as important as the characteristics of the origin and destination. This suggests a further set of built environment refinements for researchers to consider.

Boarnet and Crane have promoted the use of behavioral models that rely on a microeconomic framework to explain travel behavior. In these models, they suggest that land use influences travel behavior in its ability to affect the generalized cost, i.e. travel time, of travel. Using this framework Boarnet and Greenwald (2000) found that land use variables – including the percentage of a ¼ mile buffer with gridded roads, population density retail employment density, a subjective pedestrian environment rating, and the percentage of single family dwelling units – showed more correlation with non-work auto travel. However in a related study the authors found that land use variables measured locally (that is at the block group level) impacted non-work pedestrian travel (Greenwald and Boarnet 2001). Using the same framework, Boarnet and Sarmiento (1998) studied southern California non-work trip making and found land-use variables were generally insignificant in their models. Their choice of built environment proxies – population and employment densities – may not have fully captured urban form realities.

*Environment and Health*

Research in physical activity and public health also suggests that elements of the built environment influence behavior. For example, Giles-Corti and Donovan (2002 and 2003) found the physical environment (type of street, traffic levels) to be as important as personal factors (attitude toward exercise, past exercise history), and the social environment (club membership, dog ownership, family exercise patterns) in determining exercise levels of healthy Perth, Australia adults. In a national U.S. study, Berrigan and Troiano (2002) found that adults living in homes built between 1946 and 1973 were more likely to walk at least one mile at least twenty times per month than those living in houses built after 1973 controlling for gender, race/ethnicity, age, education, income, and health problems. While there are obvious associations between home age and neighborhood design, this analysis does not identify which elements of the built environment support walking. Frank et al (2005) found that land-use mix, residential density, and intersection density positively influenced the level of physical activity (as measured through accelerometers) of adults in the Atlanta region.

Studies of the connections between urban form and health show a small but significant relationship. However, there are still very significant measurement and research design issues. In particular, all these studies are cross-sectional and cannot

prove causality. Ewing et al (2003) developed a sprawl index at the county and metropolitan levels; based on residential density, land-use mix, the proportion of development located in the region's core, block length, and block size; and tested its relationship to self-reported obesity, BMI, and other health outcomes. Results showed a small association between the county-level sprawl index and obesity, BMI, and hypertension; metropolitan-level measures were only significantly related to minutes walked. In a study of the Atlanta metropolitan region, Frank et al (2004) found that land-use mix was positively associated with objectively measured obesity. The authors also found that the strength of the relationship between urban form and BMI varied with race, with whites having a stronger relationship than blacks.

Kelly-Schwartz et al (2004) used the same techniques as many other researchers (hierarchical linear modeling) but used somewhat more detailed measures of the built environment. Their results show a more nuanced picture of the relationship between health and the environment. The authors show a positive relationship between connected, i.e. gridded street networks and health, but a negative relationship between density and health. These findings suggest the need for more fine-grained analyses which pay careful attention to the complex relationships between health and urban form. In related work using the same data set, Doyle et al (2004) found that urban form had an impact on how much people walked but no relationship to self or physician reported health outcomes. The researchers also found that women were much more sensitive to high level of crime, and that this differing sensitivity to crime explained observed gender differences in frequency of walking and BMI.

*SES and Social Processes*

Concern with the spatial nature of social processes and outcomes has been prominent in urban sociology since the Chicago School of the 1920s and 30s (Park, Burgess, and McKenzie 1925). For example, Park's dictum stated that "social relations *are* spatial relations" (Massey 2001, emphasis in original). Recent work in this area was spurred by Wilson's (1987) book, *The Truly Disadvantaged* which suggested that growing up in a poor neighborhood had a separate effect from growing up in a poor family (Sampson 2001, Massey 2001). Other analyses (Mayer and Jencks 1989, Massey and Denton 1993, Massey 1996, Jargowsky 1997) showed an increasing concentration of

poverty and residential segregation and led to an explosion of 'neighborhood effects' research (Sampson et al 2002).

Two approaches to understanding the impacts of neighborhoods on behavior have been prominent. The first relies on indicators of neighborhood SES such as the proportion of households in poverty and the percent of female headed households from the Census measured at the tract or block group level. Brooks-Gunn et al (1993) used measures of census tract affluence and poverty as well as indicators of the portion of families on public assistance, the fraction of male workers in professional occupations, and the fraction of female-headed households to investigate the neighborhood impacts on child and adolescent development. They found neighborhood effects, particularly the presence of affluent neighbors, to be significant even after controlling for family characteristics. Their results also suggested that impact of the neighborhood varied by race and income. In a longitudinal study of nearly 450 urban African American adolescents, Connell et al (1995) found the neighborhood to have a moderate impact on the decision to remain in school. Specifically, they found that "males from less poor neighborhoods were more likely to stay in high school" once individual and family characteristics had been controlled for. Ensminger et al (1996) found living in better neighborhood (as measured by the percent living below the poverty line and the percent in white-collar occupations) to decrease the chance of leaving school early even when "family background, early school performance, adolescent family supervision, and adolescent marijuana use [were] controlled." These studies suggest that the neighborhood does have an impact on children, and that it may be important to pay as much attention to concentrated affluence as concentrated poverty.

While the first approach provides convincing evidence that neighborhoods do impact adolescent and child behavior, it fails to provide a behavioral explanation of how that influence occurs. A second line of research has concentrated on theorizing about the spatially embedded social processes that cause neighborhood impacts. The majority of this research comes from an innovative ten year study, the Project on Human Development in Chicago Neighborhoods (PHDCN), which tested the hypothesis that neighbors' willingness to act on one another's behalves strongly affects multiple adult and youth behaviors. Through surveys which measured neighborhood social control and

social cohesion, researchers showed these factors were strong predictors of violence levels, children's health outcomes, and low birth weight even after individual and family characteristics had been controlled for (Sampson et al 1997, Morenoff 1999, Morenoff 2003).   A measure of informal social control was obtained through responses to five questions about how likely  (Likert-scale) that their "neighbors could be counted on to intervene if (i) children were skipping school and hanging out on a street corner, (ii) children were spray-painting graffiti on a local building, (iii) children were showing disrespect to an adult, (iv) a fight broke out in front of their house, and (v) the fire station closest to their home was threatened with budget cut." (Sampson et al 1997).  Social cohesion was measured by respondents' agreement to several related statements: "(i) people around here are willing to help their neighbors," "this is a close-knit neighborhood;" "people in this neighborhood can be trusted," "people in this neighborhood do not share the same values."

These two concepts – control and cohesion – are combined into the term 'collective efficacy' which is defined as "social cohesion among neighbors combined with their willingness to intervene on behalf of the common good" (Sampson et al 1997). Predictors of collective efficacy were concentrated disadvantage and immigrant concentration (both negatively correlated) and residential stability (positively correlated) (Sampson et al 1997).

This approach has been extended to explicitly account for neighborhood effects on children.  The researchers identify three aspects of neighborhood life which together created collective efficacy for children: intergenerational closure, reciprocated exchange, and informal social control and mutual support of children (Sampson et al 1999). Intergenerational closure looks at the links between adults and children in a community and was measured with questions such as "parents in this neighborhood know their children's friends," adults in this neighborhood know who the local children are," and "parents in this neighborhood generally know each other."  Strong links provide "children [with] social support, parents with information, and facilitate control" (Sampson et al 1999).

Reciprocated exchange is the "intensity of interfamily and adult interaction with respect to childrearing" (Sampson et al 1999).  It was measured with questions such as

"about how often do you and people in your neighborhood do favors for each other?;" and "how often do you and people in this neighborhood have parties where other people in the neighborhood are invited?" The final aspect of collective efficacy for children, and probably the most critical for travel behavior, considers the "expectation that neighborhood residents can and will intervene on the behalf of children and depends on shared values" (Sampson et al 1999). This item was measured using questions like those described above. The focus on action embodied in the last definition highlights the difference between collective efficacy and other theories of social capital, which are more concerned with community resources (Sampson et al 1999).

Researchers found that

- intergenerational closure is positively associated with concentrated affluence, and negatively associated with the ratio of adults to children in the neighborhood;

- reciprocated exchange increases with neighborhood stability, concentrated affluence, and low population density; and

- informal social control is negatively correlated with concentrated disadvantage, immigrant concentration, and the ratio of adults to children. Concentrated affluence had positive influences, but the effect was not as strong as concentrated disadvantage.

Sampson et al (1999) conclude that "concentrated affluence is linked primarily to mechanisms that activate social networks (intergenerational closure and reciprocated exchange) whereas concentrated disadvantage is linked mainly to low shared expectations for public action regarding children." These results seem particularly important for children's travel. Common sense suggests that parents' willingness to allow children to travel independently depends on their trust of their neighbors to act on behalf of their children, both to protect their safety and control their bad behavior.

*Safety*

A factor repeatedly cited in studies of children's travel choice is safety. Parents express concern about traffic dangers and the risk of abduction or harassment (DiGuiseppi et al 1998, Dellinger 2002, Beurat and Camara 1998, Tranter 1996, STPP 2003, Hillman et al 1990, Dellinger 2002). Some research suggests that parents of

younger children (5-11 years) are most concerned with these issues.  Nationwide death statistics bear out parents' safety concerns – pedestrian and bike accidents are the third leading cause of death for children aged five to fourteen (McMillan 2002).  Analysis of recent U.S. data shows that bicycling, walking and teens driving account for the most injuries and fatalities per trip and per mile for school travel (National Research Council 2002).  Pucher and Dijkstra (2003) show that "walking and cycling in the US are much more dangerous than car travel, both on a per-trip and per-mile basis."  Researchers have generally had difficulty reflecting safety in models of travel.  This is partly the result of difficulties obtaining data.  But it is also the result of concerns that parents' perceptions of safety and the reality are very different.

Second, the use of the car for school trips has been implicated in rising congestion on the roads as well as at school sites (Tranter 1996, Surface Transportation Policy Project 2003).  Because many parents drop-off children at school on their way to work or another destination, it is unlikely that reducing the number of parents who drive their children to school will have a measurable effect on overall congestion levels.  However, decreasing auto drop-off trips could lead to a substantial decrease in congestion near school sites.  The congestion at school sites is one factor parents cite for not allowing students to walk (Anderson et al 2002, Bradshaw 2001).

*Summary*

The ecological analytical framework requires a strong understanding of how factors at each level might influence travel behavior.  Although the literature on children's travel is limited, research on travel behavior and neighborhood effects provides a solid foundation for identifying critical variables at each level.  The literature on women's travel highlights the household-level factors which may be important and brings attention to the question of whether maternal or paternal attributes have the most influence on children's behavior.  The literature reveals multiple ways of conceptualizing how place affects behavior.  Transportation offers insights into how the spatial layout of communities, such as street design, density, and sidewalk provision, influences travel patterns.  Urban sociology looks at the spatially embedded nature of social processes. Together these literatures provide a basis for answering my research questions.

# CHAPTER 3: DATA

To address the three research questions – 1) What are the current patterns of children's travel? 2) What are the relative influences of child, household, and neighborhood characteristics on children's mode choice for school trips, particularly for walk trips? 3) How can land use planning affect walking to school? – I chose to analyze the 2001 National Household Travel Survey (NHTS). The NHTS provides the only nationally comprehensive travel dataset which make my research findings generalizable. In addition, it is a well-tested and clean dataset which allows confidence in the findings. Finally, the dataset includes 65,000 households which provides for sufficient sample even when analyzing population sub-groups. The NHTS travel survey information will be supplemented with data from the Census and the FBI Uniform Crime Reports; each of these data sources is described below.

## *National Household Travel Survey*

The NHTS, which is collected by the US Department of Transportation, provides trip diaries for 66,000 households. Collected between March 2001 and May 2002, the dataset includes information on trip purpose, mode, time, length, as well as who in the household was on the trip. The dataset also includes descriptive information for each person, e.g. age, sex, and household, e.g. household size, income, auto ownership, density at residence. Each participating household was assigned a 'survey day' on which they recorded all trips. For the 2001 survey, the survey methodology included prompts to ask respondents about non-motorized trips which tend to be underreported (see US Department of Transportation (2004) for details). This new methodology led to a substantial increase in the reporting of walking trips (Pucher and Renne 2003).

For this analysis I have included only those households that:

- reported ages for all household members,
- completed travel diaries for all household members, and
- have an adult 19 or older in the household.

Given these requirements, my sample includes 58,348 households, 34,593 children, 105,185 adults, and 559,878 trips. Children – defined as those 18 and under – are present

in 36% of the households and account for 21% of all trips.  Table 1 and Table 2 provide
an overview of the sample.

**Table 1: Overview of NHTS 2001 data files- Person Level**

| Variable | All Persons | Children (18 & Under) |
|---|---|---|
| N | 139,778 | 34,593 |
| % Female | 51% | 49% |
| % White | 71% | 66% |
| % Hispanic | 7% | 9% |
| % Black | 12% | 14% |
| % Asian | 3% | 3% |
| % Multi-racial | 7% | 7% |

Applies sample weights

**Table 2: Overview of NHTS 2001 data files-Household level**

| Variable | All HHs | HHs with Children |
|---|---|---|
| N | 58,331 | 18,597 |
| HH Size | 2.5 | 3.9 |
| # of Children | 0.7 | 1.8 |
| HH Income | | |
|   % <$20,000 | 22% | 15% |
|   % >$80,000 | 17% | 23% |
| HH Vehicles | | |
|   % 0 vehicles | 8% | 5% |
|   Avg # of Vehicles | 1.9 | 2.2 |
| Location | | |
|   Avg Population Density (persons per sq mile) | 6,241 | 5,651 |

Applies sample weights

Weinstein and Schimek (2004) have shown that the standard NHTS coding of
short trip distances is highly inaccurate because many trips of less than a half mile are
coded as "0 miles."  Following their example, I recoded any trip reported as "0 blocks" to
0.055 miles (based on the NHTS' assumption that a block is 1/9 of a mile) and recoded
trips reported "0 miles" to 0.25 miles (using the midpoint of the interval from 0 to 0.5
miles).  While these corrections are not perfect, they are much better than having trips
with zero distance.

Finally, one concern with the NHTS – and any travel survey data – is the very high rates of proxy-reporting for children's travel. In fact, the NHTS requires that anyone under 13 have their data proxy reported. In the 2001 sample, data for nearly 100% of children 15 and under are proxy reported; 60% of those 16 and 17 have proxy reported records. While this is obviously necessary for the youngest children, proxy reporting may lead to under-reporting of children's trips or inaccurate descriptions of trips that were taken. If proxy reporting leads to uniform under-reporting of trips, it is less than ideal but the impacts on modeling are minimal. The problem emerges if the under-reporting of trips is correlated with demographic characteristics such as race or income. Currently, there is no easy way to estimate the magnitude of this problem and future research should focus on validating proxy trip reports for children. One important caveat is that there is reason to believe the proxy trip reports for the school trip are accurate because it is an everyday trip that parents are likely to know about.

### Census

To better understand the environment in which survey respondents live, I linked the NHTS data to Census data on socioeconomic conditions at the census tract and block group level. The census data include information on the race; age; household status, e.g. married-couple or single headed; residential stability; occupation; educational attainment; income; and housing tenure of residents at the block group or tract level. These data provide insight into how the social character of a neighborhood affects children's travel patterns.

### FBI Uniform Crime Reports

Parents consistently cite safety as a primary reason for not allowing their children to walk (Dellinger 2002, DiGuiseppi et al 1998). One component of this concern is likely based on fear of crime (the other is traffic danger). The best source of information on nationwide crime is the FBI's Uniform Crime Report (UCR). The 2001 UCR provides information on Part 1 crimes, which include murder, manslaughter, rape, robbery, aggravated assault, burglary, theft, and arson, at the county level. Unfortunately there are several states with large amounts of missing data.

*Variables*

The following section reviews the variables used in the analysis, presenting basic summary statistics and providing an overview of the expected effect of the variable on the likelihood of walking to school – one of the key outcomes studied in this research.

**Trip Characteristics**

The primary trip characteristics are distance and time. In the NHTS dataset both variables are self-reported. As Figure 3 shows most travel for children is under five miles and takes less than twenty minutes. However, both distributions have long tails. Table 3 provides summary statistics for these variables.

**Figure 3: Travel Distance and Time Distributions**
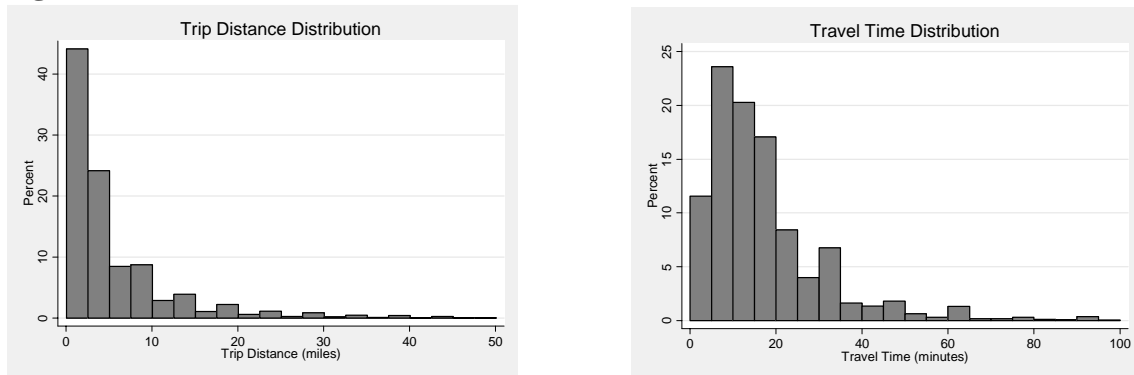


**Table 3: Trip Characteristics**

| Variable | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|
| Trip distance (miles) | 7.8 | 35.1 | .06 | 4000 |
| Travel Time (minutes) | 17.3 | 26.0 | 0 | 1,439 |

Unweighted statistics

**Child**

Hillman et al (1990) and Vliet's (1983) analyses suggest that the child's characteristics, particularly age and gender, will be very important to understanding travel patterns. These two factors appear to play an important role in determining when parents consider children ready for independent travel and for staying home alone. Much of the observed car travel for young children may reflect trips where the child 'goes-along' because there is no one else available to watch the child. Age is also important because children's activities vary greatly with age – the most important age-based transition occurring when they begin school. Additional variables at this level include

race, number of siblings, presence of older and younger siblings, and an indicator for
possession of a driver's license.

**Table 4: Child Characteristics**

| Variable | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|
| Age | 9.4 | 5.3 | 0 | 18 |
| Female (dummy) | 0.5 | 0.5 | 0 | 1 |
| Number of Siblings | 1.3 | 1.1 | 0 | 11 |
| Presence of Older Sibling (dummy) | 0.4 | 0.5 | 0 | 1 |
| Presence of Younger Sibling (dummy) | 0.5 | 0.5 | 0 | 1 |
| White (dummy) | 0.8 | 0.2 | 0 | 1 |
| Black/African-American (dummy) | 0.04 | 0.2 | 0 | 1 |
| Asian/Pacific Islander (dummy) | 0.04 | 0.2 | 0 | 1 |
| Latino/Hispanic (dummy) | 0.04 | 0.2 | 0 | 1 |
| Multi-racial (dummy) | 0.04 | 0.2 | 0 | 1 |
| Licensed Driver (dummy) | 0.15 | 0.4 | 0 | 1 |

Unweighted statistics

**Household**

At the household level, important variables reflect household structure, resources,
and parental schedules. The NHTS contains data on the number of adults and children in
the household. This allows determination of whether the child lives in a single-headed
household and whether it is a single mother or single father. Information on household
resources includes income and vehicle ownership. Through cross-referencing, it is also
possible to identify the education, occupation, work status, distance to work, and density
at work location for parents. I have also included an indicator of whether the mother and
father traveled to work on the morning of the travel, because this will probably be
important in understanding the coordination of travel schedules.

