CHAPTER 6
RESULTS OF INITIAL MILTINOMIAL REGRESSION MODELS AND DISCUSSION

6.1 Introduction

The descriptive information in the previous chapter shows that walking to and from school is not easily explained by just examining traffic safety factors. Short distance did not guarantee that children would walk to and from school; and some physical characteristics of neighbourhood environment, such as block length, may decrease the walking rates to and from school. As previous research have shown (Falb et al., 2007; Pont et al., 2009; Fyhri & Hjorthol, 2009), there are other contributing factors in choosing the child's school transportation besides traffic safety.

The purpose of this chapter has two parts: 1) to provide information on what factors parents and children consider in their decision-making about a primary school aged child's trip to school, focusing on the choice of walking autonomously over walking without an adult, taking the school bus and being driven by parents (private car or motorcycle); and 2) to determine the impact of neighbourhood safety (personal safety and traffic safety) on the school trip, associated with these identified factors.

The general hypothesis was that traffic safety is the most important influential factor on parental decision-making about a child's school travel mode; however, it is not the only one. Particularly, the analysis focused on the role of the following factors on a child's trip to and from school: neighbourhood safety, traffic safety, urban form, socio-demographic and socio-economic factors. The analysis discusses the association between journey to school and neighbourhood safety (traffic and personal) and provides an insight into a child's perception of school travel mode and the neighbourhood environment.

6.2 Analytical methods

Multinomial logistic regression models were used to examine the probability of a child walking to and from school autonomously (walking alone and walking with friends). However, walking with an adult or elder sibling was included in the analysis as well. Motorized travel modes were limited to private vehicle (car and motorbike) or school bus. Public transportation, cycling and skating were not included in this analysis because less than 5% of participants used public transportation and nobody chose cycling or skating.

In this research, the Multinomial Logistic Model that was developed by McFaddan was used to understand the mode choice for the trip to school (Domencich & McFaddan, 1975; Train, 2003). This model can represent the complexity of the mode choice decision process of travellers, because it is based on the random utility theory. It is assumed that each individual chooses the alternative that yields the highest pay off in terms of utility (Koppelman & Sethi, 2005; Salon, 2009).

6.3 Results

The multinomial logistic regression models summarized in Tables 6.1, 6.2, 6.3, 6.4 show that the likelihood of a child walking to and from school is influenced by various factors, including traffic safety and neighbourhood safety factors. The results from the non-urban form model are presented first followed by the built environment model.

6.3.1 Non-urban form model (Basic Model) (Children's transportation to school)

First, the results of the models that assessed the associations between the variables and children's travel mode to school are presented (Table 6.1). Although the perceived distance between home and school is probably the most critical variable for children in their walking to school (Beck & Greenspan, 2008; Pont et al., 2009; Fyhri & Hjorthol, 2009), surprisingly it had no affect on this model. This may be explained by the fact that most of the students stayed within walking distance from school (see previous chapter) and those who lived far from school; they walked to their parents' workplace, which was also near to the school. Many of the non-urban form variables did not affect the choice of mode.

The Wald tests that an individual or group of variables are equal to zero showed that being the only child in a family (χ^2=0.09, p= 0.7), being the average of monthly household income at low level (χ^2=0.06, p= 0.8), being the average of monthly household income at middle level (χ^2=0.1, p= 0.6), being one car in a household (χ^2=0.2, p= 0.6), having a father who is walking or using public transportation to work (χ^2=0.1, p= 0.7), having a parent who does not encourage their children to walk to school (χ^2=0.7, p= 0.3), parental concern about neighbourhood safety (χ^2=1.6, p= 0.2), children's fear of high speed cars (χ^2=0.8, p= 0.3) did not affect the outcomes of the probability of children walking with an adult over children walking on their own.

Table 6. 1: Association between non-urban form variables and travel mode of children to school

		B	Std. Error	Wald	Sig.
walk with parents/elder siblings	Intercept	14.553	4.890	8.858	.003
	HOUSHLDCAR	.363	.713	.259	.611
	[TRAF=1.00]	-.564	.599	.887	.346
	[SAFE=1.00]	1.427	1.121	1.621	.203
	[DRIVEFIT=1.00]	**-2.678**	**1.473**	**3.305**	**.069**
	[PARFEELWAK=.00]	.695	.785	.782	.376

