A Study of Travel Modes of Elementary School Students in Chapel Hill, NC

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A technical report submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Master of Science in Public Health at the School of Public Health, Department of Environmental Sciences and Engineering

Chapel Hill
2007

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Abstract

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A Study of Travel Modes of Elementary School Students in Chapel Hill, NC
(Under the direction of Donald T. Lauria, David Leith and Dianne Ward)

The proportion of youth who are overweight has more than doubled in the last 20 years, in part causing health professionals to declare an obesity epidemic in the United States. One of the main factors responsible for the epidemic of overweight and obesity is the sharp decline in physical activity and the corresponding increase in sedentary behavior in youth. Active Living by Design is a nationwide program that establishes innovative approaches to increase physical activity through community design, public policies and communications strategies. Chapel Hill, NC, was selected as one of the 25 Active Living by Design Community Partnerships in October 2003. Since then, their partnership has worked to promote physical activity and active living in schools.

In September 2004, take-home questionnaires were distributed to all students at Ephesus Elementary, Estes Hills Elementary, Phillips Middle and Scroggs Elementary schools. The surveys were designed to investigate children's commuting habits and to gauge parents' perceptions of the traffic environment and concerns regarding their children's transportation behaviors. This research focused on a statistical and quantitative analysis of the data obtained from those surveys. The analysis included fitting 2 different statistical models to the data, one aimed at explaining why some children always walked or biked and the other aimed at explaining why some children never walked or biked to school; by implication, these models provided information on why children sometimes walked or biked. The results of the logistic regression (logit) models along with supporting information from the questionnaires were used to explore policy alternatives for increasing the numbers of elementary school walkers and bikers in Chapel Hill.

Findings suggest that structural interventions such as speed bumps to slow traffic and improved sidewalks will do little to increase walkers and bikers. Rather, the main needs are to dissuade parents from driving their children to school and not to rely on driving as the main mechanism for preventing children from arriving late.
Dedication

To my loving and tolerant wife, Kama, for sticking with me through this project.
Thank you for all of your support and encouragement, and your faith in me.
Acknowledgments

To David Leith, for suggesting that I work on a subject that is important and interesting to me, and allowing me the freedom to work on a project of my choosing. This would not have happened without you. To Don Lauria, for your guidance, instruction and tolerance – thank you for working with me on a project outside of your usual work. I could not have completed this without your help. To Dianne Ward, thank you for offering your time for this work based only on the topic, not the investigator. To Maryanne Boundy, thank you for your editorial help and unending support for everything – it is truly appreciated. And for your amazing cranberry bread, which I won’t soon forget. To the parents and children who volunteered their information and time on the surveys – I would not have had a project without them. To David Bonk and Len Cone, for allowing me to use the surveys, and waiting this long for an analysis. I hope this is helpful. Thanks.
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A Study of Travel Modes by Elementary School Children in Chapel Hill, NC

Introduction

In 2004, 33.6% of children ages 2 to 19 in the United States were identified as being overweight or at risk of overweight; this proportion has more than doubled in the past twenty years.\(^1\)\(^2\) Because complications of this condition include adult onset (type II) diabetes, a serious condition that until recently has not affected children, this epidemic of childhood obesity has garnered much attention in medical, public health, and urban planning journals. Concern also exists because the long-term effects of childhood obesity are not fully known.

Although many causes ranging from genetic susceptibility to poor eating habits have contributed to the obesity epidemic, health researchers have linked obesity with both the sharp decline in physical activity and the increase in sedentary behavior of youth. Studies have found that 61.5% of children aged 9-13 years do not participate in any organized physical activity outside of school and 22.6% do not engage in any free-time physical activity.\(^3\)

Consequently, research has begun to focus on modifications to this sedentary lifestyle. One such approach is active living, which is a way of life that incorporates physical activity into daily routines.\(^4\) Health researchers have found a utilitarian approach that requires little or no additional time commitment by integrating daily physical activity with transportation needs.\(^5\) Public health and urban design groups have proposed and adopted a combination of active transportation and beneficial community design to promote healthier populations and cleaner, more efficient cities.\(^4\)\(^6\)
The Robert Wood Johnson Foundation and the Institute of Public Health at the University of North Carolina at Chapel Hill established Active Living by Design to assist community efforts to promote physical activity by incorporating changes in design, transportation, and architecture.\textsuperscript{7} To date, Active Living by Design has awarded 25 grants to interdisciplinary, community-oriented partnerships throughout the United States to develop and implement strategies to increase opportunities for routine physical activity while decreasing potential barriers.\textsuperscript{7}

Chapel Hill, NC received one of the 25 community grants in October 2003 and used the funding to promote physical activity and active living in three areas - neighborhoods, businesses, and schools, under the project name “Go! Chapel Hill.” Go! Chapel Hill is located within the planning department of the town’s municipal government offices and works closely with both the transportation and engineering departments to create informed changes within the existing transportation network. Perhaps the most successful aspect of the program to date has been the Active Routes to School program. This program tapped local parent groups who wanted to investigate the potential for their children to walk or bike safely to school, thereby increasing their daily physical activity.

Under this program, parents living in neighborhoods surrounding three elementary schools, Mary Scroggs, Estes Hills and Ephesus, were trained to use neighborhood audit tools and conducted audits of the pedestrian environment near their schools in October 2003. Following the parent assessment of the school environment, questionnaires were distributed at Ephesus Elementary School to get baseline information on children’s school commuting routines. A second round of classroom surveys was
distributed at Ephesus, Estes Hills and Mary Scroggs elementary schools in the spring 2004.

In September 2004, take-home parent questionnaires were distributed to all students at Ephesus, Estes Hills, and Scroggs elementary schools to investigate children’s commuting habits and parental perceptions of the traffic environment, the commuting activities of their children, and the barriers to walking and biking to school. These surveys were based on the example parent survey from the National Safe Routes to School Toolkit produced by the National Highway Traffic Safety Administration. The goal was to use the survey results to make programming decisions and polices that would increase the number of children who walk or bike to school, thereby changing their lifestyles and physical activity habits at a young age.

Thus, the results of the September 2004 surveys from Ephesus, Estes Hills, and Scroggs elementary schools form the basis of this research. A solid understanding of the numbers of children that walk or bike to school as well as the attitudinal variables that influence these numbers might provide a basis for increasing the number of children that walk or bike to school.

The five research objectives are:

1. To summarize the existing literature on the problems of childhood obesity, adolescent physical inactivity and its effect on health, and other relevant publications on psychology, transportation and environmental design.

2. To describe the survey questionnaire, survey respondents, and data categories in the data base generated from the survey questionnaire on travel modes of school children in the three sampled elementary schools from Chapel Hill, NC.
3. To describe the transportation mode choices of elementary school children in Chapel Hill, NC as shown by the survey, as well as other relevant and supporting facts generated by analysis of the data used in this study.

4. To use the available data and supporting information to understand why some children always walk or bike to school and why some children never walk or bike to school.

5. To address the policy implications of the study results. Can the number of walkers/bikers in Chapel Hill, NC be increased? If so, by how much? What steps and policy interventions are needed to achieve targeted increases?

1.0 Literature Review

1.1 Growth and Expansion of Suburban Areas

The built environment is comprised of transportation, land use patterns, and urban design characteristics. During the last century, zoning laws, the widespread use of the automobile, and increased road construction have contributed to changes in the built environment in the U.S.⁶ These events have resulted from technological advances and changes in the political and legal framework and have had a cumulative and permanent effect in the creation of cities, towns, fringe developments, and exurban areas where most Americans live and work.