**Table 5: Household Characteristics**

| Variable | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|
| # of Adults in HH | 2.1 | 0.6 | 1 | 10 |
| # of Children in HH (18 and under) | 2.3 | 1.1 | 1 | 12 |
| # of Vehicles in HH | 2.4 | 1.1 | 0 | 15 |
| Vehicles per Driver | 1.1 | 0.5 | 0 | 6 |
| Zero Vehicle HH (Dummy) | 0.02 | 0.1 | 0 | 1 |
| Income (000) | 60.9 | 30.3 | 2.5 | 110 |
| Father Works Full-time (Dummy) | 0.8 | 0.4 | 0 | 1 |
| Mother Works Full-time (Dummy) | 0.4 | 0.5 | 0 | 1 |
| Mother Works Part-time (Dummy) | 0.2 | 0.4 | 0 | 1 |
| Parent College-educated (Dummy) | 0.5 | 0.5 | 0 | 1 |
| Parent Prof/Mang Occup. (Dummy) | 0.5 | 0.5 | 0 | 1 |
| Father Travel to Work in AM (Dummy) | 0.4 | 0.5 | 0 | 1 |
| Mother Travels to Work in AM (Dummy) | 0.3 | 0.5 | 0 | 1 |
| Density at Father's Workplace (000) | 3.7 | 10.1 | 0 | 199 |
| Density at Mother's Workplace (000) | 3.8 | 9.9 | 0 | 186 |
| Father's Distance to Work (miles) | 10.7 | 30.0 | 0 | 1,796 |
| Mother's Distance to Work (miles) | 6.9 | 9.0 | 0 | 225 |

Unweighted statistics

**Neighborhood**

The transportation and sociology literatures suggest that neighborhoods exert an influence on behavior through the physical and social dimensions. With regard to the social environment, sociologists have found that neighborhood SES and collective efficacy significantly impact youth behavior (Brooks-Gunn et al 1993, Ensminger et al 1996, Sampson et al 1999). This research uses measures of neighborhood SES from the Census. Sampson et al (1999, 1997) showed that collective efficacy is correlated with Census measures of concentrated affluence, concentrated disadvantage, neighborhood stability, immigrant concentration, and the ratio of adults to children. Other researchers have shown SES indicators such as percent of households with incomes below poverty levels, percent of female headed households, median household income, and percent of households headed by white collar professional to show significant neighborhood impacts on youth behavior (Brooks-Gunn et al 1993, Ensminger et al 1996). The particular indicators of neighborhood SES that I chose were: the percent of people living below the poverty line, the percent of housing units that are rented, the percent of residents that are foreign born, and the percent of households having incomes above $100,000, measured at the block group level from Census 2000 data.

Researchers interested in the effects of the environment on travel behavior have been developing an ever richer set of measures in recent years. Unfortunately, the fact that the NHTS is a nationwide survey greatly limits the ability to measure the micro-environment near origins and destinations. Unlike many regional datasets, point locations for trip origins and destinations were unavailable. Instead, the NHTS identifies the census block group as the smallest geographic unit (available through the confidential version of the survey). Because of this, I used population density as a proxy measure for the built environment. Another density-based measure is a dummy variable indicating whether the block group is part of a dense, urban area. This measure is derived from a Claritas variable which accounts for residential population density at the block level with a correction factor for the densities of the surrounding areas (US Department of Transportation, 2004, Appendix Q; Miller and Hodges, 1994). This 'contextual density' is based on overlaying a grid onto the United States and converting density into centiles (0 to 99). Urban areas consist of population centers with centiles greater than 79, i.e. the densest 20% of the nation. The median density for these areas is 11,500 persons per square mile which is approximately half of the density of New York City.

There is a large literature discussing the shortcomings of only using density as a measure of the built environment. The main criticism is that while density is correlated with many built environment elements, such as presence and frequency of transit, land use mixing, and street connectivity, it does not allow us to identify how these underlying factors affect travel decisions (Handy 1996a, Crane 2000). This is undoubtedly true; however, I believe we know so little about the impacts of the environment on children that looking at density-based measures is actually quite helpful precisely because density reflects so many aspects of place. While these measures do not tell us the particular dimensions of the built environment, e.g. presence of sidewalks, which encourage certain travel patterns, they are effective at highlighting differences in behavior in rural vs. suburban vs. urban places. Future research should focus on regional studies where more detailed measures of the environment can be employed.

**Table 6: Neighborhood Characteristics**

| Variable | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|
| Population Density (ppl/sq mi) | 3,977 | 11,011 | 0 | 274,000 |
| % Black/African-American | 5.1 | 13.1 | 0 | 100 |
| % Female-headed Single Family HHs | 8.8 | 6.8 | 0 | 79 |
| % Foreign-born | 6.5 | 9.5 | 0 | 79 |
| % Below Poverty-line | 8.2 | 8.8 | 0 | 100 |
| % Renters | 26.1 | 20.6 | 0 | 100 |
| % White Collar Occupations | 27.5 | 23.1 | 0 | 100 |
| Part 1 Property Crimes (County) | 5.3 | 2.3 | 0 | 30.2 |
| Part 1 Violent Crimes (County) | 1.8 | 1.3 | 0 | 12.3 |

Unweighted statistics

**Season and Region**

As mentioned above, the survey was conducted across the United States and throughout a one and a half year period. The data collection was relatively equally distributed across months, with the spring being above average and the summer being below average (see Figure 4). The geographic sampling is much less even because certain regions, such as New York State, paid to have extra samples collected in their area. The sample weights correct for the oversampling of these areas.

**Figure 4: Distribution by Survey Month and Geography**



29
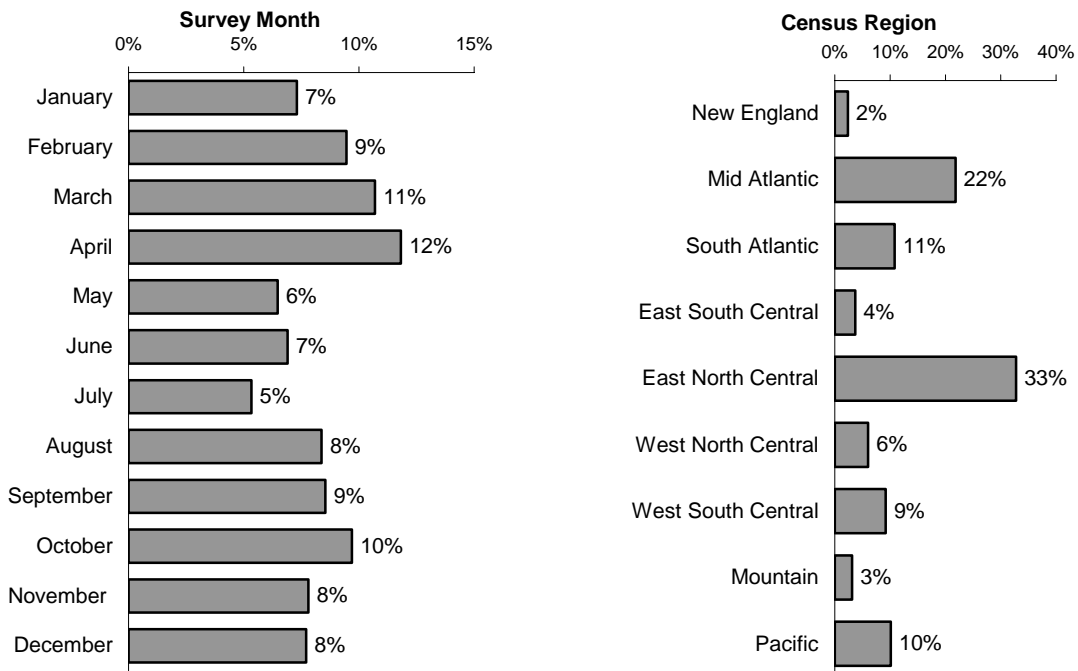
*Summary*

The NHTS, combined with Census and FBI crime data, provides information at the trip, child, household, and neighborhood levels which will make it possible to investigate my research questions. After reviewing the literature, I expect that certain factors will be particularly important in the analysis. In particular, I hypothesize the expected relationship between the variables and the likelihood of walking to school since this is one of the more important outcome variables. I expect travel time and distance to be very important in mode selection – with long distances making it unlikely for children to walk (see Table 7). I also expect age to be associated with more walking. The literature suggests that girls may be less likely to walk than boys. Asian and Latina girls may also be less likely to walk.

At the household level, higher incomes and auto ownership should discourage walking. I also expect the presence of working mothers to discourage walking. I am not certain how the structure of the household in terms of the number of adults and children will influence mode choice. At the neighborhood level, I expect population density to be associated with higher rates of walking. I am not certain what the associations between neighborhood SES variables and mode choice will be.

**Table 7: Expected Influence on Walking to School**

| Variable | Walking to School |
|---|---|
| *Trip* | |
| Trip length | - |
| *Child* | |
| Age | + |
| Female | - |
| Ethnicity (Asian/Latino) | - |
| *Household* | |
| Working mother | - |
| Income | - |
| # of Autos | - |
| # of Adults | unclear |
| # of Children | unclear |
| *Neighborhood* | |
| Density | + |
| Concentrated poverty | unclear |
| Concentrated affluence | unclear |
| Immigrant concentration | unclear |
| Female headed HHs | unclear |

## CHAPTER 4: CHILDREN'S TRAVEL CHARACTERISTICS

*Commuting in America* (Pisarski 1987, Pisarski 1996), Pucher et al's series of articles on the *Socioeconomics of Urban Travel* (Pucher and Williams 1992, Pucher et al 1998, Pucher and Renne 2003)*,* and numerous other papers and reports have given us a fact base on American adult travel.  From them, we know that nearly 85% of daily local travel uses the private automobile; there are more cars than licensed drivers; and Americans make an average of four trips per day (Pucher and Renne 2003).  But we do not know these statistics for children.  This is unfortunate because politicians and public health officials have begun to ask questions about how children travel.  To make policy decisions about investments in Safe Routes to School programs and to investigate links between children's travel and obesity, we need a good understanding of how youth are traveling.  The 2001 National Household Travel Survey (NHTS) provides the best means of assessing the current state of children's travel in the United States.

In many ways, children's travel resembles adults'.  For example, youth travel is dominated by the automobile, with nearly 75% of trips being made in a private vehicle.  Children's travel patterns are also complex; kids chain trips to reach needed afterschool activities.  But in important ways, children's travel is different.  Because of their youth, children often travel with others.  However, the burden of transporting children is not distributed equally among parents; young children are more than five times as likely to travel with their mothers as with their fathers.  Age also greatly affects how much children travel.  Infants make half as many trips as eighteen year olds. Once teens reach driving age, they make many more trips, often driving themselves.  Children from low-income, minority households without cars consistently travel less than their peers.  These children show a deficit of recreation trips, particularly for sports and exercise.  The differences are not large but they are suggestive, particularly given current concerns about obesity.

Analysis of the NHTS highlights several barriers to inquiries on children's travel.  First, it is difficult to determine whether children's trips are taken for their own needs or simply because they cannot be left at home and must therefore accompany parents.  For example, children of single parents make the most trips (once auto ownership is controlled for); however it is not clear that these children are reaching activities important

for them.  Instead, they may be making more trips simply because there is no one at home to watch them.  Second, understanding when children are allowed to travel without adults is important.  Unfortunately, the NHTS does not collect the age of non-household members on trips, making it difficult to distinguish trips children make with their peers from those made with an adult from outside the household.  Third, the NHTS does not collect data on travel cost.  This makes it impossible to ascertain how many children are paying to reach activities, particularly school.  Recent interest in the effects of the cost of travel on school attendance make this information very important (McDonald et al 2004).

This chapter addresses four research questions 1) how much are children traveling? 2) why are children traveling and, in particular, what are they doing afterschool? 3)who are children traveling with? and 4) how do the observed travel patterns vary with demographic characteristics such as age, race, sex, and income?  These questions give us a picture of children's travel at the start of the 21st century.  Before proceeding, I must highlight a methodological issue.  The NHTS dataset is so large that even small differences in trip rates between groups are often *statistically* significant.  This fact requires a somewhat more subjective view of what differences are important.  I have used ANOVA, Tukey's HSD, t- tests, percentage differences and ranks of absolute differences to identify places where differences are meaningful, that is, reflecting important variation in children's behavior.

### *How much are children traveling?*
Data from the NHTS show that those 18 and under make an average of 3.5 trips per day, with over 75% of these trips being in a passenger vehicle.  As a comparison, adults average 4.3 trips per day and make nearly 90% of their trips in passenger vehicles.  Children spend 72 minutes traveling and cover 31 miles each day; adults spend 98 minutes per day to travel 51 miles.  Given the distance that children travel each day, it is not surprising that 2.7 of these trips are by auto.  The second most common mode is walking, accounting for 12% of trips.  For trips of less than a half mile, walking has a 42% mode share.  School buses are also an important mode for children.  However, they are not the dominant mode for school travel; most children currently get to school in cars.

Bikes do not account for very much of children's travel. The overall bike mode share is only 0.8% overall and rising to 2% for trips of less than one mile.

As children mature and other travel options become available, they make more trips. Babies and toddlers have depressed trip rates because they are not able to travel by themselves (see Figure 5). Between ages 3 and 12, trip making is relatively constant but there is some variation. Young teenagers (ages 13-15) have slightly depressed trip rates because they make fewer automobile trips. Rather than being an indicator of decreased mobility, this may actually represent increased independence for children. For example, trip rates for young teenagers may decline because they are allowed to stay in the house by themselves rather than accompanying parents on all trips.

**Figure 5: Average Trips per Day by Age and Mode**
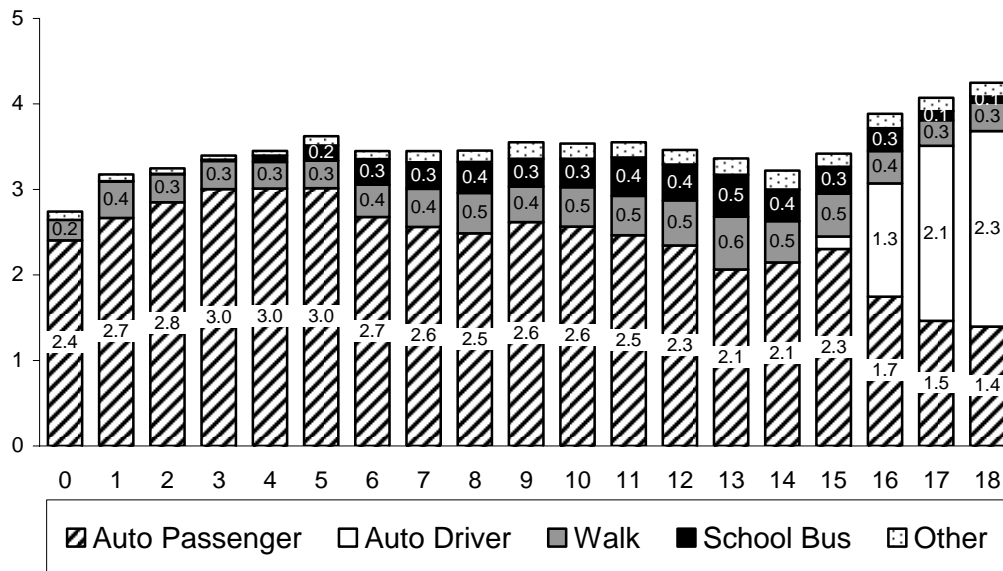


Once youth reach driving age, their behavior changes dramatically. These teens travel more because they have access to cars. In fact, 69% of teens age 16 to 18 have driver's licenses and 40% report being the primary driver of a household vehicle. Not surprisingly, this means that 16 to 18 year olds drive themselves on nearly half of their trips. This newfound automobility leads to a 40% decline in the average number of walk trips and a 33% decline in the average number of school bus trips. The 'extra' trips these teens make are to work and socialize. Increased auto accessibility leading to lower travel costs explains some of this increase in travel, but it would be foolish to ignore the role of the car in providing autonomy and freedom from adult authority for new drivers.

*Why are children traveling?*

School, shopping, and socializing with friends or relatives are the most common trip purposes. However, children's travel varies substantially from weekday to weekend and between the school year and summer. Figure 6 shows this variability for the major trip purposes and total trips per day. On 'school days[1],' children make 1.3 trips to and from school (1.6 if only children five and older are included). In the summer and on weekends, shopping, socializing and going out to eat are more important activities. Unfortunately, with many trip purposes, it is not possible to distinguish whether the trip was for the child or for the household. For example, shopping trips to buy the child new sneakers and trips to the grocery store are coded with the same trip purpose.

**Figure 6: Average Number of Trips per Day by Trip Purpose and Season**
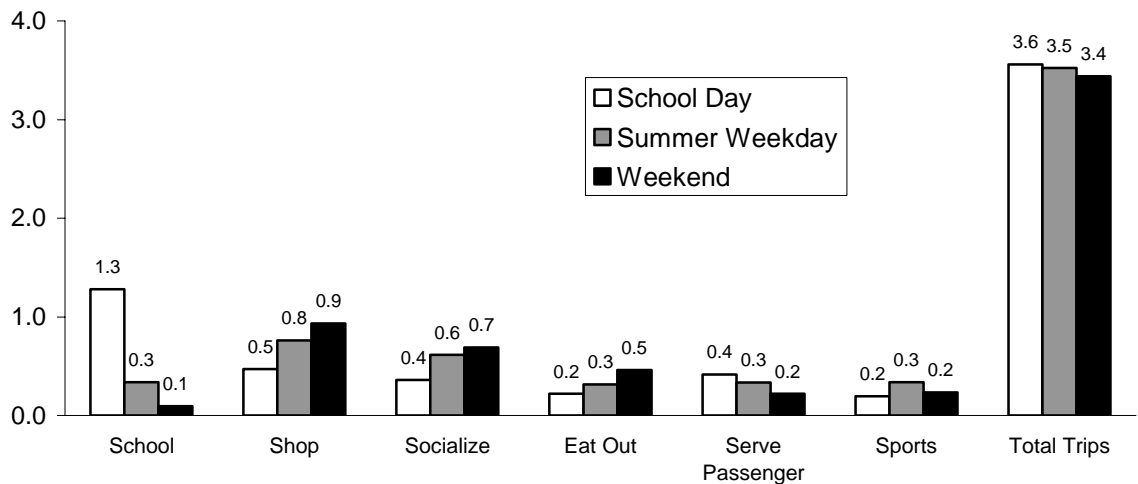


*Purpose is based on the reason the person traveled to the destination unless the destination is home. In that case, the trip purpose is the reason the person traveled to the origin.

There is also substantial variation in travel mode by trip purpose. While automobiles account for the majority of trips by all trip purposes, its level of dominance varies greatly by trip purpose (see Table 8). For example, 54% of children use cars for school trips versus nearly 90% for shopping. Instead, children rely much more heavily on school buses and walking to get to school. Walking is also important for trips to hang out with or visit friends and play sports. Not surprisingly, these are also trips where children are likely to travel without an adult.

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[1] Defined as non-holiday weekdays from September through May. The weeks around New Year's Day, President's Day, Easter/Passover, Thanksgiving, and Christmas were not included as school days.

**Table 8: Mode Split by Trip Purpose**

| Mode | School | Shop | Socialize | Meals | Sports/exercise | Total |
|---|---|---|---|---|---|---|
| Auto | 54 | 90 | 73 | 93 | 57 | 77 |
| School Bus | 30 | 0 | 1 | 0 | 1 | 7 |
| Walk | 13 | 8 | 20 | 5 | 27 | 12 |
| Bike | 1 | 1 | 4 | 0 | 12 | 2 |
| Transit | 2 | 1 | 1 | 1 | 0 | 1 |
| Other | 0 | 0 | 1 | 0 | 2 | 1 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

Columns may not sum due to rounding

**Afterschool Activity and Travel Patterns**

To better understand the complexities of children's travel, it is useful to look more carefully at the afterschool hours as a case study. In today's culture, the afterschool period is seen as a time for children's improvement. Rather than aimless afternoons exploring their neighborhoods and playing with friends, many children are spending their afterschool time engaged in sports, music lessons, clubs, and other group activities. In many cases, these activities may not be near school or home, creating a need for more travel. This period is also an important case study because it has been the focus of policymakers. For example, California voters passed Proposition 49 in 2002 to provide funding for afterschool programs (California Department of Education 2005). The NHTS provides some insights into what children are doing afterschool and how they are getting there. The main limitation of the data is that it is not an activity survey and may therefore fail to identify all activities children are engaged in. For example, time spent playing sports at the school site immediately afterschool is impossible to identify in this survey. However changes in activities while remaining at the same site are even challenging for activity surveys to accurately report.