Table 6.1: Continued

	[DRIVELIC=1.00]	**1.199**	**.639**	**3.521**	**.061**
	[YOUNG=1.00]	**-1.894**	**.860**	**4.850**	**.028**
	[KIDSNU=1.00]	-.227	.731	.096	.756
	[KIDGEN=1.00]	**-1.959**	**.611**	**10.291**	**.001**
	KIDAGE	**-1.025**	**.392**	**6.831**	**.009**
	[HOUSINCOM=1.00]	-.227	.910	.062	.803
	[HOUSINCOM=2.00]	-.324	.786	.170	.680
	[DADTRVLMOD=1.00]	.226	.636	.126	.723
driven by parents	Intercept	-20.791	6.651	9.773	.002
	HOUSHLDCAR	**2.936**	**.953**	**9.499**	**.002**
	[TRAF=1.00]	**1.503**	**.816**	**3.391**	**.066**
	[SAFE=1.00]	**17.480**	**.869**	**404.172**	**.000**
	[DRIVEFIT=1.00]	**-3.183**	**1.708**	**3.472**	**.062**
	[PARFEELWAK=.00]	**4.344**	**.983**	**19.534**	**.000**
	[DRIVELIC=1.00]	-.442	.889	.247	.619
	[YOUNG=1.00]	**-1.844**	**1.071**	**2.967**	**.085**
	[KIDSNU=1.00]	**2.199**	**.920**	**5.710**	**.017**
	[KIDGEN=1.00]	-.964	.802	1.445	.229
	[HOUSINCOM=1.00]	-1.536	1.252	1.504	.220
	[HOUSINCOM=2.00]	-1.116	.945	1.395	.238
	[DADTRVLMOD=1.00]	**-1.544**	**.902**	**2.929**	**.087**
use school bus	Intercept	1.848	6.323	.085	.770
	HOUSHLDCAR	**1.791**	**.876**	**4.179**	**.041**
	[SAFE=1.00]	**-2.868**	**1.545**	**3.447**	**.063**
	[DRIVEFIT=1.00]	-2.226	1.770	1.581	.209
	[PARFEELWAK=.00]	**7.335**	**1.287**	**32.491**	**.000**
	[KIDSNU=1.00]	1.209	.909	1.771	.183
	[KIDGEN=1.00]	**-1.965**	**.796**	**6.100**	**.014**
	KIDAGE	-.338	.516	.430	.512
	[HOUSINCOM=2.00]	**-2.391**	**.954**	**6.286**	**.012**
	[DADTRVLMOD=1.00]	.472	.836	.320	.572

Note: the reference category is: walk with friends/alone; variables are significant at $p \leq 0.05$, $0.1 > p > 05$ is defined as modest relationship

The results showed that children's characteristics (KIDAGE (p=0.009<0.05), KIDGEN (p=.001<0.05), and YOUNG (p=0.028<.05), had the strongest effect on the probability of children walking to school with an adult over their walking to school on their own. Parental attitudes (DRIVFIT; (p=0.069<0.1) had a modest effect on choosing walking with an adult over children autonomous walking to school. The control variables for children's characteristics showed that younger children were more likely to walk to school with an adult over walking to school on their own. Girls were also more likely to walk with their parents or elder siblings to school than boys. This result is consistent with other literature that showed that parents are more concerned about their female children (Fyhri & Hjorthol, 2009; Johansson, 2003). Households with only one child between 6-11 years old are willing to let their children walk to school on their own. Moreover, in families with only one person with a driving licence (most likely the father) children are more likely to walk with their parents. The results also showed that if the school time or location do not let the parents and more likely the fathers pick up and drop their children to school on their way to go to work, children are more likely to walk to school on their own.

The variables in the next models (comparing being driven by parents over walking independently and taking school bus over walking to school on their own); used the same variables as the previous model but varied in the effect on the model.

The Wald tests that an individual or group of variables are equal to zero in the second model showed that being the average of monthly household income at low level (χ^2=1.5, *p*= 0.2), being the average of monthly household income at middle level (χ^2=1.3, *p*= 0.2), being at least one person in household who is holding driving licence (χ^2=0.2, *p*= 0.6), children's age (χ^2=0.001, *p*= 0.9) and children's gender (χ^2=1.4, *p*= 0.2), did not affect the outcomes of the probability of being driven by parents over walking on their own.

As the conceptual model suggested, household car ownership (HOUSHLDCAR; *p*=.002<.05), father's travel mode to work (DADTRVLMOD; *p*=.087<0.1) may also influence the child's trip to school. Households with at least one car are more likely to send their children to school in a private car, especially if the fathers drive to their work and are able to drop the children on their way to school. These variables highlight the transportation options in a household and socio-economics. It also showed that in these households, parents do not encourage their children to walk to school on their own.

