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Potential cost savings of promoting active travel to school

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ABSTRACT

This study is an effort to quantify potential cost savings of children's walking, as a form of active travel to school. The data were collected in Tehran, from a cross-sectional cohort of more than 4700 high school and middle school students. This study looks at a wide range of policy sensitive variables, such as safety and distance to school in various scenarios. The findings indicate if the safety concerns of parents associated with their children walking to school are alleviated, the direct and indirect annual costs of obesity decreases by US$719 per student. Further, a 1% decrease in the distance from home to school diminishes the annual per capita health costs associated with obesity by about US$30. However, the amount of financial savings varies among different segments of society. For instance, tackling parental safety concerns advances active travel modes, particularly among girls and high school students, while low income families experience the smallest increase in active modes.

1. Introduction

Occurrences of obesity among children have increased dramatically in recent decades (Ogden et al., 2006). A study in the U.S. showed that among students aged 6 to 11 the predominance of obesity had increased from 6% to 20%, and among students aged 12 to 19 it had increased from 5% to 18% (Ogden et al., 2006). Obesity increases the risks of common diseases including myocardial infarction, stroke, type II diabetes, cancer, hypertension, depression, osteoarthritis, and asthma (Ebbeling et al., 2002) so greatly that about 21% of the U.S. healthcare and medical budget is spent for the overweight and obesity related health issues (Cawley and Meyerhoefer, 2012). The statistics are also applicable to Iran, where almost half of the Iranians aged between 15 and 65 are overweight or obese (Janghorbani et al., 2007). Recent studies indicate that prevalence of obesity in Iran is more than that in China (0.5% to 1.5%), Thailand (6.8%) and Singapore (5.9% to 8.5%), but less than the obesity rate in Turkey (14.1% to 32.4%) and the U.S. (20% to 25%) (Janghorbani et al., 2007).

Physical activity and a healthy diet are two well-recognized ways of controlling obesity. The U.S. Surgeon General declared regular moderate physical activity as a key contributor to a healthy lifestyle (Lifshitz and Hall, 2002). Children are recommended to do physical activities such as walking or biking to school. Hence, some researchers (Cooper et al., 2005; Sirard et al., 2005) are optimistic of diminishing the prevalence of obesity by encouraging active modes of travel in school trips. Yet, the share of active modes in school trips has decreased in recent years. A study in the U.S. showed the use of active modes in school trips had dropped from 40.7% to 12.9% between 1969 and 2001 (McDonald, 2007a). A similar study in Toronto, Canada, also showed the share of walking had declined from 53.0% to 42.5% for schoolchildren 11–13 years and 38.6% to 30.7% for schoolchildren 14–15 years between 1986 and 2006 (Buliung et al., 2009).

Policymakers are struggling to find solutions for children's travel mode to school. For example, "walk school bus" and "safe routes to school" programs aim to promote walking by addressing parental safety concerns (Staunton et al., 2003). This has a substantial economic burden on the government to improve infrastructures, to educate, and to promote and enforce the required tasks to encourage active modes of travel. SAFETEA-LU (2005), for instance, allocated more than $600 million in 2005 to encourage safe routes to school in the U.S. Therefore, it is imperative to reveal the economic returns of such policies, in particular for policymakers and urban planners. Promoting active modes of travel has the added benefits of: (1) The reduction in network congestion (Department of the Environment and Heritage, 2004), (2) positive environmental impacts such as a decrease in air pollution and energy consumption (Wilson et al., 2007), and (3) positive physical and mental health outcomes (Sallis et al., 2004).

This study quantifies the potential health cost savings of children's walking not only as a travel mode to school, but also as an access and egress mode to public transit. We explore two major points: children's travel behavior and the health benefits of walking in Tehran, Iran. The paper unfolds as follows. The literature of both health benefits of

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physical activity and mode choice of school trip are reviewed, followed by a discussion on the research method, and a description of the employed data for the analysis. Then, a three-level nested logit model is tested to scrutinize the influential variables on mode choice decisions of school trips. Using the model, selected policies promoting active modes of travel to school are evaluated in terms of their cost savings in the health care. The paper concludes with remarks that underscore potential benefits in active modes of travel to school and suggestions for future studies.

2. Background

This section provides a background on how the health benefits of physical activity are quantified, followed by a review on the research that discusses children's tendencies to walk in school trips. This research is not to introduce a new cost estimation method, but rather to apply a conventional approach to quantify the health benefits of promoting active modes of travel among students. Therefore, reviews of both subjects are essential.

2.1. Health benefits of physical activity

Physical activity aids in obesity prevention, especially in children (Sallis et al., 2004), although there are other physical and mental benefits as well (Lawlor and Hopker, 2001). One reason for such a tendency is that obesity itself stimulates several other diseases to the extent that more than 20% of the healthcare expenditures in the U.S. are associated with obesity (Cawley and Meyerhoefer, 2012). Table 1 compares some studies that investigated obesity costs in different countries. As seen, these costs vary among different European countries and account between 0.09% and 0.61% of their GDP (Fry and Finley, 2005). Similarly, studies in Canada (Birmingham et al., 1999) and Australia (Segal et al., 1994) found that around 0.2% to 0.6% of their GDP is spent on obesity related costs. Studies in the United States (Wolf and Colditz, 1998; Colditz, 1992) show that obesity related costs are between 70 and 90 billion dollars, which is about 0.95% to 1.74% of the GDP. This amount might be due to higher prevalence of obesity in the U.S. (Müller-Riemenschneider et al., 2008). Obesity costs are classified into direct and indirect costs, with much less awareness from the latter (Fry and Finley, 2005). Direct costs are usually defined as a dollar value of personal healthcare, hospital-care, nursing services, and medication costs. Indirect costs are generally defined as the value of lost productivity due to sickness or early death (Colditz, 1992). Few studies (Popkin et al., 2006; Borg et al., 2005) have investigated direct and indirect obesity costs separately. Popkin et al. (2006) found in China that direct and indirect obesity costs account for 0.48% and 3.58% of the GDP, respectively.

There are two common approaches to quantify obesity costs. First, diseases that are caused by obesity are determined along with the magnitude of their effect. Having the costs of each specific disease, the obesity cost is then estimated. A study (Colditz, 1992) in the U.S. showed that poor health is rooted in obesity. In 1992, 57% of individuals with type II diabetes and 90% of the people with gallbladder disease caused by obesity cost 11.3 and 2.4 billion dollars in health costs, respectively. Further, Colditz (1992) argued that 19% of expenses related to cardiovascular diseases (around 22 billion dollars) are due to obesity. This study also pointed out that the economic cost of obesity is around 5.5% of total healthcare costs, which is approximately 39.3 billion dollars.

