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Evaluating the Factors Affecting Student Travel Mode Choice

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Abstract. This study examines the factors that influence the mode choice of students in school trips using a multinomial logit model. It is found that students in not neighborhood schools, students from families with high income, high school students and female students are less likely to walk or bike in compare to other students. It is also found that there is no strong correlation between school size and whether the school is a neighborhood school. The methodology and results of this study help planners and policy makers to evaluate and prioritize Safe Routes to School programs.

INTRODUCTION

Walking and biking to school has become a concern for public health and transportation planners and policy makers around the world during recent years. Streets are becoming more congested and children have less physical activity and are more likely to use motorized travel modes to go to school (1). Schools have become large trip generators in local areas which cause morning and afternoon congestion on the streets (2). Therefore, Safe Routes to School programs are being developed in some countries to encourage and enable children to walk or bike to school.

According to the U.S. National Household Travel Survey (NHTS) in 2001, less than 15 percent of students between the ages 5 and 15 walk to and from school in the United States (3). A recent study by the U.S. Environmental Protection Agency (EPA) in 2003 found that only about 8 percent of students walk or bike to school and more than 77 percent are driven to school (4). In England, 61 percent of primary-aged children walked to school in 1992 to 1994. This number dropped to 52 percent in 2002 and 2003, while between 30 and 40 percent of students travel to school by car (5). In Denmark, nearly 60 percent of the trips to school are accomplished by foot and bike and only about half of the students live within 1.5 km from their school (6).

The objective of this research was to identify and study the factors influencing the travel behavior of Iranian students traveling to school. This was done by surveying 7,443 students

between the ages 7 and 17 in Mashhad, Iran. The collected data were then analyzed using multinomial logit modeling. The results of the research will help planners to develop a better understanding of children's travel behavior and more effective policies and programs. It can also provide researchers a comparison to show international similarities and country-specific differences in students' travel behavior. Planners and policy makers can benefit from the proposed methodology and study results to evaluate and prioritize Safe Routes to School programs.

BACKGROUND

The literature review focused on examining the factors that affect students travel behavior. Several previous studies have been performed, aimed at analyzing the relationship between children's school travel and different factors.

A nation-wide study including a sample of U.S. students, aged 9-15 years in 2004 found that only 47.9% of those students who live within 1 mile of school are active travelers. Demographic, geographic, attitudinal and behavioral factors were the main variables examined in that study (7). Another survey was conducted to collect information on factors affecting the mode choice of Texas A&M University students. The results showed that travel time, travel cost, income, expenses, household type, number of hours in school, gender and ethnicity were the important factors (8). A study in Gainesville, Florida surveyed many variables including overall density, the balance of jobs and residents, the job mix, the commercial floor area ratio, sidewalk coverage, bike lane and paved shoulder coverage, street tree coverage and accessibility measures in addition to household income, auto ownership, license ownership, and walk time and bike time. The results suggested that students are more likely to walk or bike to smaller schools in walkable environments than to larger schools in remote locations (4). Danish studies showed that there is an even split between walking, biking, car and public transit in 5-8 years old students,

while 15-16 years old students are more likely to bike to school. Walking and using public transit is the same for all ages. They also found that girls bike to school less than boys, while girls walk and use public transit more than boys. The results indicated that income level and type of family do not significantly influence students' travel mode choice (9). Another study showed that other factors such as neighborhood safety, traffic safety, household transportation options, social/cultural norms, and socio-demographics may be equally important (2). A study at 34 California public schools indicated that fifth-grade students are more likely to walk and bike to school in neighborhoods with higher population density and smaller sized schools (10). The influence of school size in students travel mode decisions requires further research (4).