The rise of the suburbs is a direct result of the decline of the crowded, industrial cities of the 19th century. The densely-populated urban areas were seen by critics as disease-ridden and polluted; the corrective action was to move people out of the city and into the suburbs. The ensuing zoning laws in the less populated areas thus prohibited high-density, mixed-use development and promoted suburban growth. These laws were
promulgated in part by public health officials and planners to curb the spread of diseases, such as tuberculosis, and to improve the quality of life for many Americans by removing them from the pollution, disease, and close quarters of the city.\textsuperscript{6,9,10} As a result, the single-use zoning and development patterns of the suburbs along with their lower housing costs enticed the populations of the city centers to relocate to the urban fringe and led to the growth of the suburbs.\textsuperscript{9,11}

After World War II, the return of soldiers and the consequent baby-boom created huge housing shortages.\textsuperscript{10} These shortages were met and expedited by loan programs managed by the Federal Housing Administration and the Veterans Administration that financed mortgages for more than eleven million new homes in the suburbs.\textsuperscript{11} Such low-cost suburban housing led to a huge movement to the outlying areas and created an increased demand for an improved infrastructure in the newly-populated suburbs.\textsuperscript{9,10}

Initially, it seemed that the cities would survive the flight to the suburbs because most business and commerce were conducted in or near downtown areas.\textsuperscript{6} However, the increase in automobile ownership post-World War II combined with the relocation of workplaces and stores to the suburbs eliminated the need for suburban residents to travel to the central city.\textsuperscript{9,10} The suburbs took on characteristics of their counterpart cities, providing all that was needed for the new residents without the inconvenience of travel to the central city for daily needs. Aided up by the ubiquity of the automobile and cheap fossil fuels, the suburbs became a place of their own.\textsuperscript{12}

\subsection*{1.2 Transportation and Health}

Neighborhood design, automobile-dependent transportation, and the existence of 'bedroom communities' made transportation a prominent issue in the new suburbs. The transportation infrastructures present in most urban areas today are largely predicated on
This reliance on fossil fuels for transportation is a source of environmental degradation and public health problems. These problems are exacerbated in the suburbs by street patterns that depart from the grid approach found in many cities in favor of circuitous, sprawling street networks. Such networks increase distances between destinations and make automobile travel the mode of choice for even the most proximal destinations. Increased automobile use has increased traffic congestion. Air pollution caused by the large number of vehicles emitting ozone precursors and particulate matter is also a source of health problems for older adults and children, especially children with asthma.

Dependence on the automobile and the lack of supportive environments for walking and biking in many urban and suburban areas have also decreased the prevalence of walking and bicycling. Limited investment in bike paths and sidewalks compared to road construction has decreased the available resources for walking programs and biking projects. For these reasons, walking or biking are not attractive transportation options.

In the same sixty years that automobile travel has become the mode of choice in the U.S., a shift toward increasingly sedentary lifestyles has occurred. This increase is in part attributable to sedentary occupations, the increased time spent in traffic, and the replacement of walking and biking with the automobile. Physical inactivity is a side-effect of a sedentary lifestyle; furthermore, research has shown that physical inactivity contributes to excessive weight gain, chronic diseases such as diabetes and coronary heart disease, decreased lifespan, and increased medical expenses.
1.3 Physical Activity and Health

In 1996, the Centers for Disease Control and Prevention issued the first Surgeon General’s Report on Physical Activity and Health and targeted the more than 60% of U.S. adults who do not get any regular physical activity. This report emphasized the importance of physical activity to maintain a healthy lifestyle and specified that physical activity need not be strenuous to confer health benefits. The report recommended at least thirty minutes of daily, moderate-intensity, physical activity for both adults and children. This recommendation was contrary to current exercise regimes, which advocated twenty minutes of high-intensity exercise on three or more days each week. By taking a more inclusive view of physical activity, the new recommendations opened the door to community-based interventions and programs. This approach appealed to broader audiences and was easier to implement, while providing the same benefits as strenuous, high-intensity physical activity.

The prescription of increasing physical activity is seriously needed because physical inactivity has contributed to the current worldwide obesity epidemic. Obesity is defined by the Centers for Disease Control and Prevention as a body mass index (BMI) higher than 30 for adults, and overweight is defined for adults at a BMI between 25 and 30. For children, overweight is defined as a BMI higher than the 95th percentile for children of the same age and sex. The number of overweight and obese Americans has risen sharply and the proportion of overweight youth has more than doubled in the last 20 years. In 1999-2002, more than 65% of adults at least 20 years of age were identified as either overweight or obese while more than 30% of children age 6 through 19 were overweight.
Childhood obesity is of special importance because of its long-term health complications and increased potential for a shorter lifespan.\textsuperscript{25} Recently, childhood obesity has been linked to the dramatic increase of non-insulin-dependent (type 2) diabetes mellitus in adolescent populations.\textsuperscript{26,27} Adults with type 2 diabetes have an increased susceptibility to other cardiovascular conditions, while children with this disease are more likely to have heart attacks, strokes, or other cardiovascular conditions much earlier in life.\textsuperscript{26,27} Since physical activity decreases the prevalence of obesity and is recommended for maintaining health, then increasing the amount of physical activity has been linked to disease prevention and a healthier, longer life.\textsuperscript{2}

1.4 Walking and Bicycling to School

Walking or cycling to school contributes to higher levels of physical activity for school-age children.\textsuperscript{28} Children who walk to school tend to be more active overall than those who do not, are more likely to be active as adults, and less likely to be obese.\textsuperscript{29,30} As a lifestyle change, walking and biking to school improves cardiovascular health and contributes to improved quality of life and psychological well-being.\textsuperscript{22,31}

The proportion of children who lived within one mile of school and walked or biked decreased from 87\% in 1969 to 63\% by 2001.\textsuperscript{32,33} Overall, the proportion of children who walked or biked any distance dropped from 42\% in 1969 to 16\% in 2001;\textsuperscript{32,33} this finding is partially caused by the replacement of neighborhood schools by much larger “megaschools” that are located farther from home for many children.\textsuperscript{34,35} Since 1969, the number of schools has decreased by more than a thousand, while the number of students has increased by two million.\textsuperscript{36}

Other barriers that may limit the number of children who walk or bike to school include crime and traffic danger.\textsuperscript{36} Although crime is a legitimate concern of parents, the
number of violent crimes against youth has dropped over the past thirty years, and of
those crimes, the numbers are lowest in and around schools.\textsuperscript{36} Furthermore, the number
of traffic-related deaths and injuries in youth and adolescents declined by more than 50%
between 1987 and 2000.\textsuperscript{36} If barriers to physical activity can be addressed through
objective, empirical evidence, an increase in the physical activity of children may be
possible.

1.5 Safe Routes to School

Many health researchers hypothesized that the return of physical activity in the
form of walking and biking to school might lead to an overall increase in physical
activity for youth. Thus, need exists for programs that promote safe, active transportation
for students from their home to school. Safe Routes to School is an international program
that is designed to increase the percentage of students who safely walk or bicycle to
school.\textsuperscript{37} This program addresses issues such as the engineering of pedestrian facilities,
the enforcement of speed limits and pedestrian laws, and the education of students,
parents, and school staff to encourage walking and biking to school.\textsuperscript{36}

Safe Routes to School began in Denmark in the mid-1970s following designation
of the region as having the highest child pedestrian accident rate in Europe.\textsuperscript{38} In response,
the city of Odense began a pilot program to evaluate the transportation environment
around its 45 schools. Traffic improvements were made and within ten-year period the
rate of child pedestrian and cyclist casualties dropped by more than 80%.\textsuperscript{38} The success
of this program led to the start of similar programs in Europe, Canada, Australia, New
Zealand and the United States.\textsuperscript{37} In the evaluation of other European programs,
Timperio and co-workers found that the success of those programs, in terms of the
number and rate of children who walked or biked to school, was heavily influenced by
parental perceptions of safety.\textsuperscript{39} Perceptions of these barriers and motivating factors have also affected the rates of walking and biking in the U.S. as well.\textsuperscript{39}

1.6 Parental Perceptions

Parents have often perceived a more negative side of the transportation and safety environment than their children, as expressed by concerns for traffic safety and the presence of strangers in their neighborhood.\textsuperscript{39} Although most children felt neither issue was a concern, these concerns often dictated parental support and permission for their children to engage in the walk and bike to school program.\textsuperscript{39}

