International Journal of Sustainable Transportation

ISSN: 1556-8318 (Print) 1556-8334 (Online) Journal homepage: https://www.tandfonline.com/loi/ujst20

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To cite this article: Mintesnot Woldeamanuel (2016) Younger teens' mode choice for school trips: Do parents' attitudes toward safety and traffic conditions along the school route matter?, International Journal of Sustainable Transportation, 10:2, 147-155, DOI: 10.1080/15568318.2013.871664

To link to this article: https://doi.org/10.1080/15568318.2013.871664

INTERNATIONAL JOURNAL OF SUSTAINABLE TRANSPORTATION
2016, VOL. 10, NO. 2, 147–155
http://dx.doi.org/10.1080/15568318.2013.871664

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Younger teens' mode choice for school trips: Do parents' attitudes toward safety and traffic conditions along the school route matter?

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ABSTRACT

Walking, bicycling, and all other alternative-to-driving modes of transportation used by teenagers promote physical activity, which is important for creating a healthy and sustainable community. On the other hand, most younger U.S. teens are being driven by their parents to and from school and other activities, which gives them fewer opportunities for physical activities. This research investigates factors affecting the mode choice of younger teens. The focus of the study is to analyze the effect parents' views of the safety and traffic conditions along school routes have on younger teens' mode choice. The study uses the 2009 U.S. National Household Travel Survey (NHTS; USDOT, 2009). Younger teens in this study are defined as the age group from 12 to 16 years old, which is a nondriving, active age group. The results of the study show that there is a strong correlation between parental attitude and younger teens' mode choice. Factors that affect parents' decisions to drive their teens to and from school include distance between home and school, traffic congestion, and crime along school routes.

ARTICLE HISTORY
Received 7 April 2013
Revised 29 November 2013
Accepted 29 November 2013

KEYWORDS
Mode choice; NHTS 2009; parents' attitude; travel behavior; younger teens

1. Introduction

There is increasing interest in the decisions made about travel by parents and children, including the decisions related to mode choice, because they are an important part of a sustainable transportation planning process. Walking, bicycling, and any other alternative-to-driving modes of transportation used by teenage students promote physical activity, which is important for creating a healthy and sustainable community. On the other hand, parents drive most U.S. teenagers to school and other activities, giving them fewer opportunities for physical activities. Empirical evidence suggests that once they have arrived at some given activity, children who were driven were less physically active than those who walked or bicycled there (Mackett, 2002; Mackett & Paskins, 2004).

Walking and bicycling behavior in the United States has changed drastically over the past several decades. According to a study by the U.S. Federal Highway Administration, in 1969 about half of all U.S. students walked or biked to school (USDOT-FHA, 1972). Similar studies showed that at the start of the 21st century, fewer than 15% of all school trips are made by walking or bicycling, and over half of all children arrive at school in private automobiles (USDOT-FHA, 2001). This decline in walking and bicycling has had adverse effects, including an increase in the risk for a variety of health problems (US-CDC, 2004).

Although researchers have studied the travel patterns of adults over the years, there are limited studies on teenagers' travel behavior. However, the study of younger teenagers' physical activity (including walking and bicycling) to school is gaining important ground as an area of study in several fields, including child development, public health, sustainability, and transportation (Campbell, 2007; Darling, 2005; Sener & Bhat, 2011).

Despite the health and social benefits of walking and cycling, fewer and fewer teenagers are walking or bicycling to and from their school. This is correlated to the various reasons why parents choose to drive their children to and from school. According to the U.S. Center for Disease Control (CDC), safety concerns influence parents' attitudes; parents consistently cite traffic danger as a reason why their children are unable to bicycle or walk to school (US-CDC, 2005). Although there are objective measures of safety, most parents decide based on *perceived* measures of safety of the travel mode itself, or of the walking and bicycling environments. If other social and environmental factors support the behavior in question, then over time these perceived negative attitudes may become a lifestyle (Johansson et al., 2011). Negative perception of the built environment (such as safety and traffic conditions) would then be associated with reduced levels of walking, bicycling, and other physical activity (Carver, Salmon, & Campbell, 2005; Carver, Timperio, & Crawford, 2008). For example, an article published in the *Journal of Preventive Medicine* revealed that inner-city children are engaged in less physical activity than suburban children because inner-city parents expressed much greater anxiety about neighborhood safety than suburban parents did. In the inner-city population, children's physical activity levels correlated negatively with parental anxiety about neighborhood safety (Weir, Etelson, & Brand, 2006).

There is a growing interest in connecting the perceived measures of the built environment to travel behavior and

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physical activity. Behavior analysts agree that the inclusion of perception and attitude variables in travel behavior analysis, especially with regard to mode choice, increases the quality of the estimates and provides a deeper understanding of the underlying dynamics of the choice process. This is important because studies on travel behavior usually stress only the complex interdependencies between various causes of travel behavior, such as sociodemographic variables, urban form, and transport systems (Holz-Rau & Scheiner, 2010).