In the second approach, total healthcare expenses are collected in a specified period of time. Then, itemized costs, including hospitalization, doctors' visits, and non-functionality periods, are approximated based on the manuals such as Working Group Methods in Health Economic Evaluation (Krauth et al., 2005). Finally, costs of obesity are estimated pursuant to the observed Body Mass Index (BMI) for a sampled population. Wolfenstetter (2012) conducted a study based on this approach among 2581 individuals aged 25 to 65 in Germany. The information on hospitalization and ambulatory care of individuals in a 12-month period was gathered through personal interviews, along with additional information on weight and height. The result showed that direct and indirect costs are, respectively, 1093 and 2474 Euros per year for people suffering from obesity.

2.2. School trip behavior and health benefits of active modes of travel

The school trip behavior has become a hot debate among policymakers and academics (Ermagun and Levinson, 2016). Recent research, which supports these concerns, focuses mainly on students' health and the side effects of school trips' from a city planner's point of view. Policymakers are looking for new ways of promoting physical activity in the student's daily routine. Studies recommend at least 60 min of daily physical activity for students (Salmon and Timperio, 2007). These recommendations can be partially realized through various travel modes, including, walking, biking, and taking public transit during school trips (Tudor-Locke et al., 2001).

Studies (Ermagun et al., 2015a, 2015b; McDonald, 2008a; Schlossberg et al., 2005, 2006; Dellinger and Centers for Disease Control Prevention, 2002) have been conducted to explore the

Table 1
Summary of Obesity Costs Studies.

First Author	Year	Country	Obesity Costs (US$ 2012)		Investigated Cases
			Direct	Indirect	
Colditz	1992	U.S.	9.81 billion	–	Type II diabetes, cancer, gallbladder, hypertension, cardio-vascular
Segal	1994	Australia	904 million	–	Type II diabetes, coronary arteries, hypertension, gallbladder, breast and colon cancer
Wolf	1998	U.S.	79 billion	–	Type II diabetes, cancer, gallbladder, hypertension, cardio-vascular, muscular
Swinburn	1997	New Zealand	129 million	–	Type II diabetes, coronary arteries, hypertension, gallbladder, breast and colon cancer
Seidell	1995	Netherland	930 million	–	Overall treatment costs
Levy	1995	France	7.3 billion	–	Hypertension, gallbladder, breast and colon cancer, prostate, joint sclerosis, myocardial infarction, gout
Thompson	1998	U.S.	10.6 billion	–	Type II diabetes, coronary arteries, hypertension, hyperlipidemia, stroke, gallbladder
Birmingham	1999	Canada	1.6 billion	–	Type II diabetes, coronary arteries, hypertension, hyperlipidemia, stroke, gallbladder, breast cancer, lung obstruction
Popkin	2006	China	7.6 billion	57 billion	Hospital costs, doctor visit costs, medicine, inability, disability, mortality
Pereira	2000	Portugal	298 million	–	Type II diabetes, coronary arteries, hypertension, gallbladder, breast and colon cancer
Fu	2008	Taiwan	5.6 billion	–	Cardiovascular disease, hypertension, diabetes, hyperlipidemia, stroke, vascular
Borg	2005	Sweden	310 million	423 million	Hospital costs, costs related to premature death
Sepulveda	2010	U.S.	2907 mean dollars per person		Overall treatment costs
Tran	2013	Canada	1.27 to 11.08 billion dollars		A systematic search of costs associated with obesity or intervention program
Nasir	2015	U.S.	598 to 2695 dollars per person		CDC's Obesity Cost Calculator

Note: These are general cost of obesity and not directly reflective of school children, and are converted to US$ 2012 for ease of comparison.

Table 2
Summary of School Trip Studies.

First Author	Year	Country	Age of Sample	Modes			Mode Choice Method						Female	
				Active (walk/ Bike)	Autom-obile	Public Transit	School Bus	Descrip-tive	Binary Logit	Multin-omial Logit	Nested Logit	Logistic Regress-ion	Active	Autom-obile
Ermagun	2015	Iran	12–17	×	×	×	×				×		+	–
Loureiro	2014	Portug-al	13–15	×	×	×				×			+	
Dave	2013	India	7–15				×		×			×		
Park	2013	U.S.	–	×	×	×	×		×					
Deka	2013	U.S.	5–15	×	×					×				
Samimi	2012	Iran	12–17	×	×	×	×		×				+	
McDonald	2012	U.S.	5–18	×	×	×	×			×			–	
Johansson	2012	Sweden	11–15	×	×	×		×					–	
Alemu	2011	Japan	15–18	×	×	×				×				
Leslie	2010	Austral-ia	10–14	×	×	×			×				+	
Wilson	2010	U.S.	7–12	×	×	×				×				
Mitra	2010	Canada	11–13	×	×				×					
Zwerts	2010	Belgium	10–13	×	×	×	×	×						
Larsen	2009	Canada	11–13	×	×	×	×					×		
Marshal	2010	U.S.	5–12	×	×		×			×				
McDonald	2009	U.S.	10–14	×	×	×	×	×						
Yarlagadda	2008	U.S.	< 18	×	×	×	×			×			–	+
Wen	2008	Austral-ia	9–11	×	×	×						×	–	
McDonald	2008a	U.S.	7–14	×	×	×				×			–	+
McDonald	2008b	U.S.	5–18	×	×	×	×		×				–	
McMillan	2007	U.S.	9–11	×	×				×				–	+
Martin	2007	U.S.	9–15	×					×					
Mota	2007	Portug-al	12–16	×	×	×			×					
Kerr	2007	U.S.	5–18	×								×	–	
Kerr	2006	U.S.	5–18	×								×		
Merom	2006	Austral-ia	5–12	×	×	×		×					–	
Timperio	2006	Austral-ia	5–6, 10–12	×								×	–	
Schlossberg	2006	U.S.	12–15	×	×	×						×	–	
Schlossberg	2005	U.S.	12–14	×	×	×		×					–	
Ewing	2004	U.S.	7–18	×	×		×			×				

First Author	Female	Age			Income			Distance			Safety		
	Public Transit	Active	Autom-obile	Public Transit	Active	Autom-obile	Public Transit	Active	Autom-obile	Public Transit	Active	Autom-obile	Public Trans-it
Ermagun	–	+	–	+	–	+		–	+	+	–	+	–
Loureiro		+									–		
Dave													
Park					–	–					–		
Deka					+	+		–	–				

(continued on next page)

