Modeling Students' Walking and Biking Activities to School

-based on the Safe Routes to School Survey in Florida

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Abstract

The students' walking and biking activities were modeled with the data collected before and after the implementation of some SRTS improvements in Florida. Altogether 797 student survey forms and 3,778 parent survey forms were collected.

A linear regression model was established to predict the students' walking/biking rates at school level. Schools with higher percentage of students within ½ mile, higher weighted grade level, higher percentage of male students, and large student family would achieve higher walking/biking rates. A binomial Logit model was also used to estimate the probability of the students' walking and biking activities.

INTRODUCTION

Currently, the majority of parents choose family vehicle and school bus as their children's travel mode to school. Only a very small portion of parents let their children walk or bike to school. Studies showed that as much as 25% of morning rush-hour traffic can be school related as the majority of students choose automobiles as their primary travel mode to school.

The Safe Routes to School (SRTS) program is aimed at encouraging elementary and middle students to walk or bike to school by providing safer and more comfortable routes to students through education, encouragement, engineering and enforcement measures. As part of the Florida SRTS program, a pilot survey was conducted for both students and parents before and after the SRTS education, encouragement, engineering, and enforcement program started. This study is to model the students' walking and biking activities and the SRTS improvements' impact with the data collected from the SRTS survey.

LITERATURE REVIEW

A safe, comfortable and healthy travel mode to school is very important to students and their school life. SRTS is gradually being accepted by schools as a possible alternative to improve students' travel condition to school. There have been quite a few past studies and research on SRTS and factors that affect students' travel mode to school.

Students' travel behavior to school is a complicated socio-economic activity. Previous research indicated that many factors affect students' travel mode to school. The characteristics of the children, parents, the household and its location were considered as factors that affect children's travel mode to/from school[1]. A study at Texas A&M University indicated that travel time, travel cost, income, expense, household type, number of hours in school, gender and ethnicity were important factors in the students' travel mode choice[2]. It was also found that students with shorter walking or biking times to school were found significantly more likely to walk or bike[3]. Urban form is important but not the sole factor that influences school travel mode choice, other factors such as perceptions of neighborhood safety and traffic safety, household transportation options and social/cultural norms may be equally important[4]. The barriers that prevent students from walking to school are distance, traffic, weather, crime and policy, and through the SRTS program, there have been an observable shift from driving to walking or biking on students' travel mode to school[5].

The SRTS program is widely deployed in the United States and also around the world. Besides the health and physical activity benefits associated with the SRTS program, its safety effects is also worthy of examination, but little research has been done on the effects that the SRTS program may have on the pedestrian and bicyclist travel safety of youth. The effect of ten countermeasures most relevant to SRTS on children pedestrian safety was examined and found that most of those benefits are

largely presumed rather than known[6].

METHODOLOGY

Commonly the SRTS improvements, including engineering, education, encouragement, etc, were implemented at school level. This study is to root out those factors significantly associated with the schools' walking/biking rates by investigating the relationship between schools' walking/biking rates and some school-level factors, including demographic factors (such as distribution of distance from home to school, age, gender, etc), social-economic and environmental factors in the school areas, etc. The results could facilitate to deploy the proper SRTS improvements for candidate schools in the future.

A linear regression model was used to predict the students' walking and biking rates at school level. Linear Regression estimates the coefficients of the linear equation that involves one or more independent variables that best predict the value of the dependent variable.

The students' walking and biking activities were also investigated at microscope level. The Binomial Logit model was used to model the student's walking and biking activities. Logit model is used to model a relationship between a dependent variable Y and one or more independent variables X.

DATA COLLECTION

To evaluate the effectiveness of the SRTS program, surveys were conducted before and after the deployment of the improvements. The standard survey form designed by the National Center for Safe Routes to School was adopted.

Before and After Period Survey

Before the implementation of those SRTS projects, a survey (denoted as "before period survey" below) on the students' travel behavior was conducted in April 2007 at 14 schools which had applied for the national SRTS funding. To track the possible changes on student travel to/from school and the parent response to the SRTS projects, a second survey (denoted as "after period survey" below) was conducted at 13 of those 14 schools in April 2008, one year after the before period survey. Those 13 schools that completed both the before and after period survey were included in this study.

Student and Parent Survey

Both the before period and after period survey consist of a student survey and a parent survey. In the student survey conducted in the classroom, teachers were asked to record how students arrived at school and their planned travel modes to home after school on three consecutive days (from Tuesday to Thursday). The following information were recorded on the tally sheets distributed to the teachers: school name, survey date, class grade level, number of students enrolled in the class, weather of the weekday, and number of students with each travel mode to/from school. The parent

survey was distributed as a homework assignment to the students with the following three categories of questions included: (1) the student's travel activities, such as travel modes to/from school and corresponding travel time, (2) student's demographic information, such as grade level, distance to school, gender, family size and home location, etc, and (3) parent's subjective feelings/opinions on their child's walking/biking activities, such as school /child's attitude, their feeling about fun, enjoyment and health of the activity, etc.

Sample Size

Totally 1,124 student survey forms and 19,386 parent survey forms were distributed in the before and after period survey, among which 797 student survey forms and 3,378 parents survey forms were returned. Table 1 summarized the sample size and response rate in the before and after period survey.