Therefore, the purpose of the current study is to analyze parents' attitude toward safety and traffic conditions and its effect on their younger teenagers' mode choice, using the 2009 National Household Travel Survey (NHTS). The research focuses on the nondriving teens because: (a) the maximum age for the NHTS survey sample for school travel is 16, and (b) once teenagers reach 16, they often get driver's licenses and begin to make independent decisions (Clifton, 2003). That makes studies on the travel behavior of younger teens between the ages of 12 and 16 important because mode choice at this age is decided in part by their parents. Additionally, travel behavior learned during this age could affect behavior and lifestyles in later teenage years and adulthood, thus contributing to the effort of creating a sustainable transportation system.

This paper consists of seven sections. The second section presents the literature review, focusing on the power of the attitude variable in modeling travel behavior. The third and fourth sections explain the methodology and data source, respectively. Sections five and six describe the analysis results, focusing on the effect of attitude and socioeconomic variables on mode choice. The final section describes the study's conclusion.

2. Previous works

There are a growing number of empirical studies that explain the effect of attitude on travel behavior, especially mode choice. Decades ago, most of the research focused on socioeconomic variables in predicting mode choice. This is evident in the work of Hartgen (1974), who analyzed the relative strength of socioeconomic and attitudinal variables in predicting mode choice. The result revealed that situational factors (such as socioeconomic variable) account for 80%−90% of variation explained by the models, whereas *attitudes* account for 10%−20%. However, soon after, Gilbert and Foerster's (1977) work reported results reflecting that attitudinal variables are important in mode choice decisions and that they can significantly increase the explanatory power of mode choice models.

Similar researchers agreed that consideration of latent variables, such as attitudes, views, perceptions, etc., for the travel mode choice model increases its explanatory power (Outwater et al. 2003; Popuri, Proussaloglou, Ayvalik, Koppelman, & Lee, 2011). Analysis of the data from a recent attitudinal survey conducted by the Regional Transportation Authority (RTA) in Northeastern Illinois showed that from a statistical standpoint, the attitudinal factors improved the intuitiveness and goodness of fit of the model (Popuri et al. 2011). Outwater et al. (2011) also argued that inclusion of nontraditional attributes, such as attitudes, can improve mode choice models and reduce bias constants. The result of Parkany, Gallagher, and Viveiros (2004) suggest that behavior processes including attitudes are better at explaining choices, compared to using only objective measures to explain behavior.

Although there are several studies on the effect of perception on mode choice, there are only a few studies on the effect of parents' attitudes toward the built environment on their children's travel behavior. The most recent work is by Seraj, Sidharthan, Bhat, Pendyala, and Goulias (2012), which analyzes parental attitudes toward their children's walking and bicycling behavior. Although their research focuses on variables that influence parents' attitude, the effect of parents' attitude toward the safety of the walking and bicycling environments on travel behaviors, especially the mode of travel they choose for their children, remains unaddressed. Their research focused on schoolchildren of all ages, and was inspired by previous work that suggests the presence of strong associations between attitudes and travel behavior, which led to theoretical frameworks describing the underlying reasons for and nature of the associations between attitude and behavior (such as Ajzen & Fishbein, 2005 and Van Acker, Wee, & Witlox, 2010). Additionally, Sener and Baht (2011) used the 2000 San Francisco Bay Area Travel Survey to analyze the effects of a variety of built environment and demographic variables on teenagers' activity behavior. The result indicated that parents' participation in physical activity (including walking and bicycling) constitutes the most important factor influencing teenagers' physical activity participation level. This is true for younger teens, because they are more dependent on their parents' travel decisions. For example, Clifton (2003) found that younger teens use alternative modes such as walking and bicycling at much higher rates than older teens, but then appear to abandon these more physical modes as soon as the automobile become an option. Marzoughi (2010) also had the same results for his sample of the Greater Toronto Metropolitan area. According to the study, younger teens tend to walk more and older teens tend to take transit more, for both school and discretionary travel. The reason for this, according to the Transportation Research Board (2005), is that the steady decentralization of metropolitan area populations widely dispersed suburban locations, increasing the travel distance to many destinations, including school. Therefore, these factors highlight the importance of more studies on younger teens' travel behavior in relation to their environments.

3. Research methods: Binary logit model

The model used in this study is to analyze the effect of parents' attitude and other sociodemographic variables on mode choice of younger teens (those that are not eligible for a driver's license). Choice models are widely used in economic, marketing, transportation, and other fields to represent the choice of one from among a set of mutually exclusive alternatives. A multinomial model could be the ideal model if there are more than two available choices. However, the multinomial logit model (MLM) suffers from certain weaknesses when used in discrete choice modeling (MLM suffers from independence of irrelevant alternatives [IIA]), principally when the errors are not independent (Greene, 2000). Alternative-specific multinomial probit regression was proposed to possibly relax the independence of irrelevant alternatives by allowing different error structures; however, it requires that the data structure be choice-specific.

Nested logit model also relaxes the IIA assumption but also requires the data structure to be choice-specific. The NHTS data set used for this research is respondent-specific, therefore, this study aimed to analyze the mode choice behavior using the binomial logit model. Although the available alternatives (mode choices) are more than two, the choices are transformed into a binary dummy variable such as: car or otherwise (1, 0), public transit or otherwise (1, 0), and walking/bicycling or otherwise (1, 0). It is statistically reliable to create the dummy variables because, in the survey, parents got to choose only one mode of travel among a list of choices.