Several researchers have tried to find the most influential factors in students' travel behavior (2, 4, 7, 8, 9, 11). In this regard, the literature suggests a wide range of variables within two general classes of:

- Non-urban factors: gender, age, grade level, ethnicity, income, household type, auto ownership, school size, social/cultural norms, etc.
- Urban factors: land use patterns, availability of sidewalks, population and employment density, job mix, jobs and residence balance, school location, travel time, travel distance, travel cost, school centeredness within neighborhoods, accessibility, neighborhood safety, traffic safety, etc.

A previous study by Yee et al. also shows that concerns for safety, school distance and the young age of the child are the top three reasons parents did not let their child walk or bike to school.

They conducted a parent survey to find out the desired safety improvements. Parent recommendations to improve walking and biking safety included suggestions for additional traffic controls and crossing guards; a focus on reducing traffic speeds in the school zone; and increased police presence to improve the safety and security of children walking or biking (13).

DESCRIPTION OF STUDY AREA

Mashhad is Iran's second largest city with a population of 2,457,083 and area of 195 square kilometers in 2006. The population density in Mashhad is about 12,600 per square kilometer which is much denser than U.S. cities but comparable with large cities in Europe. Mashhad has 947,812 resident students in elementary, secondary and high school grades (12). A recent study by the Transportation and Traffic Organization of Mashhad in 2006 showed that 21.6 percent of outbound trips were to school and 28.8 percent of the daily trips were performed using a car (12). In this study, we divided the city into seven geographical zones. Figure 1 shows the location of sampled schools and the boundaries of city zones on a map of Mashhad.