The results also showed that having more than one child while both of them are going to school (YOUNG; p=.085<0.1) makes parents drive their children to school rather than allowing them to walk. Parental concerns about personal safety in a neighbourhood (SAFE; p=.00<.05) increased using private car to send children to school over walking to school independently. This supports the hypothesis that parent's perception of lack of safety in the neighbourhood prevents children's physical activities in outdoor spaces and moving around independently (Bringolf-Isler et al., 2008; Farver et al., 2000). Concerns about traffic safety also influenced a child's travel pattern. Children reported that a fear of high-speed cars decreases their walking to school independently when being driven by parents is available.

In the last model, the Wald tests that an individual or group of variables are equal to zero showed that being at least one person in a household who holds a driving licence (χ^2=0.1, p= 0.7), having a father who is walking or using public transportation to his work (χ^2=0.3, p= 0.5), presence of another child between 6-11 years old in a household (χ^2=0.4, p= 0.4), children's age (χ^2=0.4, p= 0.5) and increase in the number of children in a household (χ^2=1.7, p= 0.1), children's fear of high speed cars (χ^2=1.7, p= 0.1), did not affect the outcomes of the probability of taking a school bus over walking on their own.

Households with lower monthly income (HOUSINCOM; p=0.012<.05) were less likely to send their children to school by school bus. An increase in the number of cars in a household increased the likelihood of using a school bus over walking to school; this may be explained by the higher monthly income in a household. This is consistent with other studies that showed that the number of cars in a household affects the children's school travel pattern (Pont et al., 2009; Hine, 2009; Dissanayake & Morikawa, 2010; Scheiner, 2010). Households in which parents never encourage their children to go to school on their own (PARFEELWAK; $p=.00<.05$) are more likely to send them to school by school bus. Parental concerns about neighbourhood safety (SAFE; $p=.063<0.1$) also increase the probability of taking the school bus over walking to school independently. Finally, female children (KIDGEN; $p=.014<.05$) are more likely to take the school bus to go to school over walking independently than male children.

6.3.2 Non-urban form model (Basic Model) (Children's transportation back home)

In the models that compared the probability of other alternatives over walking independently from school, only six variables were retained in the model (Table 6.2). The first model evaluated the probability of children walking from school with an adult over children walking from school independently.

In this model, the Wald tests that an individual or group of variables are equal to zero showed that being at least one person in a household who holds a driving licence (χ^2=0.4, p= 0.7), average of low monthly household income (χ^2=0.1, p= 0.7), average of middle monthly household income (χ^2=1.1, p= 0.2), parents who encourage their children to walk back home on their own (χ^2=1.01, p= 0.3), did not affect the outcomes of the probability of walking with adults over walking on their own back home.

Table 6. 2: Association between non-urban form variables and travel modes of children back home

		B	Std. Error	Wald	Sig.
walk with parents/elder siblings	Intercept	1.287	.944	1.859	.173
	[SAFE=1.00]	**-1.585**	**.896**	**3.128**	**.077**
	[PARFEELWAK=.00]	.455	.451	1.016	.313
	[DRIVELIC=1.00]	.299	.431	.482	.488
	[STRANG=1.00]	**.774**	**.406**	**3.633**	**.057**

Table 6.2: Continued

	[HOUSINCOM=1.00]	-.223	.589	.144	.704
	[HOUSINCOM=2.00]	-.533	.506	1.113	.291
driven by parents	Intercept	-17.968	.964	347.277	.000
	[SAFE=1.00]	**15.904**	**.686**	**537.521**	**.000**
	[PARFEELWAK=.00]	**3.928**	**.867**	**20.549**	**.000**
	[DRIVELIC=1.00]	**-3.778**	**1.190**	**10.075**	**.002**
	[STRANG=1.00]	-.766	.642	1.426	.232
	[HOUSINCOM=1.00]	.393	1.066	.136	.712
	[HOUSINCOM=2.00]	-.060	.701	.007	.932
school bus	Intercept	1.323	1.223	1.171	.279
	[SAFE=1.00]	**-3.520**	**1.182**	**8.875**	**.003**
	[PARFEELWAK=.00]	**4.691**	**.741**	**40.062**	**.000**
	[DRIVELIC=1.00]	-.746	.549	1.845	.174
	[STRANG=1.00]	.351	.508	.479	.489
	[HOUSINCOM=1.00]	**-2.065**	**.814**	**6.439**	**.011**
	[HOUSINCOM=2.00]	**-1.384**	**.575**	**5.807**	**.016**

Note: the reference category is: walk with friends/alone; variables are significant at $p \leq 0.05$
$0.1 > p > 05$ is defined as modest relationship

Parents and children with a negative perception about neighbourhood safety (SAFE; $p=0.077<0.1$) make parents walk with their children back home relative to allowing them to walk on their own. This is consistent with other literature that showed that when choosing the school transportation mode for primary aged children, concerns about personal safety were more important than traffic safety (Johansson, 2003; Ahlport et al., 2008).