When travelers are faced with two alternatives (a choice of specific mode [i] over the others [j]), the probability that j is chosen is equal to [1 − P(i)]. The general form of the binomial logit model is:

$$\text{Prob}\,[Y_i = 1 \mid \text{the chosen mode}] = \text{Exp}\left(\alpha + \sum \beta_i x_i\right) / \left[1 + \text{Exp}\left(\alpha + \sum \beta_i x_i\right)\right] \quad (1)$$

The model application is based on the utility theory, which assumes that the decision maker's preference for an alternative is captured by a value called utility (U). The decision maker selects the alternative in the choice set with the highest utility U (the chosen mode) $= \alpha + \beta_i x_i$

Where:

1. β_i is the coefficient associated with the independent variables
2. x_i is the value of independent variables
3. α is the constant (intercept) estimated by the model

The estimation of the equation's parameters (intercepts and beta coefficients) rests upon a method called maximum likelihood (ML). ML basically assumes that the underlying relationship between any independent variables and the dichotomous dependent variable (Y) follows a probability function (also called likelihood function). Several computer programs are available to handle the logistic regression model, and in this study we used LIMDEP V-9, econometric software developed by Econometric Software, Inc.

3.1 *Goodness of fit*

Several indicators are available for assessing goodness of fit of a given logistic regression model. Some of them are maximum likelihood ratio, Chi square, X^2, and Pseudo R^2. In the ordinary least square context, the coefficient of determination (R^2) has an interesting property of providing an indicator of how well a set of independent variables explain the variance observed in the dependent variable (Draper & Smith, 1981). In logistic regression, the Pseudo R^2 represents the proportion of error variance that an alternative hypothesis reduces in relation to a null hypothesis. The recommended formula for Pseudo R^2 is:

$$Pseudo\ R^2 = X^2 / \left(N + X^2\right)$$

where X^2 is the Chi-square statistics for overall fit of the model, and N is the total sample size. The Pseudo R^2 ranges from 0 to 1.

4. Data

Mode choice is a binary variable (created as the dummy variable of choosing a specific mode or not), which is considered a dependent variable. The travel mode chosen for trips to and from school in the survey were split into three categories: personal vehicle, public transit, and walk/bike. "Other" is treated as a reference variable, so results show only the three modes. The five-point Likert-scale attitude toward the predefined five issues (attributes) associated with the safety and traffic condition of the school route, along with socioeconomic and demographic variables, were considered as independent variables. The sample data is taken from the National Household Travel Survey (NHTS) by sorting and filtering the attitude and mode choice variables for school-related trips. NHTS is one of the most prominent telephone surveys run by the U.S. Department of Transportation, and is conducted periodically to assess the mobility of the American public. The 2009 NHTS is a nationally representative survey of travel behavior conducted from April 2008 through April 2009. There is a separate section in the survey that deals with school travel only, in which parents were interviewed about their children's travel characteristics to and from school. The minimum age was identified as 5, and the maximum was 16. For the purpose of this study, the 12 to 16 age group is considered (it is notable that the preteen age of 12 is included), because the focus of this study is on young teens' travel behavior. The information about children's travel characteristics is based on their parents' response to the survey. The survey includes latent responses on how parents view various aspects of the safety and traffic conditions along school routes. On a scale of 1 to 5, where 1 means "not an issue" and 5 means "a serious issue," parents were asked how much each of the five attributes of the walking and bicycling environments affected their decision to allow their children to walk or bike to or from school. The five attributes are:

1. Parents' attitude toward *crime* along the route between home and school,
2. Parents' attitude toward *school distance* along the route between home and school,
3. Parents' attitude toward *traffic speed* along the route between home and school,
4. Parents' attitude toward *traffic amount* along the route between home and school, and
5. Parents' attitude toward the *weather* condition in the school area.

Although the effect of parental attitude on mode choice is the main focus of this study, some socioeconomic and demographic variables were also added, as presented in Table 1. At the start of the analysis several variables that comprise household and parents' characteristics were included in the model. However, the inclusion of several variables results in important variables yielding statistically insignificant results (due to collinearity). So ultimately, variables presented in Table 1 are included in the model.

5. Results: Descriptive

A descriptive analysis, as presented in Figure 1, shows that the majority of younger teens are driven to school. There are also a

Table 1. Description of variables ($N = 7550$).

Modes of travel	Personal vehicle (count (%))	Public transit (count (%))	Walking/bicycling (count (%))	Other (count (%))
Mode to school	4008 (53.09%)	2859 (37.87%)	581 (7.70%)	102 (1.35%)
Mode from school	3303 (43.75%)	3260 (43.18%)	875 (11.59%)	112 (1.48%)

Parents' attitude toward the safety and traffic conditions	Not an issue (1)	A little bit of an issue (2)	Somewhat of an issue (3)	Very much an issue (4)	A serious issue (5)
Crime	4089 (54%)	1171 (16%)	981 (13%)	409 (5%)	900 (12%)
Distance	1530 (20%)	620 (8%)	930 (12%)	1069 (14%)	3401 (45%)
Traffic speed	1062 (14%)	635 (8%)	1247 (17%)	1387 (18%)	3219 (43%)
Traffic amount	865 (11%)	622 (8%)	1092 (14%)	1447 (19%)	3524 (47%)
Weather	2438 (32%)	1386 (18%)	2010 (27%)	825 (11%)	891 (12%)