Parental concern for traffic danger prevents many children from walking or biking to school.\textsuperscript{36,40} One study found that parents are more concerned about their child walking or biking to school when they are from low-density, low-walkability neighborhoods.\textsuperscript{41} However, these concerns may be unfounded because traffic-related pedestrian fatalities for 5 to 9-year olds have decreased to less than 1 in 100,000 children in recent years.\textsuperscript{42}

Parental perceptions of the transportation environment do not always align well with objective assessments of the transportation environment.\textsuperscript{42} Many parents have a limited understanding of the pedestrian environment and their child’s capability to safely navigate it.\textsuperscript{42} Hence, researchers have recommended educational programs for parents that address traffic issues, travel distance, and crime and that focus on improvements in the transportation environment and the health benefits of physical activity.\textsuperscript{39,41,42}

1.7 Survey Methodology and the Safe Routes to School Survey

Survey methodology has been used to evaluate the opinions, habits, perceptions, disease status and demographic information of populations worldwide.\textsuperscript{43} The Safe Routes to School Toolkit provides survey methodology that is tailored to understand and promote safe walking and biking to school.\textsuperscript{8} Two types of surveys are recommended:
(1) a student survey of transportation mode choice for administration by teachers in the classroom and (2) a survey for parents to collect demographic, attitudinal, and transportation mode use information. These surveys have been used to evaluate the California Safe Routes to School legislation and the Marin County, California Safe Routes to School program.\textsuperscript{46,47}

1.8 Logistic Regression

Logistic regression analysis was used in this study to quantify the effects of specific determinants on travel behavior in youth. Logistic regression is a mathematical modeling approach which is useful in describing the relationship of predictors, such as the determinants in this study, to dichotomous dependent variables\textsuperscript{48}. The dependent variable in the case of this analysis was walking and biking to school. Logistic regression models are useful in situations where the response variable of interest takes only one of two possible values\textsuperscript{48}. It is then possible to derive, from the model that best fits the available data, which predictors can be associated with specified dependent variable outcomes.

Dummy variables for predictor variables are used in logistic regression models to make predictions about the dependent variable based on the relative contribution of the predictor variables\textsuperscript{49}. With a one-unit increase or decrease in the dummy variables, the logistic regression equation returns the predicted probability of the event in question. The closer the probability is to 1, the more likely it is that the given independent variables (with positive dummy values) are related to the outcome in question\textsuperscript{49}. In this analysis, we aim to determine which determinants are related to walking and biking to school to inform policy decisions that would increase the prevalence of walking and biking to school.
The returns by grade for the three elementary schools are shown in Table 2. The table shows that parents with children in all grades participated in the survey and that all three schools had approximately the same representation.

Table 2. Distribution of Questionnaires by Grade, Child One*

<table>
<thead>
<tr>
<th>School</th>
<th>K</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ephesus</td>
<td>12</td>
<td>18</td>
<td>17</td>
<td>15</td>
<td>10</td>
<td>9</td>
<td>83</td>
</tr>
<tr>
<td>Estes Hills**</td>
<td>16</td>
<td>17</td>
<td>22</td>
<td>30</td>
<td>22</td>
<td>20</td>
<td>128</td>
</tr>
<tr>
<td>Scroggs</td>
<td>15</td>
<td>20</td>
<td>11</td>
<td>16</td>
<td>25</td>
<td>21</td>
<td>109</td>
</tr>
<tr>
<td>Total</td>
<td>43</td>
<td>55</td>
<td>50</td>
<td>61</td>
<td>57</td>
<td>50</td>
<td>316</td>
</tr>
<tr>
<td>Average</td>
<td>14.3</td>
<td>18.3</td>
<td>16.7</td>
<td>20.3</td>
<td>19.0</td>
<td>16.7</td>
<td>--</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>2.1</td>
<td>1.5</td>
<td>5.5</td>
<td>8.4</td>
<td>7.9</td>
<td>6.7</td>
<td>--</td>
</tr>
</tbody>
</table>

*Totals calculated by grades reported for first child, 3 respondents not included due to lack of grade information provided. **Estes Hills sums to 128 due to 1 child in grade 7 reported.

Figure 1 shows a comparison of the distribution of useful questionnaires by grade with the actual distribution of students in the Chapel Hill-Carrboro school district. The figure suggests that these data may be reasonably representative of the current student distribution. The kindergarten grade is under-represented slightly by the respondent group, and the upper grades, 3-5, are slightly over-represented, but the distributions are similar overall. Although the respondent group approximates the distributions of students overall, the sample group is not random because the responses are self-reported; self-selection bias may therefore exist.
2.1. Questionnaire Description

The questionnaire was divided into sixteen sections and was printed on both sides of a single page; it is included in Appendix A. The questionnaire was distributed as the second of a two-page document which included a cover letter and a map showing the three elementary schools with their respective walkzones and nearby roads.

The first section of the survey was labeled and coded as Section '0'; the coding form is presented in Appendix B. Section 0 was used to determine walkzone status for responding households. Section 1 asks the parent to name the school that their children attend as well as the sex and grade level for up to four children.

Section 2 asked parents to use the map to determine the approximate distance from their home to the school; Section 3 asked for the street name. Section 4 requested information about how their children usually travel to and from school. This section was divided into two grids, one for traveling 'to school in the morning' and about the other
for traveling 'from school in the afternoon'. Appendix B shows details of the coding scheme used for the travel modes in Section 4.

Sections 5 and 6 asked 'yes' or 'no' questions regarding the existence of a protective environment for bike storage and if the parents had concerns about traffic safety along their child’s route to school. Room was available in Section 7 for parents to comment about these concerns.

Section 8 was divided into four sub-sections to explore parents’ reasons as to why they might drive their child to and/or from school. Sub-sections A, C and D were similarly formatted, with a single heading (e.g., Safety) and four to eight reasons why the parent drove their child to and/or from school. Sub-section B asked parents to rank six improvements that would 'bring a greater sense of safety' if their child were to walk or bike to school.

Section 9 provided respondents with a list of eight circumstances under which they might allow their child to walk or bike to school. Parents were instructed to select as many factors as they felt applied. Sections 10 and 11 asked if respondents were willing to help 'Go! Chapel Hill' establish and maintain a walk-to-school program and/or a bike-to-school program. Section 13, the final section of the questionnaire, asked if the respondents had any 'comments or suggestions' regarding the 'Healthy Routes to School initiative'.

3. Transportation Mode Choices of Respondents

3.1 Walkzones

Of the 320 households represented in the final analysis, 137 were located within the designated Chapel Hill walkzone. A walkzone is a region within a 1.5 mile walking
distance of a school as delineated by the local education agency. Because the walkzone is an area where students are expected to walk to school, these households are legally ineligible for school bus service. Therefore, the walkzone defines transportation mode choice by way of exclusion for students.

The average distance from school reported in the survey was 1.41 miles. About half of the households in the survey were located within one mile of the school their children attended. Figure 2 shows the cumulative distribution of households by distance. Slightly more than 60% are within 1.5 miles of school, and more than one-fourth of the respondents' households are more than two miles from the school.

![Graph showing distribution of households by distance](image)

Figure 2. Distribution of Households by Distance
3.2 Reasons behind main mode choices

Transportation mode choice was divided into two categories, main mode and all modes. For this analysis, the main mode was the most useful as it represented the most common transportation choice of the students. Although 32% of the respondents listed two children enrolled in the designated elementary school and 4% had three or more children, the data were compiled for the transportation habits of only Child #1 from the 320 respondents. The transportation habits of the oldest child were assumed to dictate those of the younger siblings, and choosing the oldest sibling would facilitate the most effective data analysis.

Table 3 describes the main mode split for child #1 in the morning and afternoon. Mode split is defined as the proportion of total trips using various modes of transportation (Atlanta Regional Commission, 2004). The data show that bus ridership is greater in the afternoon, with a corresponding decrease in the percentage of children driven home from school in the afternoon, as well as slight increase in walking and 'other' modes. More importantly, Table 3 shows that the largest proportion of students arrive at school in the morning via automobile and depart in the afternoon by various other modes, as evidenced by the increase in afternoon bus ridership. This analysis will focus on main travel modes in the morning.