The majority of children use autos (48%), school buses (33%), or walking (15%) to leave school[2]. Departure times from school vary, but 76% of students leave school between 2pm and 4pm; another 12% leave between 4pm and 6pm. Presumably most of those in the latter category participated in activities or after-care at school. Children's

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[2] These are mode splits for the *unlinked* trip from school.

afterschool activities vary with age and when they leave school. The vast majority of students go straight home from school (76%), but there is important variation by age (see Figure 7). Junior high students are the most likely to go straight home; presumably because parents trust them to be home alone and they are not able to work or drive. For example, 5% of elementary students go to a daycare afterschool; almost no older students do this[3]. Three percent of high school students work and no younger children do. High schools students are somewhat more likely to spend their afterschool time socializing with friends (5%), making serve passenger trips (5%), and shopping (4%). Much of this activity is possible because they are allowed to travel independently and often have car access.

**Figure 7: Trip Purpose for First Afterschool Trip by Age**
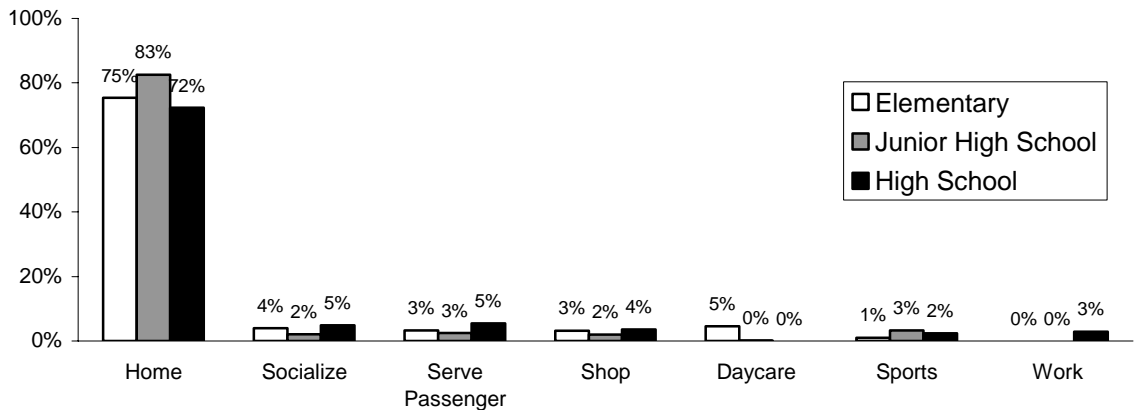


Note: only includes students leaving school between 2pm and 6pm

The differences in afterschool activity patterns and maturity by age have modal implications as well. When going straight home afterschool, a large proportion of students ride the school bus (see Table 9). This is particularly true for junior high students who use the bus for half of their trips home. High school students are most likely to use cars, largely because many of them have access to a household vehicle. The patterns change for trips to hang out with friends and socialize. Large numbers of elementary and junior high students walk for these types of trips. In contrast, 69% of high school students drive to hang out with friends. These differences again reflect the fact that high school students have car access and driver's licenses.

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[3] Although some older students may be participating in after-care programs at their school. However, as mentioned above, this survey does not report that information.

**Table 9: Mode Share by Trip Purpose and Grade for Afterschool Trips**

| | Home | | | Socialize | | |
|---|---|---|---|---|---|---|
| | K-6 | 7-8 | 9-12 | K-6 | 7-8 | 9-12 |
| Auto | 38 | 29 | 55 | 49 | 26 | 69 |
| School Bus | 43 | 50 | 27 | 24 | 31 | 17 |
| Walk | 17 | 15 | 13 | 27 | 35 | 9 |
| Other | 2 | 6 | 5 | 0 | 8 | 5 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

One final aspect of afterschool travel behavior is to consider all trips children make afterschool. The data show that 42% of students go directly home and remain there for the evening (see Table 10). Another 36% of kids go straight home from school and then go out. Fifteen percent of students report making multiple stops on the way home from school, but then remain at home for the evening. Finally, 8% of kids make stops on their way home from school and then make additional trips after reaching home. These data suggest an interaction between the number of stops on the way home from school and trips taken after reaching home. Forty-six percent of children going straight home from school make another trip once they get home; only 36% of students that stop on their way home make more trips after arriving. These findings suggest substitution between trips made on the way home and those made after getting home. The same substitution pattern has been observed in adults for trips after work (Bhat and Singh 2000).

**Table 10: Distribution of Afterschool Trips by Number of Stops**

| | | Post-home arrival trips | | |
|---|---|---|---|---|
| | | 0 | 1+ | Total |
| **Unlinked Trips from** | 1 | 42 | 36 | 77 |
| **School to Home** | 2+ | 15 | 8 | 23 |
| | Total | 56 | 44 | 100 |

*Who are children traveling with?*

Who children travel with, particularly if they travel alone, reflects their age and maturity level. Babies make nearly all of their trips with parents; 18 year olds make less than a quarter of their trips with parents (see Figure 8). The proportion of children traveling alone begins to grow when children enter school, largely due to walking trips to school, and continues to increase as youth age. The increased number of trips taken

alone when children reach 16 reflects their high levels of automobile access and the fact that they can now drive themselves. Trips with people outside the household grow once children enter school, largely because this category includes school bus trips. In the teen years, trips with persons outside one's household make up at least quarter of trips. These numbers probably reflect teens driving each other. However, because the NHTS does not report any information for travelers who are not members of the household, it is impossible to be certain.

**Figure 8: Children's Travel Companions by Age**
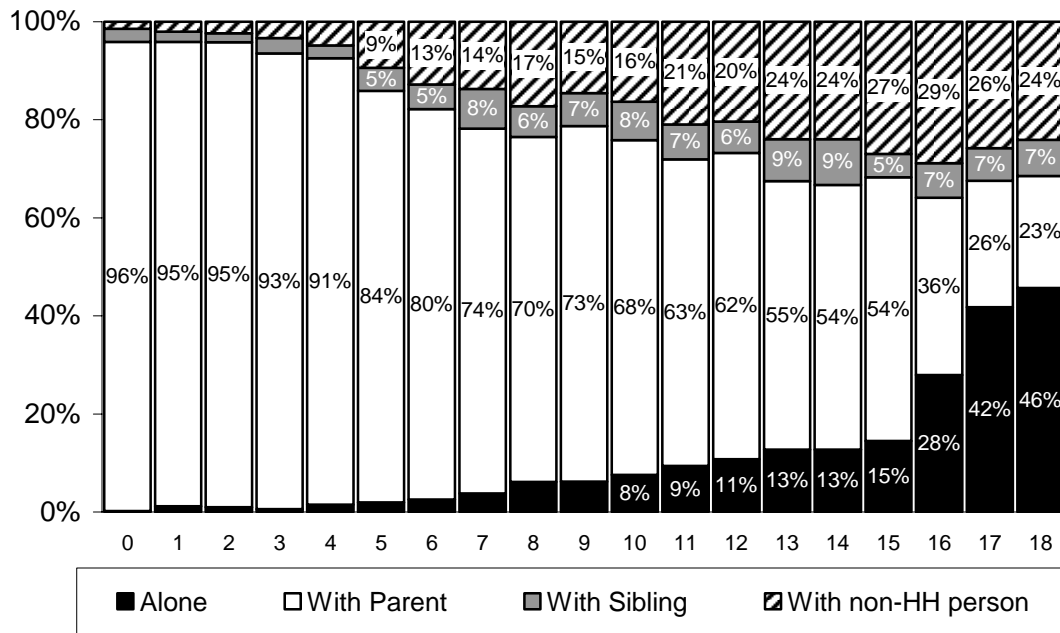


Several researchers have suggested normative reasons for paying particular attention to how much children travel by themselves or with peers. First, independent travel presents a way for children to learn about their communities (Hillman et al 1990, Banerjee and Lynch 1977, Valentine 1997). Southworth (1990) promotes this view by noting "before the automobile children were relatively free to explore their whole community, but today most urban and suburban children grow and learn in virtual isolation from vital processes of society." Tranter (1996) echoes this position "independent mobility is important for children's own personal, intellectual and psychological development and for allowing them to get to know their own neighbourhood and community."

Hillman et al (1990) show that English schoolchildren had less travel freedom in 1990 than in 1971. For example, 50% of schoolchildren aged 6 to 11 were allowed to ride buses alone in 1971; while only 14% were allowed to do so in 1990. The authors note that the largest declines in independent mobility have affected the youngest children. The authors assert that these changes have impacted mode shares for the school trip. In 1990, more students were driven at the expense of walking trips.

When children travel with a parent, it is usually the mother. In fact, the gap between trips taken with mothers and fathers is quite striking (see Figure 9). In intact households, children five and under make 50% of their trips with their mothers and 10% with their fathers[4]. This gap equates to children making about one more trip day with their mothers than their fathers. As children mature, they make proportionately fewer trips with their mothers and the gap narrows; the proportion of trips taken with fathers hardly varies with age. Children's increasing maturity allows them to travel by themselves or with friends, i.e. to meet some of their own travel needs. At the same time, parents may feel more comfortable leaving the child in the house by themselves and not require the child to come on each trip.

**Figure 9: Children's Percent of Trips with Mothers and Fathers, Intact Households**
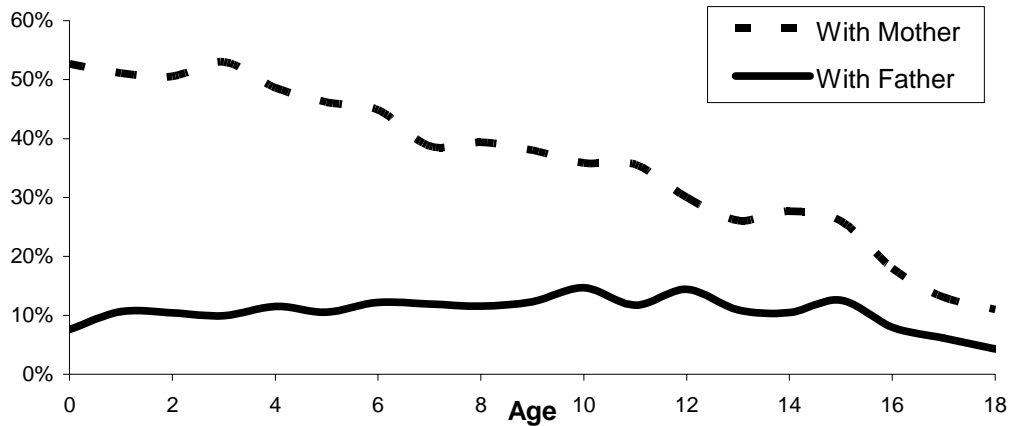


Three factors likely account for the observed gap in children's travel with mothers and fathers: 1) mothers earn less and therefore have a lower value of time, making it economically efficient for them to take responsibility for children's travel, 2) mothers work fewer hours and therefore are more available to transport children and must take

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[4] Trips where the mother and father are both present are classified separately and are not included here.

children on more of their own trips, or 3) gender roles give mothers more responsibility for children's travel regardless of their income or availability. Controlling for the effects of hours worked and personal income is necessary to directly test this hypothesis. Unfortunately the NHTS does not collect this data. However, they do collect parental work status (full-time, part-time), occupation, and education which can serve as proxies.

In all intact households, children make 36% of their trips with mothers and 11% with fathers (see Table 11). Controlling for parental availability shows that when both parents are full-time workers, the differential drops to 16 percentage points. In households where both parents are college educated and have managerial or professional jobs, the differential drops slightly to 13 percentage points. These numbers suggest mothers are more likely to make trips with their children because in many households they work less and earn less. However, a large portion of the observed differences are unexplained by work status, occupation, and education, suggesting gender roles influence mothers' responsibility for children's travel.

**Table 11: Children's Trips with Mothers and Fathers by Parental Work Status, Occupation, and Education**

| HH Type | % of Children's Trips | | Difference |
|---|---|---|---|
| | With Mothers | With Fathers | |
| Intact | 36 | 11 | 25 |
| Full-time workers | 30 | 14 | 16 |
| Mang/Prof occupations with college+ | 30 | 17 | 13 |

Across all trip purposes, children make a higher proportion of trips with mothers than fathers. However, the gap is largest for serve passenger and shopping trips, and lowest for sports trips (see Table 12). Previous research (McGuckin and Murakami 1999) has found that mothers make more trips for household-sustaining purposes. Therefore it is not surprising that these are the trip purposes with the biggest gaps. Two factors affect this: 1) mothers are more likely to have responsibility for meeting children's travel needs, and 2), children make more 'go-along' trips with mothers and the trips mothers take them on are for household-sustaining purposes such as shopping.

**Table 12: Children's Travel Companions by Trip Purpose**

| Travel Companions | School | Shop | Socialize | Serve Passenger | Meals | Sports |
|---|---|---|---|---|---|---|
| Family | 3 | 24 | 17 | 12 | 33 | 12 |
| Mother | 29 | 47 | 28 | 57 | 31 | 33 |
| Father | 8 | 11 | 7 | 12 | 10 | 14 |
| Siblings | 6 | 3 | 9 | 5 | 5 | 10 |
| Alone | 44 | 6 | 20 | 5 | 6 | 17 |
| Other | 11 | 9 | 18 | 9 | 15 | 14 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

*How do travel patterns vary with demographic characteristics?*

Previous research on adult and children's travel suggests there is important variation in the patterns described above by sociodemographic characteristics. With adults, we know that men travel differently than women; we might expect the same in children. It is also clear that economic status is correlated with the quality and availability of travel options, such as auto ownership. The remainder of this section considers how travel patterns vary by race, sex, income, auto ownership, and household structure.

**Race**

Trip rates vary by race and ethnicity. Whites make the most trips (3.7); blacks make the fewest (3.1) (see Table 13). This variation is present even after accounting for household income. Racial differences in trip rates are attributable to the greater number of passenger vehicle trips made by whites (2.9 auto trips per day for whites vs. 2.3 for non-whites). Other races use alternative modes more to meet their travel needs. For examples non-whites make five times as many transit trips as whites (0.02 trips per day for whites vs. 0.10 for non-whites) and one and a half times as many walk trips (0.35 for whites vs. 0.52 for non-whites).

**Table 13: Average Number of Trips by Race & Income**

| Race | Income | | | |
|---|---|---|---|---|
| | 0-30k | 30-60k | 60k+ | All |
| White | 3.4 | 3.6 | 3.8 | 3.7 |
| Hispanic | 3.2 | 3.5 | 3.6 | 3.3 |
| Black | 3.0 | 3.2 | 3.4 | 3.1 |
| Asian | 2.5 | 2.8 | 3.7 | 3.2 |
| Multi | 3.1 | 3.3 | 3.3 | 3.2 |
| All | 3.2 | 3.5 | 3.7 | 3.5 |

Social and recreation trips account for 75% of the overall difference in trip rates between whites and non-whites. Within the category of social and recreation, non-whites made fewer sports and exercise, socializing, and dining out trips (see Figure 10). For example, whites made 0.3 sports and exercise trips compared with 0.2 for non-whites. While this difference is small (but still statistically significant), there is a consistent finding that non-whites make fewer social and recreation trips.

**Figure 10: Racial Differences in Social and Recreation Trip Rates**
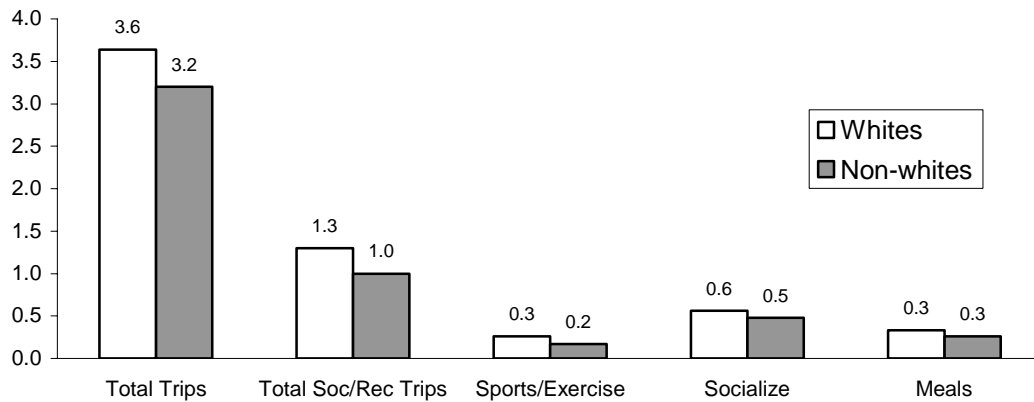


**Sex**

Previous research (Hillman et al 1990, Vliet 1983) found that girls are more restricted in their travel behavior than boys. These authors have suggested that parents are more protective of girls, leading them to travel less by themselves and travel shorter distances. My analysis shows that there are sex-based differences in trip rates, but that they vary with age (ANOVA F=7.17, p<0.01 for age and sex interaction). These gender differences are most important for students just entering elementary school (ages 5-7) and older teenagers (ages 16-18) (see Figure 11). As theory predicts, boys aged 5 to 7 make more trips than girls (3.6 vs. 3.4). However a more careful analysis shows that while

boys do walk and bike more than girls, the only statistically significant difference is the number of auto trips (2.9 for boys vs. 2.6 for girls). Perhaps more importantly, when girls do travel they have the same mode split as boys (76% auto). Therefore boys are simply making more trips – presumably reflecting the fact that they participate in more activities outside the home or because parents are less likely to trust young boys alone in the house.

**Figure 11: Average Number of Trips by Mode, Sex & Age**
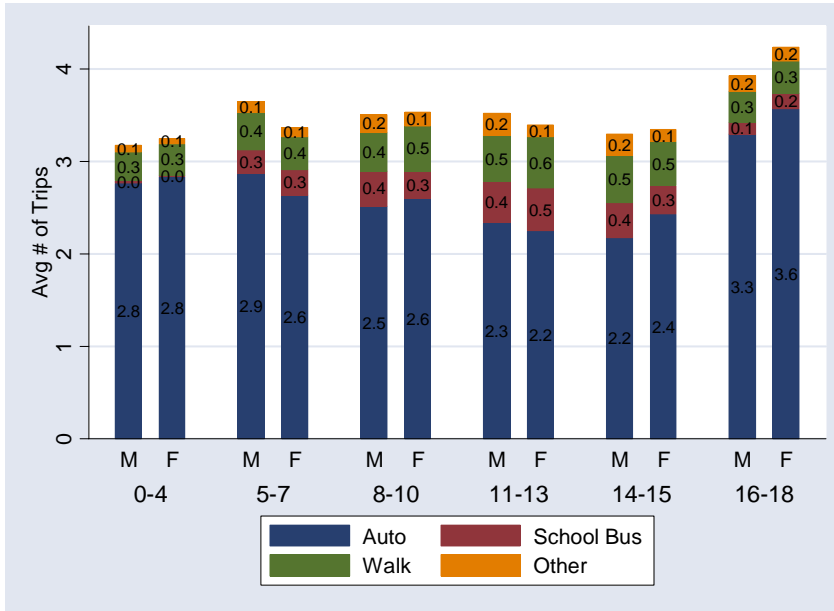


The majority of the difference in trip rates between 5 to 7 year old boys and girls comes from differences in the number of social and recreational trips (see Figure 12). Trip purpose data show that boys make approximately 20% more social and recreation trips than girls (1.3 vs. 1.1). The observed differences in social and recreational trip making reflect the fact that boys make more trips to exercise and play sports (0.16 vs. 0.12) and visit friends (0.26 vs. 0.21). In a reversal, girls are making more trips than boys by age 16. The majority of these extra trips are for shopping. The extra trips are taken in the car; however girls are more likely to be the passenger (1.8 vs. 1.3 auto passenger trips). At this age, boys drive more than girls (2.0 vs. 1.7). Despite this girls still make more auto trips (3.6 vs. 3.3).