Table 2 *(continued)*

First Author	Female	Age			Income			Distance			Safety		
	Public Transit	Active	Autom-obile	Public Transit	Active	Autom-obile	Public Transit	Active	Autom-obile	Public Transit	Active	Autom-obile	Public Trans-it
Samimi		−			−			−			−		
McDonald								−			−		
Johansson		−											
Alemu													
Leslie													
Wilson		+		+		+		−	−				
Mitra		+			−			−					
Zwerts		+			−			−			−		
Larsen					−			−					
Marshal		+		+				−		+			
McDonald											−		
Yarlagadda			+	+				−	+				
Wen									+				
McDonald	−	+		+	−	+	−		+				
McDonald		+			−			−					
McMillan	−	+			−	+	−				−		
Martin		−									−		
Mota		−											
Kerr		+			−			−					
Kerr											−		
Merom		+			−			−					
Timperio		+			−			−					
Schlossberg		+			−			−					
Schlossberg		+			−			−					
Ewing					−			−					

Note: + and − signs are, respectively, positive and negative correlation between dependent and independent variables.

desirability of each travel mode, especially walking, in school trips. From the methodology side, most of the studies utilized descriptive statistics (Dellinger and Centers for Disease Control Prevention, 2002) or binary logit formulation (Schlossberg et al., 2005, 2006) to investigate the effect of interest variables on travel mode choice decisions. Only a few took advantage of multinomial logit model (McDonald, 2008a), and rarely used nested logit model specifications (Ermagun and Samimi, 2015).

Table 2 provides a summary of selected studies with a focus on modeling methods and variables of interest. As per Table 2, influential parameters fall into three major categories: students' characteristics, households' characteristics, and built environment variables. Students' age and gender are among the most important characteristics that influence travel mode choice. However, there are contrary findings that could be explained by the difference in sampled data and modeling approach. Household income, parental education, and car ownership are among household characteristics that affect mode choice in school trips. Some studies (McDonald, 2008a) found a negative correlation between these variables and use of active modes of travel, meaning that more affluent people are less inclined to have their children walk to school. Among urban design and built environment variables, travel distance from home to school and population density are indicated to be influential. All previous studies (Ermagun and Samimi, 2016; Ermagun et al., 2016; Wilson et al., 2010; Ewing et al., 2004), unanimously, declared an inverse relationship between travel distance and walking to school. McMillan (2007), for instance, showed that students who reside less than 1 mile away from school tend to use active modes three times more. Mitra (2013) explored school travel behavior in transportation, urban planning, health, and environmental psychology disciplines in a review paper and summarized some of the existing evidences. Fyhri et al. (2011) recognized traffic and convenience for the parents as primary reasons for taking children to school by car in Denmark, Finland, Great Britain and Norway. However, Zhu and Lee (2009) found distance and safety concerns as the primary factors that correlate with propensity to walk to school in Austin, Texas.

3. Survey design and descriptive statistics

Tehran has an area of over 700 km^2, and a population of around 8 million, almost 15% of which are students (Municipality of Tehran, 2006). According to official Iranian government sources, there are 566,331 middle and high school students in the city of Tehran, 4700 of which are sampled in this study. The data collection effort and the descriptive statistics about the travel behavior of students in Tehran are discussed as follows. The data used in the analysis are also depicted in Table 3.

3.1. Data collection

Four categories of data are used in this study: built environment characteristics, transportation system specifications, students' travel data, and households' demographics. The first two categories were obtained from the latest transportation master plan (Municipality of Tehran, 2006) that includes population density, travel time, and cost of each travel mode. To collect data for the other two categories, a revealed preference survey was conducted among 4700 students 12–17 years old in May 2010 in Tehran. We selected students using a stratified sampling method to control for gender, age, and residential zone from 94 middle and high schools. We distributed a questionnaire among the students, and asked for their parents to fill out the survey. The survey included 19 questions, and was divided in two sections. The first section addressed socioeconomic and demographic information, such as number of children, level of education, car ownership, number of driver licenses in the household, occupation, and level of income. The second section covered school trip information such as travel modes to and from school, parental concerns in choosing travel modes, walking time to school, and transportation costs. Out of 4700 distributed questionnaires, 3441 were completed and returned to school. This resulted in 73% return rate. However, many surveys had to be thrown out due to incomplete information causing the sample size to drop to 3272. For further information on the survey method and the data collection effort, we refer the reader to Ermagun and Levinson (2017) and Ermagun and Samimi (2017).