Table 3. Main Mode Choice for Child One*

<table>
<thead>
<tr>
<th>Mode</th>
<th>Morning, %</th>
<th>Afternoon, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>47</td>
<td>31</td>
</tr>
<tr>
<td>Bus</td>
<td>24</td>
<td>35</td>
</tr>
<tr>
<td>Walk/Bike</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

*Table entries are % of total responses
In the remainder of this section, students were divided into two groups according to those who **always** walk or bike as their main mode, and those who **never** walk or bike. Table 9 shows the percentage of students who **always** and **never** walk or bike by one-way distance. Approximately 95% of students living more than 1.0 mile from school never walk or bike. Only 2% of students living more than 1.0 mile from school always walk or bike. A majority of students who live within 0.5 mile always walk or bike. Nearly 1 in 5 students who live between 0.5 and 1.0 mile always walk or bike. Clearly, Table 9 shows a strong relationship between distance and mode choice.

Table 9. Never & Always Walk or Bike by Distance

<table>
<thead>
<tr>
<th>Distance</th>
<th>% Never Walk/Bike</th>
<th>% Always Walk/Bike</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.25 mile</td>
<td>22</td>
<td>68</td>
</tr>
<tr>
<td>0.25 - 0.50 mile</td>
<td>33</td>
<td>50</td>
</tr>
<tr>
<td>0.50 - 1.00 mile</td>
<td>65</td>
<td>19</td>
</tr>
<tr>
<td>1.00 - 1.50 mile</td>
<td>97</td>
<td>0</td>
</tr>
<tr>
<td>1.50 - 2.00 mile</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>More than 2.00 mile</td>
<td>98</td>
<td>2</td>
</tr>
</tbody>
</table>

The distribution by grade of students who always and never walk or bike to school is presented in Table 10. The percentages for children who never walk or bike are consistently high for all grades with an average of 73%. On an average, only 19.5% of the children always walk or ride; this rate is slightly lower for kindergarteners yet higher for children in first and second grades. The proportion of students who **never** walk or bike is not equal to the proportion of students that do **not** always walk or bike because the **never** group is a subset of the **not always** population who may engage in other modes of transportation.
Table 10. Never & Always Walk or Bike by Grade

<table>
<thead>
<tr>
<th>Grade</th>
<th>% Never Walk/Bike</th>
<th>% Always Walk/Bike</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>76</td>
<td>11</td>
</tr>
<tr>
<td>1</td>
<td>70</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>67</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>74</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>72</td>
<td>20</td>
</tr>
<tr>
<td>Avg.</td>
<td>73.2</td>
<td>19.5</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>4.6</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Parents’ concerns about high speed vehicles are compared in Tables 11a and 11b for students who never walk or bike and students who always walk or bike, respectively.

In Table 11a, 284 of the 320 respondents do not think there are too many high speed vehicles. Of these parents, 70% (199) have children who never walk or bike, thus indicating that high speed traffic is not the impediment of concern. Table 11b shows that only 1 of the 65 parents with children who always walk or bike had concerns about high speed vehicles.

Table 11a. Concern about High Speed Vehicles: Never Walk or Bike

<table>
<thead>
<tr>
<th>Too Many High-Speed Vehicles?</th>
<th>Never Walk or Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>199</td>
<td>284</td>
</tr>
<tr>
<td>Yes</td>
<td>31</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>230</td>
<td>320</td>
</tr>
</tbody>
</table>

Table 11b. Concern about High-Speed Vehicles: Always Walk or Bike

<table>
<thead>
<tr>
<th>Too Many High-Speed Vehicles?</th>
<th>Always Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>64</td>
<td>284</td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>320</td>
</tr>
</tbody>
</table>
Parents’ perceptions of a lack of sidewalks along their child’s route to school are compared by mode groups in Tables 12a and 12b. Ironically, parents of children who *never* walk or bike were three times more likely to perceive their sidewalks as adequate. However, of the 49 parents who thought that sidewalks were inadequate, 40 (82%) had children who *never* walked or biked.

**Table 12a. Perceived Lack of Sidewalks: Never Walk or Bike**

<table>
<thead>
<tr>
<th>Sidewalks Inadequate or Do Not Exist?</th>
<th>Never Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate</td>
<td>190</td>
<td>271</td>
</tr>
<tr>
<td>Inadequate</td>
<td>40</td>
<td>49</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>230</strong></td>
<td><strong>320</strong></td>
</tr>
</tbody>
</table>

**Table 12b. Perceived Lack of Sidewalks: Always Walk or Bike**

<table>
<thead>
<tr>
<th>Sidewalks Inadequate or Do Not Exist?</th>
<th>Always Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate</td>
<td>61</td>
<td>271</td>
</tr>
<tr>
<td>Inadequate</td>
<td>4</td>
<td>49</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>65</strong></td>
<td><strong>320</strong></td>
</tr>
</tbody>
</table>

The distribution of parents who drive their child to school enroute to work for convenience is presented by mode group in Tables 13a and 13b. The tables show that these parents were more likely to have children who never walk or bike. The proportion of parents that drop their child off on the way to work was 78% for children who never walk or bike. For children who always walk or bike, the proportion was much smaller, at 10%.
Table 13a. Drop Off Child on the Way to Work for Convenience: Never Walk or Bike

<table>
<thead>
<tr>
<th>Drop Off on the Way to Work for Convenience</th>
<th>Never Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>164</td>
<td>235</td>
</tr>
<tr>
<td>Yes</td>
<td>66</td>
<td>85</td>
</tr>
<tr>
<td>Total</td>
<td>230</td>
<td>320</td>
</tr>
</tbody>
</table>

Table 13b. Drop Off Child on the Way to Work for Convenience: Always Walk or Bike

<table>
<thead>
<tr>
<th>Drop Off on the Way to Work for Convenience</th>
<th>Always Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>56</td>
<td>235</td>
</tr>
<tr>
<td>Yes</td>
<td>9</td>
<td>85</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>320</td>
</tr>
</tbody>
</table>

The proportion of parents that drive their child to school to prevent tardiness as compared by mode group is presented in Tables 14a and 14b. These tables show that of the 64 parents who drive their child to prevent tardiness, 78% had children who never walk or bike. Of the children who always walk or bike, 11% (7 of 64) are driven to prevent tardiness.

Table 14a. Drop Off So the Child is Not Late: Never Walk or Bike

<table>
<thead>
<tr>
<th>Drop Off so Child is Not Late</th>
<th>Never Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>180</td>
<td>256</td>
</tr>
<tr>
<td>Yes</td>
<td>50</td>
<td>64</td>
</tr>
<tr>
<td>Total</td>
<td>230</td>
<td>320</td>
</tr>
</tbody>
</table>

Table 14b. Drop Off So the Child is Not Late: Always Walk or Bike

<table>
<thead>
<tr>
<th>Drop Off so child is Not Late</th>
<th>Always Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>58</td>
<td>256</td>
</tr>
<tr>
<td>Yes</td>
<td>7</td>
<td>64</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>320</td>
</tr>
</tbody>
</table>
The distribution of parents who thought the child’s age was an important factor in transportation mode is presented in Tables 15a and 15b. The proportion of parents who said their child is too young to walk or bike is twice as high for children who never walk or bike to school as it is for children who always walk or bike to school. Of the 68 children who were judged by their parents to be too young to walk or bike, 57 (84%) never walked or biked to school.