**Figure 12: Average Number of Trips by Purpose, Sex & Age**
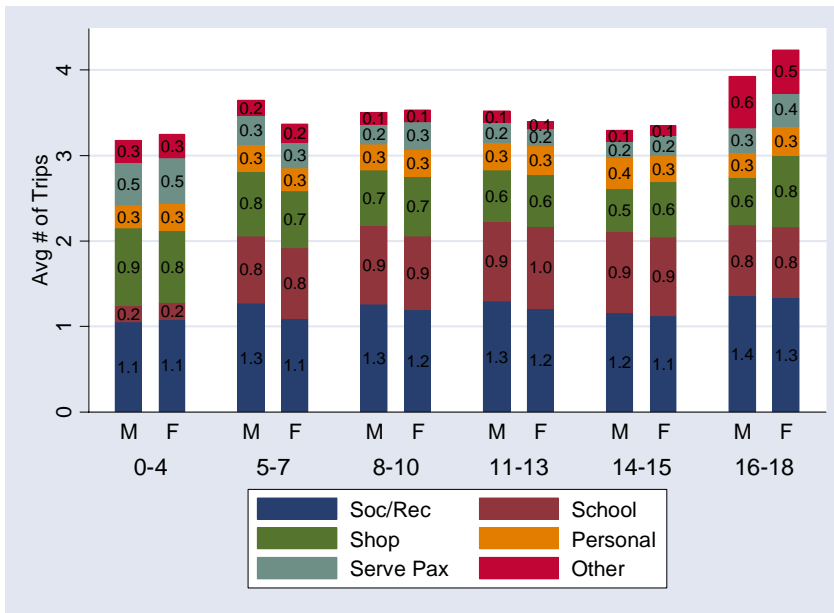


**Income**

Household characteristics determine the resources available for and the rules that govern travel for children. Youth from households with incomes above $80,000 take 19% more trips, spend 9% less time traveling, and cover 36% more miles (see Table 14). This suggests the children from low-income households may be foregoing some activities, particularly for recreation. In fact, differing numbers of social and recreation trips account for almost all of the variation in trip rates between the highest and lowest income groups.

**Table 14: Variation in Trip Rates by Household Income**

|  | Income | | | | |
|---|---|---|---|---|---|
|  | 0-20k | 20-40k | 40-60k | 60-80k | 80k+ |
| Trips per Day | 3.1 | 3.3 | 3.6 | 3.7 | 3.7 |
| Travel Time per Day (minutes) | 77 | 74 | 71 | 70 | 70 |
| Distance Traveled per Day (miles) | 25 | 29 | 32 | 31 | 34 |
| Walk Trips per Day | 0.6 | 0.5 | 0.4 | 0.4 | 0.3 |
| Auto Trips per Day | 2.2 | 2.5 | 2.8 | 3.0 | 3.1 |
| Social/Rec Trips per Day | 0.9 | 1.1 | 1.2 | 1.2 | 1.4 |

Within the category of social and recreation trips, the biggest differences are for sports and exercise trips (ANOVA F-test=36.85, $p<0.01$), and going out for meals (ANOVA F-test=30.11, $p<0.01$). Children from households earning over $80,000 make more than double the number of sports and exercise trips and nearly double the number

trips for meals eaten outside the home as their peers from the lowest-income homes (less than $20,000). It is not surprising that wealthier households eat out more. But given the current concern about childhood obesity, the lower levels of sports/exercise trips for low-income households may be problematic. The difference in trip rates for sports may simply reflect the fact that upper-income children are more likely to be involved in *organized* sports, and that these activities are easier to report in a survey than unstructured after-school and weekend play activities. However, these findings highlight the need for further exploration of the links between physical activity and SES (Sallis et al 2000).

**Auto Availability**

Given the importance of auto travel in explaining the travel differential between poor and rich children, analysis of household auto availability is the obvious next step. As Figure 13 shows, auto availability, defined as the ratio of vehicles to drivers, strongly correlates with trip making. The most critical differences in behavior occur between zero-vehicle households and all others. Children in households with cars make 42% more trips than those without cars, but they actually travel nearly 9 minutes less each day. As auto availability increases, children make more car trips.

**Figure 13: Average Trips per Day by Car Availability and Mode**
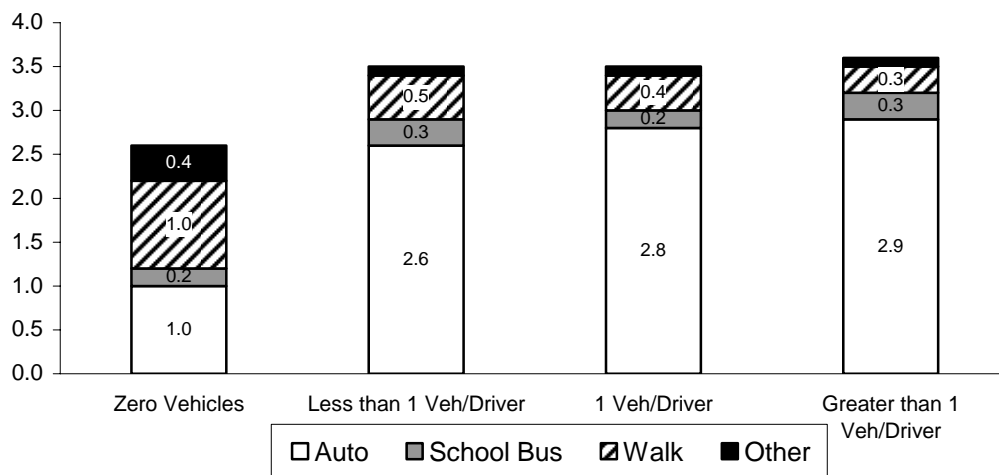


**Household Structure**

Research on the travel patterns of single and married parents has found that single mothers travel differently from either married women or single fathers (Rosenbloom 1989a; Kostyniuk et al 1989; Johnston-Anumonwo 1989, Rutherford and Wekerle 1989).

Single mothers' travel patterns tend to be less complex with fewer linked and chauffeured trips than married women. Rosenbloom (1989a) speculated that their travel patterns are "less responsive to the needs of children or household than those of married mothers, perhaps because they face more constraints with fewer alternatives." Underlying this research has been a concern that the travel problems of single mothers may become the travel problems of their children. At first glance, the NHTS data seems to show that children of single parents – men or women – do travel less than their peers from intact households. Children in single parent households make fewer automobile trips (2.4 vs. 2.8 for children in 2 adult households) and are less likely to travel by car when they do make trips (67% by auto vs. 75% for children in 2 adult households).

However, deeper analysis reveals that household auto ownership strongly impacts the relationship between number of adults and children's travel. After accounting for auto ownership, we find that children of single parents make more trips than their counterparts (see Table 15). Unfortunately, it is difficult to know if all this travel is for the child's benefit or if it amounts to 'babysitting on the go'. Kostyniuk et al (1989) showed that after controlling for auto ownership, single parents did travel more than married parents. It is likely that their children are accompanying them on many of these trips. To fully investigate this issue, surveys must probe deeper into why the trip is being made and for whose benefit.

**Table 15: Average Number of Trips by Number of Adults and Vehicles**

| Number of Adults | Number of Vehicles | | | | Average |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3+ | |
| 1 | 2.9 | 3.3 | 3.9 | 4.2 | 3.4 |
| 2 | 2.6 | 3.3 | 3.5 | 3.8 | 3.6 |
| 3+ | 2.0 | 2.9 | 3.2 | 3.3 | 3.2 |
| Average | 2.7 | 3.3 | 3.5 | 3.7 | |

***Barriers to Analysis of Children's Travel***

To make informed policy decisions, researchers, elected officials, and advocates need a detailed picture of how children are traveling. The NHTS provides a great start on this but it lacks several critical pieces of information. One important piece of information is whether the trip was made for the child's direct benefit. Children travel for two reasons. First, just as adults do, they want to reach activities like school and afterschool programs. But children also travel because their parents are traveling. They

may be accompanying parents to spend time together or because no other form of babysitting is available. Having a way to distinguish trips taken for the child's benefit, the household's benefit, e.g. grocery shopping, and for babysitting would make analysis of trip rates more useful.

Many researchers have identified trips taken without adults – that is, independently, as a critical feature of children's travel and development (Hillman et al 1990, Banerjee and Lynch 1977, Southworth 1990, Tranter 1996). In the current dataset, it is not possible to fully estimate independent travel. Trips taken with peers are indistinguishable from trips taken with non-household adults. This makes it difficult to fully describe children's independent travel and also causes difficulties in studying how non-household adults share responsibilities for children's travel through carpools and newer arrangements such as 'walking school buses'. Adding questions to future surveys addressing the age of non-household travel companions and the 'true' purpose of children's trips would greatly assist further analysis of children's travel.

Finally, the issue of transportation affordability for school travel has become important in several regions. Most notably, elected officials and youth advocates in the San Francisco Bay Area created a program to broaden access to programs and activities, and improve attendance through the distribution of free bus passes to students (McDonald et al 2004). These programs raise the question of how much children are paying to get to school – either to ride the school bus or take public transit. Because the NHTS does not collect data on cost, it is difficult to assess the scale of this issue.

### *Conclusions*

What this entire analysis reveals is that children's travel has moved way beyond simplistic images of children being carted back and forth to school on yellow school buses or walking around the neighborhood. Children today need to reach many destinations and must rely on autos and parents to do so. This automobility has two major implications. First, parents, particularly mothers, spend significant amounts of time transporting children. Second, auto access is central to the travel patterns of driving-age teens. Many of them have primary access to a household vehicle, and they use it!

School, shopping, and socializing are the primary reasons children travel. One problem with current survey data for children is that it is impossible to determine whether

the trip was taken for the child's benefit or if she was simply 'going along.' This difference is particularly important for shopping trips; many of which may prove to be grocery store trips rather than sneaker shopping trips. The finding that children of single parents make the most trips, after controlling for auto ownership, suggests that these babysitting or 'go along' trips are an important part of children's travel patterns and need to be better understood.

The analysis consistently showed that children from low-income or minority households traveled less than their peers and that the foregone trips were often for social and recreation purposes. In particular, these students made fewer sports and exercise trips. As mentioned previously, this may simply reflect the fact that middle and upper class children are more likely to be involved in organized sports and therefore have the act recorded on a survey. Nevertheless, the current concern with physical activity and obesity make this an area for further analysis.

# CHAPTER 5: SCHOOL TRAVEL CHANGES, 1969 TO 2001

School travel has been getting a great deal of press lately. Alarmed by the doubling in rates of overweight children and adolescents (Ogden et al 2002), public health officials are searching for ways to introduce exercise into children's days. Walking to school has caught the attention of policymakers as one way to get kids to be more physically active (Killingsworth and Lamming 2001, Kann et al 1998, US Department of Health & Human Services 1996, Cooper et al 2003, Tudor-Locke et al 2002). To accomplish this goal, the Centers for Disease Control (CDC) have launched the KidsWalk-to-School program to encourage parents to walk their children to school (CDC 2005). Many states have created Safe Routes to School (SR2S) programs which fund infrastructure and education projects near schools to make it easier for children to walk (STPP 2003). The federal government is even considering starting a nationwide SR2S program which would expand the program to all fifty states. Despite all this attention, the academic literature on school travel, has until recently, been quite thin. This paper seeks to fill this gap by asking 1) how has school travel changed in the last thirty years, and 2) what factors have affected the changes in how children travel to school? Investigating these questions may suggest policy prescriptions to increase walking to school.

Between 1969 and 2001, children's school travel changed greatly in the United States. The share of trips made by auto has gone from 16% of all school trips in 1969 to 55% today; biking and walking have slipped from 42% to 13%. These changes are huge and may have important health implications. A large portion of the decline in walking to school can be explained by increasing distance between home and school, particularly for elementary school children. In 1969, 45% of elementary school students lived less than a mile from their school; today fewer than 24% live within this distance. This same pattern occurs at the middle and high school levels. The simple fact is that most children do not live within a walkable distance of their schools. When children do live close to school, substantial numbers walk. For example, 69% of students living within a half mile of school choose to walk.

However, changing distances between home and school cannot fully explain the decline in active travel to school. In 1969, 87% of students living less than one mile of

their schools walked; in 2001, this number was 54%. Larger societal forces such as increased auto ownership, mothers' labor force participation and changing social norms have affected the proportion of students walking to school. The remainder of this article describes changes in children's travel patterns between 1969 and 2001 and looks at how policies which affect distance to school and attitudes towards walking have changed in recent decades. The article concludes by considering what these data mean for planners.

### *Data*

This analysis uses data from the US Department of Transportation to analyze how children's travel to school has changed in recent decades. The 1969 data comes from a report published by the US DOT that focused exclusively on children's school travel (Beschen 1972). It contains detailed information on trip mode, distance, and travel time by grade level on trips between home and school. Unfortunately, the report groups walking and biking into one category.

Data on current patterns come from the 2001 NHTS. To make the 2001 data comparable to the 1969 data, I constructed a set of trip tours between home and school that occurred on weekdays between September and May. The use of trip tours was essential to capture times when children used multiple modes to get to school, e.g. walking to the school bus stop, or made a stop on the way to school, e.g. accompanied a sibling to their school. An unlinked trip was considered part of a linked trip until the child reached a terminal destination such as home or school.

Analysis of the trip tour data showed that 9% of students stopped on the way to school. Of these students, 64% spent less than 15 minutes at intermediate destinations. A small number of students made very long intermediate students. For example, 2.5% of all students spent more than 30 minutes at an intermediate stop. These tours were eliminated from the analysis because those children likely engaged in another significant activity before going to school, such as going to a doctor or attending before-school care. The exclusion of these children does not significantly alter the findings presented in this chapter. The final data set contained records for 10,755 trips from home to school. Table 16 presents summary statistics for the 1969 and 2001 datasets.

**Table 16: Summary Statistics for Trips from Home to School, 1969 and 2001**

|                      | 1969    | 2001   |
|----------------------|---------|--------|
| Unweighted N         | ~6,000* | 10,775 |
| % Elementary (K-6)   | 58%     | 60%    |
| % Intermediate (7-8) | 15%     | 15%    |
| % High School (9-12) | 26%     | 25%    |
| % Female             | NA      | 49%    |

*Report only identifies that 6,000 households were interviewed; presumably many of these households had more than one school age child.
Note: 2001 data only reported ages; these have been converted to grades assuming Kindergarteners are 5.

Much of the data presented in this chapter relies on measures of the distance between home and school. In both 1969 and 2001, distances were self-reported; but the 1969 survey used in-home interviews which may have led to more accurate distance estimation. The 1969 survey reported distance between home and school; in 2001, respondents reported the distance for each unlinked trip. When students go directly from home to school, as 91% of students in the sample did, the trip length equates to the distance from home to school. However, when students make at least one stop between home and school, e.g. to drop off a sibling at their school, the distance traveled on the tour may no longer equate to the distance between home and school. To deal with this issue, I have calculated the total distance traveled between home and school (potentially an overestimate for those with stops on the way to school) and distance for the unlinked trip to school (an underestimate for those with stops on the way to school). I rely on the distance traveled during the trip tour from home to school in my analysis but note if the results would be different if unlinked distances were used.

Survey respondents tend to round their responses about travel time and distance. For example, 13% of people reported traveling exactly one mile to school. This means that the precise definition of ranges matters, particularly for the construction of histograms. In all charts and analyses, I have followed the convention of the 1969 survey and do not include the top point of the range. For example, a bar labeled 0.5-1 mile would not include trips of 1 mile.

Finally, the results reported here use the sample weights calculated by NHTS survey designers to make the sample representative of the U.S. population. The application of the weights ensures comparability between the 2001 data and 1969 figures, which were also weighted.

*School Travel Trends*

Perhaps the best way to begin the study of school travel is to look at where we have been. Comparison of the 1969 and 2001 data shows a restructuring of how children get to school in the past thirty years. Nearly half of all students used to walk or bike to school; now 13% of children walk. That drop has been accompanied by a rise in automobility. The remainder of this section describes how modal splits, trip distance, and travel time have changed for trips to school.

## Mode

In the past thirty years, there have been dramatic shifts in how children travel to school. The use of the automobile has soared to a 55% mode share from 16% in 1969, while walking and biking rates have declined nearly 70% from 42% in 1969 to 13% in 2001 (see Figure 14). The increase in automobility has come from a near four-fold increase in adolescents driving themselves to school and a tripling of the proportion of students that are driven to school – either by parents or friends. The use of other modes, such as school buses and public transit, has not changed as much.

**Figure 14: Mode Share for Trips to School, 1969 and 2001**
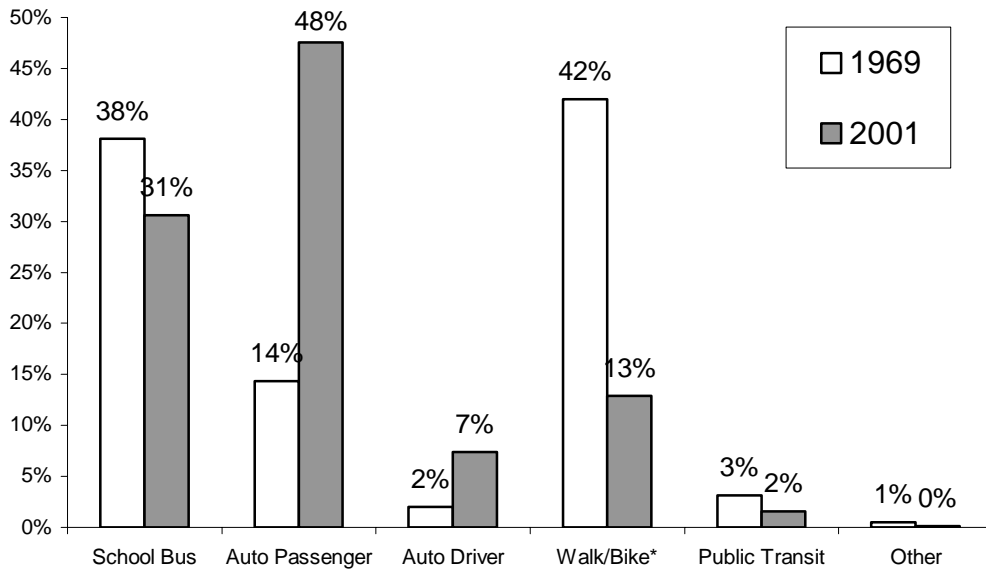


*Walk and bike are reported together in 1969; in 2001 walk accounted for 12% and biking for 1%

The overall averages mask variation by school type. While students at all three levels switched from walking and biking to being driven to school, high school students also experienced a dramatic reduction in school bus use accompanied by a commensurate

increase in driving to school. In 1969, 38% of high school students rode the bus to school; this number declined by nearly half to 19% in 2001 (see Table 17). Similarly, only 8% of high school students drove themselves to school in 1969. By 2001, 29% of students drove to school. These findings reflect the high levels of automobile access of today's teens. Over 40% of teens 16 to 18 had primary access to a household vehicle in 2001. In addition, many school districts have eliminated school bus service for high school students (McDonald 2005).

**Table 17: Mode Split for Trips to School, 1969 and 2001**

| | 1969 | | | | 2001 | | | |
|---|---|---|---|---|---|---|---|---|
| Mode | Elem. | Inter. | HS | All | Elem. | Inter. | HS | All |
| School Bus | 37.3 | 42.3 | 37.7 | 38.1 | 33.0 | 39.4 | 19.4 | 30.6 |
| Auto Pax | 12.2 | 12.3 | 19.8 | 14.3 | 50.8 | 46.2 | 40.5 | 47.5 |
| Auto Driver | - | - | 7.6 | 2.0 | - | - | 29.4 | 7.4 |
| Walk/Bike | 49.3 | 41.6 | 26.4 | 42.0 | 15.4 | 11.5 | 7.8 | 12.9 |
| Public Transit | 0.8 | 2.7 | 8.1 | 3.1 | 0.7 | 2.9 | 2.8 | 1.6 |
| Other | 0.4 | 1.1 | 0.4 | 0.5 | 0.1 | 0.0 | 0.1 | 0.1 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Note: 2001 data only reported ages; these have been converted to grades assuming Kindergarteners are 5.

**Trip Distance**

One cause of the switch from walking to driving is that children now live much farther from school than in 1969. For example in 1969, 35% of students lived less than 1 mile; in 2001 only 18% of students lived so close (see Figure 15). At the same time, the number of students living more than three miles from their school has grown by nearly twenty percentage points from 33% in 1969 to 52% in 2001. Perhaps more important, the change in distance to school has been most heavily focused on elementary school children. Today only 24% of elementary children live less than a mile from school. In 1969, this number was nearly double (see Table 27 in Appendix 1 for detailed numbers).