Table 1 Sample Size in the Before and After Period Survey

Survey Period	Student Survey				Parent Survey		
	Number of Survey Forms Distributed	Number of Survey Forms Returned	Response Rate	Number of Trips Recorded	Number of Survey Forms Distributed	Number of Survey Forms Returned	Response Rate
Before Period	457	383	84%	22,755	12,318	2,978	24%
After Period	635	381	60%	16,850	7,068	800	11%
Total	1,124	797	-	39,605	19,386	3,778	-

DATA ANALYSIS

School-level Walking/Biking Rate Model

To predict the school-level walking/biking rate, a linear regression model was established. A dummy variable was designed to consider the impact of SRTS improvements. To avoid counting the impact of improvements repeatedly, those subjective factors were not included in the model (for example, parents would be more likely to let child walk/biking to school after the SRTS engineering or educational programs).

$$y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 \quad (4)$$

where, y- School-level walking/biking rate;

x_1- Weighted distance from home to school;

x_2- Male student percentage;

x_3- Average number of children in the family;

x_4- Weighted grade level;

x_5- Dummy variable for improvement (0 for before period and 1 for after period).

The model was calibrated with the data collected in the before and after period survey, as shown in Table 2. Only 26 observation values were included (13 from the before period and 13 from the after period respectively). Better performance could be expected when the sample sizes are enlarged.

The model coefficient value indicated that, at school level, the walking/biking rate will increase with increase on weighted grade level, male student percentage and average children number in the student family; and on the other side, will decrease with increase on weighted distance. The SRTS improvements alone (school flasher in this study) could increase the walking/biking rates at about 3%. This model could be used to estimate the school-level walking/biking rates with fundamental student information available and predict the school-level walking/biking rates after the implementation of certain SRTS programs.

Table 2 Coefficient Value of School-Level Walking/Biking Rate Model

Model Parameters	a_0	a_1	a_2	a_3	a_4	a_5	R^2
Coefficient Value	-0.048	-0.074	0.205	0.038	0.012	0.031	0.435
Significance Level	0.763	0.029	0.317	0.610	0.048	0.267	

Modeling Students' Walking/Biking Activity with Binary Logit Model

Based on the statistical analysis results, generally five categories of factors were significantly associated with the students' travel modes to /from school. These factors are distance, grade, allowable walking/biking grade, student attitudes and SRTS improvements. An additional effort was made to investigate to what degree those factors have impacted the students' walking/biking activities.

The Binary Logit model was selected here to quantify the impacts of those factors on students' walking/biking activities. The Binary Logit model establishes the relationship between discrete binary variables and the independent variables, which can be formulated as following:

$$p(Y=1|\mathbf{x}) = \pi(\mathbf{x}) = \frac{e^{g(\mathbf{x})}}{1+e^{g(\mathbf{x})}} \qquad (2.2)$$
$$p(Y=0|\mathbf{x}) = 1-\pi(\mathbf{x})$$

in which $g(\mathbf{x}) = \beta_0+\boldsymbol{\beta}_1\mathbf{x}_1+\boldsymbol{\beta}_2\mathbf{x}_2+\ldots+\boldsymbol{\beta}_p\mathbf{x}_p$, while $\mathbf{x}_i$'s denote the independent variables.

In this study, $\mathbf{x}$ represents all the factors significantly associated with the walking/biking activities. The variables were defined as the following:

- **Y**: Travel Modes, with Walk/Bike =1, Otherwise = 0;
- $\mathbf{X_1}$: Distance, with 5 levels, i.e., less than ¼ mile, ¼ mile to ½ mile, ½ mile to 1 mile, 1 mile to 2 miles and more than 2 miles. Four design variables were created; that is, $\mathbf{X}_1 = (x_{11}\ x_{12}\ x_{13}\ x_{14})^T$;
- $\mathbf{X_2}$: Grade, with 9 levels, i.e., kindergarten to 8th. Eight design variables were created; that is, $\mathbf{X}_2 = (x_{21}\ x_{22}\ x_{23}\ x_{24}\ x_{25}\ x_{26}\ x_{27}\ x_{28})^T$;
- $\mathbf{X_3}$: Allowable walking/biking grade, with 9 levels, i.e., 1st-8th and "never". Eight design variables were created; that is, $X_3=(x_{31}\ x_{32}\ x_{33}\ x_{34}\ x_{35}\ x_{36}\ x_{37}\ x_{38})^T$;
- $\mathbf{X_4}$: Student attitudes, with 2 levels, i.e., yes and no. One design variable was generated; that is, $\mathbf{X}_4 = (x_{41})$.
- $\mathbf{X_5}$: Dummy Variable for SRTS improvement, with 2 levels, i. e., yes and no. One design variable was generated; that is, $\mathbf{X}_5 = (x_{51})$.

The model was then fitted with the data collected from the parent survey. Final model fitting results were listed in Table 3. This method can be used to quantify the effects of different factor on the students' walking/biking rate.

Table 3 Parameters of the Binary Logit Model

Parameter values	Variables							
	Constant	Distance						
	B_0	x_{11}	x_{12}	x_{13}	x_{14}			
	-1.313	-1.132	-2.084	-4.069	-4.207			
Parameter values	Variables							
	Grade							
	x_{21}	x_{22}	x_{23}	x_{24}	x_{25}	x_{26}	x_{27}	x_{28}
	0	-1.2200	0	0	2.146	2.586	2.914	0
Parameter values	Variable							
	Allowing walking/biking grade							
	x_{31}	x_{32}	x_{33}	x_{34}	x_{35}	x_{36}	x_{37}	x_{38}
	0	3.587	2.204	0	0	2.626	0	-0.518
Parameter values	Variable							
	Student attitudes							
	x_{41}							
	0.729							
Parameter values	Dummy variable							
	SRTS improvements							
	x_{51}							
	-1.158							

CONCLUSIONS

The students' walking and biking activities were modeled with the travel data collected through the SRTS survey before and after the implementation of the SRTS improvements. To better understand the students' walking and biking activities at

microscopic and macroscopic level respectively, a linear regression model was established to predict the students' walking and biking rate at school level, and a binomial Logit model was established to estimate the student's individual travel mode.

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