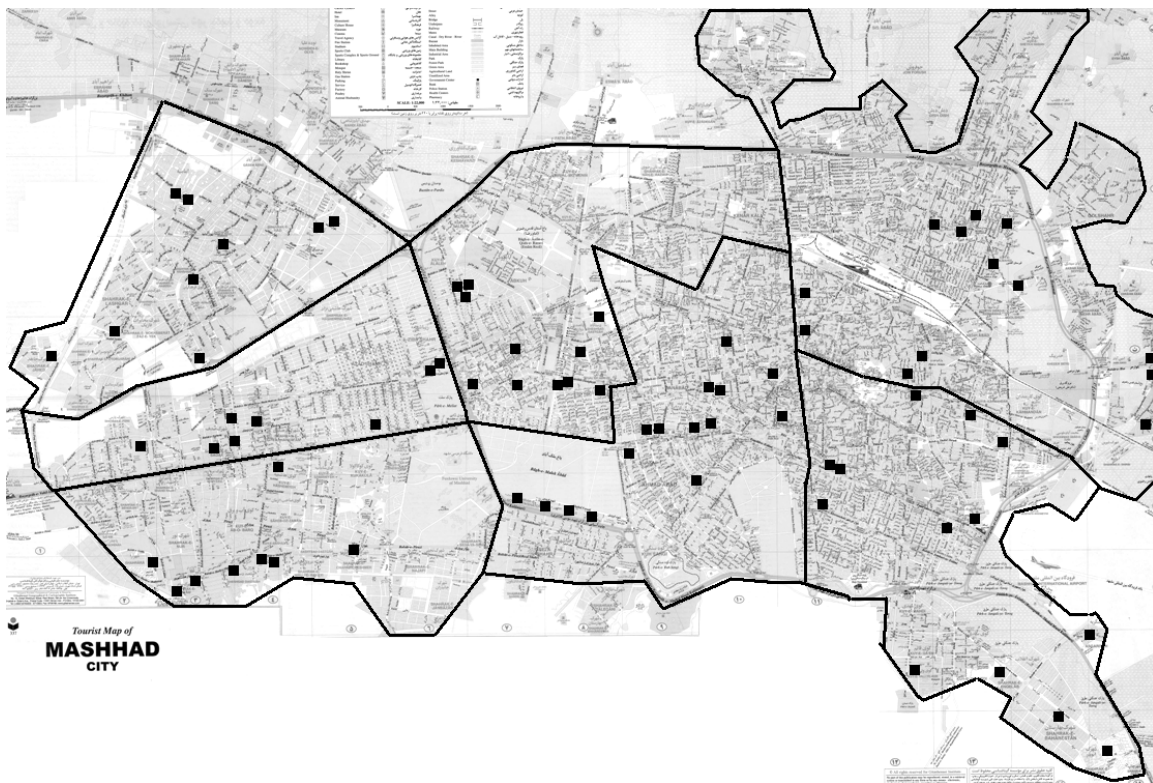


FIGURE 1 Locations of Sampled Schools and Urban Zones in Mashhad

METHODOLOGY

The aim of this study was to describe the influence of six factors on students' mode choice: age, gender, grade, household income, school size and whether they attended a neighborhood school. The initial assumption was that these factors are important variables in a student decision about a trip to school. A discrete choice model was estimated using the SPSS software package to understand which of these factors may have equal or greater influence on a student mode choice. In addition, the correlation between school size and whether it was a neighborhood school was examined. A previous study suggested that students walk or bike to smaller schools more than larger schools (4). This conclusion raises a question. Does the size of a school (number of students or area) really indicate that it is a neighborhood school? If false, what factors really distinguish neighborhood schools from ones that are not? In this study by using the term "neighborhood schools", we mean those schools that more than 90% of their students live in the same city zone where the school is located or live within 5 kilometers of the school.

A student travel survey was designed to identify the school trips of 7 to 17 years old students using a stratified sample. A similar survey was conducted in Pasadena, CA, to create a citywide Safe Routes to School program in 2005 (13). The survey includes three parts. The first part asked the student to write his/her age, gender, and grade. The second part consists of two questions about what travel mode the student typically used to get to school and return home from school. Each of the questions includes 9 possible travel modes to school: parents' car, carpooling, school bus, public bus, taxi, walking alone, walking in group, biking alone and biking in group. In the third part, students were asked to determine the reasons for not walking or biking to or from school. This survey involved a large sample of students, 7,443 students in 78 schools, in Mashhad, Iran. It was conducted in February and March 2008. The survey was done in the classrooms with the help of the teacher and two surveyors to make sure that students fully understand how to answer the questions properly. An additional survey of school administrators

was also conducted at the same time. Administrators were asked to answer a few questions about the number of students in school, whether the school was a neighborhood school, availability of school buses, if biking is allowed, and student families' average level of income. In this survey, students were not asked for their travel distance because authors believe that students in elementary and secondary schools are not able to estimate their travel distance correctly. Moreover, the clear definition of neighborhood schools used in this study makes the authors sure about the travel distance of students in each school. If a school is neighborhood, it is assumed that all the students in that school live within 5 kilometers of the school. However, the definition of neighborhood schools may vary due to regional differences.

Data Summary

Table 1 reports modes of travel for school trips from the Mashhad survey. It can be seen that walking and biking represents 46.5% of all trips to school and 50.1% of trips from school. It can be concluded that students are more likely to walk or bike returning from school to home. Using a car (parents' car and carpooling) decreased from 11% in going to school to 6.4% in coming back from school. The percentage of walking in a group increased from 15.7% in going to school to 27.6% in coming back from school. It clearly shows that students are more likely to walk when they are in a group in returning from school to home. Nearly 30% of students use school buses and 12% use public transit to travel to/from school. The slight increase in using public transit and school buses returning home compared to going to school might be because the students were tired due to after school activities in the afternoon. Only about 0.2% of students bike to and from school which is surprisingly very low.