Socioeconomic and demographic variables	
Gender of the student	
Male	3997 (53%)
Female	3553 (47%)
School type	
Public	6589 (87%)
Private	961 (13%)
Urban size (residence location)	
Not in urban area	2853 (38%)
Urban with pop. 50,000−199,999	1017 (13%)
Urban with pop. 200,000−499,999	696 (9%)
Urban with pop. 500,000−999,999	616 (8%)
Urban with pop. 1,000,000+ without subway/rail	1466 (19%)
Urban with pop. 1,000,000+ with subway/rail	902 (12%)
Distance from home to school	
Less than 1/4 mile	303 (4%)
Between a 1/4 to 1/2 mile	339 (4%)
1/2 mile to 1 mile	621 (8%)
1 mile to 2 miles	1352 (18%)
More than 2 miles	4935 (65%)
Other continuous variables	
Household income	Median category = $75,000−$79,999; minimum category = <$5,000; maximum category = >$100,000
Household size	median = 4; min. = 2; max. = 13
Number of vehicles in the HH	median = 2; min. = 0; max. = 14
Number of eligible drivers in the HH	median = 2; min. = 0; max. = 9

significant number of school trips made by public transit (including the school bus). Only a few of the trips to and/or from school are made by walking or biking. The walking/biking issues that concern parents the most are: school distance, the speed of traffic along the school way, and the amount of traffic along school routes. Crime and weather are the least of their concerns, according to the descriptive result (Figure 2).

Figures 3 through 5 describe the difference between trips *to* and *from* school in mode choice vis-a-vis parents' attitude toward the safety and traffic conditions along the routes to school. Although there is no significant difference in mode choice and attitude pattern between trips *to* and *from* school, the graphs show that there is a slight variation in parents' attitude for these trips in terms of the mode they choose for their younger teens. Following the general trend exhibited in Figure 2, three issues, namely distance between home and school, traffic speed, and the amount of traffic along the school route, are very important for parents who drive their children to and from school. Those concerns are also identified in parents that let their children use public transportation.

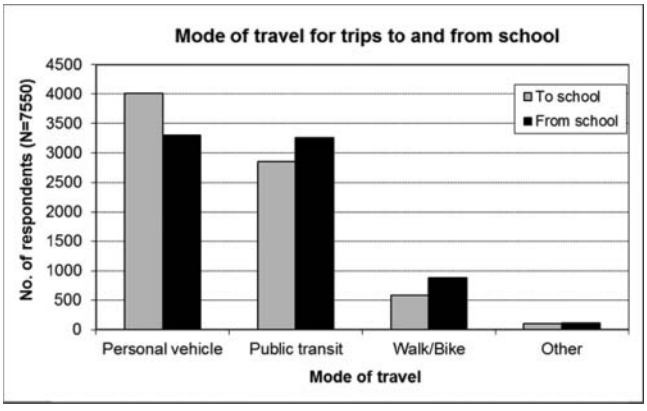

Figure 1. Mode of travel to and from school.

6. Results: Binomial logit model

The binary logit model is used to examine the effect of parents' attitudes and the socioeconomic variables on mode choice. Tables 2 and 3 represent the beta weights and the corresponding p values as statistical hypothesis tests, with the purpose of determining the relationship between a set of independent variables (parental attitude and socioeconomic) and the dependent variable (mode choice). The sign associated with the beta coefficient indicates the direction of the effect that a particular independent variable has on the dependent variable. The positive sign with the attitude variables can be interpreted in such a way that regardless of their

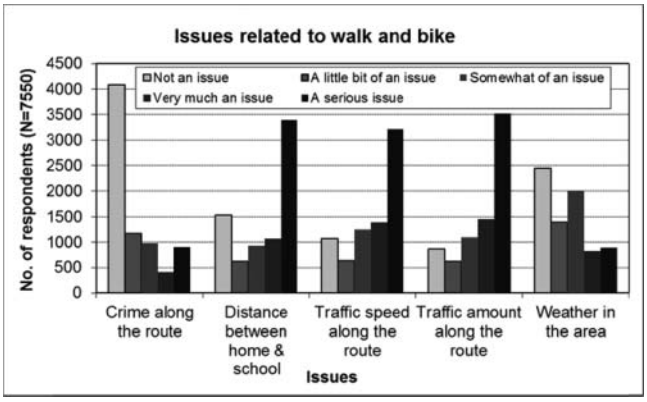

Figure 2. Parent attitude toward the safety and traffic conditions along school routes.

concerns, parents use the mode they choose (e.g., driving) to transport their children (or those attitude variables don't deter them from using the mode). The negative sign means there is an inverse relationship between the attitude (as well as other sociodemographic variables) and mode choice. The statistical significance of the relationships is captured based on the p value. As shown in Tables 2 and 3, all the variables with a p value of <0.05 were found to exert a significant effect on mode choice. The rest of the variables indicated by an asterisk have no significant effect on the mode choice. The likelihood ratio, the chi square, and Pseudo R^2 were used as goodness-of-fit measures. For example, in the case of private vehicle use (columns 2 and 3 of Tables 2 and 3), the corresponding Pseudo $R^2 = 0.1$ indicates that the model accounts for a 10% reduction in error variance. Although it