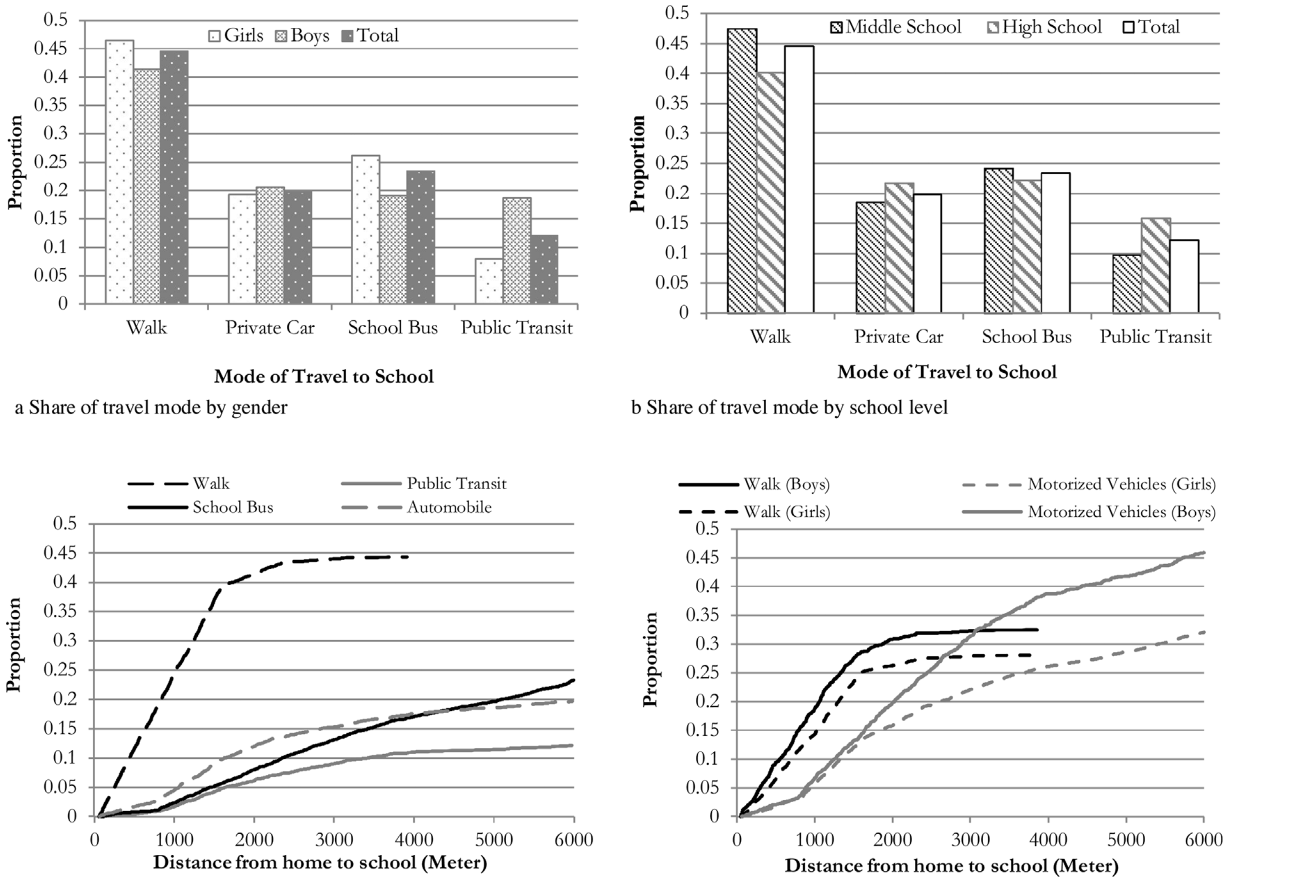
3.2. Descriptive statistics

The descriptive analysis indicates 43% of students chose to walk to school in the morning, and 49% in the afternoon. More parents reported driving their children to school in the morning, when they are on their way to work, and the student walking home in the afternoons when the parent does not have the option to leave work to drive them home. For students, there is less of a time issue in the afternoon, giving them the ability to spend more time walking home. Further, girls chose to walk home from school at a higher rate, allowing them to socialize with friends after school. Due to Iranian cultural norms, girls have fewer after-school outdoor activity options, so this gives them the ability to see their friends socially outside of school. One-third of parents reported driving from home only to take their child to school, while another 35% of parents drove their child on the way to work. For the trip home, 38% of parents reported driving to the school to pick up their

Table 3
Description of Explanatory Variables Used in the Model.

Variable	Description	Average	Std. Dev.
DISTANCE	Distance between home and school (meter)	979.29	576.80
GENDER	1: Male/0: Female	0.40	NA
AGE	Age of children between 12 and 17 years old	14.10	1.61
LEVEL	1: High School/0: Middle School	0.39	NA
AUTO	Number of cars in a household	1.01	0.68
INCOME	1: Less than 5/2: 5–10/3: 10–15/4: 15–20/5: 20–25/6: more than 25 million Iranian Rials[a] household income	2.11	1.23
SAFETY	1: If parents are primarily concerned about their children travel safety/0: Otherwise	0.31	NA
COMFORT	1: If parents are primarily concerned about their children travel comfort/0: Otherwise	0.18	NA
TRF_LIMIT	1: Students that live or study in a limited traffic zone/0: Otherwise	0.11	NA
AUTO_TIME	Automobile travel time to school (minute)	9.91	8.75
EDUCATION	Educational level of parents 1: less than a high school diploma/2: high school diploma/3: bachelor of science/4: master of science or equivalent/5: higher degrees	2.02	NA
HIGH_EDU	1: If EDUCATION is greater than 2/0: Otherwise	0.25	NA
WALKTRNT	Distance between home and the nearest bus station (meter)	571.21	449.72
POPDENS	Population density in each zone (person per m^2)	0.02	0.01
ESCORT	1: If parents accompany their kid to school/0: Otherwise	0.36	NA
NORM_COST	Out-of-pocket automobile travel cost (10 Rials) divided by INCOME	212.04	118.84

[a] 11,800 Iranian Rails was equivalent to 1 USD in May 2011.



a Share of travel mode by gender

b Share of travel mode by school level

c Cumulative density function of travel mode over distance

d Cumulative density function of travel mode over distance by gender

Fig. 1. Data Descriptive.

child, while 16% reported picking up their child on their return home from work.

Overall, girls were more likely than boys to choose active modes of transportation to and from school. However, because girls are not permitted to ride bicycles in Tehran, the 1.3% of students who chose biking was excluded from the analysis. For the purpose of clarity, school buses in Tehran are not free like in most Western countries. This mode of transportation is considered the most expensive, as schools charter these buses at the request of the parents and they act more like private car services, offering door-to-door service for the students. Fig. 1 shows a descriptive modal split among schoolchildren stratified by gender and level of education.

4. Methodology

The framework of this research is comprised of four major steps to estimate the cost benefits of promoting active travel modes among students (Fig. 2).

The first step consists of using a three-level nested logit model to expound on how school travel mode decisions are made. Logit models are widely used in analyzing discrete choice situations because of their closed-form probability function that simplifies the estimation and interpretation of the model (Train, 2009). In multinomial logit models, error terms are assumed to be independently and identically distributed (IID). This leads to the IIA (independence of irrelevant alternatives) property that implies the ratio of the probabilities of two alternatives is not changed when the utility of a third alternative varies (Train, 2009). This is not true in some school trip mode choice situations. For instance, when walking becomes less attractive for a family for safety issues, other alternatives are more likely to be chosen. However, school bus is expected to become more appealing compared to public transit, as the latter mode has its safety concerns for the family. This faulty result happens when travel safety could not be quantified and entered into the model as an exogenous variable, and therefore its effect is transferred to the error component. In such situations, a nested logit model structure could partially solve the problem. Alternatives with correlated error terms are grouped into a nest to avoid the IID assumption (McFadden, 1978). Nested logit models still benefit from a closed-form probability function, and allow for more flexible substitution patterns (McFadden, 1978). The third and second levels of a three-level nested logit model are, respectively, called trunk and branch; actual choices are placed in the lowest level. Coldren and Koppelman (2005) formulated the choice probability in a three-level nested logit model as per equation 1. In this equation, choices, branches, and trunks are respectively denoted by i, n, and m. The probability of choosing i in the trunk m and branch n is the probability of choosing m, conditional on choosing n, and also conditional on choosing i. τ_m and τ_n are also estimated using equations 2 and 3. μ is called the nest parameter which is a measure of the independence between the unobserved values of alternatives in a nest. McFadden (1978) proved that if the nest parameter falls in the range of 0 to 1, then a nested logit model will be compatible with utility maximization behavior. In general, the nest parameters for a trunk must be greater than the nest parameters of the branches under that trunk.

$$P_i = P_m \times P_{n|m} \times P_{i|n} = \frac{exp\left(\frac{1}{\mu_m}\tau_m\right)}{\sum_{m' \in M} exp\left(\frac{1}{\mu_{m'}}\tau_{m'}\right)} \times \frac{exp\left(\frac{\mu_m}{\mu_n}\tau_n\right)}{\sum_{n' \in N} exp\left(\frac{\mu_m}{\mu_{n'}}\tau_{n'}\right)} \times \frac{exp(\mu_n V_i)}{\sum_{i' \in n} exp(\mu_n V_{i'})} \quad (1)$$