Table 15a. My Child is Too Young to Walk or Bike to School: Never Walk or Bike

<table>
<thead>
<tr>
<th>Too Young to Walk/Bike to School</th>
<th>Never Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>173</td>
<td>252</td>
</tr>
<tr>
<td>Yes</td>
<td>57</td>
<td>68</td>
</tr>
<tr>
<td>Total</td>
<td>230</td>
<td>320</td>
</tr>
</tbody>
</table>

Table 15a. My Child is Too Young to Walk or Bike to School: Always Walk or Bike

<table>
<thead>
<tr>
<th>Too Young to Walk/Bike to School</th>
<th>Always Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>57</td>
<td>252</td>
</tr>
<tr>
<td>Yes</td>
<td>8</td>
<td>68</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>320</td>
</tr>
</tbody>
</table>

The distributions of parents who believed distance was an important factor in deciding their child’s transportation mode are presented in Tables 16a and 16b. The proportion of parents who reported that it was too far for their child to walk or bike to school was much greater for children who never walked or biked to school than for children who always walked or biked. Of the 97 children whose parents said they were too young to walk or bike to school, 93 (96%) never walked or biked to school.
Table 16a. Too Far for My Child to Walk or Bike to School: Never Walk or Bike

<table>
<thead>
<tr>
<th>Too Far to Walk/Bike to School</th>
<th>Never Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>137</td>
<td>223</td>
</tr>
<tr>
<td>Yes</td>
<td>93</td>
<td>97</td>
</tr>
<tr>
<td>Total</td>
<td>230</td>
<td>320</td>
</tr>
</tbody>
</table>

Table 16b. Too Far for My Child to Walk or Bike to School: Always Walk or Bike

<table>
<thead>
<tr>
<th>Too Far to Walk/Bike to School</th>
<th>Always Walk/Bike</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>62</td>
<td>223</td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>97</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>320</td>
</tr>
</tbody>
</table>

4. Determinants of Travel Modes in Chapel Hill

In Section 4 of the questionnaire parents were asked to indicate all the travel modes used by each of their elementary school-age children in getting to (morning) and from (afternoon) school each day as well as the frequency of each mode. Unfortunately, these questions were not well designed and implicit instructions were not given. Because the categories in these questions overlapped, the risk for unclear equivocal answers further increases. For example, categories for reporting the frequency of the transportation mode included options of ‘every day’, ‘2-3 times weekly’, ‘once a week’, or ‘occasionally.’ All choices are vague and caused some respondents to check multiple boxes when only one answer was expected. Hence, interpreting these data posed some problems.

Despite the vagueness in some responses, two answers had no potential for overlap and were clear. These responses were: those children who never walked or biked to school and those who always walked or biked. Thus it was decided to fit two different statistical models to the questionnaire data; one model aimed to explain why
some children *always* walked or biked and the other to explain why some children *never* walked or biked. These models are referred to in this report as the *Always* and *Never* models.

Both models were logistic (or logit) in which the dependent variable (Y) was assigned the value 1 if the child always (never) walked or biked and zero for other situations. Logit analysis converts the 0,1 values of the dependent variable to a probability (p) which is a continuous variable that takes values in the range 0-1. In this section, \( p_a = \) probability that a child always walks or bikes to school, and \( p_n = \) probability that a child never walks or bikes to school. A complicating issue for some respondents was the use of one travel mode going to school in the morning and a different mode returning home in the afternoon. Hence, it was decided to focus only on morning answers because more children walked or biked in the morning than in the afternoon. Another complicating issue was that some parents had more than one child in the same school, and in a few cases children from the same family used different travel modes. Thus it was decided to focus only on Child #1, which covered the vast majority of cases. Hence, the models reported in this section are only for the travel modes used by Child #1 in the morning; the extent to which these models represent 2nd and 3rd children in the same family and afternoon as well as morning travel is discussed below.

The logit models of this research have the form shown in eq 1, where \( i = a \) for *Always* and \( n \) for *Never*

\[
pi = \frac{\exp(\sum \beta ij Xij)}{1 + \exp(\sum \beta ij Xij)}
\]

In eq 1, \( Xij \) is the jth explanatory variable in the model that is hypothesized to explain or ‘determine’ the dependent probability variable, and \( \beta ij \) is its coefficient that is estimated
by fitting the model to the values of the explanatory variables using regression analysis.

In this research, the statistical package STATA was used for fitting the logit models to the data.

The probability of students who could never be expected to walk or bike to school was initially assumed to depend on seven explanatory variables, as shown in Table 17; this model with a full complement of explanatory variables was called the Full-Never Model.

Table 17. Full-Never Model

<table>
<thead>
<tr>
<th>Question</th>
<th>Variable</th>
<th>Description of variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>X1</td>
<td>distance from the school in miles, a categorical variable</td>
</tr>
<tr>
<td>8A2</td>
<td>X2</td>
<td>=1 if too many high speed vehicles</td>
</tr>
<tr>
<td>8A3</td>
<td>X3</td>
<td>=1 if sidewalks are inadequate or do not exist</td>
</tr>
<tr>
<td>8C1</td>
<td>X4</td>
<td>=1 if I drop my child off on the way to work</td>
</tr>
<tr>
<td>8C4</td>
<td>X5</td>
<td>=1 if I don’t want my child late for school</td>
</tr>
<tr>
<td>8D1</td>
<td>X6</td>
<td>=1 if my child is too young to walk/bike to school</td>
</tr>
<tr>
<td>8D6</td>
<td>X7</td>
<td>=1 if the weather is bad</td>
</tr>
</tbody>
</table>

X1, the response to question 2, was the distance to school in miles. Strictly speaking, X1 is a categorical variable that takes values in certain categories (0.25 mile or less, 0.25-0.5 mile, 0.5-1.0 mile, 1.0-1.5 mile, 1.5-2.0 mile, over 2.0 mile). For modeling purposes, the categories were changed to discrete values to make distance a continuous variable. The upper limit of each range was used as the continuous value, except in the case of students who lived more than 2.0 mile from school, in which case an arbitrary value of 2.5 was used, in keeping with the 0.5 mile increments in the 3 previous categories. All of the other explanatory variables in Table 1 (X2, ..., X7) were binary variables restricted to values of 0 or 1. X2, the response to question 8A2, was assigned 1 if the parent thought there were too many high-speed vehicles on the road; X3 = 1 if sidewalks are inadequate; etc., as explained in Table 17.
The Full-Never model is shown in Table 18. Table 18 reveals that two variables, X2 and X3, are unmarked and hence are not significant and can be eliminated from the model. It is important, however, to discuss them because they seemed to be plausible explanatory variables. X2 concerns vehicles on the roads that move too fast; respondents said that this factor does not account for their children never walking or biking to school. The implication for policy seems important: installing traffic bumps, or lowering speed limits, or taking similar measures aimed at slowing traffic probably would not reduce the probability of students never walking or biking. The other insignificant variable is X3, sidewalks. Like X2, parents said that poor or lacking sidewalks are not the reason why children never walk or bike, so by implication, fixing or installing sidewalks cannot be expected to reduce the probability of never walking or biking.

Table 18. Logit Fit of Full-Never Model

| Variable | Coefficient (β) | Std. Error | Z     | P>|z| |
|----------|-----------------|------------|-------|------|
| X1       | 2.605           | 0.452      | 5.76  | 0.000*** |
| X2       | 0.088           | 0.722      | 0.12  | 0.903 |
| X3       | -0.009          | 0.601      | -0.02 | 0.987 |
| X4       | 0.671           | 0.404      | 1.66  | 0.096* |
| X5       | 1.054           | 0.457      | 2.31  | 0.021** |
| X6       | 0.836           | 0.466      | 1.80  | 0.072* |
| X7       | -0.830          | 0.442      | -1.88 | 0.060* |
| constant | -2.506          | 1.193      | -2.10 | 0.036** |

* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Once the insignificant variables were identified, the model was re-estimated without them; the results for what we call the Reduced-Never model are reported in Table 19, where all the explanatory variables are seen to be statistically significant. Moreover, the values of the coefficients in Table 19 are not much different from those in Table 18.
Table 19. Logit Fit of Reduced-Never Model

| Variable | Mean | Coefficient (β) | Std. Error | Z    | P>|z| |
|----------|------|-----------------|------------|------|-----|
| X1       | 1.41 | 2.951           | 0.369      | 8.00 | 0.000*** |
| X4       | 0.27 | 0.675           | 0.404      | 1.67 | 0.095*  |
| X5       | 0.2  | 1.027           | 0.450      | 2.28 | 0.023** |
| X6       | 0.21 | 1.062           | 0.434      | 2.45 | 0.014** |
| X7       | 0.19 | -0.819          | 0.436      | -1.88| 0.060*  |
| constant | 1.00 | -2.627          | 0.410      | -6.40| 0.000***|

* significant at 10% level; ** significant at 5% level; *** significant at 1% level

All the coefficients in Table 19 have expected signs except X7. For example, the positive coefficient of distance X1 indicates that longer distances have the effect of increasing the probability that the child will never walk or bike, which is logical and expected. The positive coefficient of X4 logically indicates that children dropped off by parents on their way to work have higher probability of never walking or biking, which also applies to X5, parents who don’t want their children to be late for school, and X6, parents who think their child is too young to walk or bike to school. The sign of X7 is counterintuitive; bad weather would be expected to increase the probability of never walking or biking, but the model indicates the reverse. However, this variable is only significant at the 10% level, and is not a strong determinant of the dependent variable. Thus, overall the model seems highly plausible and provides a basis for understanding why some children never walk or bike to school: because of parental concerns about distance, tardiness, young age of the child, or a matter of convenience as parents drop them off on the way to work.