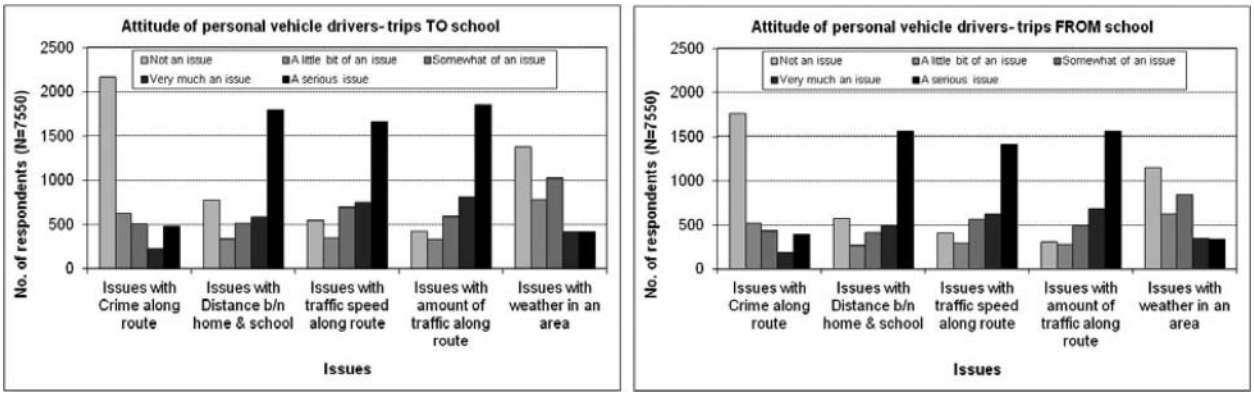

Figure 3. Parent attitude toward the safety and traffic conditions vs. personal vehicle use.

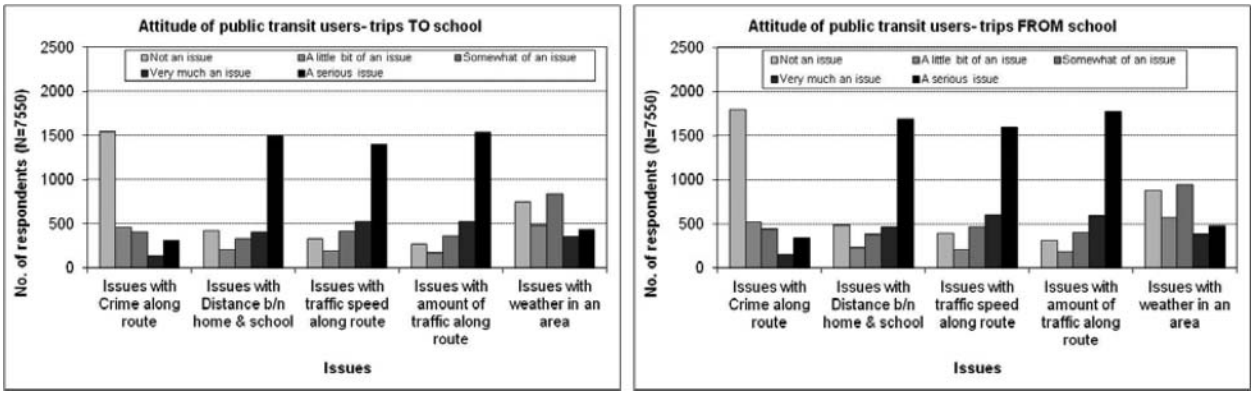

Figure 4. Parent attitude toward the safety and traffic conditions vs. public transit use

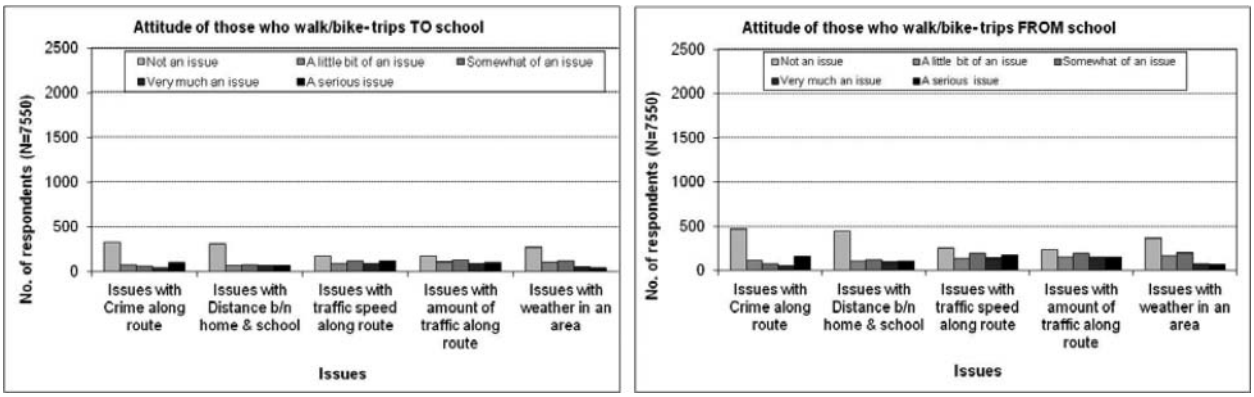

Figure 5. Parent attitude toward the safety and traffic conditions vs. walking and bicycling.