**Figure 15: Trip Distance Distribution for Trips to School, 1969 and 2001**
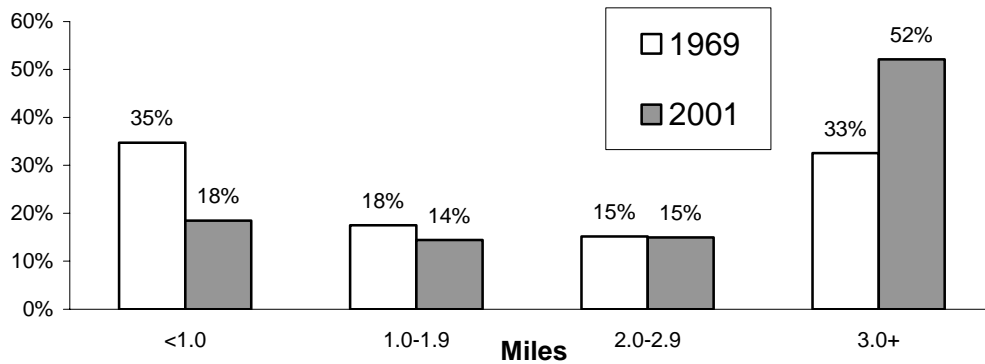


The changing spatial distribution of students in relation to their schools has important mode choice implications.  Analysis of current data suggests that distance has a strong effect on mode choice (a contention which will be statistically tested in Chapter 6).  While only 13% of students walk to school overall, large numbers still choose to walk when they live close to school (see Figure 16).  For trips under a quarter mile, walking accounts for 79% of trips; under a half-mile 69%; and under a mile, 54%.  Beyond one mile, only 3% walk.  Of course, the problem is that over 80% of students live one or more miles from their school.  This finding is critical because it recasts the issue of walking to school from a motivation question – why don't kids walk to school – to a school location question – why don't children live near their schools?

**Figure 16: Mode Share for Trips to and from School by Trip Distance, 2001**
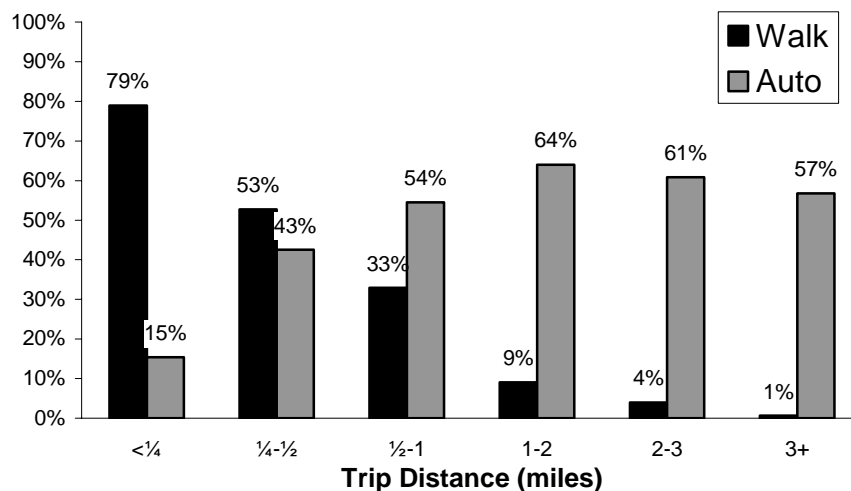


Automobile mode share increases with distance from school until two miles and then declines slightly for longer trips, presumably because parents are reluctant to make long trips to drop children off and school buses become more available.  School bus use

grows steadily once school is more than one mile away, presumably because most school districts only offer busing outside of a one to one and a half mile radius (see Table 28 in Appendix 1). The grouping of walking and biking into one category might imply that they are equally important modes for the school trip[5]. This is not true. Only 0.7% of students bike to school. At most, biking accounts for 2.4% of trips between a half mile and one mile. While researchers tend to discuss all 'active' or 'non-motorized' modes together, these data suggest the emphasis in school travel should be on walking.

**Travel Time**

Despite the large changes in mode split and trip distances for school trips, travel times have been fairly constant between 1969 and 2001. As Figure 17 shows, the distribution of travel times looks remarkably similar in each year. The most noticeable shift has been a six percentage point decline in the proportion of students traveling between 10 and 19 minutes to school. However, this is accompanied by slight upticks in the two adjacent categories. Families have compensated for living farther from school by using faster modes like the car. These findings are analogous to studies of adult travel which have shown small increases in work trip travel times accompanied by large increases in trip distance (Mokhtarian and Chen 2003, Hu and Reuscher 2004).

**Figure 17: Travel Time Distribution for Trips to School, 1969 and 2001**
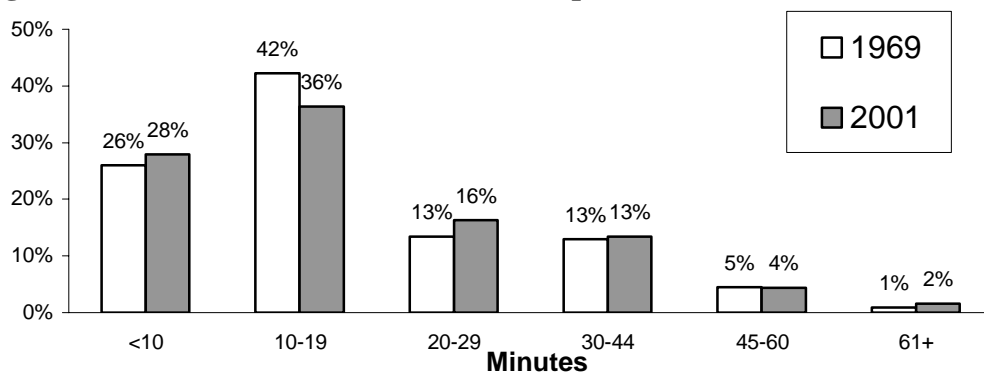


*Explanatory Factors*

Comparisons of the 1969 and 2001 school travel data show that mode split has changed greatly for children's trips to school. The above analysis showed that longer travel distances between home and school may be an important cause of the shift to

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[5] As mentioned above, the two categories were only grouped because the 1969 data reports walking and

automobility for the school trip.  However, it is not possible to explain the observed decline in walking by changing trip distances alone.  For all trip distances, students today walk and bike less than students in 1969 (see Figure 18).  For example, 88% of elementary children living less than one mile from school walked or biked in 1969.  In 2001, students facing this relatively short trip walked or biked 54% of the time and were driven 38% of the time (see Table 30 in Appendix 1).

**Figure 18: Walk/Bike Mode Share by Trip Distance, 1969 and 2001**
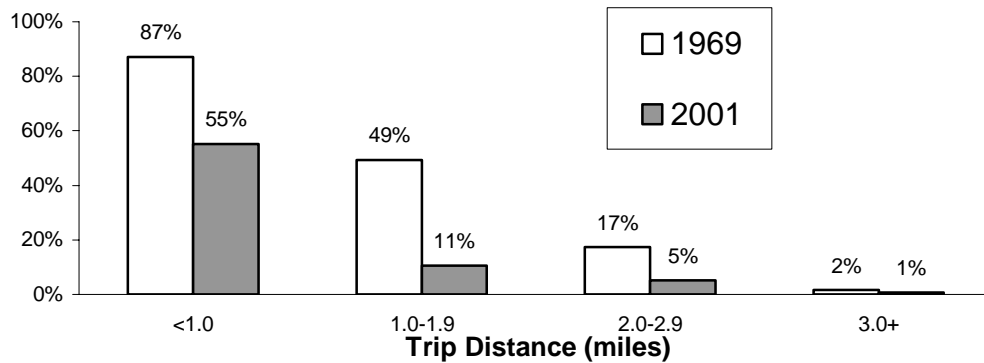


A simple thought experiment helps estimate how much changing distances to school have affected the decline in walking to school.  Imagine if all that changed between 1969 and 2001 was a shift in the distribution of trip lengths.  No other changes occurred; families did not buy more cars and women did not enter the labor force in larger numbers.  In other words, only distance to school changed while all other factors were held constant.  If this were the case, we would expect the 1969 walking rates by trip distance to predict the likelihood of walking at a particular distance from school and the 2001 distribution of students by trip distance to predict where students live.  A weighted average of these numbers predicts the walk/bike share we would expect if all that changed between 1969 and 2001 was an increase in trip length.  This model estimates a walk/bike share of  26% which is approximately halfway between the actual 1969 walk/bike share of 42% and the 2001 value of 13%.  This suggests that the increase in trip distances accounts for half of the decline in walk mode shares and the commensurate increase in driving.

Therefore any consideration of why school travel has changed must consider factors affecting distance such as suburbanization and school consolidation as well as

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biking as one category.

factors influencing children's travel options and household attitudes to walking.  The following sections describe the school and societal trends that have influenced where children live in relation to school and the likelihood of walking.  The first part considers school policies such as district consolidation, school busing, and school choice; the second looks at larger demographic shifts such as suburbanization and mothers' labor force participation.

### School Policy

Policies affecting school location such as district consolidation, school siting, and school choice affect how far students travel to school.  School transportation policies have reduced the availability of free school transport for many students which may make students more likely to use autos to get to school.

*School Siting Guidelines*

Each state sets school siting standards which guide school districts as they undertake new construction and retrofit existing schools.  The standards come from guidelines set by the Council of Educational Facility Planners (CEFPI).  Until 2004, these guidelines required a set acreage per student which varied by grade level (CEFPI 1991).  The location and programs offered at the school did not affected the required acreage for the school campus.  Critics have charged that these guidelines led districts to build schools on the outskirts of communities where larger parcels were available and less expensive (Vincent forthcoming, Ewing and Greene 2003).  In addition, some districts found that retrofitting existing schools in built-out areas was unfeasible since they did not conform to the guidelines.  This often meant that the school was closed and a new one built in an outlying area (Vincent forthcoming).  Building schools on the outskirts of communities has very direct effects of trip lengths – it increases them.  This suggests that the guidelines may have contributed to the drop in walking to school.

In July 2004, the CEFPI revised their school siting guidelines to eliminate mandatory minimum sizes (CEFPI 2004a).  By the end of 2004, 22 states had adopted these revised guidelines (Vincent forthcoming).  At the same time, they released a publication on smart growth and school planning (CEFPI 2004b).  It is too soon to judge the impact of these new policies – land will still be expensive in the hearts of

communities.  But they make it easier for communities to design walkable schools and suggest that previous school siting guidelines may have made it less likely for students to walk.

*School Consolidation*

School consolidation has also affected how far children must travel to reach school.  In the post-WWII era there has been an emphasis of consolidating school districts to ensure that all schools offer a wide range of educational and enrichment programs.  From 1952 to 2002, the number of school districts in the United States declined 80% (Vincent forthcoming).  By definition, the closing of schools and restructuring of districts increased trip distances for many students.  Recently the small schools movement and advocates for strong rural education have opposed this trend (Vincent forthcoming, Andrews et al 2002).  The debate on school consolidation has mainly focused on educational outcomes but some authors (Andrews et al 2002) contend that transportation costs and opportunity costs of travel time should figure more heavily into the debate over school closures.  Although this opposition may slow the pace of school consolidation, it is not likely to undo the changes of the past thirty years and is one reason for increased distances between home and school.

*School Choice*

Recent decades have seen a rise in school choice.  Although private and religious schools have been long-standing alternatives to the public school system, many students now have the option of attending magnet and charter schools at no cost.  The Federal No Child Left Behind legislation, which was signed in January 2002, also provides a new mechanism for school choice.  Under this legislation, students in schools which have not attained 'adequate yearly progress' for at least two years have the option of attending a 'higher-performing' school (US Department of Education 2005).  In practice, most school choice options often mean students moving from a neighborhood school to a better school out of the local area.  This may be one factor behind the shift in the distribution of distances between home and school.

*School Bus Elimination*

      After WWII, there has been a tradition of providing school transportation – often free – to all students. These efforts are embodied in the fleets of yellow school buses that are common sights in many American communities. However, because there is no constitutionally guaranteed right to free school transportation (<u>Kadrmas v. Dickinson Public Schools</u>, 487 U.S. 450, 462 (1988)), many school districts have eliminated free school transportation in recent years to save money (McDonald 2005). This trend has been particularly prominent in states where there are no requirements for districts to transport students to school, such as California and Massachusetts.

      Unfortunately the NHTS does not ask respondents about the availability of school buses in their area. Without this data, it is impossible to conclude that the elimination of school buses has caused the rise in auto trips to school. However, school bus use has dropped overall and it has dropped most dramatically at the high school level where many districts chose to first eliminate school bus service.

## Societal Trends

      Demographic and attitudinal shifts in American society have also affected the proportion of students walking to school. Suburbanization, rising levels of auto ownership and mothers' labor force participation have likely made it more likely for children to be driven to school.

*Suburbanization*

      Underlying the outward shift in the distribution of trip distances is the continued suburbanization of America. I will not attempt to cover this extremely complicated topic here; largely because volumes have already been written (see Jackson 1985 for consideration of the larger historical and social contexts and Pisarski 1996 and Pisarski 1987 for a description of how suburbanization has affected travel patterns). Suffice it to say that suburbanization has been marked by a movement to lower density development, higher automobile ownership, and a tendency to commute from suburb to suburb rather than the central city. This has made it difficult for many communities to consider having most children within walking distance of school.

      At low densities, it is not possible to put schools within walking distance of all students. For example, to fill an elementary school (~250 students) would require a

catchment area of 42 square miles at a density of 50 people per square mile and a catchment area of 2 square miles at a density of 1,000 people per square mile (see Table 18).  In either case a large portion of students will end up living beyond walking distance to school.  Considering that 1) 36% of households with children between six and fifteen live at densities less than 1,000 people per square mile and 2) that much of the growth in the United States' population is occurring in the exurban fringe, it will be difficult for planners to effect a radical shift in the proportion of students that walk to school in many communities – even communities where new schools are being built.

**Table 18: Estimated Area and Travel Distances for 250-person Elementary School**

| Density (ppl/mi$^2$) | School Catchment Area (mi$^2$)* | Maximum Travel Distance (mi)** |
|---|---|---|
| 50 | 41.7 | 3.6 |
| 500 | 4.2 | 1.2 |
| 1,000 | 2.1 | 0.8 |
| 5,000 | 0.4 | 0.4 |
| 15,000 | 0.1 | 0.2 |
| 50,000 | 0.0 | 0.1 |

*Assumes 12% of the population is elementary-school aged.
**Maximum travel distance is the radius of a circle with area equal to the school catchment area.  This assumes that the school would be located at the center of the catchment area.
Note: This is obviously a very hypothetical example; it is intended to give a sense of the order of magnitude of these numbers.


*Auto Ownership*

In 1970, there were 0.97 vehicles per licensed driver (US Department of Transportation 2003).  By the mid 1970s, the number of vehicles outstripped the number of drivers by the mid 1970s and today there is close to 1.2 vehicles per driver in the United States.  The availability of cars makes it significantly easier—and to some extent possible at all—to drive children to school.

Analysis of 2001 NHTS data supports the idea that greater automobile access may have caused the decrease in walking rates to school.  Children from households without cars or with fewer vehicles than drivers are much more likely to walk (see Figure 19).  This is not surprising and reflects the need to use alternative modes when cars are not available.  Obviously there are also correlations between auto ownership, income, and household location, but this data suggests that increasing auto ownership leads to lower

walking rates (Chapter 6 presents a multivariate analysis which controls for these correlations). It is important to note that auto access is not destiny. Students from households with more than one vehicle per driver living within a half mile of their school walk to school over 60% of the time.

**Figure 19: Travel Mode To and From School by Auto Availability**
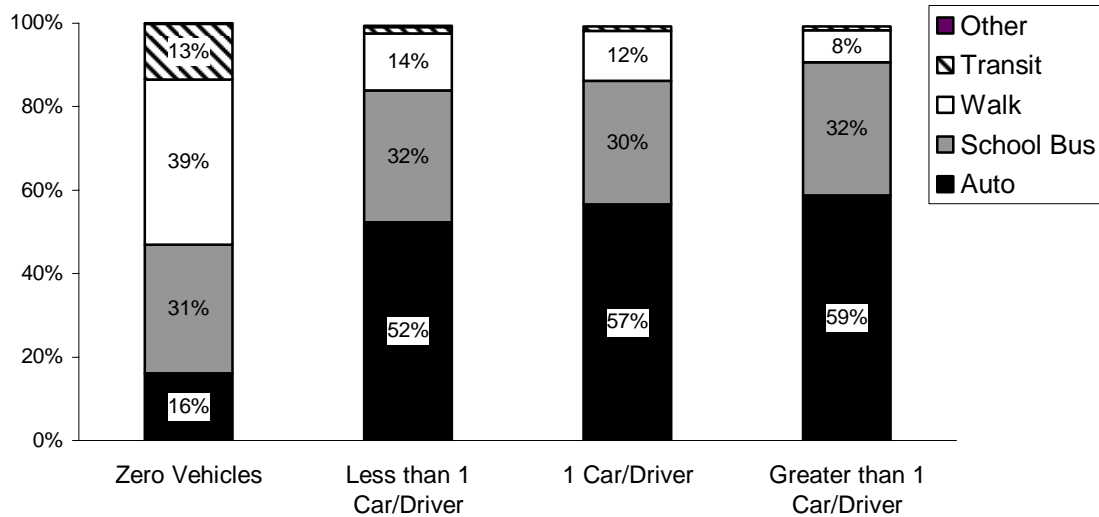


Auto availability makes parents more likely to drop children off at school, but it also makes teens more likely to drive themselves to school. For example, over 40% of teens 16-18 have primary access to a household vehicle. This makes it possible for a large portion of high school students to drive to school or catch a ride with a friend. These high levels of auto access are reflected in the mode choice data. In 1969, 8% of high school students drove themselves to school; now 29% do.

*Mothers' Labor Force Participation*

Since the 1960s women have entered the workforce in large numbers *and* mothers of school age children have opted to remain in the labor force. Women's labor force participation rates have risen nearly 40% since the early 1970s to 2001 (U.S. Department of Labor 2004a). Women with children, particularly young children, have experienced even higher increases in labor force participation (US Department of Labor 2004b, Hayghe 1996). This trend may be particularly critical. Within households, mothers are likely to have primary responsibility for children's travel (McDonald 2004). If mothers are working, they may be very likely to drop off children at school on their way to work.

The 2001 data show that as mothers spend more time in the paid labor force their children are less likely to walk to school (see Table 19). For example, children in intact households walk to school the most (16%) when their mothers are not in the paid labor force. In female-headed single parent households, walking rates are lowest when mothers work full-time (11%); there is little difference in behavior when mothers are homemakers or part-time workers.

**Table 19: Mode Split for Trips to School by Maternal Work Status**

| Mode | Female headed HHs | | | Couple HHs | | |
|------|---------|---------|---------|---------|---------|---------|
| | Home-maker | Part-time | Full-time | Home-maker | Part-time | Full-time |
| Auto | 32 | 38 | 59 | 53 | 58 | 58 |
| Walk | 24 | 27 | 11 | 16 | 8 | 9 |
| School Bus | 36 | 30 | 26 | 30 | 32 | 31 |
| Other | 8 | 5 | 3 | 2 | 2 | 2 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

The 2001 data also show that 72% of the time working women drop children at school, they are on their way to work (see Figure 20). Only 46% of working fathers coordinate these trips. This may help explain why maternal work status is so influential on children's travel behavior. Women are very likely to coordinate their travel with their children's; working fathers are less likely to do so.