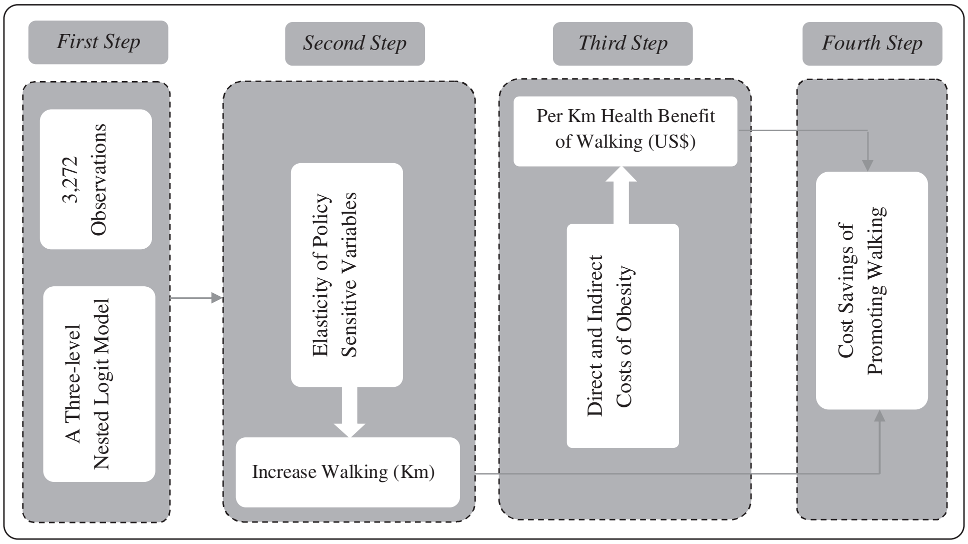


Fig. 2. Framework of the Study.

$$\tau_n = ln\left(\sum_{i' \in N_j} exp\left(\mu_n V_{i'}\right)\right) \quad (2)$$

$$\tau_m = ln\left(\sum_{n' \in N_m} exp\left(\frac{\mu_m}{\mu_{n'}}\tau_{n'}\right)\right) \quad (3)$$

In the second step, the elasticity of policy sensitive variables is accessed using the estimated model. Elasticity of a variable is the percentage change in the probability of the decision variable, when the variable of interest is increased by 1% (Hensher et al., 2005). An elasticity of −0.2 for travel distance, for instance, implies that students' probability to walk is increased by 0.2% for every percent decrease in the home to school distance. To estimate the elasticity, the change in the probability of the decision variable should be calculated for each individual observation and then averaged over the entire sample. To calculate the direct and cross elasticity of continuous variables, equation 4 and equation 5 are used, respectively (Wen and Koppelman, 2001). The direct elasticity formula is collapsed to $(1 - P_i)\, \beta x_i$ when i is assigned to a single nest with no other alternatives. Likewise, the cross elasticity is collapsed to $-P_n \beta x_i$ in this condition. This concept of elasticity could not be applied to 0–1 variables, such as *Safety*, since 1% change in a dummy variable is meaningless (Hensher et al., 2005). Instead, pseudo-elasticity is used that implies the magnitude of change in the probability of the decision variable when the dummy variable is increased from 0 to 1.

$$\text{DirectElasticity} = \frac{\sum_n P_n P_{i|n}\left[(1 - P_i) + \left(\frac{1}{\mu_n} - 1\right)(1 - P_{i|n})\right]}{P_i}\beta x_i \quad (4)$$

$$\text{CrossElasticity} = -[P_i + \frac{\sum_n \left(\frac{1}{\mu_n} - 1\right)P_n P_{i|n} P_{i'|n}}{P_{i'}}]\ \beta x_i \quad (5)$$

In the third step, the costs of obesity for each person, both direct and indirect, are determined. Comprehensive studies that quantify obesity costs are rarely conducted in Iran and very sporadic worldwide. Edwards (2008), for instance, translated minutes spent walking into energy consumption and the reduction in obesity prevalence. He found that the return cost of 8.3 min moderate walking is almost $4500 dollars annually. However, in a more detailed study, Genter et al. (2008) showed that direct and indirect obesity return costs of one kilometer of moderate walking is US$4.27 per person. Outputs of the latter study are utilized to translate obesity cost returns of different policies that target school trip modal selection behaviors.

In the fourth step, economic benefits are estimated for the reduction of obesity in regard to the policy sensitive variables of interest, namely home-to-school distance and safety. The results are discussed for different segments of population with respect to gender, age, income, and car ownership. The health cost saving is calculated in three phases:

1. We transformed the walking travel time to distance for home to school along with the access and egress of public transit. The walking times were asked in the questionnaire and modified by Google maps information, inputting the origin and destination of each trip. Assuming an average walking speed of 4.8 km/h for students (O'Sullivan and Morrall, 1996), we finally converted the walking travel times to distance.
2. We calculated the average change in walking distance using the elasticity value of interest parameters for walking and public transit modes of travel. Public transit encompasses walking for children who walk in their access and egress. Thus, this walking travel distance is also considered in the analysis.
3. We finally multiplied the average change in walking distance by US $4.27, the direct and indirect obesity returns of one kilometer of moderate walking. This health savings is estimated among different segments of population. Although adopting the U.S. cost rates may be argued due to the differences in health care system and medical costs, we employed such rates due to unavailability of reliable local data.

5. Model and results

A three-level nested logit model is used to explain school travel mode choice. As shown in Fig. 3, travel modes are classified in two general categories: active and non-active modes. Walking is the only mode in the *active* nest, as cycling is omitted from the data due to the infrequent usage in Tehran. Transit, private car, and school bus are classified under the *non-active* nest. *Non-active* nest extends into two sub-nests, namely *transit* and *private*. The latter is then divided into *school bus* and *private car*. The developed tree structure has a better fit than other possible structures, as per pseudo McFadden R squared statistical test.