Table 2. The influence of attitude and other variables on mode choice TO school.

	Mode TO school					
	Personal vehicle		Public transportation		Walk/bike	
	β	p value	β	p value	β	p value
Constant	1.18	0.00	−5.43	0.00	1.48	0.00
Attitude—crime	0.07	0.00	−0.07	0.00	0.11	0.01
Attitude—distance	−0.04	0.03	−0.01	0.51*	−0.08	0.07*
Attitude—traffic speed	−0.08	0.00	0.07	0.02	0.03	0.58*
Attitude—traffic amount (congestion)	0.05	0.05	0.04	0.16*	−0.29	0.00
Attitude—weather	−0.12	0.00	0.20	0.00	−0.15	0.00
Gender—male	−0.20	0.00	0.12	0.02	0.51	0.00
HH income	0.03	0.00	−0.04	0.00	0.02	0.15*
HH size	−0.24	0.00	0.20	0.00	0.20	0.00
HH driver count	0.40	0.00	−0.38	0.00	−0.29	0.00
HH vehicle count	0.06	0.03	−0.07	0.02	−0.11	0.07*
Distance to school	0.07	0.01	0.72	0.00	−1.21	0.00
School type—public	−1.53	0.00	1.83	0.00	0.85	0.00
Urban size (residence)	−0.03	0.01	0.01	0.65*	0.15	0.00
N = 7550 (12- to 16-year-old students and responses of their parents)	LL Function = −4842.928; Restricted LL = −5218.871; Chi square = 751.88; Pseudo R^2 = 0.1		LL Function = −4335.401; Restricted LL = −5008.761; Chi square = 1346.72; Pseudo R^2 = 0.15		LL Function = −1197.003; Restricted LL = −2048.053; Chi square = 1702.101; Pseudo R^2 = 0.18	

seems small, the other goodness-of-fit measures (such as the chi square), indicate that the mode best fits the data.

6.1 *The effect of parental attitude variable on younger teens mode choice*

6.1.1 *Private vehicle*

All of the attitude variables show a significant effect on the choice of a private vehicle for a trip to school. Attitude toward distance, traffic speed, and weather have negative beta coefficients. This shows their inverse relationship with the choice of private vehicle. Therefore, parents' negative views on distance, traffic speed, and weather have a lesser effect on the likelihood of younger teens to be driven to school by their parents than parents' views on other attributes. On the other hand, traffic congestion and crime along the school route is positively related to the choice of private transportation, showing that the reason parents drive their younger teens to school could likely be their perception of crime and the amount of traffic along the school route. For the trip *from* school, most of the attitude variables are not statistically significant with p values of >0.05, except in the case of crime, which has a positive relationship. When parents think that crime might be an issue for walking and bicycling, they tend to drive their younger teens for trips *from* school. Figure 6 shows the sensitivity of the effect of attitude on mode choice. According to the analysis results, the probability of the use of private car decreases with an increase in parents' concern with distance and traffic speed.

Table 3. The influence of attitude and other variables on mode choice FROM school.

	Mode FROM school					
	Personal vehicle		Public transportation		Walk/bike	
	β	p value	β	p value	β	p value
Constant	0.14	0.47	−5.00	0.00	2.11	0.00
Attitude—crime	0.08	0.00	−0.10	0.00	0.15	0.00
Attitude—distance	−0.02	0.32*	−0.01	0.50*	−0.14	0.00
Attitude—traffic speed	−0.04	0.16*	0.04	0.16*	−0.04	0.41*
Attitude—traffic amount (congestion)	0.03	0.26*	0.10	0.00	−0.29	0.00
Attitude—weather	−0.13	0.00	0.17	0.00	−0.03	0.44*
Gender—male	−0.22	0.00	0.09	0.07*	0.46	0.00
HH income	0.03	0.00	−0.03	0.00	0.02	0.07*
HH size	−0.20	0.00	0.15	0.00	0.15	0.00
HH driver count	0.41	0.00	−0.34	0.00	−0.29	0.00
HH vehicle count	0.04	0.10	−0.05	0.09*	−0.08	0.12*
Distance to school	0.17	0.00	0.71	0.00	−1.15	0.00
School type—public	−1.59	0.00	1.77	0.00	0.95	0.00
Urban size (residence)	−0.04	0.00	0.00	0.77*	0.17	0.00
N = 7550 (12- to 16-year-old students and responses of their parents)	LL Function = −4746.896; Restricted LL = −5174.091; Chi square = 854.3887; Pseudo R^2 = 0.1		LL Function = −4469.155; Restricted LL = −5162.783; Chi square = 1387.256; Pseudo R^2 = 0.16		LL Function = −1625.271; Restricted LL = −2707.91; Chi square = 2165.277; Pseudo R^2 = 0.23	