The same seven variables that were hypothesized for the Full-Never model were selected for the Always model. The variables, their regression coefficients, and their statistical significance are presented in Table 20.
Table 20. Logit Fit of Full-Always Model

| Variable | Coefficient ($\beta$) | Std. Error | Z      | P>|z| |
|----------|----------------------|------------|--------|------|
| X1       | -2.871               | 0.493      | -5.83  | 0.000*** |
| X2       | -1.094               | 1.046      | -1.05  | 0.296 |
| X3       | -0.569               | 0.698      | -0.82  | 0.414 |
| X4       | -1.052               | 0.450      | -2.34  | 0.019** |
| X5       | -1.210               | 0.522      | -2.32  | 0.021** |
| X6       | -0.353               | 0.513      | -0.69  | 0.491 |
| X7       | 0.070                | 0.455      | 0.15   | 0.878 |
| constant | 3.842                | 1.169      | 3.29   | 0.001*** |

** **significant at 5%; *** **significant at 1%

Of the seven variables Table 20, four are not significant (X2, X3, X6 and X7) and can therefore be eliminated. Variables X2 and X3 both represent concerns about traffic, X6 represents individual concerns, and X7 is an environmental factor affected by parental perceptions. The difference in the significant variables between the two models illustrates some of the differences that exist between children who always walk or bike and those who never walk or bike.

Once the insignificant variables were identified, the model was re-estimated; the Reduced-Always model is in Table 21. All of the explanatory variables are statistically significant at the 1% or 5% level, and the coefficient values do not differ much from their values in the full model. All of the coefficients in the final model except for the constant term are negative, which is expected. The model predicts the rate of always walking or biking to school, thus model coefficients would be expected to have signs opposite of those in the Reduced-Never model. Overall the model seems highly plausible.
Table 21. Logit Fit of Reduced-Always Model

| Variable | Mean | Coefficient (β) | Std. Error | Z    | P>|z| |
|----------|------|-----------------|------------|------|-----|
| X1       | 1.41 | -2.788          | 0.400      | -6.98| 0.000*** |
| X4       | 0.27 | -1.119          | 0.456      | -2.45| 0.014**  |
| X5       | 0.2  | -1.350          | 0.502      | -2.69| 0.007*** |
| constant | 1.00 | 1.985           | 0.383      | 5.18 | 0.000*** |

** significant at 5%; *** significant at 1%

Figure 3 shows the predicted probabilities of walking and biking for the Always and Never groups using the logit models in Tables 21 and 19, respectively, while holding all explanatory variables except distance at their average values. As distance increases, the probability of children never walking or biking increases until it reaches a maximum at 2.6 miles. Conversely, the probability of children always walking or biking decreases with distance until it reaches a zero probability at 2.6 miles.

![Figure 3. Predicted Probabilities of Always and Never Walking or Biking by Distance](image-url)

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5. Policy Analysis and Conclusions

1. As of November 15, 2006, the Chapel Hill-Carrboro elementary school system has 4,999 enrolled children; for analysis purposes this number rounded to 5,000. As a means for analyzing district-wide policies aimed at increasing walking and biking to school, we can apply the results of the survey to the population of enrolled students in the Chapel Hill-Carrboro City Schools district. Although the results of the survey are not representative of the district population, the conclusions from the survey can serve to inform potential policies aimed at increasing walking and biking to school.

2. Figure 2 shows that about half (2,500) children live within one mile of school, and all (100%) of the children who routinely walk or bike to school live within one mile. Therefore the prime candidates for walking or biking will be assumed to be drawn from this pool of about 2,500 children who live within one mile of school. Although the prospects of getting children who live farther than one mile to walk or bike do not seem strong, these children should not be entirely dismissed as candidates for walking or biking.

3. At present, about 18% of the children represented by the survey routinely walk and about 3% routinely bike to school (from Table 3); the percentages are about the same in both morning and afternoon. Hence, we can estimate that about 1,050 children (or 21% of 5,000) routinely walk or bike both ways.

4. With a candidate pool of 2,500 children, of whom 1,050 actually walk or bike (about 40%), the difference, i.e. 1,450 children, constitute the group that could be targeted to change their present transport modes to include walking or biking at least some of the time. This number represents a substantial number of children, which implies a campaign should be launched to educate the roughly 2,000 households who live within
a mile of their school about the benefits of walking or biking and to try to facilitate walking/biking using all the means suggested by the data from this study.

One such means identified by the study data was a walking school bus. Parents that responded to questions regarding safety improvements and circumstances under which they would allow their children to walk or bike to school seemed to favor a walking school bus. Of the parents who selected safety improvements, 27% said that a walking school bus would improve the safety of their child if s/he was to walk or bike to school. Of the parents who responded with circumstances under which their child would walk or bike to school, 29% said that they would allow their child to walk or bike if they were accompanied by a parent, and 13% said they would allow their child to walk or bike if they were accompanied by other children. Although the percentages are not a majority, there seems to be parent support for a walking school bus or similar program, which might allow more children to walk or bike to school. Additionally, if the walking school bus were to meet at a specified point on a regular basis, children who live further than one mile from school may be able to walk to school with a large group, on a pre-selected path, under adult supervision.

5. In addition to identifying children that walk or bike to school, we can make some calculations regarding the number of children that are driven to school. These numbers are a little less optimistic. Table 3 indicates that 47% of the children are driven to school in the morning and 31% are driven home in the afternoon; these percentages translate to 2,350 children in the morning and 1,550 in the afternoon. Thus, about 800 children (i.e., 2,350 less 1,550) who are driven in the morning find an alternative way to get home in the afternoon.
6. Because the number of walkers and bikers in morning and afternoon is about the same, the 800 children who are driven in the morning but use alternative modes in the afternoon are probably not switching to walking or biking. These 800 children may be candidates for walking or biking home in the afternoon, assuming that parents who drop their child off in the morning would not be willing to change their morning habits.

7. Conducting an educational program strictly targeted at this relatively small group of children may not be reasonable. About one-third of the children who are driven to school in the morning and choose another mode in the afternoon live within one mile of their school. This fraction translates to about 250 viable candidates for walking home in the afternoon given that these children were driven in the morning and assuming a 100% successful educational program.

8. Looking at these numbers, it should not be taken for granted that parents who drive their children to school in the morning are not going to change their behavior. Little would be served by trying to convince the parents who are drivers that it is okay to drive in the morning, but to consider the possibility of letting their children walk home in the afternoon. Rather, it would seem much more useful to aim at changing the practice of all parents who drive their children. After all, more than 2,000 children being driven to school (40%) is a sizeable number, and this pool should be targeted for education about the benefits of regular physical activity, especially those drivers who live within a mile of school.