Table 4 represents the estimates of the model based on the final nesting structure. The nest parameters are fixed to 1 for *active* nest and *transit* sub-nest, since they include only one alternative (Hensher et al., 2005). The other nest parameters, however, are determined in a full information maximum likelihood estimation process. As seen, the nest parameters are significantly greater than 0 according to the student's *t*-

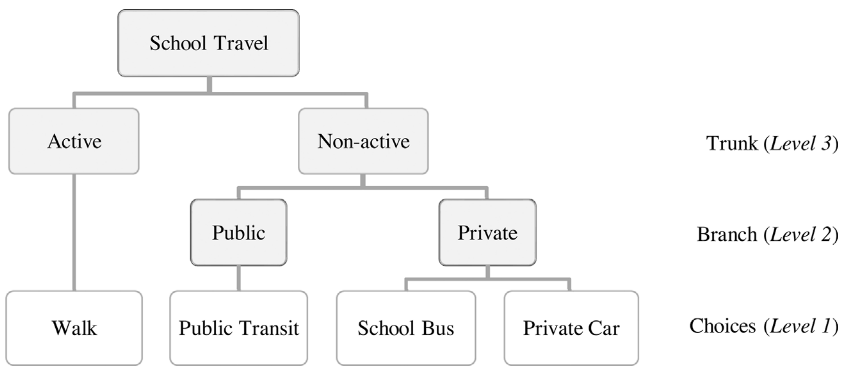


Fig. 3. Tree Structure for the Three-level Nested Logit Model.

Table 4
Results of the Nested Logit Model.

Variables	Alternatives	Coefficient	t-Value	Standard Error
Constant	Automobile	−6.370***	−2.92	2.181
AUTO_TIME		−0.027***	−4.06	0.006
NORM_COST		−0.002***	−4.62	0.000
AUTO		0.44***	3.84	0.115
Constant	School Bus	−6.186***	−2.70	2.288
AGE		−0.123***	−3.10	0.039
TRF_LIMIT		0.667***	2.78	0.243
INCOME		0.443***	6.85	0.064
COMFORT		0.512***	3.61	0.142
Constant	Public	−7.452***	−3.79	1.967
TRF_LIMIT		1.818***	6.79	0.267
AGE		0.155***	3.23	0.048
GENDER		1.09***	7.11	0.153
SAFETY		−0.579***	−3.65	0.158
AUTO		−0.822***	−5.39	0.152
WALKTRNT		−0.0006***	−3.27	0.000
INCOME		−0.304***	−2.74	0.111
HIGH_EDU		−0.753***	−3.90	0.193
SAFETY	Walk	−1.667***	−11.40	0.146
AUTO		−0.548***	−4.43	0.123
POPDENS		11.815***	2.52	4.682
ESCORT		−1.874***	−12.49	0.150
GENDER		−0.357**	−2.30	0.155
DISTANCE		−0.001***	−16.18	0.000
TRF_LIMIT		0.733***	2.55	0.287
HIGH_EDU		−0.387***	−2.45	0.158
Inclusive value parameters:				
Non Active		0.77***	3.37	
Active		1	Fixed Parameter	
Private		0.64***	2.78	
Public		1	Fixed Parameter	
Restricted log likelihood		−3,686.84		
Log likelihood at convergence		−2,354.24		
McFadden Pseudo R-squared		0.36		
Sample size		3272		

Note: ***, **, * means significance at 1%, 5%, 10% level.

test and significantly less than 1 according to the Wald test. They thus comply with the utility maximization theorem and the tree structure proposed in Fig. 3 does not collapse to a multinomial logit model. Log-likelihood ratio statistic with a Chi-squared test is used to evaluate the model fit (McFadden, 1978). We used the student's *t*-test to investigate the significance of each individual coefficient. The variables of students' characteristics, household specifications, built environment variables, and parental reservations were significant in the model, and are elaborated as follows.

5.1. General discussion

Age and gender of students were found significant among the student characteristics. We found a negative correlation between age and probability of school busing, and positive correlation between age and taking public transit. This may be due to the tendency of older students to seek independence (Loureiro and Gaspar de Matos, 2014; Mitra et al., 2010; McDonald, 2008b). We found girls more likely to walk, and less likely to take public transit. Due to some cultural and social limitations for girls in Tehran (Samimi and Ermagun, 2012), they may have less opportunity to participate in outside school activities, which makes them more willing to walk to school and find more independent opportunities to socialize.

Number of vehicles, family income, and parental education were found effective among the household characteristics. In accordance with previous studies (Zwerts et al., 2010; McDonald, 2008a), we also found a greater probability of taking public transit and walking diminishes as car ownership increases. This may be attributed to the low cost of private car use in Tehran. Further, high-income households are more likely to use school buses, as this type of service is provided by the private sector and low-income families cannot generally afford it. Similarly, parents with at least a college degree have less probability of using public transit or walking.

Travel distance, access to transit station, population density, and travel time/cost are among the built environment characteristics that are found significant in the model. As expected, travel distance and willingness to walk are negatively correlated. Similarly, better access to transit stations motivates the use of public transit to school. We further found a positive association between population density and willingness to walk. This tendency is attributed to higher levels of safety in more dense areas. Auto travel time and cost were also found instrumental on transportation mode choice with a negative impact on private car desirability. It should be noted that we have set non-chosen mode attributes to zero. Normalized auto travel cost (cost over income) is used in the model to demonstrate a systematic taste variation among households with different levels of income (Train, 2009).

Comfort and safety are two significant dummy variables in the model that show parental reservations about their children's travel mode. In line with previous studies (Loureiro and Gaspar de Matos, 2014; McDonald and Aalborg, 2009), we found safety is the first and foremost concern of parents who do not encourage walking and public transit modes in school trips. It could be because the Tehran transit system is overcrowded and unreliable, in particular, during morning peak hours when children are travelling to school. A study in the United States (Transportation Research Board, 2002), for example, stated that the rate of injury and death among children who walk or bike to school is 40% more than children who use school bus or private car. Similarly, another study (Roberts et al., 1995) in New Zealand showed that accident probability is 14 times more likely for students who walk in congested streets with more than 750 vehicles per hour than that in streets with less than 250 vehicles per hours. Such concerns triggered more than 50% of parents to personally pick up and drop off their children (Boarnet et al., 2005). We found that parents are also concerned about their children's travel convenience on school trips. Similar to previous studies (McDonald and Aalborg, 2009), the results show

Table 5
Elasticity and Pseudo-elasticity of Interest Variables.

Attribute	Primary Alternative	Public	Automobile	School Bus	Walk
Elasticity of Continuous Variables					
Auto_time	Automobile	0.056	−0.190	0.071	0.030
Auto	Public	−0.730	0.099	0.099	0.049
	Automobile	−0.126	0.291	−0.156	−0.066
	Walk	0.197	0.197	0.197	−0.356
Norm_cost	Automobile	0.134	−0.449	0.173	0.069
Age	Public	1.817	−0.378	−0.378	−1.175
	School Bus	0.420	0.530	−1.208	0.227
Income	Public	−0.565	0.082	0.082	0.039
	School Bus	−0.290	−0.354	0.589	−0.164
Walktrnt	Public	−0.283	0.051	0.051	0.024
Popdens	Walk	−0.142	−0.142	−0.142	0.147
Distance	Walk	0.598	0.598	0.598	−1.940
Pseudo-elasticity of Dummy Variables					
High_edu	On Average	−37.35	32.99	32.99	−12.91
Escort	On Average	115.38	115.38	115.38	−67.13
Safety	On Average	21.96	117.70	117.70	−59.92
Comfort	On Average	−10.54	−13.60	44.24	−4.57
Trf_limit	On Average	148.43	−61.38	−23.93	9.05

that parents, who are concerned about their child's convenience, are more inclined toward school bus.