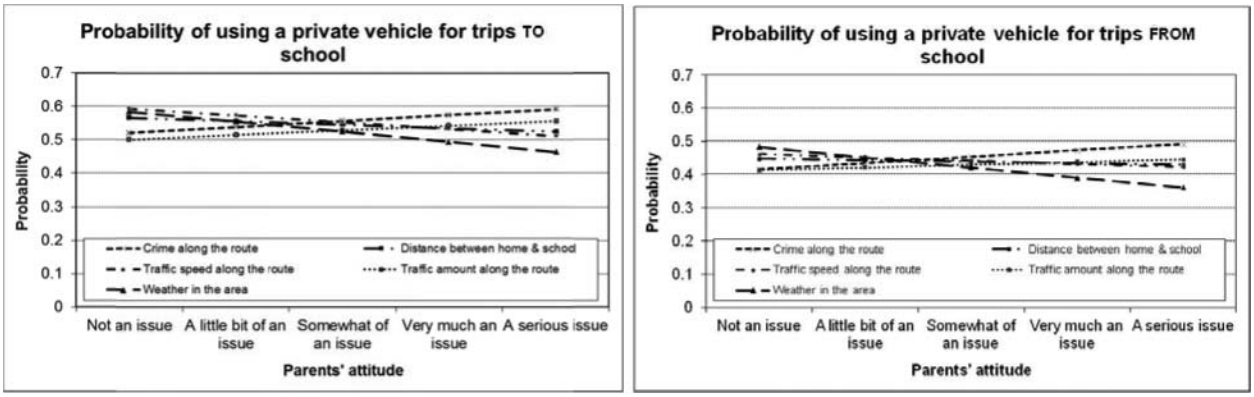

Figure 6. Likelihood of using private car vs. parent attitude.

6.1.2 *Public transit*

Parents' attitude toward distance and traffic amount (congestion) are the two variables with no significant effect on choosing public transit as a means of travel for younger teens. Crime, one of the statistically significant variables, is negatively related to public transit choice, meaning parents who view crime as a serious issue have less likelihood of letting their younger teens use public transit (including school buses). The traffic speed and the weather did not appear to deter parents from letting their younger teens use public transit (refer to Figure 7 for the sensitivity analysis results). The model yielded similar results for trips *from* school.

6.1.3 *Walk/bicycle*

The only variable statistically insignificant for the mode "walk/bicycle" is parents' attitude toward traffic speed along the school route (p value of 0.58). Parents' attitude toward distance and traffic congestion are negatively related with walking and bicycling to school. This means that the longer the distance between home and school, and the more congested the roads are, the less likely the children are to walk or bicycle to school. Interestingly, weather conditions in the school/residence area also related to a smaller likelihood of walking and bicycling to school. Parents' attitude toward school crime seems to have no effect on young teen's decisions regarding walking or bicycling to school (Fig. 8). The model yielded somewhat similar results for the trip *from* school.

6.2 *The effect of socioeconomic variables on younger teens' mode choice*

All the socioeconomic and demographic variables included in the model have a significant effect on mode choice except for a few variables indicated with an asterisk in Tables 2 and 3. The overall direction of correlation is the same for trips *to* and *from* school, showing that there is no significant variation in the trip pattern for trips *to* and *from* school. Gender is one of the predictor variables, in that male students are less likely to be driven to and from school than female students. However, male students are more likely to use public transit and walk or bicycle. Household income is a statistically significant variable; higher income relates to the higher likelihood of driving younger teens to and from school, and a lower probability of using public transit. However, income appeared to have no effect on biking and walking choices, with a p value of >0.05. The higher the size of the household, the lower the likelihood of being driven, and the higher the probability of using public transit or walking/bicycling. The number of drivers and numbers of vehicles in the household positively related to being driven to and from school, while negatively correlating with public transit use and walking and cycling.

Although the subjective measure of distance is negatively correlated with the choice of private car, the results on the objective measure of distance show that the further apart the school and homes are, the higher the probability of being

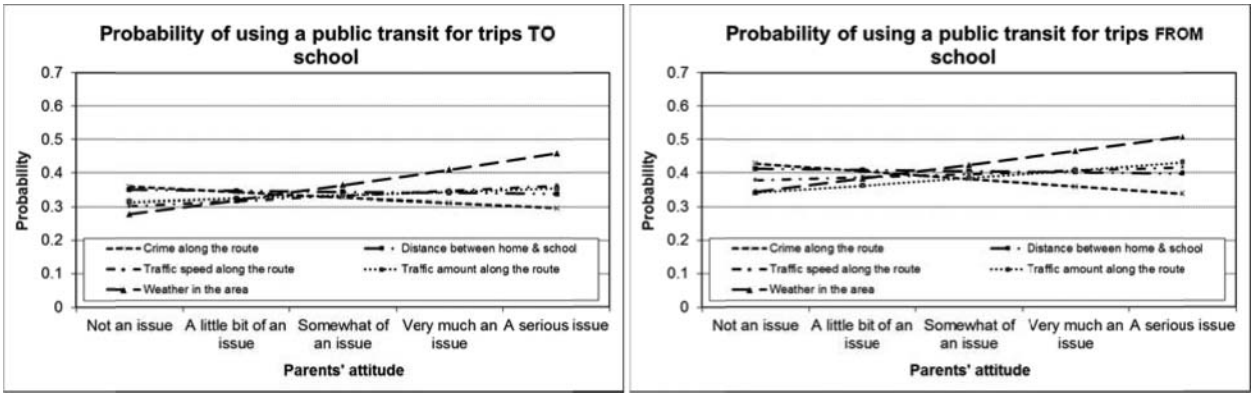

Figure 7. Likelihood of using public transit vs. parent attitude.