**Figure 20: Parents' Trip Tour When Taking Children to School, Auto only**



Intact HHs, Both Full-Time Workers
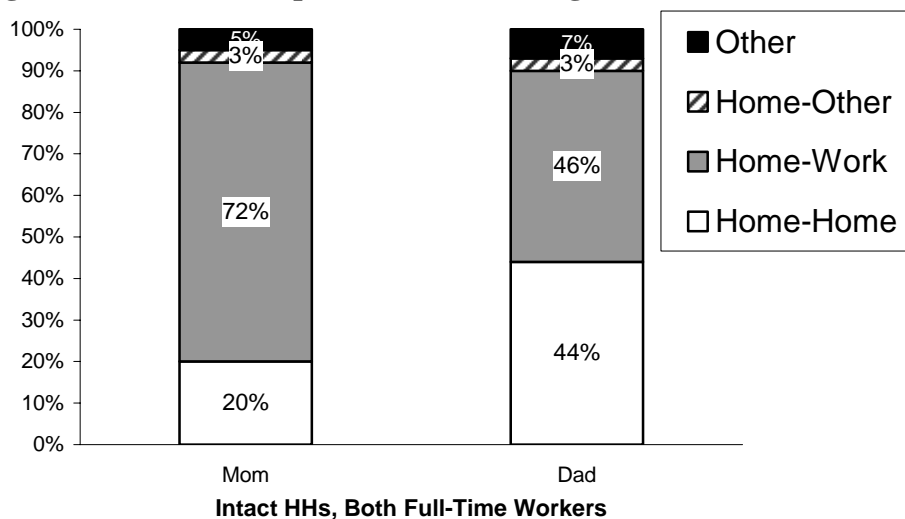
*Safety and Social Norms*

Another factor which parents consistently cite as a reason for not allowing their children to walk is safety concerns (DiGuiseppi et al 1998, Dellinger 2002, Beurat and

Camara 1998, Tranter 1996, STPP 2003, Hillman et al 1990).  Both traffic danger and stranger danger worry parents.  Due to much increased tripmaking and automobility, traffic levels have increased in recent decades (Hu and Reuscher 2004).  Assessing personal safety concerns is more difficult.  Highly publicized child kidnappings may have made parents more aware of potential dangers to children, even if those high profile incidents are relatively rare.  Safety concerns may be linked to a change in social norms about the appropriateness of allowing children to travel by themselves to school and within the neighborhood.  As Caitlin Flanagan (2004) notes in a memoir about being a child in the late 60s and early 70s,

> "anxiety as a precondition of the maternal experience had not yet been invented.  We kids were topped up with Salk vaccine, our fathers had saved the world, and our neighborhoods were chock-full of busybody housewives who delighted in scolding other people's errant children.  Terrible things happened then, just as they do today.  But they tended not to have the titanic significance of the contemporary event.  Once, when I was in third grade, we were all given purple-and-white mimeographed letters to bring home to our mothers.  The letters reported that a child molester had been preying on children walking home from the next elementary school over.  'What's a child molester?' I kept asking my mother, who stood in the kitchen reading the letter in a concerned way.  That was not for me to know—but neither was it sufficient cause for my mother to forbid me to roam the neighborhood after school.  I should just 'be careful.'  My mother and her friends probably would not have made a best-seller of the 'The Lovely Bones.'"

This story reveals very different social norms for acceptable freedoms for children and may help explain how children's travel to school could have changed so drastically.

### Conclusion

What this analysis reveals is that automobility has become a critical part of getting children to school.  A prime cause of this change is that students live further from school than in the past.  As discussed above, there are multiple explanations for why children are traveling longer distances to get to school including suburbanization, school siting regulations, and school choice.  Not all of these factors should trouble us.  Should we really lament a decline in walking to school if it means children can attend better and more diverse schools?  However, in some cases, the fact that many students live outside walkable distances is the product of poor planning.

So what can planners do about school travel?  While it is beyond the purview of planners to affect mothers' labor force participation rate or many of the larger societal trends, planners do impact where children live in relation to their schools and should be a part of discussions over school siting and neighborhood design.  If we want kids to be more active and walk to school, reasonable walking distances for children must become planning criteria as communities site new homes, schools, and child-focused destinations.

The dialogue between school planning and land use planning has recently been rekindled.  Smart growth advocates have returned to Perry's (1939) neighborhood units which placed elementary schools at the center of the community and placed children at the center of planning.  This may prove to be a powerful model in higher-density areas and is already appearing in practitioner's guides on how to do good planning (Atlanta Regional Commission 2005, Vincent forthcoming).

But planners and advocates must remember that not every area is Forest Hills. Perry's model will not work at lower densities.  In these areas, schools must draw from a large geographic area to fill classrooms.  My calculations showed that densities had to be above 1,000 to 2,000 people per square mile to make short school trips possible for large numbers of students.  The fact that 41% of American children live at densities of less than 1,000 limits the opportunities for integrating school and land use planning to reintroduce physical activity into children's lives.  This finding should not discourage planners from working to design communities where children can walk to school.  But it should cause them to focus their efforts on places where this outcome is a realistic possibility.

## CHAPTER 6: SCHOOL TRIP MODE CHOICE

The previous chapter presented data on how the school trip has changed since 1969 and the factors associated with the sharp decline in walking rates for elementary, middle, and high school students.  This chapter looks in greater detail at the current decisions that parents and children are making about the morning trip to school.  The goal of this research is to identify factors which have a strong effect on mode choice, particularly the decision to walk to school, and develop a model which can be used to test the effects of various land use strategies on the decision to walk to school.   Identifying factors which make children more likely to walk to school is essential to creating and refining policies aimed at getting children to be more active by walking to school.  To meet these goals, I develop a mode choice model for the morning school trip for elementary and middle school students.  I limit the analysis to younger children because much of the current policy debate focuses on how to get younger children to walk more and because, as the previous chapters have shown, adolescents have very different travel behavior than children.

### *Methodology*

This research relies on the multinomial logit models developed by McFadden to understand mode choice for the trip to school (see Domencich and McFadden (1975), Ben-Akiva and Lerman (1985), and Train (2003) for model derivation).  The model structure assumes that children and their parents, as a family unit $n$, choose their travel mode, $j$, to maximize utility, $U_{nj}$.  The assumption that children's travel modes are chosen to maximize household utility is critical, since it is clear that the parents' wishes may completely determine mode choice.  Although each household knows $U_{nj}$, it is unknown to the researcher.  Instead researchers observe $V_{nj}$ which is a function of observable factors.  Assuming $U_{nj}=V_{nj}+\varepsilon_{nj}$ and $\varepsilon_{nj}$ is distributed iid (independently and identically distributed) extreme value results in a closed form representation for the probability of choosing each mode, $j$, for each person, $n$.  It is:

$$\Pr(Y = j)_n = \frac{\exp(V_{nj})}{\sum_{l \in J} \exp(V_{nl})}$$

**Model Specification**

In this model, decisionmakers face a choice between driving, walking and taking a school bus or transit to school. The representative utility of each mode for each person, $V_{nj}$, is a function of trip, child, household, and neighborhood characteristics.

$$V_{nj} = \alpha_j + \beta_j T_{nj} + \delta_j C_n + \gamma_j HH_n + \kappa_j N_n, \text{ where}$$

$V_{nj}$ represents the observed utility to person n of mode j;

$\alpha_j$ is an alternative specific constant;

$T_{nj}$ is the travel time required for person n to complete the journey by mode j;

$C_n$ represents the characteristics of the individual such as age and gender;

$HH_n$ represents household factors such as income;

$N_n$ represents measures of the built and social environment such as density and concentrated poverty.

This model requires that explanatory factors vary with the choice; variables such as travel time and cost easily fulfill this property. To include characteristics of individuals, households, and neighborhoods, which do not vary with choices, requires interacting these variables, such as age, with a choice specific dummy (Greene 2000, Train 2003).

In multinomial models, only differences in utility matter. Therefore, coefficients can enter at most J-1 of the J utility equations. I have chosen auto as the reference mode, with only auto travel time entering its utility function. In addition, it was assumed that students would value travel time differently for each mode. Therefore, the coefficients on the travel time variables are not constrained to be equal, i.e. $\beta_j \neq \beta_i$ for all $j \neq i$.

**Choice Sets**

For the multinomial model, the universal choice set was auto, bus/transit, and walk. Although transit and school bus may seem like very different modes, I have combined them to ensure that this mode is available to all students. In many cities, there is no school bus service. Instead students use public transit to get to school. Because I have no information on whether a school bus is available for the school trip, I make the assumption that transit or a school bus will be available[6]. Clearly, there are important

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[6] Unfortunately, there are no national statistics on the availability of school buses or transit to the school population.

differences between school buses and public transit – primarily the fact that students share space on public transit buses with adults. This may affect parents' and students' perceptions of safety and comfort for each of these modes. Future research will be needed to study the possibility of analyzing these modes separately. Because very few students biked to school (~1%), I have excluded this mode from the analysis.

Many students live quite far from school, making walking an unrealistic choice. Because of this, I tested a model which eliminated walking from an individual's choice set if estimated walk time was greater than one hour. This led to restricting the choice set of 2,777 of the 5,525 students in the sample. Analysis of the model with a restricted choice set versus an unrestricted choice set showed no appreciable differences in coefficients. Therefore I present results of models estimated with unrestricted choice sets.

**Interpreting Model Coefficients**

Coefficients from logit models tend to be uninformative. In linear models, the coefficient on any variable succinctly describes the effect of that variable on the outcome variable of interest. In logit models, the effect of any one variable on the outcome depends on the values of all variables and coefficients. Because of this, I have calculated marginal effects and elasticities for variables of interest. For any dummy variable, D, the marginal effect for each individual is computed as

$$\frac{\Delta \Pr(Y_n = j)}{\Delta D_n} = \Pr(Y_n = j \mid D_n = 1) - \Pr(Y_n = j \mid D_n = 0)$$

For a continuous variable, X, the marginal effect[7] is

$$\frac{\partial \Pr(Y_n = j)}{\partial X_{nk}} = \beta_{X_{nk}} \Pr(Y_n = j)\left[\delta_{jk} - \Pr(Y_n = j)\right], \text{ where } \delta_{jk}=1 \text{ if j=k and } \delta_{jk}=0 \text{ if j}\neq\text{k}$$

In the analysis, I also test the interaction effect between a dummy variable, D, and a continuous variable, X. Following Ai and Norton (2003), the marginal effect of the interaction term is computed as

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[7] The result shown assumes that the variable of interest, X, only enters the utility function of mode j. The formulas become more complicated when accounting for more complex utility functions, i.e. socio-demographic factors that appear in both the walk and bus utility functions.

$$\Delta \frac{\partial \Pr(Y_n = j)}{\partial X_k} = \frac{\Delta}{\Delta D_{nk}} \left[ \left( \beta_{x_{nk}} + \beta_{D \cdot X} D_{nk} \right) \Pr(Y = j) \cdot \left( \delta_{jk} - \Pr(Y = k) \right) \right]$$

Computing average effects for the sample is always problematic in logit models. As is clear from the formulas above, the marginal effect of any variables depends on all other coefficients and variables. Multiple authors have shown that the best approach to this problem is to compute marginal effects for each individual and then average across the sample. This is preferable to computing the effects on the 'average individual' because of the non-linear shape of the probability curve (see Train (2003), p. 34 for explanation). In this case, it is also advantageous to weight each marginal effect by the likelihood of choosing that mode.

$$\frac{\overline{\partial \Pr(Y = j)}}{\partial X_k} = \frac{1}{N} \sum_{n=1}^{N} \Pr(Y_n = j) * \frac{\partial \Pr(Y_n = j)}{\partial X_{nk}}$$

For continuous variables, it is also instructive to look at elasticities. Elasticities provide information on the expected change in the probability of choosing a certain mode for a 1% change in an explanatory variable. Although some authors, e.g. Ewing and Greene 2003, estimate elasticities at the mean value of other covariates, it is preferable to calculate elasticities for each individual and then average over the sample (Ben-Akiva and Lerman 1985). This accounts for the problem described above with differences between the average probability at the mean utility and the average of individual utilities. Following Ben-Akiva and Lerman (1985), the aggregate elasticity is a probability weighted average of individual elasticities.

$$E_{x_{nk}}^{\overline{\Pr(Y=j)}} = \frac{\sum_{n=1}^{N} \Pr(Y_n = j) E_{x_{nk}}^{\Pr(Y_n = j)}}{\sum_{n=1}^{N} \Pr(Y_n = j)}$$

where $E_{x_{nk}}^{\Pr(Y_n = j)} = \frac{\partial \Pr(Y_n = j)}{\partial x_{nk}} \bullet \frac{x_{nk}}{\Pr(Y_n = j)}$

**Correlation**

I expect significant correlation in error terms among children from the same household. Because of this, I used robust estimates of coefficient standard errors which

provide more conservative tests of all hypotheses.  The cluster command in Stata was used to produce these estimates.

*Data*

As in the previous analyses, I used data from the NHTS to identify children who traveled to school.  Because children's travel behavior changes greatly when they reach high school and have increased levels of auto access, I restricted the sample to children between the ages of 5 and 13 who "went to school as a student" on a weekday from September to May.  In addition, I only included households who reported household income and had been geocoded to a census block group.  The latter restriction was necessary to test the importance of neighborhood factors which were measured through census proxies.

This analysis relies on reasonable reporting of trip distances.  Because of this, I eliminated any trips with unreasonable travel speeds.  In particular, I limited motorized trips to a maximum speed of 70 miles per hour and walking trips to 10 miles per hour.  In both cases, these values were at or near the 99 percentile of the distribution of travel times for the respective modes.  Finally, I limited the analysis to students who used autos, walked, and rode the school bus or public transit to school.  Given these restrictions, my sample includes 5,525 children from 3,708 households.  The unit of analysis is the trip tour from home to school rather than unlinked trips.  This accounts for the fact that many children travel with siblings in the morning, often making stops at their schools as well.  The key outcome variable for both models is the mode used to travel to school (see Table 20 for the mode distribution).

**Table 20: Mode Distribution**

| Mode | Number in Sample |
|---|---|
| Auto | 2,482 (45%) |
| School Bus | 2,364 (43%) |
| Walk | 637 (12%) |
| Public Transit | 42  (1%) |
| Total | 5,525 |

**Trip Characteristics**

The primary trip characteristics is travel time.  The usual method of estimating travel times is with an origin-destination travel time matrix.  This is impossible with

national data.  Because of this, I used speed factors to translate the reported trip distance into time.  The speed factors were calculated from the dataset based on the median travel speeds by mode and whether the household was located in an urbanized area.  For motorized modes, there were substantial speed differentials depending on whether the household was located in a (census-defined) urbanized area.  For example, the median automobile speed in urbanized areas was 17 mph compared with 28 mph for non urbanized areas.  Table 21 lists all speeds.

**Table 21: Speed Factors**

| Mode | Speed (mph) |
|---|---|
| Auto | |
|    Urbanized Area | 17 |
|    Rural Area | 28 |
| School Bus | |
|    Urbanized Area | 9 |
|    Rural Area | 14 |
| Walk | 2.7 |

The time of year and the region of country where the trip occurred are accounted for with dummy variables for season (spring is the omitted category) and census region (Pacific is the omitted category).

**Other Characteristics**

All other explanatory variables have been described in Chapter 3.  Table 22 presents summary statistics for this sample population.  The average trip distance among all elementary and middle school students was four miles.  The demographic characteristics show that the sample has fewer minority members, and is higher income than the population of the United States.  Nearly 40% of students in the sample have parents that both work full-time; 11% of children live in single-headed households.  Most of the children live at moderate densities – an average of 4,400 people per square mile which is equivalent to half the density of Berkeley.

**Table 22: Description of Variables**

| Variable | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|
| *Trip Characteristics* | | | | |
|    Trip distance (miles) | 4.0 | 4.6 | 0 | 41 |
|    Walk travel time (min) | 88.4 | 101.6 | 1 | 911 |
|    Auto travel time (min) | 11.4 | 12.6 | 0 | 145 |
| *Individual Characteristics* | | | | |
|    Age | 9.3 | 2.5 | 5 | 13 |
|    Female | 0.5 | 0.5 | 0 | 1 |
|    # of siblings | 1.5 | 1.1 | 0 | 7 |
| *Household Characteristics* | | | | |
|    Black | 0.1 | 0.2 | 0 | 1 |
|    Asian | 0.0 | 0.2 | 0 | 1 |
|    Latino | 0.0 | 0.2 | 0 | 1 |
|    Multi | 0.1 | 0.2 | 0 | 1 |
|    Vehicles per driver | 1.1 | 0.5 | 0 | 6 |
|    Income (000) | 60.3 | 30.6 | 3 | 110 |
|    Single-headed HH (dummy) | 0.1 | 0.3 | 0 | 1 |
|    Mom works FT (dummy) | 0.4 | 0.5 | 0 | 1 |
|    Dad works FT (dummy) | 0.8 | 0.4 | 0 | 1 |
|    Mom traveled to work in AM (dummy) | 0.4 | 0.5 | 0 | 1 |
|    Dad traveled to work in AM (dummy) | 0.6 | 0.5 | 0 | 1 |
|    Distance to work-Mom | 7.0 | 8.4 | 0 | 139 |
|    Distance to work-Dad | 11.6 | 36.5 | 0 | 1,228 |
| *Neighborhood Characteristics (Block Group)* | | | | |
|    Residential density (000) | 4.4 | 14.5 | 0 | 251 |
|    Dense, urban area (dummy) | 0.1 | 0.3 | 0 | 1 |
|    Ratio of children to adults | 0.4 | 0.1 | 0 | 1 |
|    % Foreign born residents | 1.0 | 1.9 | 0 | 32 |
|    % of households with income >$100k | 14.1 | 13.8 | 0 | 100 |
|    % of residents below poverty line | 8.2 | 8.9 | 0 | 100 |
|    Median year built | 1967 | 40.7 | 1939 | 1999 |
|    % of residents who moved within 5 yrs | 44.8 | 14.5 | 0 | 100 |
| *Crime (County)* | | | | |
|    Part 1 property crimes (per 1,000 ppl) | 5.3 | 2.3 | 0 | 15 |
|    Part 1 violent crimes (per 1,000 ppl) | 1.7 | 1.3 | 0 | 12 |

*Model Development*

      The MNL model of school trip mode choice includes factors at the trip, individual, household, and neighborhood level. Factors were retained in the model if they were significant at the 0.05 level or if there was a theoretical or research reason for keeping the variable. For example, a dummy variable for female was retained in the walk utility function, even though the coefficient was not statistically significant, so that the influences of gender on travel behavior could be fully investigated. Table 23 lists the coefficients for this model.

**Table 23: Multinomial Model Results**

| Variable | Auto Coeff. | Auto P-value | Bus/Transit Coeff. | Bus/Transit P-value | Walk Coeff. | Walk P-value |
|---|---|---|---|---|---|---|
| Intercept | | | 0.01 | 0.97 | -0.39 | 0.34 |
| *Trip Characteristics* | | | | | | |
| Auto travel time | -0.02 | <0.01 | | | | |
| Walk travel time | | | | | -0.14 | <0.01 |
| *Child Characteristics* | | | | | | |
| Age | | | 0.10 | <0.01 | 0.23 | <0.01 |
| Female (dummy) | | | -0.12 | 0.05 | -0.07 | 0.56 |
| Number of siblings | | | 0.08 | 0.05 | 0.18 | 0.01 |
| *Household Characteristics* | | | | | | |
| Income (000) | | | -0.01 | <0.01 | -0.00 | 0.07 |
| Mom works in AM (dummy) | | | -0.17 | 0.03 | -0.33 | 0.03 |
| *Neighborhood Characteristics* | | | | | | |
| Population Density (000) | | | | | 0.02 | <0.01 |
| Urban area (dummy) | | | -0.67 | <0.01 | | |
| % below poverty line | | | -0.01 | 0.03 | 0.02 | 0.02 |
| % Foreign born residents | | | 0.05 | 0.05 | 0.08 | 0.04 |
| % moved within 5 years | | | -0.01 | <0.01 | | |
| *Region* | | | | | | |
| New England | | | | | -0.30 | 0.51 |
| Mid Atlantic | | | | | -0.56 | 0.04 |
| East North Central | | | | | -0.16 | 0.53 |
| West North Central | | | | | -1.20 | 0.01 |
| South Atlantic | | | | | -0.50 | 0.13 |
| East South Central | | | | | -1.93 | 0.03 |
| West South Central | | | | | -0.80 | 0.05 |
| Mountain | | | | | 0.31 | 0.38 |
| *Summary Statistics* | | | | | | |
| N | *5,525* | | | | | |
| *Log Likelihood* | *-4,244* | | | | | |
| *Model $\chi^2$* | *383.9* | | | | | |
| *Prob* | *<0.01* | | | | | |
| *Pseudo-$R^2$* | *0.30* | | | | | |

At the trip level, bus travel time was not included as an explanatory variable. Including this variable led to highly unstable models and non-sensical results, i.e. coefficients on the travel time for multiple modes were non-negative. These findings are consistent with Ewing and Greene (2003) who in their analysis of student travel in Florida found it difficult to estimate bus travel times and asserted their belief that the decision to ride the bus is made without regard to bus travel time. Although further research is necessary, there is preliminary evidence that decisions to ride the bus are made without regard to travel time.