5.2. Elasticity analysis

Table 5 shows the elasticity of interest variables. The elasticity of *AUTO_TIME* variable shows that a 1% increase in private car travel time diminishes the probability of choosing this mode of travel by 0.190%. As a result, the probability of public transit, school bus, and walking increases by 0.056%, 0.071%, and 0.030%, respectively. A 1% increase in home-to-school distance decreases the probability of walking by 1.940%. However, the probability of other modes of travel increases by 0.598%. An increase of 1% in population density has a positive correlation with probability of walking by 0.147%.

The pseudo-elasticity analysis indicates the change in probability of choosing various modes of travel, when the value of dummy variables shifts from 0 to 1. The results of *SAFETY* variable, for instance, show parental safety concern may diminish the probability of walking by 59.92%. The probability of driving and school busing increases by 117.70% among these families. If parents accompany their child to school, it is less probable to walk by 67.13%. It is interesting to follow the elasticity of other variables in Table 5.

6. Policy assessment

This section argues for an estimation and discussion on the expected economic savings from obesity reduction due to active travel modes to school. As shown in Table 6, obesity costs are estimated for two major policies: (1) to improve the level of safety for school trips and (2) to decrease home-to-school distance by advocating neighborhood schools. Each item is further discussed in two parts: discussing practical ways to implement the policy and identifying the expected monetary saving for obesity reduction. To calculate the daily return cost per capita, we multiplied the daily walking increase in kilometers by 4.27, which is the direct and indirect obesity return of one kilometer of moderate walking. The daily return cost per capita is then multiplied by the 210 school days in Tehran. This results in the annual return cost per capita.

This study found that an average of $719.3 saving per year in the direct and indirect costs of obesity is expected for each student, if safety concerns of parents regarding their children's school trips are resolved. This amount varies among different student segments. For instance, this saving is $40 more for girls than boys, since on average they are more likely to walk to school. As shown in Table 6, high-income households would benefit more from safe routes to school programs. Elasticity

TABLE 6
Obesity Costs Return for Major Promoting Active Travel Policies.

Variable	Community Group	Daily Walking Increase (meter)	Daily Return Cost Per Capita (US$)	Annual Return Cost Per Capita (US$)
Safety	Total	802.2	3.42	719.3
	Boys	772.5	3.29	692.7
	Girls	817	3.48	732.6
	High school	985.3	4.20	883.5
	Middle school	683	2.91	612.4
	Low-income	190.3	0.81	170.6
	Non-car owning	289.6	1.23	259.6
Distance to school	Total	34.1	0.14	30.5
	Boys	38.8	0.16	34.7
	Girls	30.9	0.13	27.7
	High school	45.1	0.19	40.4
	Middle school	26.9	0.11	24.1
	Low-income	8.1	0.03	7.2
	Non-car owning	7.3	0.03	6.5

Note: All costs are based on 2012 U.S. dollar values.

values are valid in a small vicinity of the observed values. Pseudo-elasticity of dummy variables should then be cautiously considered since large changes, which are unavoidable for dummy variables, could be questionable. Therefore, we should be cautious to compare the results of continuous variables versus dummy variables, as the former is a 1% change and the latter is a movement from 0 to 1.

Various policies, including walking services and enhancing pedestrian facilities, have been practiced worldwide to enhance the safety of school trips (Matthews, 1992). Safe routes to school (Staunton et al., 2003) is a program that aims to create safe, convenient, and amusing opportunities to promote walking and biking among students. For instance, in 2005, the U.S. Congress approved legislation to make safe routes to school in 50 states of America (SAFETEA-LU, 2005). In accordance with the law, $612-million was distributed over a period of 4 years. Each state was obligated to enhance pedestrian facilities, and to provide applicable educational programs. Alameda, California is another example that extensively promoted active travel modes among students by making the routes safer (McDonald, 2007b). The city spent more than 2.3 million dollars in 2010 to execute three main plans for 215,000 students. Safety policies are costly, thus city officials need to be aware of the potential health benefits for children before policy implementation.

We also found a reduction in the annual obesity costs by about $30.50 per person, if distance to school is reduced by 1%. However, the amount of financial savings varies among different segments of society. Reducing travel distance by 1% for middle and high school students, for example, increases daily walking amount by 26.9 and 45.1 m on average, respectively. Such findings allow city officials to apply tailored policies in different neighborhoods. Eventually, as illustrated in Table 3, the average home to school walking distance is about 980 m in Tehran. Our study demonstrated that by reducing this walking distance to 800 m, annual direct and indirect costs of obesity decrease about $687 per person. If city planners want to promote walking, long-term policies such as building schools near residential complexes instead of city outskirts should be considered. This way, accurate identification of students' distribution across the city, land uses, transportation system, and a broad economic justification of such policies are essential. Promoting neighborhood schools have obvious health benefits for students, as they are more accessible on foot. Social drawbacks are discussed in the literature (McDonald, 2010), since developing neighborhood schools may delay the growth of under-developed communities. Supporting local or regional schools are generally costly for the governments, and a financial justification is keenly desired. California, for instance, spent about $25 billion in order to enhance infrastructures and school facilities from 2002 to 2004 (McDonald, 2008a). Having an estimate of the health benefits of a neighborhood school could help decision makers get a broader picture of the policies before implementation.

7. Conclusion

This study was an attempt to estimate direct and indirect obesity cost savings that are expected when active modes of travel are promoted among students in Tehran. The study investigated the behavior of choosing transportation modes in school trips by applying a three-level nested logit model. Identifying the effective variables on the parents' choice of travel mode is essential for researchers and policymakers to encourage active travel modes in school trips. This provides an opportunity to increase physical activity in the adolescent period and prevent public health problems in the future. Moreover, promoting the use of active transportation modes in school trips will reduce morning traffic congestion, which comes with environmental benefits as well. Active travel modes to school are expected to decrease in the coming decade(s) if current policies remain in-place. Vehicle ownership is increasing and travel safety concerns are growing. This is expected to lean parents toward non-active modes of travel. A tremendous amount of health benefits, on the other hand, are expected, should active modes of travel be encouraged.

On the analysis side, this study investigated a broad range of influential variables on mode choice decisions. Parental attitudes and built environment variables need to be studied more closely so that policy or coordinated programs such as "safe routes to school" and "walking school bus" can be implemented successfully to continue to incentivize parents to use active transportation modes.