TABLE 1 Travel Modes for School Trips from Mashhad Survey

Mode	Going to school		Coming back from school		
	Count	Percent	Count	Percent	
Parents Car	765	10.3	420	5.6	6.4
Carpooling	52	0.7	57	0.8	
School Bus	2,304	31	2313	31.1	31.1
Public Bus	633	8.5	733	9.8	12.4
Taxi	232	3.1	192	2.6	
Walking Alone	2,234	30	1,626	21.8	
Walking in Group	1170	15.7	2,051	27.6	50.1
Biking Alone	43	0.6	37	0.5	
Biking in Group	10	0.1	14	0.2	

As can be seen in Figure 2, the use of car is the same for all ages while public transit is used up from 1% to 25% with increase in age. Walking/biking increases until age 14 where it drops substantially. Students between ages 15 to 17 are more likely to use motorized modes compared to others. Nearly 60% of high school students use public transit, school bus, and car to travel to school. Elementary schools due to their traditional design may support more students to walk and bike compared to secondary and high schools (2). Traditional schools due to the geographic scale they serve are located in neighborhoods for a small proportion of population. The results confirmed this conclusion that students between ages 7 to 14 have more likelihood to walk and bike to school compared to ages 15 to 17 years. However, in high schools, using school bus decreases with increase in age. Fear of social/cultural abnormalities may be a primary barrier to students to less walk or bike to school in little ages. More after school activities may be another reason for high school students for less walking or biking to school.

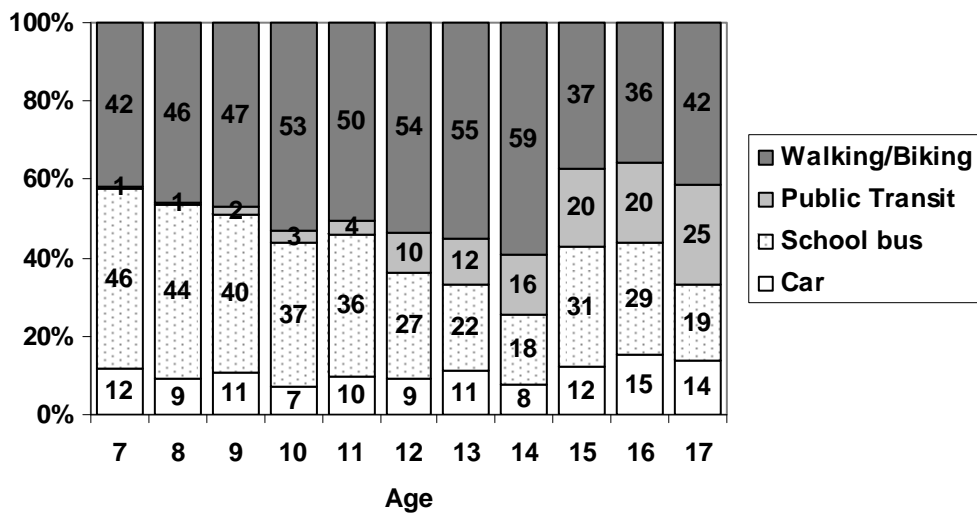


FIGURE 2 Modal Split on Trips to School (Going to School Only) for Students Between Ages 7 to 17 Years.

Analytical Method

Students' modal split analysis based on considered variables were studied to understand how children's travel behavior varies. In addition, a multinomial logit regression model was used to examine the likelihood of a student using cars (parents' car and carpooling), school buses, and public transit (bus and taxi) in comparison to walking/biking in going school. Some of the observed modes with low p-values were merged together to obtain a better significance in the regression. Variables were selected based on findings in the literature. The variables considered in the regression were age, gender, grade, family income, school size, and whether the school was a neighborhood school.

RESULTS OF MODAL SPLIT ANALYSIS

Figures 3 and 4 show the modal split for students, males and females, between ages 7 and 17 years old in traveling to school. For boys aged 7 to 14 walking and biking and using public transit increase considerably, while using school bus decrease with increase in age. For girls aged 7 to 11, the likelihood of using each possible mode in school trips remains constant. For girls aged 12 to 14 walking and biking and using public transit increase. Surprisingly there is a big drop in walking and biking rates for both girls and boys aged 15 to 17. On average only 40% of high school students between ages 15 and 17 walk or bike to school. The results confirmed this conclusion that students between ages 7 and 14 are more likely to walk and bike to school compared to students aged 15 to 17. However, in high schools, the use of school buses decreases with increase in age.