Many of the household level variables proved to not affect mode choice. Wald tests that an individual or group of variables are equal to zero showed being in a single-headed household ($\chi^2$ =0.9 p=0.7), having a mother or father working full-time ($\chi^2$ =4.3 p=0.4), having a father who left for work on the morning of the travel day ($\chi^2$ =1.7 p=0.4); did not affect outcomes. Surprisingly, the model showed no effect of vehicle ownership ($\chi^2$ =3.1 p=0.2), as measured by the ratio of vehicles to drivers, on behavior. This finding is likely the result of the correlation between household income and vehicle ownership. Because of this, only household income was retained in the model.

Control variables for season and census region showed that season of the year had no effect on behavior ($\chi^2$ =2.1 p=0.4), while region was significantly associated with walking to school ($\chi^2$ =29.1 p=<0.01).

*Analysis*

This section describes the influence of trip, child, household, and neighborhood factors on mode choice to identify the factors with the strongest influence on behavior. Because the current debate on children's travel is focused on walking to school, I concentrate my analysis on walking but also present statistics for the effects on the auto mode. The primary metrics for assessing the effect of each variable on behavior are the average marginal effect, $\overline{\dfrac{\partial \Pr(Y = j)}{\partial X_k}}$, and the aggregate elasticity, $E_{X_k}^{\overline{\Pr(Y=j)}}$. As described above, both these statistics are weighted averages with the weights equal to the probability of choosing mode $j$. Table 24 contains both these measures for the auto and walk modes. The following sections discuss the interpretation of this data in detail.

**Table 24: Marginal Effects and Elasticities**

| Variable | Auto Marginal Effect | Auto Elasticity | Walk Marginal Effect | Walk Elasticity |
|---|---|---|---|---|
| *Trip Characteristics* | | | | |
|     Auto travel time | -0.0016 | -0.09 | 0.0002 | 0.34 |
|     Walk travel time | 0.0016 | 0.14 | -0.0029 | -0.90 |
| *Child Characteristics* | | | | |
|     Age | -0.0120 | -0.55 | 0.0040 | 0.86 |
|     Female (dummy) | 0.0118 | | -0.0003 | |
|     Number of siblings | -0.0097 | -0.07 | 0.0030 | 0.11 |
| *Household Characteristics* | | | | |
|     Income (000) | 0.0007 | 0.20 | 0.0000 | -0.06 |
|     Mom works in AM (dummy) | 0.0197 | | -0.0055 | |
| *Neighborhood Characteristics* | | | | |
|     Population Density (000) | -0.0002 | -0.01 | 0.0004 | 0.06 |
|     Urban area (dummy) | 0.0602 | | 0.0056 | |
|     % below poverty line | 0.0008 | 0.02 | 0.0005 | 0.11 |
|     % Foreign born residents | -0.0054 | -0.02 | 0.0012 | 0.03 |
|     % moved within 5 years | 0.0013 | 0.27 | 0.0001 | 0.14 |

**Trip Characteristics**

Review of the calculated marginal effects and elasticities shows that travel time – in essence distance to school – has the strongest effect on the decision to walk to school (see Table 24). A one minute increase in walk travel time leads to a 0.3% decline in the probability of walking; a 10% increase in walk travel time leads to a 9% decrease in the probability of walking. Children are less sensitive to auto travel times, but they are still important. A one minute increase in auto travel time leads to a 0.02% increase in the probability of walking; a 10% increase in auto travel time leads to a 3.4% increase in the likelihood of walking. While there are other factors with elasticities and marginal effects of the same magnitude as travel time, those variables have limited ranges. For example, the marginal effect of age on walking is greater than the marginal effect of walk travel time on walking, but the age marginal effect requires a change of one year versus one minute for travel time.

These average effects obscure some of the important variability in sensitivity to travel time. As Figure 21 shows, the marginal effect of walk travel time on the probability of walking is strongest for individuals who are moderately likely to walk, i.e. Pr(Y=Walk) ~0.5. In contrast, individuals who are very likely or very unlikely to walk are insensitive to walk travel time. The marginal effect of auto travel time on the

probability of walking exhibits a different character. The effect is essentially zero for those likely to walk and only becomes large for individuals who are very unlikely to walk. While these graphs are simply visual representations of the mathematical relationships assumed in the choice model (and in that sense are tautological), they do make clear that changes in walk travel time only matter to those on the fence. Students facing long commutes (with essentially zero probability of walking) are not sensitive to walk travel time; neither are students who live very close to school and are likely to walk.

**Figure 21: Direct and Cross Marginal Effects on the Probability of Walking**
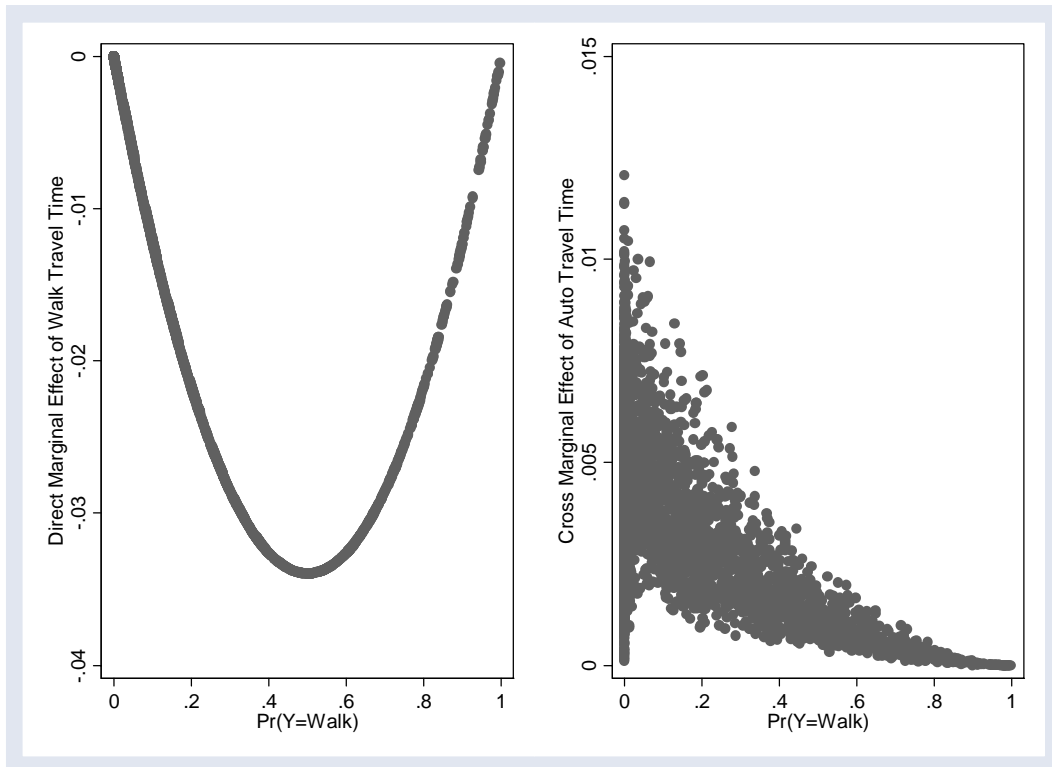


**Child Characteristics**

Although distance and travel time are probably the most critical variables, several individual and household level characteristics are also important. Not surprisingly, the child's age has a strong effect on the likelihood of walking to school. A one year increase in age leads to a 0.4% increase in the probability of walking and a corresponding 1.2% decline in the likelihood of being driven. Having siblings also makes children less likely to be driven to school and more likely to walk. This effect is likely to result from

parents' increased comfort allowing children to walk when they are accompanied and the increased time costs for parents of dropping off multiple children at school.

One consistent finding in the limited literature on children's travel is that girls have a more circumscribed travel world than boys which leads them to make fewer independent and walking trips than boys (Vliet 1983, Hillman et al 1990). This analysis shows that girls are more likely to be driven to school; being female increases the probability of being driven by 1%. But girls are no less likely to walk to school than boys. Being female only decreases the probability of walking to school by 0.03%, which while statistically significant from zero is not practically different from zero.

These findings suggest that gender may not play a role in walking to school. Because this finding is contrary to previous research, I also test a different model specification where the effects of gender act through travel time, i.e. I created interaction terms between gender and travel time[8]. The results again show that gender has little effect on walking to school. For example, on average the negative marginal effect associated with walk travel time is 0.006% higher for girls than boys. Compared with the base marginal effect of walk travel time of 0.3%, this is negligible. Figure 22 shows this graphically; it is obvious that there is little variation by gender in the marginal effect of walk travel time on the probability of walking.

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[8] Under this revised model specification, the auto utility function was defined as
$U_{auto,n} = \beta T_{An} + \beta D_{Fn} T_{An}$, where $T_{An}$ is auto travel time and $D_{Fn}$ is a dummy variable equal to one for females. A similar conversion was done for the walk utility function.

**Figure 22: Direct Marginal Effect of Travel Time on Walking by Gender**
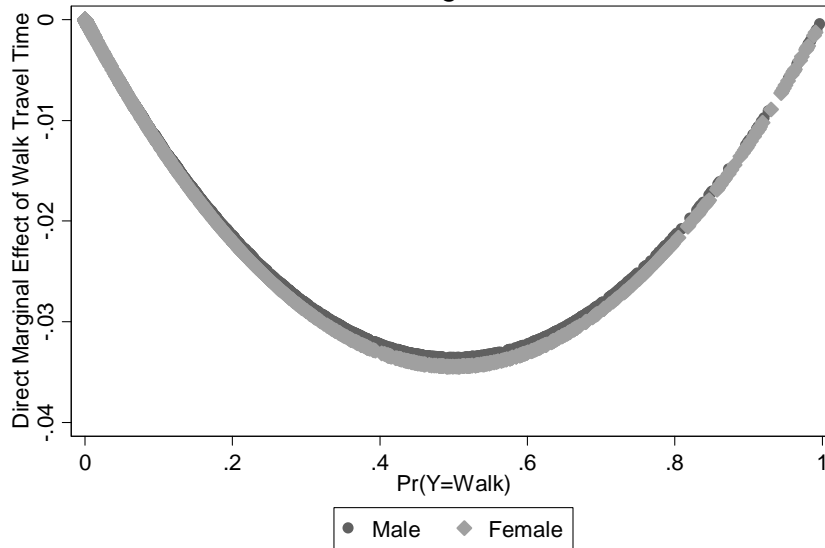


**Household Characteristics**

At the household level, income has moderate effects on travel behavior. For example, increasing income by 10% leads to a 0.6% decline in walking and a 2% increase in being driven. More interesting is the finding that the mothers' work travel – and not the fathers' – affects behavior. If the mother made a morning trip to work, the child was 2% more likely to be driven and 0.6% less likely to walk to school. At the same time, the father's work travel has no impact on the child's travel mode. The corresponding variable for fathers showed no impact on children's mode choices. These results reflects the fact that women have the majority of responsibility for children's travel (McDonald 2004) and that women often condition their choice of occupation and work location on their household obligations (Madden 1981).

It is also interesting to note that dummy variables for race and ethnicity were uniformly insignificant ($\chi^2$ =12.8 p=0.2). Simple averages of walk rates by race and ethnicity show large variation by racial group. For example, 10% of whites walk to school while 22% of African-American children walk. However, the apparent racial variation is better explained by factors such as household income, density, and neighborhood composition.

**Density**

Population density is positively associated with walking, even after accounting for trip distance. However, an increase of 1,000 people per square mile leads only to a 0.04% increase in the probability of walking and a 0.02% decline in the probability of driving. In fact, as Figure 23 shows, there is little relationship between the probability of walking and density is quite weak. But, before dismissing the effects of the built environment on school trip mode choice as negligible, it is critical to remember that the largest effect of the built environment is on distance to school. As density increases distance to school decreases (r=-0.13, p<0.01). This effect of the environment is captured in the travel time variables, as well as the density measure.

**Figure 23: Probability of Walking by Population Density**
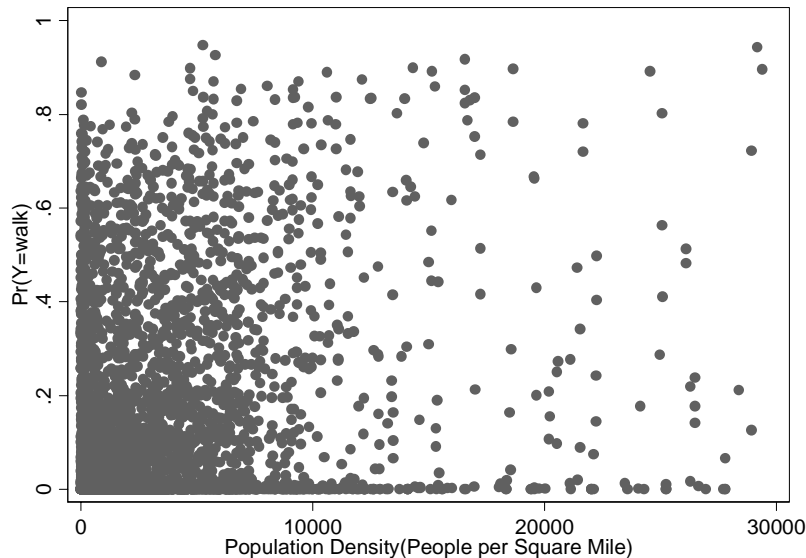


A dummy variable indicating the respondent lives in a dense neighborhood (densities usually greater than 15,000 people per square mile) is negatively associated with bus use. This represents less an effect of the built environment on behavior than the effect that there is very limited school bus provision in high density areas. Although the bus mode also includes public transit, very few respondents used transit. This means that the bus utility function mainly reflects the characteristics of school bus riders.

**Social Environment**

Among the neighborhood level variables were several Census measures which other researchers have shown to be correlated with social processes (Sampson et al 1999)

and outcomes such as school leaving (Connell et al 1995, Ensminger et al 1996) and crime (Sampson et al 1997). This research has suggested that, in answer to Wilson's (1987) question, growing up in a poor neighborhood has a differential effect from growing up poor. In this analysis, I hypothesized that living in neighborhoods with high levels of social control and cohesion makes it more likely for children to walk to school, presumably because parents feels comfortable allowing their children to be in the neighborhood. Lacking direct measures of control and cohesion, I relied on Census proxies measures which Sampson et al (1999) have shown to be correlated with social processes. These proxies are: concentrated disadvantage (% living below the poverty line), concentrated advantage (% of households with incomes greater than $100,000), immigrant concentration (% of residents who are foreign born), residential stability (% of residents who have moved to the neighborhood in the last five years), and child density (ratio of children to adults in the neighborhood).

Two of these factors – concentrated advantage and child density – had no association with mode choice and were dropped from the model. A Wald test that the coefficients on the remaining neighborhood-level variables are simultaneously equal to zero suggests that the built and social environment near the child's home does affect travel behavior ($\chi^2$ =100.8 p=<0.01). However, the model results contradict the hypothesis. According to the model, being in a high poverty neighborhood with low residential stability and a large immigrant population – that is an area with low social control and cohesion – is associated with higher levels of walking. These are exactly the findings we would expect for individual level variables, but not what I had hypothesized at the neighborhood level. These findings suggest that Census data is too weak a proxy for neighborhood social process such as control and cohesion. To truly test the hypothesis that neighborhood social control and cohesion affecting travel behavior to school will require additional survey data that asks about respondents' feelings about their neighborhoods. The Census neighborhood measures simply provide confirmation that poor individuals tend to live in poor neighborhoods where auto access is low and distances to school are often short – making walking highly likely.

**Crime**

Finally, the FBI Uniform Crime Reports provide an indicator of violent and property crimes in the community. Unfortunately, this data is available at the county level and many counties do not report data. Because of the missing data, I estimated the effects of crime in a separate analysis from those described above. This analysis was limited to those households who lived in counties with available crime data. All variables were identical to the model described above with the addition of the crime statistics. The results show that crime decreases the likelihood of walking to school ($\beta$=-0.02, p=0.6); however, the coefficient is not significant. The lack of significance likely reflects the coarse nature of the crime data and suggests a need for further analysis with neighborhood level data.

*Conclusions*

Four findings emerge from this analysis which may be useful to researchers seeking to understand children's travel behavior and policymakers seeking to increase the proportion of children walking to school.

**#1: Travel time has the strongest effect on mode choice.** When choosing modes for the school trip, families largely appear to be minimizing their children's travel time. Children are also much more sensitive to walk travel time than auto, reflecting the fact that most people are not willing to walk long distances. The large impact of walk travel time on mode choice suggests that large numbers of students will walk to school only when they live close to school. Given that over 80% of students currently live more than a mile from their schools, this is a significant obstacle to current policies designed to increase walking rates.

**#2: Gender and race do not have large effects on mode choice.** Basic averages and previous research have suggested that gender and race should have a strong effect on mode choice. The model shows that race has no effect on mode and that gender has a very weak effect, and one in the opposite direction of previous findings.

**#3: Dense places encourage walking to school.** Density has a weak positive association with walking to school. But density has its strongest effect on mode choice through trip distance. As density increases, children tend to live closer to their schools. As shown above, it is distance – that is travel time – that has dramatic effects on behavior.

**#4: More research is needed to understand the effects of the social environment on children's travel behavior.** The importance of neighborhood social processes has been well documented by the sociology literature. Transportation researchers need to consider how these factors might affect their research as well. Doing so will require transportation surveys to incorporate questions about people's neighborhoods.

# CHAPTER 7: POLICY IMPLICATIONS AND CONCLUSIONS

Previous chapters provided insights into how much children are traveling, analyzed changes in school travel between 1969 and 2001, and identified factors influencing mode choice for the school trip. While these findings are important and interesting in their own right, there is a critical need for research to inform policy on children's travel. Practitioners – both in planning and public health – have implemented programs to make communities more walkable and elevate levels of everyday physical activity. For example, grassroots efforts to encourage children to walk to school, e.g. Safe Routes to Schools, have converged with public health efforts to increase physical activity levels in children by having them walk to school, e.g. the Center for Disease Control's KidsWalk-to-School program. The net result has been increased funding to make schools more walkable destinations.

But neither of these programs affects the variable with the most influence on walking to school – trip lengths. To greatly increase the number of students walking to school, planners and policymakers need to locate schools nearer students through neighborhood school programs or students nearer schools through densification efforts. To address the spatial distribution of students and schools, school and land use planners must begin to work together. This coordination is essential because there is substantial new school construction and renovation of aging schools planned across the country. California, for example, has passed over $20 billion in bonds for K-12 construction in the past six years (Posnick-Goodwin 2004). The design and location of schools built with this money will have a substantial impact on children's travel behavior and communities.

Pressure from smart growth advocates has already started the dialogue between school and land use planners. The Council of Educational Facility Planners International (CEFPI) (2004b) authored a guide to advise facility planners on how their projects can fit with smart growth goals; EPA commissioned a study of how school siting affects air quality and community design (Ewing and Greene 2003); and the National Trust for Historic Preservation (2003) documented the benefits of retaining small schools in existing areas rather than building on the fringe of communities. These efforts are important, but they often fail to critically evaluate how land use will affect school travel (Ewing and Greene 2003 is an exception). To address this gap, I consider how three land

use policies – neighborhood schools, street connectivity, and density – will impact children's school travel. The model developed in the previous chapter provides a means of testing how each policy will affect walk mode shares for the school trip. The final sections of this chapter summarize key research findings and discuss ideas for future research.

### *Neighborhood Schools*

Until June 2004, the school siting guidelines of the CEFPI recommended one acre of land for every 100 students plus ten acres for an elementary school, 20 acres for a middle school, and 30 acres for a high school (CEFPI 1991). These guidelines were not context sensitive and required large campuses which, in many communities, could only be accommodated at the edge of town. These size requirements made it difficult for schools to be integrated into the community leading to long distances between home and school and low walking rates (Ewing and Greene 2003, National Trust for Historic Preservation 2003). New guidelines from CEFPI remove size standards allowing much more flexibility in school design (CEFPI 2004a). In addition, the organization has encouraged educational facility planners to consider smart growth in their school designs (CEFPI 2004b). By the end of 2004, 22 states had adopted the new guidelines (Vincent forthcoming).

Advocates of smart growth and walking to school have encouraged districts to use this new flexibility to build neighborhood schools. The idea harks back to Perry's (1939) vision of neighborhood units which contain an elementary school and ample play space. This type of design makes it possible for most children to live within walking distance of school. From a transportation perspective, neighborhood schools affect trip lengths by decreasing the distance from home to school. Therefore to understand how a shift to neighborhood schools might affect walking behavior, I created scenarios that specify each student's distance to school. These scenarios estimated each student's likelihood of walking given the trip length and then averaged over the sample to estimate the expected walk mode share. For example, one scenario estimates walk mode share if all students lived exactly one mile from school. While this is unrealistic, it gives a good sense of the sensitivity of mode choice to distance.