On the policy side, the purpose of this study was to inform policymakers of the financial health benefits of encouraging walking for school trips. These findings may help policy makers better apply policy both in the short and long term, which may include "safe routes to school" and "school sitting" (McDonald, 2010). The findings of this study demonstrated that if parental safety concerns are alleviated regarding their children walking to school, both the annual direct and indirect costs of obesity per capita falls by US$719.3. Findings also demonstrated that the potential enactment of such alleviation policies among different sections of society yields different outcomes. For instance, tackling parental safety concerns advances active travel modes, particularly among girls and high school students, while low income families experienced the smallest increase in active modes. Such findings can better inform policy makers in the implementation of public policy. Among other findings in this study was that if the distance from home to school is decreased by 1%, the annual per capita health costs associated with obesity fall by about $30.50. Such studies could inform policymakers of the potential costs and benefits that are expected to come with active travelling of students.

While the results of this research offered important insights into the role of the long- and short-term policies to promote active transportation modes in diminishing costs of obesity, there are limitations that make room for future studies.

- This study only collected the information of school trips among middle and high school students. Elementary school should be considered to complete the study, because it is expected to have different trip patterns, although the survey methodology can be various for this age range.
- Instead of using obesity cost rates from another country, one way to obtain more realistic results is to perform such local studies. Yet scant evidence has been offered to indicate the either direct or indirect costs of obesity in Tehran.
- Built environment variables including pedestrian density, green space availability, and other land use variables could be appended to the data at a disaggregate level.
- Systematic taste variation was investigated due to nested logit models, while mixed logit models also have the capability of considering random taste variation.
- Public transit is a quasi-active mode of travel due to encompassing walking and biking in the most of access and egress trips. Considering a cross nested logit model hosting public transit mode in both active and non-active nests may improve the results of modeling.

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References

Alemu, D.D., Tsutsumi, J.I.G., 2011. Determinants and spatial variability of after-school travel by teenagers. J. Transp. Geogr. 19 (4), 876–881.
Birmingham, C.L., Muller, J.L., Palepu, A., Spinelli, J.J., Anis, A.H., 1999. The cost of obesity in Canada. Can. Med. Assoc. J. 160 (4), 483–488.
Boarnet, M.G., Day, K., Anderson, C., McMillan, T., Alfonzo, M., 2005. California's Safe Routes to School program: impacts on walking, bicycling, and pedestrian safety. J. Am. Plann. Assoc. 71 (3), 301–317.
Borg, S., Persson, U., Ödegaard, K., Berglund, G., Nilsson, J.A., Nilsson, P.M., 2005. Obesity, survival, and hospital costs–findings from a screening project in Sweden. Value Health 8 (5), 562–571.
Buliung, R.N., Mitra, R., Faulkner, G., 2009. Active school transportation in the Greater Toronto Area, Canada: an exploration of trends in space and time (1986-2006). Prev. Med. 48 (6), 507–512.
Cawley, J., Meyerhoefer, C., 2012. The medical care costs of obesity: an instrumental variables approach. J. Health Econ. 31 (1), 219–230.
Colditz, G.A., 1992. Economic costs of obesity. Am J. Clin. Nutr. 55 (2), 503S–507S.
Coldren, G.M., Koppelman, F.S., 2005. Modeling the competition among air travel itinerary shares: GEV model development. Transp. Res. Part A: Policy Pract. 39 (4), 345–365.
Cooper, A.R., Andersen, L.B., Wedderkopp, N., Page, A.S., Froberg, K., 2005. Physical activity levels of children who walk, cycle, or are driven to school. Am. J. Prev. Med. 29 (3), 179–184.
Dave, S.M., Raykundaliya, D.P., Shah, S.N., 2013. Modeling trip attributes and feasibility study of co-ordinated bus for school trips of children. Procedia-Social Behav. Sci. 104, 650–659.
Deka, D., 2013. An explanation of the relationship between adults' work trip mode and children's school trip mode through the Heckman approach. J. Transp. Geogr. 31 (1), 54–63.
Dellinger, A.M., Centers for Disease Control Prevention (2002), 1999. Barriers to children walking and biking to school–United States. MMWR. Morb. Mortal. Wkly. Rep. 51 (32), 701–704.
Department of the Environment and Heritage, 2004. State of the Air: Community Summary 1991–2004. Australian Government, Canberra.
Ebbeling, C.B., Pawlak, D.B., Ludwig, D.S., 2002. Childhood obesity: public-health crisis, common sense cure. Lancet 360 (9331), 473–482.
Edwards, R.D., 2008. Public transit, obesity, and medical costs: assessing the magnitudes. Prev. Med. 46 (1), 14–21.
Ermagun, A., Levinson, D., 2016. Intra-household bargaining for school trip accompaniment of children: a group decision approach. Transp. Res. Part A Policy Pract. 94, 222–234.
Ermagun, A., Levinson, D., 2017. Public transit, active travel, and the journey to school: a cross-nested logit analysis. Transp. A Transp. Sci. 13 (1), 24–37.
Ermagun, A., Samimi, A., 2015. Promoting active transportation modes in school trips. Transp. Policy 37 (1), 203–211.
Ermagun, A., Samimi, A., 2016. How are children accompanied to school? J. Urban Plann. Dev. 04016002.
Ermagun, A., Samimi, A., 2017. Mode choice and travel distance joint models in school trips. Transportation 1–27.
Ermagun, A., Hossein Rashidi, T., Samimi, A., 2015a. A joint model for mode choice and escort decisions of school trips. Transp. A Transp. Sci. 11 (3), 270–289.
Ermagun, A., Rashidi, T.H., Lari, Z.A., 2015b. Mode choice for school trips: long-term planning and impact of modal specification on policy assessments. Transp. Res. Rec. 2513, 97–105.
Ermagun, A., Samimi, A., Rashidi, T.H., 2016. How far is too far? Providing safe and comfortable walking environments. Transp. Res. Rec. 2586, 72–82.
Ewing, R., Schroeer, W., Greene, W., 2004. School location and student travel analysis of factors affecting mode choice. Transp. Res. Rec. 1895 (1), 55–63.
Fry, J., Finley, W., 2005. The prevalence and costs of obesity in the EU. Proc. Nutr. Soc. 64 (3), 359–362.
Fu, T., Wen, T., Yeh, P., Chang, H., 2008. Costs of metabolic syndrome related diseases induced by obesity in Taiwan. Obes. Rev. 9 (1), 68–73.
Fyhri, A., Hjorthol, R., Mackett, R.L., Fotel, T.N., Kytt, M., 2011. Children's active travel and independent mobility in four countries: development, social contributing trends