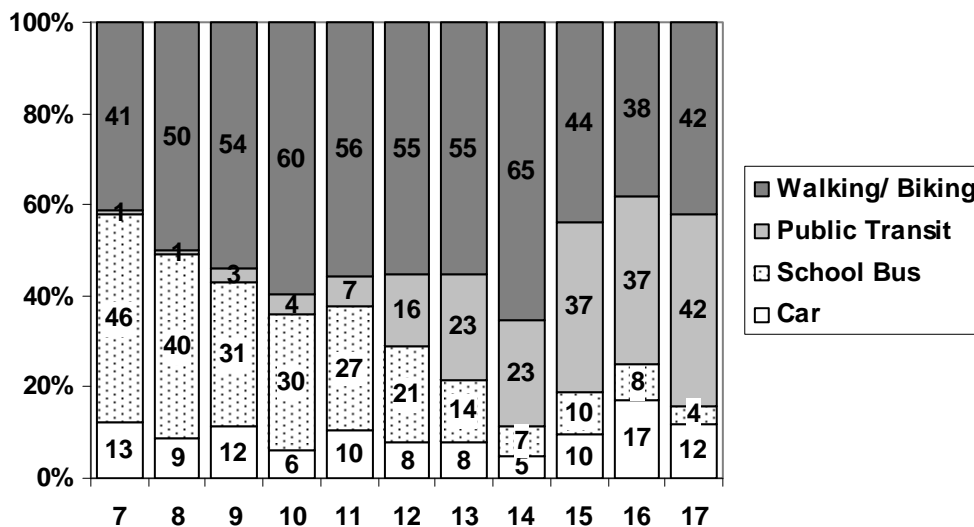


FIGURE 3 Modal Split for Boys Only on Trips to School for 7 to 17 Years Old Students.

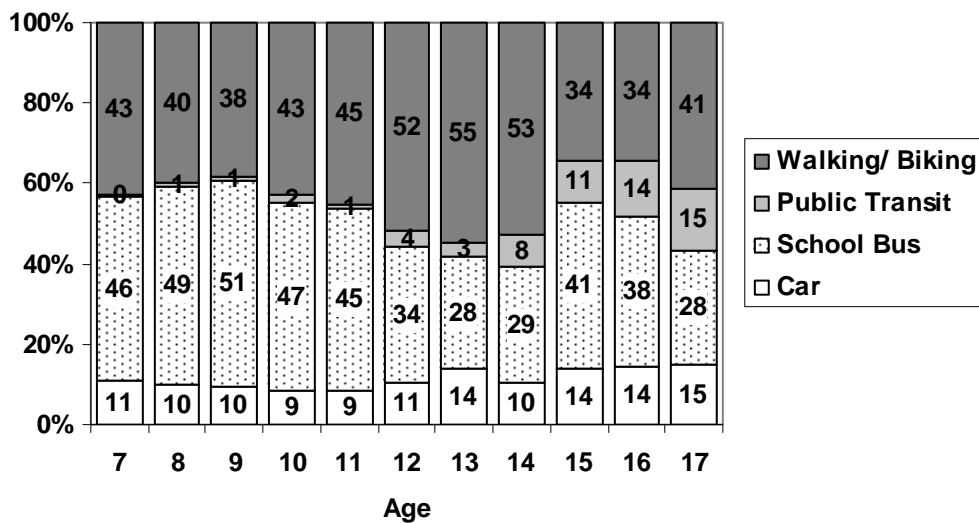


FIGURE 4 Modal Split for Girls Only on Trips to School for 7 to 17 Years Old Students.