9. Given the analysis in the preceding paragraphs, we can use the results of the logistic regression model with the independent variables set at their mean values to estimate the potential effectiveness of educational programs on rates of walking and biking. Let us begin by using the model for Always walking or biking, whose regression coefficients
and mean values of the explanatory variables are shown in Table 21. For this estimation, we will only focus on children living within one mile of school. From Figure 2, 12% (600 children) live within 0.25 mile, 15% (750 children) live between 0.25-0.50 mile, and 25% (1,250 children) live between 0.50-1.00 mile. Thus, 2,600 children (a little higher than the estimate in paragraph 2 above) live within a mile of school. Using the Always model with mean values for all the variables except distance, the probability is 0.67 that a child will always walk/bike if s/he lives within 0.25 mile. Hence, with 600 children living within that distance, the model predicts that 402 of them (0.67*600) will always walk or bike. The probability for children living 0.25-0.50 mile is 0.50, which implies that 375 of them always walk or bike, and the probability for children between 0.5 and 1.0 mile is 0.20, which implies that 250 of them always walk or bike. Thus, the model predicts that 1,027 children (= 402+375+250) always walk or bike, which is very close to the result in paragraph 3 above.

10. Now suppose that instead of setting X4 (the variable that denotes whether a child is dropped off at school on their parents’ way to work) at its mean value, it is set to zero; this change implies that no one living within a mile of school ever drives her children to school. In this case, the model predicts that 1,186 children would always walk or bike. Hence, if all parents living within a mile could be convinced not to drive their children, the number of children who would always walk or bike would increase by about 160, a 15% increase. This increase represents an upper bound because all parents will not stop driving, but nevertheless the effort to change driving practices definitely seems worthwhile.

11. The opposite hand of this analysis is to use the Never model to make similar predictions. Figure 3 shows that the probability that a child never walks or bikes
increases as the distance to school increases. If we make an analysis similar to the one in paragraph 9 above in which the explanatory variables are set at their mean values, it is estimated that 1,224 children living within one mile of school never walk or bike under present circumstances. Thus, with a total of 2,600 children living within one mile, 1,027 of whom always walk or bike and 1,224 of whom never walk or bike, the model predicts that about 350 children (= 2,600 - 1,027 - 1,224) sometimes walk or bike.

12. Now let us assume that the drivers of children living within a mile could be convinced not to drop their children off on the way to work; i.e. we set variable X4 equal to zero. In this case, the number of children living within a mile of school who would never walk or bike would decrease from 1,224 to 1,120, or about 100 children. Thus, the number of children who might sometime walk or bike could be expected to increase from about 350 to 450 if the only policy intervention were to completely change parents from dropping their child off on the way to work to not driving their child.

13. Recall that the Never model includes several explanatory variables. Instead of focusing only on changing the behavior of parents who drop their child off on the way to work, let us assume that parents are also convinced that they should not be overly concerned about getting their children to school on time (X5). Clearly this intent would be a hard sell to the parents, but our purpose here is to predict what the payoff might be if such a convincing case could be made and whether as a matter of policy it is worthwhile to try. Thus we set both X4 and X5 to zero, which predicts that the number of children who would never walk or bike would further decrease to 1,022, i.e. by an additional 100 children. It follows that the pool of children who might sometime walk or bike could be increased from 350 (by doing nothing) to about 550 if parents could be convinced to stop dropping their child off on the way to work and stop worrying about getting them to
school on time. Furthermore, these results are only for households within a mile of school and could be higher if all households in the school district were targeted for these interventions.

14. It seems reasonably clear from this analysis that structural interventions such as speed bumps and improved sidewalks will have little impact on increasing the number of children who walk and bike to school. Rather, the kinds of interventions suggested by these data are more in the nature of educational campaigns such as convincing parents not to drop their children off on the way to work and to change household practices to ensure that children arrive to school on time. Furthermore, it seems that little will be served by focusing unduly on households located more than about one mile away from school. Not only does this analysis identify which interventions seem to be most important (or unimportant), but it also enables quantification of rough upper and lower bounds on the payoffs from those interventions.

Given a successful educational intervention that could convince parents who live within one mile not to drop their child off on the way to work and alleviate their fears of their child being late, more than 350 additional students would walk or bike to school at least sometimes during the week. It should be noted that an educational program would more than likely educate parents on additional issues pertaining to walking and biking to school, and therefore may reach parents who are not in our target population. If the educational component of the program is structured in a way that it covers a broad array of transportation-related topics, then parents who drive their child to school may be more aware of children who walk and bicycle, improving pedestrian safety conditions. Additionally, the program may create a broader dialogue among parents and school staff regarding transportation to and within the vicinity of schools. Increasing the number of
parents that are educated about the health benefits of walking and biking, as well as the safety and environmental factors that affect pedestrian modes of transportation, will improve the quality and accessibility of the pedestrian transportation system in and around schools.

15. Examples of educational programs exist, with a prominent example being the Marin County Safe Routes to School demonstration project. Marin County’s Safe Routes to School program was one of the first in the United States, and in 2000 Marin County was chosen to develop a national model program for Safe Routes to School. The project coordinators used the pilot project to develop an educational program for local schools that included education in the classroom, contests, mapping, and community involvement. After the program was implemented, a 57% increase in walking and biking and a 29% decrease in the number of children driven to school were recorded.

In Arlington, MA, a similar program was initiated that included efforts at education and promotion of walking and biking to school. The program was directed at students and parents from two elementary schools; organizers targeted parents by sharing project plans and successes with them, as well as educational information. A year after the program began, walking to school increased from 19% to 24%, and evaluation showed that 150 students were walking and biking to school that previously had not.

16. If the educational programs and matters of convenience can be addressed, perhaps the number of children that walk or bike to school can be further increased. This study shows the need for educational programs that increase parent understanding of the importance of walking and bicycling to school. Many strategies have been employed to inform parents about the health benefits of their children walking and biking to school. The most effective educational programs are multifaceted, including informational,
promotional and hands-on activities that involve parents and their children. The Pedestrian and Bicycle Information Center (PBIC), in their Safe Routes to School Guide, recommend print materials, web sites, and emails targeted at educating parents about environments and communities that are conducive to walking and bicycling. The PBIC also recommends conducting programs at the schools, including traffic safety days and training classes for parents on Safe Routes to School. Partnering with local media to produce stories on walking and biking to school may also be useful in raising awareness and fostering dialogue between parents, children, school staff and individuals promoting biking and walking in the schools.

Education is a sustainable solution for the problem of decreased walking and biking to school. The results of this analysis show that educational efforts should be aimed at parents and their perceptions of walking and biking. The relative importance of factors such as the convenience of driving their child to school or dropping their child off due to concerns about being late should be primary foci of an educational program. Costs of convenience should be compared to the long-term health benefits for their child, improved environmental quality, improved pedestrian safety, and a decrease in traffic congestion that are direct results of increased pedestrian and bicycle traffic. Educational programs that continue to inform children and parents about the benefits of walking and biking to school will ensure a supportive environment for safe walking and bicycling to school for future students and a healthier student population.
Resources Cited:


(4) Active Living by Design. Active Living by Design Primer. 2007.


(10) Thomas GS. The United States of Suburbia: How the Suburbs Took Control of America and What They Plan to Do with It. Amherst, New York: Prometheus Books; 1998.


See attached walk zone map to determine the following:

- We are in school walk zone
- We are NOT in school walk zone

Please return this survey to your child’s teacher by December 2nd. Thank you!