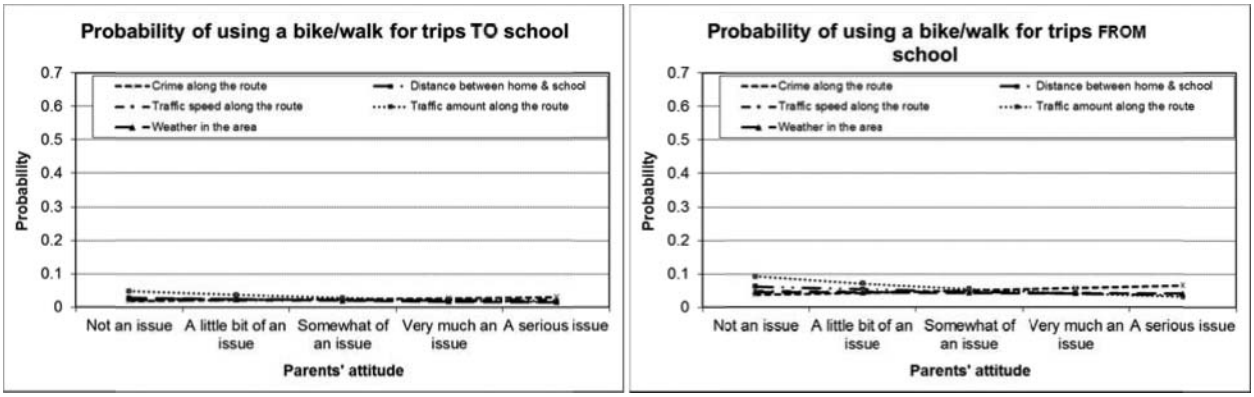

Figure 8. Likelihood of walking and bicycling car vs. parent attitude.

driven to school and of using public transit. Distance is also an impeding factor for walking and bicycling to and from school.

Public school students are less likely to be driven by their parents, and more likely to use public transit, and walk or bicycle. The size of the urban area where the homes and schools are located seems to have no effect on the public transit choice. However, the densely populated areas are related to a smaller likelihood of being driven and a greater likelihood of walking or bicycling.

7. Conclusion

Several studies agreed that walking and bicycling as well as using public transportation are sustainable modes of travel that encourage healthy living. Particularly, less driving to school is crucial for the development of the younger teen's personal health. However, it is apparent that more and more parents drive their children to school, even over short distances. When talking about sustainable transportation, the mode choice of younger teens in getting around is often overlooked. Thus, this research contributes to the limited body of literature on younger teens' travel patterns by studying the effect of parents' attitudes and other socioeconomic and demographic variables on their children's transportation. Because parents are the ones who most often choose a mode for their younger teens, understanding their decision process is important. Although there is a vast body of literature on the effect of attitude on mode choice, parental attitude as a proxy independent variable and its effect on children's travel behavior has not been assessed in previous empirical works. Additionally, even though the travel behavior of adults is a widely researched topic, when it comes to mobility patterns, teenagers—especially the younger ones—are an understudied demographic. Teens do not have the same needs, demand patterns, or freedom of choice as working adults. Therefore, the modeling, as well as the descriptive results of the study, provides significant insight into the travel behavior of younger teens and setting goals to achieve a more sustainable society. A sustainable approach for transportation planning requires that from a young age children adopt positive environmental values that influence their own decisions when they become adults.

The results of this study show that parents' attitude has a significant effect on transportation decisions, and that younger teens' mode choice can be a function of their parents' view of the safety and traffic conditions. For example, a parental attitude about distance between home and school is one of the major factors that explains whether children are driven to school. In this study, the attitude variable (subjective measure of distance) is supported by the actual distance (as objective measure), showing that although parents perceive that distance has less effect on their decision to drive their younger teens, the actual distance indicates that it is the most important factor in parental decisions. Therefore, distance between home and school plays a significant role in discouraging younger teens from walking or bicycling to school. It is true that in most metropolitan areas, the distance between home and school is great. Also, in areas where the walking and cycling environments are not appealing, the shorter distance may seem longer in parents' or students' minds. This research also shows the influence of parents' attitude toward traffic congestion and, even more important, crime on the mode choice of younger teens.

The indicator variables identified in this paper will be useful to planners and policymakers, allowing them to identify the travel demand of younger teens and aiding them in developing appropriate plans and policies. In addition, the research makes empirical, conceptual, and methodological contributions such as incorporating attitude variables into mode choice models.

There are limitations to this research that require a careful interpretation of the results. For example, aggregate (national) data is used for the analysis, although different cities have different land use, public transportation availability, sidewalks and bike lanes, etc., which can affect parents' attitude. Although the NHTS data sample for each state or city is small, further research looking into the effect of parents' attitude on children's mode choice for different geographical and social settings is important. Also, the trips considered for the analysis are trips to and from school, while students travel patterns for after-school programs could be different and require a separate analysis. In addition, the influence of working couples on their teenage children's travel patterns (Loo & Lam, 2013) should be considered when further investigating the issue of school trips.

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