Figure 5 shows the modal split for trips to school for male and female students. Results indicate that girls are less likely to prefer walking or biking while they are more likely to use school bus to travel to/from school. Only 42 percent of girls walk/bike to school while more than 50 percent of boys prefer walking or biking. Results show that 38 percent of girls and 22 percent of boys use school bus to go to school. In Figure 6, the modal split for students with different level of income (low, middle and high) has been shown. For students with low level of income, 79 percent walk or bike, 11 percent use public transit and only 5 percent use school bus in school trips. 50 percent of students with middle level of income prefer walking and biking and only 30 percent of them use school bus to travel to school. For students with high level of income, only 19 percent of students walk or bike to school while 51 percent of them use school bus and 16 percent use a car to travel to school.

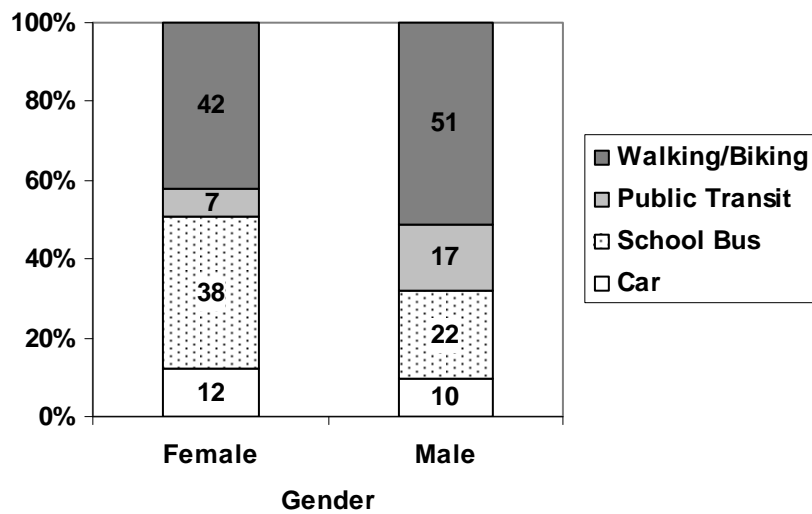


FIGURE 5 Modal Split on Trips to School for Students by Gender.

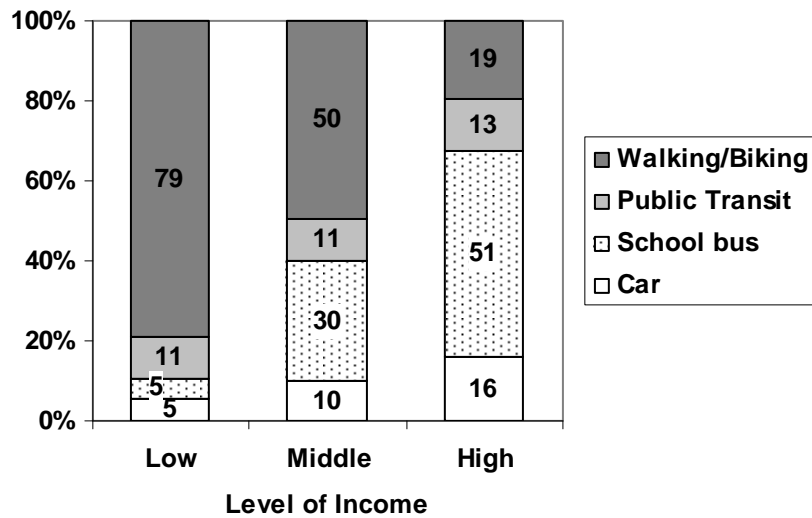


FIGURE 6 Modal Split on Trips to School for Students by Level of Income.

MODEL RESULTS AND DISCUSSION

Table 2 summarizes the multinomial logit model estimates for trips going to school. The table also includes model fitting information, likelihood ratios, and Pseudo R-square values.