1. Please use the following to describe your children who attend __________ Elementary School:

| Child #1 | boy | girl | grade |  | Child #2 | boy | girl | grade |
|----------|-----|------|-------|  |----------|-----|------|-------|
|          |     |      |       |  |          |     |      |       |

2. Please use the attached map to indicate (approximately) the distance from your home to the school:

- □ 1/4 mile or less
- □ 1/4 to 1/2 mile
- □ 1/2 to 1 mile
- □ 1 to 1 1/2 miles
- □ 1 1/2 to 2 miles
- □ over 2 miles

3. What is the name of the street on which you live?

4. Please indicate below how your child usually travels to and from school:

**TO SCHOOL IN THE MORNING**

| CHILD | #1 | #2 | #3 | #4 |  | #1 | #2 | #3 | #4 |  | #1 | #2 | #3 | #4 |  | #1 | #2 | #3 | #4 |
|-------|----|----|----|----|  |----|----|----|----|  |----|----|----|----|  |----|----|----|----|
| walk  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |
| bike  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |
| driven|    |    |    |    |  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |
| carpool|   |    |    |    |  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |
| school bus | | | | |  | | | | | | | | | | | | | | |
| other |    |    |    |    |  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |

**FROM SCHOOL IN THE AFTERNOON**

| CHILD | #1 | #2 | #3 | #4 |  | #1 | #2 | #3 | #4 |  | #1 | #2 | #3 | #4 |  | #1 | #2 | #3 | #4 |
|-------|----|----|----|----|  |----|----|----|----|  |----|----|----|----|  |----|----|----|----|
| walk  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |
| bike  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |
| driven|    |    |    |    |  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |
| carpool|   |    |    |    |  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |
| school bus | | | | |  | | | | | | | | | | | | | | |
| other |    |    |    |    |  |    |    |    |    |  |    |    |    |    |  |    |    |    |    |

5. □ yes □ no Does the school provide a safe place to store bikes?

6. □ yes □ no Do you have concerns regarding traffic safety along the routes to school?

7. Please describe your concerns regarding traffic safety by indicating specific streets and/or intersections that are problematic.
8. If you drive your child to and/or from school, why do you make that choice? Please mark all that apply:

**SAFETY**

- [ ] my child would not obey safety rules
- [ ] there are too many high-speed vehicles
- [ ] the sidewalks are inadequate and/or do not exist
- [ ] the bike paths are incomplete or not wide enough
- [ ] there is no safe place for my child to cross the street
- [ ] there are "scary people" along the way to/from school
- [ ] there are unfriendly dogs along the way to/from school
- [ ] other __________________________

**SENSE OF SAFETY** – Please rank in order of importance the following that would bring a greater sense of safety if your child were to walk/bike to school.

1. Crosswalks
2. Bike lanes
3. Pedestrian Signals
4. Sidewalks
5. Flashing Signal Lights
6. Walking School Bus - An adult led student group walking together to school.

**CONVENIENCE**

- [ ] I drop my child off on my way to work
- [ ] my child is carrying a backpack that is too heavy
- [ ] my child is carrying a project or a musical instrument
- [ ] so that my child will not be late for school
- [ ] other __________________________

**OTHER**

- [ ] my child is too young to walk/bike to school
- [ ] my child is too young to ride the bus to school
- [ ] it is too far for my child to walk/bike to school
- [ ] other __________________________

9. Would you allow your child to walk or bike to and/or from school under any of the following circumstances? Please mark all that apply:

- [ ] he/she was accompanied by other children
- [ ] he/she was accompanied by other parents
- [ ] he/she was provided with safety training
- [ ] there were more and/or better sidewalks
- [ ] the bus ride is too long for my child
- [ ] there is no secure place to store his/her bike
- [ ] the weather is bad
- [ ] there were more and/or better bike paths
- [ ] there was a secure place to store his/her bike
- [ ] the crossing guards were more effective
- [ ] the cars slowed down

10. [ ] yes [ ] no Are you willing to help us establish and maintain a walk-to-school program?

11. [ ] yes [ ] no Are you willing to help us establish and maintain a bike-to-school program?

If you answered “yes” to either or both of the above questions, please complete the following:

My name is: ________________________________ My telephone number is: ________________________________

My email address is: ________________________________

13. Do you have comments, questions, and/or suggestions regarding our Healthy Routes to School initiative?

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________
Question 0

See attached walk zone map to determine the following:

1 [ ] We are in school walk zone

0 [ ] We are NOT in school walk zone

Please return this survey to your child’s teacher by December 2nd. Thank you!

1. Please use the following to describe your children who attend Elementary School:

   [ ] Child #1 [ ] boy [ ] girl [ ] grade
   [ ] Child #2 [ ] boy [ ] girl [ ] grade
   [ ] Child #3 [ ] boy [ ] girl [ ] grade
   [ ] Child #4 [ ] boy [ ] girl [ ] grade

2. Please use the attached map to indicate (approximately) the distance from your home to the school:

   [ ] 1/4 mile or less [ ] 1/2 to 1 mile [ ] 1 1/2 to 2 miles
   [ ] 1/4 to 1/2 mile [ ] 1 to 1 1/2 miles [ ] over 2 miles

3. What is the name of the street on which you live?

4. Please indicate below how your child usually travels to and from school:

   TO SCHOOL IN THE MORNING
   4A.AM1-4A.AM4 = ALL MODES (all categories) 4B.AM1-4B.AM4 = MAIN MODE (only every day and 2-3 times/wk.)

   CHILD | #1 | #2 | #3 | #4
   --- | --- | --- | --- | ---
   walk | every day | | | 
   bike | | | | 
   driven | | | | 
   carpool | | | | 
   school bus | | | | 
   other | | | | 

   FROM SCHOOL IN THE AFTERNOON
   4A.PM1-4A.PM4 = ALL MODES (all categories) 4B.PM1-4B.PM4 = MAIN MODE (only every day and 2-3 times/wk.)

   CHILD | #1 | #2 | #3 | #4
   --- | --- | --- | --- | ---
   walk | every day | | | 
   bike | | | | 
   driven | | | | 
   carpool | | | | 
   school bus | | | | 
   other | | | | 

5. [ ] Y = 1 [ ] N = 0 No response = Blank Does the school provide a safe place to store bikes?

6. [ ] Y = 1 [ ] N = 0 No Response = Blank Do you have concerns regarding traffic safety along the routes to school?

7. Please describe your concerns regarding traffic safety by indicating specific streets and/or intersections that are problematic.

   1 = Wrote Something 0 = Wrote Nothing
If you drive your child to and/or from school, why do you make that choice? Please mark all that apply:

SAFETY

☐ SA1 my child would not obey safety rules
☐ SA2 there are too many high-speed vehicles
☐ SA3 the sidewalks are inadequate and/or do not exist
☐ SA4 the bike paths are incomplete or not wide enough
☐ SA5 there is no safe place for my child to cross the street
☐ SA6 there are “scary people” along the way to/from school
☐ SA7 there are unfriendly dogs along the way to/from school
☐ SA10 other ________________________________

SB SENSE OF SAFETY – Please rank in order of importance the following that would bring a greater sense of safety if your child were to walk/bike to school.

1 Crosswalks
2 Bike lanes
3 Pedestrian Signals
4 Sidewalks
5 Flashing Signal Lights
6 Walking School Bus - An adult led student group walking together to school

SC CONVENIENCE

☐ SC1 I drop my child off on my way to work
☐ SC2 my child is carrying a backpack that is too heavy
☐ SC3 my child is carrying a project or a musical instrument
☐ SC4 so that my child will not be late for school
☐ SC10 other ________________________________

SD OTHER

☐ SD1 my child is too young to walk/bike to school
☐ SD2 my child is too young to ride the bus to school
☐ SD3 it is too far for my child to walk/bike to school
☐ other ________________________________

Would you allow your child to walk or bike to and/or from school under any of the following circumstances? Please mark all that apply:

☐ 9.1 he/she was accompanied by other children
☐ 9.2 he/she was accompanied by other parents
☐ 9.3 he/she was provided with safety training
☐ 9.4 there were more and/or better sidewalks
☐ 9.10 other ________________________________

10  ☐ yes ☐ no Are you willing to help us establish and maintain a walk-to-school program?

11  ☐ yes ☐ no Are you willing to help us establish and maintain a bike-to-school program?

11B. C. D. If you answered “yes” to either or both of the above questions, please complete the following: 1=ANSWER, 0=BLANK

11B. My name is: ________________________________

11C. My telephone number is: ________________________________

11D. My email address is: ________________________________

13. Do you have comments, questions, and/or suggestions regarding our Healthy Routes to School initiative?

1= ANSWER, 0 = BLANK