With the current trip length distribution, the model predicts that 11.5% of students in the sample will walk to school. Changing the proportion of children walking to school requires large decreases in how far children travel to school. For example, if all children lived a half mile from their school the model estimates that 36% would walk (see Figure 24). If students lived one mile from their school, 13% would walk. The numbers predicted by the model are lower than the observed averages, which were described in Chapter 5, because these scenarios assume all other factors such as density remain constant. In reality, places where neighborhood schools are possible also have higher-densities and lower auto ownership. For these reasons, the predicted walk mode shares are conservative estimates.

**Figure 24: Walk Mode Share: Distance to School Scenarios**
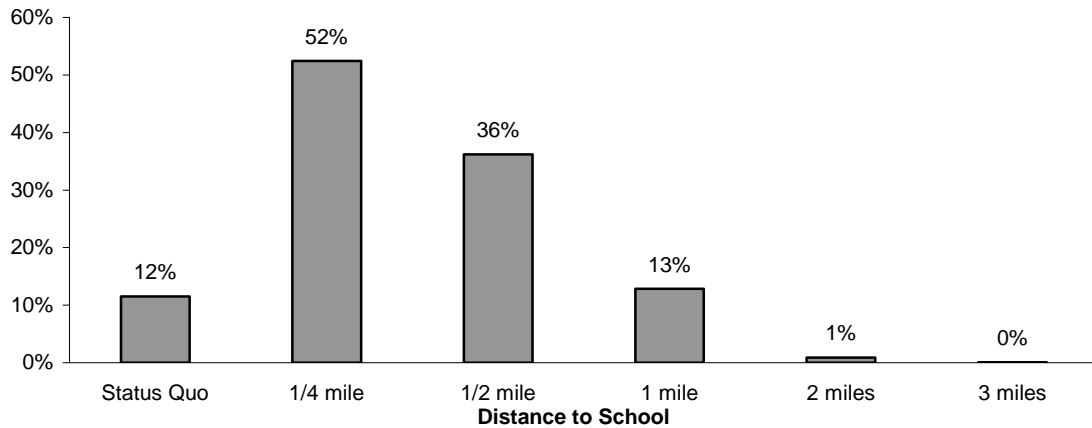


Using distance to school as a criterion in school siting and renovation decisions would give individual communities a chance to increase walking to school. Building schools near students – within a mile or preferably a half mile – will result in more students walking and potentially in health benefits. Overall walking rates do not change if the maximum distance to school is two or three miles. This places severe constraints on the size of the 'neighborhood' that can support a school.

A few simple calculations show the neighborhood schools model is only possible at moderate to high densities. A maximum walk distance of one mile requires that all students live in a three square mile area; a maximum walk distance of a half mile equates to an area of less than a square mile. If schools must draw from a larger area to get enough students, the model predicts no change in overall walk rates (because the majority of the students would live beyond a walkable distance). As was noted in Chapter 5 this

finding means that neighborhood schools are only possible at moderate to high densities with large numbers of school-age children in small geographic areas. For example, in an area with 500 persons per square mile, only fifty elementary school-aged children would be expected to live within a half mile radius of a school (see Table 25). That is hardly enough to support a one-room schoolhouse, nevermind a conventional elementary school.

**Table 25: Number of Elementary School Aged Children by Density and Distance**

| Density (People/mi$^2$) | Elementary School Maximum Distance to School (miles) | | | High School Maximum Distance to School (miles) | | |
|---|---|---|---|---|---|---|
| | ¼ | ½ | 1 | ¼ | ½ | 1 |
| 500 | 12 | 47 | 188 | 7 | 27 | 110 |
| 1,000 | 24 | 94 | 377 | 14 | 55 | 220 |
| 2,000 | 47 | 188 | 754 | 27 | 110 | 440 |
| 5,000 | 118 | 471 | 1,885 | 55 | 220 | 880 |
| 10,000 | 236 | 942 | 3,770 | 69 | 275 | 1,100 |

Assumes 12% of the population is elementary school-aged and 7% is high school-aged and that neighborhoods are circular.

While there is little agreement on the ideal size of schools, even advocates for small schools consider 300 to 900 students a reasonable range, with 300 being appropriate for elementary schools and 900 for high schools (Vincent forthcoming). As Table 25 shows, creating a neighborhood elementary school (~300 students) where all children live within one mile of the school only becomes possible at densities greater than 1,000 people per square mile. To have students live within a half mile of their school, densities must be closer to 4,000 people per square mile. Creating a high school with 900 students living within one mile requires 5,000 people per square mile.

The NHTS data show that 36% of households with children 6 to 15 live at densities of less than 1,000 people per square mile and 64% live at densities of less than 4,000 people per square mile. This means that the neighborhood schools model is not a possibility in many existing communities. But, the scenarios do show that dense, new communities can plan around distance to school, and provide another argument for retrofitting schools in dense, urban locations rather than moving them. The information above also suggests that neighborhood schools work best at the elementary level. The smaller size of elementary schools makes them a possibility in more areas.

Finally, planners must address the equity impacts of neighborhood schools. Many schools, particularly schools in low-income, urban areas, are already very segregated; and

national statistics also reflect a trend toward resegregation of schools (Orfield 2001, Rickles et al 2004). Assigning children to neighborhood schools may only exacerbate this problem in areas with high levels of residential segregation. Consider that the primary method for desegregating schools after the *Brown* decision was to switch children from their neighborhood school. While it could be argued that residential segregation should be tackled directly rather than making schools deal with it, planners and advocates for walking to school need to consider the equity impacts of neighborhood schools.
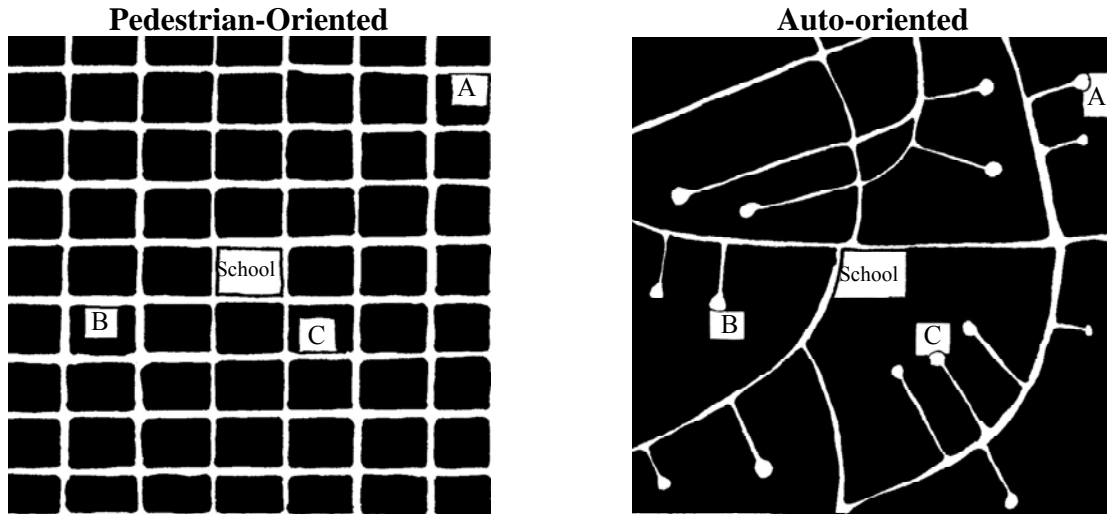
### *Street Connectivity*

Community design can have an important, but somewhat subtle, effect on how children get to school. While many elements of neighborhood design affect how children travel to school – the provision of sidewalks is an obvious example, I will focus on the overall layout of the neighborhood and particularly on street connectivity. Two archetypal neighborhood types have been well-documented in the literature – pedestrian-oriented neighborhoods with grid street patterns and auto-oriented neighborhoods with many cul-de-sacs (see Southworth and Owens 1993, Cervero and Radisch 1996, Cervero and Gorham 1995). Differing levels of street connectivity in these neighborhoods can greatly affect the trip distance between home and school – even if the straight arrow distance is the same.

To highlight how neighborhood design can affect walking behavior, I constructed two hypothetical neighborhoods – one with a grid street pattern and the other with many cul-de-sacs. In all other respects, the neighborhoods are identical. Population density is the same in both areas (even though that is unlikely to be true in reality) and the school is in the same central location in each neighborhood (see Figure 25). Three households with students traveling to school have been identified. Each household is identical and the location of their home is the same in each neighborhood, i.e. straight-line distance from each household to the school is the same in each neighborhood. What differs between neighborhoods is the route that each student must take to get to school. Assuming the students are all exactly the same (they are assumed to have the population average values for continuous variables and to be the reference person for all dummy

variables, i.e. male), I calculate the network distance between home and school to understand what walk and auto mode shares would be in each situation.

**Figure 25: Archetypal Neighborhoods**

| Pedestrian-Oriented | Auto-oriented |
|---|---|



Based on Southworth and Owens (1993)

The results show that the street network in areas with poor street connectivity can reduce the probability of walking for some students.  For example, the student living in house A must travel nearly six times as far in an auto-oriented neighborhood as a traditional, grid neighborhood (see Table 26).  This translates to a dramatic reduction in the likelihood of walking.  In the traditional neighborhood, the probability of walking is 73%, while in the auto-oriented neighborhood that probability drops to 30%.  The other locations do not show any significant effect of neighborhood design on modal decisions. This example shows that neighborhood design can affect walking mode choice simply by affecting the trip distance.  Placing schools in neighborhoods will not be effective at encouraging children to walk to school unless the street network allows them to access the school efficiently.  It should also be stressed that in reality other features of the neighborhood such as density and sidewalk availability, would also differ between the two neighborhoods.  Therefore, the model results present a conservative (or minimum) estimate of differences in mode behavior between the two areas.

**Table 26: Walk and Auto Mode Shares by Household**

| Location | Pedestrian-Oriented Neighborhood | | | Auto-Oriented Neighborhood | | |
|---|---|---|---|---|---|---|
| | Distance to School (miles) | Walk Share | Auto Share | Distance to School (miles) | Walk Share | Auto Share |
| A | 0.13 | 73 | 14 | 0.75 | 30 | 36 |
| B | 0.58 | 41 | 30 | 0.58 | 41 | 30 |
| C | 0.25 | 65 | 18 | 0.30 | 62 | 20 |

*Density*

Many of the popular planning movements today advocate some form of clustering or intensifying development as a way to reduce reliance on the automobile and decrease human impacts on the environment (Smart Growth Network 2004). Using the model, I am able to test the effects of simply increasing density *without* changing the location of schools in relation to neighborhoods. The analysis shows that changing density without considering school location will have a negligible effect on walking to school (see Figure 26). This does not mean that density in general has no effect on walking to school. As we saw earlier, students in higher density areas are more likely to walk to school because trip distances are shorter. What the scenarios show is that densification is not a magic strategy to get more children walking. In order for children to walk to school, planners must consider how schools fit into high density development projects. This again emphasizes the need to coordinate land use regulations (which control density) with school siting guidelines (which control school location) if policymakers want to encourage children to walk to school.

**Figure 26: Walk Mode Share: Density Scenarios**
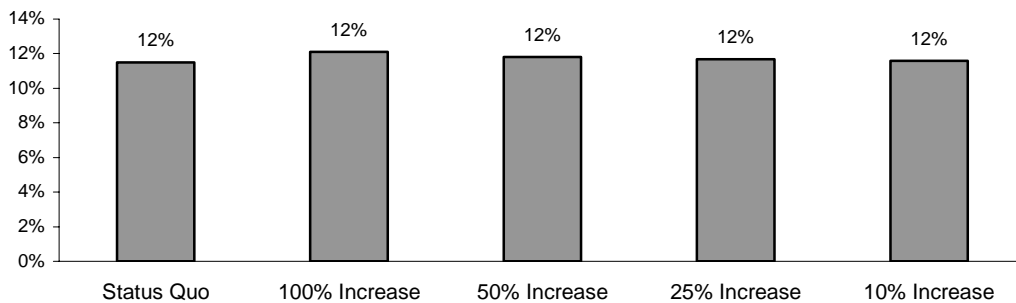
*Conclusions*

Long trip lengths are one of the primary reasons many students do not walk to school today. Programs addressing the safety of walking to school, such as SR2S, are essential but they do not address the spatial distribution of students and schools. If policymakers want to substantially increase walking rates, the analyses and policy scenarios suggest that placing schools in neighborhoods is an effective policy option. The scenarios show that large increases in walk mode share could be achieved if most students lived within one mile of their school. But there are some important caveats. First, neighborhood schools are only possible at moderate to high densities where there are enough students living in small geographic areas to fill classrooms. In addition, the neighborhood school model is best suited for elementary education because these schools are smaller and are better-suited to smaller areas. Finally, advocates for neighborhood schools have not discussed the potential equity impacts of this policy. In areas with high levels of residential segregation, neighborhood schools could increase school segregation.

These findings suggest a need for better integration of land use and school planning. Including children's distance from school as a planning criterion could be an effective way to change community design and encourage walking. This coordination is most necessary in moderate and high density areas and places designing large-scale developments. However, even in low-density areas, planners can optimize school and development placement so that a large portion of students live within a walkable distance of their school.

Finally, the scenarios emphasize the inter-relatedness of the policy options. It is not enough to place schools within neighborhoods unless those neighborhoods have a street design that facilitates access. It is not enough to encourage densification of communities if that is not accompanied by siting schools within walking distance of many students. What quickly becomes clear is that land use policies to increase walking to school are a part of the larger movement toward smart growth and transit-oriented development. What is not clear is how important the goal of getting more kids to walk to school is to the majority of Americans. Is it important enough for people to consider re-designing their communities? I do not know the answer to that question, but with emergence of new school siting guidelines I suspect there may be a series of natural

experiments as some communities opt to develop schools on smaller sites within their communities. These case studies may provide the next source of data in studying school transportation.

*Future Research*

In conducting research on children's transportation, it quickly becomes clear how much we do not know. Five areas stand out as being important areas for future research. First, it is obvious that parents play an important role in children's travel. However, the models presented in this chapter fail to fully capture how the parents' availability and own trip patterns may influence the child's behavior. Future models should capture the relationship between the child's school location and the parents' work locations as a means of better understanding and explaining why so many children are driven to school today. Both quantitative (mode choice models) and qualitative (focus groups and interviews) efforts will increase understanding of the household decision processes around children's travel.

Second, the role of the neighborhood social environment deserves much more attention. The sociology literature points to a strong influence of the social environment on outcomes as varying as infant mortality, birth weight, and crime (Morenoff 1999, Morenoff 2003, Sampson et al 1997). The models in this chapter provide preliminary evidence that the social environment may influence travel behavior as well. To fully investigate this area, researchers must go beyond Census proxies of neighborhood factors and look at psychometric measures to quantify these effects.

Third, this research did not fully explore children's non-school travel. Given that school trips account for, at most, half of children's weekday travel, it is critical to investigate these other trips. In adults, researchers have found that the built environment exerts stronger effects on non-work as compared to work trips (Cervero and Duncan 2003). It will be important to see if this effect is also true for children. In addition, understanding how much of children's travel is actually babysitting on the go is important.

Fourth, much of the debate about walking to school and school siting has been done without consideration of the costs of getting children to school. Many districts currently provide school bus service to students who live beyond walking distance.

However, there is a trend toward eliminating this service to save costs (McDonald 2005). There may be a strong cost argument for designing schools that require minimal bus transportation regardless of the health implications. However, this area has not yet received much attention.

Finally, implicit in much of the policy interest in children's travel is the idea that walking to school has health benefits. The existing research on this question is contradictory. One study showed that walking to school provided a substantial portion of children's physical activity in Russia (Tudor-Locke 2002); research on US children found that walking to school only represented 2% of weekly physical activity for five-year olds (Metcalf et al 2004). Research integrating physical activity measures, e.g. accelerometers, with activity and travel survey data will be needed to resolve this question.

To begin to present a full picture of children's travel, these areas need to be investigated more fully. Ideally the results will be useful for children's travel policies and give us more insights into the travel behavior of children and parents.

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# APPENDIX 1: ADDITIONAL SCHOOL TRIP DATA

**Table 27: Trip Length Distribution for Trips to School, 1969 and 2001**

| Distance(miles) | 1969 | | | | 2001 | | | |
|---|---|---|---|---|---|---|---|---|
| | Elem. | Inter. | HS | All | Elem. | Inter. | HS | All |
| <1.0 | 45.2 | 26.3 | 16.6 | 34.7 | 23.6 | 12.4 | 10.1 | 18.5 |
| 1.0-1.9 | 17.6 | 18.9 | 16.6 | 17.5 | 16.6 | 10.6 | 11.6 | 14.4 |
| 2.0-2.9 | 12.4 | 17.6 | 19.8 | 15.2 | 13.9 | 18.6 | 15.3 | 15.0 |
| 3.0+ | 24.8 | 37.2 | 47 | 32.6 | 45.9 | 58.4 | 63.0 | 52.1 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Note: 2001 data only reported ages; these have been converted to grades assuming Kindergarteners are 5.

**Table 28: Mode Split by Trip Distance, 2001**

| Distance(miles) | 2001 | | | | | | |
|---|---|---|---|---|---|---|---|
| | <¼ | ¼-½ | ½-1 | 1-2 | 2-3 | 3+ | Avg. |
| School Bus | 5.0 | 3.3 | 9.1 | 24.1 | 32.2 | 4.05 | 30.6 |
| Auto Pax | 14.1 | 41.6 | 50.8 | 59.2 | 54.8 | 46.5 | 47.5 |
| Auto Driver | 1.3 | 1.0 | 3.7 | 4.8 | 6.1 | 10.3 | 7.4 |
| Walk | 78.9 | 52.7 | 32.9 | 9.0 | 3.9 | 0.6 | 12.2 |
| Bike | 0.3 | 1.4 | 2.4 | 1.7 | 1.2 | 0.0 | 0.7 |
| Public Transit | 0.0 | 0.0 | 0.8 | 1.1 | 1.4 | 2.1 | 1.6 |
| Other | 0.0 | 0.0 | 0.4 | 0.0 | 0.3 | 0.0 | 0.1 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Note: 2001 data only reported ages; these have been converted to grades assuming Kindergarteners are 5.

**Table 29: Trip Time Distribution for Trips to School, 1969 and 2001**

| Time(minutes) | 1969 | | | | 2001 | | | |
|---|---|---|---|---|---|---|---|---|
| | Elem. | Inter. | HS | All | Elem. | Inter. | HS | All |
| <10 | 30.5 | 21.7 | 18.6 | 26.0 | 30.9 | 22.1 | 24.2 | 27.9 |
| 10-19 | 43.5 | 39.8 | 41.0 | 42.2 | 35.7 | 34.1 | 39.6 | 36.4 |
| 20-29 | 11.1 | 15.2 | 17.4 | 13.4 | 15.0 | 20.9 | 16.7 | 16.3 |
| 30-44 | 10.8 | 16.5 | 15.9 | 13.0 | 13.1 | 16.4 | 12.5 | 13.5 |
| 45-60 | 3.5 | 6.5 | 5.7 | 4.5 | 3.9 | 5.3 | 5.2 | 4.4 |
| 61+ | 0.6 | 0.3 | 1.4 | 0.9 | 1.5 | 1.3 | 1.8 | 1.5 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Note: 2001 data only reported ages; these have been converted to grades assuming Kindergarteners are 5.

**Table 30: Mode Split for Trips to School of Less than 1 Mile, 1969 and 2001**

| Mode | 1969 | | | | 2001 | | | |
|---|---|---|---|---|---|---|---|---|
| | Elem. | Inter. | HS | All | Elem. | Inter. | HS | All |
| School Bus | 5 | 1 | 3 | 5 | 8 | 3 | 2 | 6 |
| Auto Pax | 7 | 7 | 9 | 7 | 38 | 29 | 26 | 36 |
| Auto Driver | 0 | 0 | 4 | 1 | 0 | 0 | 16 | 2 |
| Walk/Bike | 88 | 91 | 81 | 87 | 54 | 67 | 53 | 55 |
| Public Transit | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 0 |
| Other | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Note: 2001 data only reported ages; these have been converted to grades assuming Kindergarteners are 5.