TABLE 2 Multinomial Logit Model Parameters for Car, School Bus and Public Transit with Walking/Biking as Base Mode in Trips to School

Variables	Car			School Bus			Public Transit		
	Coeff.	SE	Sig.	Coeff.	SE	Sig.	Coeff.	SE	Sig.
Intercept	-0.314	0.714	0.660*	0.414	0.559	0.459*	-3.299	0.802	0.000
Age	-0.022	0.037	0.556*	-0.133	0.028	0.000	0.102	0.041	0.014
Log(school size)	0.028	0.175	0.871*	0.578	0.141	0.000	0.295	0.198	0.137*
Grade									
Elementary	-0.159	0.269	0.554*	0.139	0.206	0.500*	-1.954	0.310	0.000
Secondary	-0.126	0.152	0.408*	0.015	0.121	0.899*	-0.523	0.150	0.000
High school	0.000	-	-	0.000	-	-	0.000	-	-
Gender									
Male	-0.241	0.088	0.006	-0.839	0.070	0.000	1.294	0.091	0.000
Female	0.000	-	-	0.000	-	-	0.000	-	-
Level of income									
Low	-1.953	0.144	0.000	-2.692	0.133	0.000	-0.994	0.133	0.000
Middle	-1.113	0.104	0.000	-1.039	0.079	0.000	-0.884	0.109	0.000
High	0.000	-	-	0.000	-	-	0.000	-	-
Neighborhood									
No	0.648	0.108	0.000	1.212	0.081	0.000	0.707	0.118	0.000
Yes	0.000	-	-	0.000	-	-	0.000	-	-
Model Fitting Information	Model Fitting Criteria					Likelihood Ratio Tests			
	-2 Log Likelihood					Chi-Square		Sig.	
Intercept Only	7720					-		-	
Final	4074					3646		0	
Pseudo R-Square	Cox and Snell			Nagelkerke			McFadden		
	0.387			0.425			0.202		

The reference category is: Walking and Biking

* Not significant at the 0.05 probability level

For travel by car relative to walking and biking, the standard error for age as a variable is 0.037 with a p-value of 0.556 and the standard error for school size is 0.175 with a p-value of 0.871. If we set our alpha level to 0.05, we would fail to reject the null hypothesis and conclude that the

regression coefficients for age and school size are not satisfactory. A similar conclusion can be made for grade. For boys relative to girls, the relative risk of preferring travel by car to walking/biking would be expected to decrease by a factor of 0.241. In other words, girls are more likely than boys to prefer traveling by car to walking/biking. Findings in the literature suggested that level of income does not significantly influence students travel mode choice (9). These results did not support that conclusion. For students with low income relative to high income, the relative preference for travel by car over walking/biking would be expected to decrease by a factor of 1.953 and for students with middle income, the relative risk to prefer car to walking/biking would be expected to decrease by a factor of 1.113. In other words, students with lower income are more likely than students with higher income to prefer walking/biking to travel by car. For students not in neighborhood schools relative to those in neighborhood schools, the relative risk to prefer travel by car to walking/biking would be expected to increase by a factor of 0.648. In other words, students in neighborhood schools are more likely to walk or bike to school.

For travel by school bus relative to walking and biking, grade as a variable did not reach a satisfactory level of significance. For older students relative to younger, the relative risk factor for preferring travel by school bus to walking/biking with each year increase in age would be expected to decrease by a factor of 0.133. In other words, younger students are more likely than older students to prefer school buses to walking/biking. For students in larger schools, the relative risk factor for preferring travel by school bus to walking/biking with one order of magnitude increase in school size would be expected to increase by a factor of 0.578. In other words, students in larger schools are less likely to prefer walking and biking to taking the school bus. For boys relative to girls, the relative risk to preferring school buses to walking/biking would be expected to decrease by a factor of 0.839. In other words, girls are more likely than boys to prefer taking the school bus to walking/biking. Fear of social/cultural stigma might be a barrier to girls walking and biking to school. For students with low level of income relative to high income the relative risk to preferring taking the school bus to walking/biking would be expected to decrease

by a factor of 2.692 and for students of middle income the relative risk to prefer taking the school bus would be expected to decrease by a factor of 1.039. In other words, students with lower income again are more likely than students with higher income to prefer walking and biking to taking the school bus. Students in non-neighborhood schools relative to students in neighborhood schools are more likely to ride the school bus than walk/bike by a factor of 1.212.

For public transit relative to walking/biking, school size as a variable did not reach a satisfactory level of significance. For boys relative to girls, the relative risk of preferring public transit to walking/biking would be expected to increase by a factor of 1.294. This means boys are more likely than girls to prefer public transit to walking/biking. Students in elementary schools are less likely than high school students to use public transit by a factor of 1.954 and students in secondary schools are also less likely to prefer public transit to walking/biking by a factor of 0.523 relative to high school students. For older students compared to younger, the relative risk factor to prefer public transit to walking/biking with each year older would be expected to increase by a factor of 0.102. Low income students are less likely than high income students to prefer public transit to walking/biking by a factor of 0.994 and middle income students are also less likely than higher income students to use public transit rather than walking/biking by a factor of 0.884. In other words, older students, those in higher grades and those with higher income are less likely to prefer walking and biking to public transit. Boys are also more likely than girls to use public transit. As expected, students in neighborhood schools are also more likely to prefer walking/biking to public transit by a factor of 0.918.

School Size and Neighborhood School Correlation

It was found that there is no strong correlation between school size and whether the school is a neighborhood school. Table 3 shows descriptive statistics for neighborhood and not neighborhood

schools in the database. The total number of schools studied was 78, and 43 of them were neighborhood schools compared to 35 that were not.

As can be seen in Table 5, there was a neighborhood school with as many as 700 students and a non-neighborhood school as small as 97 students. Although the mean number of students in neighborhood schools relative to non-neighborhood schools was smaller, the maximum and minimum number of students in each school does not support a conclusion about the correlation between school size and whether the school is a neighborhood school. In neighborhoods with higher density of population, neighborhood schools can be large while in neighborhoods with lower density, non-neighborhood schools can be so small. Urban factors such as population, density, job mix, and residence-to-jobs balance in addition to school size may have a combined influence on whether the school is neighborhood school, but this requires further research.

TABLE 3 Descriptive Statistics for Neighborhood and not Neighborhood Schools in the Mashhad Database

	School Size (number of students)			
	Mean	S.D.	Min	Max
Neighborhood School				
Yes	266	142	50	700
No	427	208	97	925
Total number of schools		78		
Pearson Correlation Coefficient		-0.421		
Square of Pearson Correlation Coefficient		0.177		

CONCLUSIONS

This study's findings indicate that age, gender, and family income of students and neighborhood characteristics of school affect a student's mode choice. School size and student's grade were two other factors that were examined. Results show that student's age is a stronger variable than

student's grade in student mode choice. It was also found that family income was the most influential factor among the considered variables which contradicts Jensen's result (9). The next greatest factor was proved to be whether the school was a neighborhood school.

The results of the analysis conclude that students with lower income are more likely to walk or bike. While girls are less likely than boys to prefer walking or biking relative to traveling by school buses and cars. It was also confirmed that students in neighborhood schools walk and bike to/from school more. This study also points to the need for more research on the effects of urban factors such as density, residence and jobs balance, and commercial/resident area to enhance understanding of students travel mode choice.

Finally, the findings give transportation professionals and planners a better understanding of some cross-country comparisons of student's behavior. Planners and policy makers can also use the presented methodology and results to evaluate and prioritize Safe Routes to School programs. In this case study, to encourage more students to walk or bike, Safe Routes to School programs should focus on not neighborhood schools, female students, schools that have more students from families with high level of income, and high schools. This study and the literature also suggest that attitudes and culture in different communities are important factors for students' travel mode choice (9).

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