In the second model, the Wald tests that an individual or group of variables are equal to zero showed that the average of low monthly household income (χ^2=0.1, p= 0.7), average of middle monthly household income (χ^2=0.007, p= 0.9), and children's fear of being abducted or harassed (χ^2=1.4, p= 0.2), did not affect the outcomes of the probability of being driven with parents over walking on their own back home.

Parents reported that if there is only one person in their family who holds a driving licence (DRIVELIC; p=.002<.05), parents are less likely to drive their children back home relative to allowing them to walk on their own. It also showed that parents who never encourage their children to walk to school (PARFEELWAK; *p*=.00<.05) are more likely to pick them up by private car relative to allowing them to walk back home independently. Finally, parental negative perception of personal safety in the neighbourhood (SAFE; *p*=.00<.05) does not make parents pick their children up in the afternoon by private car. This may be explained in that there are other factors that impact on choosing this transportation mode in the afternoon; as the descriptive data in the previous chapter showed, the majority of the study population has only one car in a household. In addition, primary schools are half-day schools in Iran, which does not match with the parents' work schedule when both of them are working.

Parents who do not encourage their children to walk to and from school are more likely to choose motorized modes for their children to go and from school. Some parents believed that walking to school for such a short distance while carrying a heavy bag may not be considered as doing exercise. Moreover, children are in a rush to arrive at school on time in the morning and do not enjoy walking. The other parents were more concerned about the level of air pollution in the neighbourhood, so were reluctant to allow their children to walk to and from school unless there were no other alternatives for them. They thought that walking in such polluted air is not good for their children's health. The above variables highlight the values parents have about their children's active commuting to school.

In the third model, the Wald tests that an individual or group of variables are equal to zero showed that holding a driving licence by at least one person in a household (χ^2=1.8, *p*= 0.1), and children's fear of being abducted or harassed (χ^2=0.4, *p*= 0.4), did not affect the outcomes of the probability of taking children to school over children walking on their own back home.

Children from low and average monthly household income (HOUSINCOM; $p=.011< 0.05$) are less likely to take the school bus back home. The result also showed that children, whose parents never encourage them to walk (PARFEELWAK; $p=.00< 0.05$), do not walk from school back home. The probability of taking a school bus back home for children whose parents have a negative perception of safety in the neighbourhood (SAFE; $p=.003<.05$) is more relative to walking. The findings also suggested that children's age, gender and concerns about traffic safety do not play a role in children's walking from school back home.

The education level of parents, presence of younger siblings (under 5 years old) and mothers' occupation had no effect on children's walking to school on their own. Additionally, parents believed that interacting with other children while walking to school is not important. It may even spoil their children's behaviour unless they know all the children who are walking together and their families as well, which seems difficult. This is an unexpected result, as other studies showed that the presence of other children who walk to school increases the perception of safety and convinces parents to allow their children to walk to school as well (Bringolf-Isler et al., 2008).

The results showed that a reported distance between home and school that is less than one kilometre did not increase the probability of children walking to and from school.

6.3.3 Built environment model (Expanded model) (Children's transportation to school)

The model was then expanded to include traffic safety and neighbourhood safety variables from urban design measurement to enhance the predictability (Cervero, 2002). The combined models generate more reliable estimates when compared with the basic models (Dissanayake & Morikawa, 2010). The addition of these variables changed some of the relationships between the variables in the basic model (Table 6.3). Children's fear of high-speed cars, and monthly household income were not more significant. The children's fear of motorcycles using pedestrian pathways instead of streets were entered into the model after adding built environment variables. Fitting starting time and dismissal time of schools with parents' schedule, presence of siblings between 6-11 years old were significant in the previous model but not more significant after entering the built environment variables.

Only two traffic safety variables were significant in the built environment model. The proportion of street segments with a completed pavement network (NOPAV; p= 0.017<0.05) did not increase the probability of children's walking to and from school on their own, which was an unexpected result. However, the pavement's width (PAVWIDTH; p=.013<.05) affects the probability of children walking to school with an adult. Pavements narrower than 1 metre make parents walk with their children to school. However, increasing the pavements' width had no effect on choosing travel mode.

Table 6. 3: Association between no-urban form and urban form variables with travel modes of children to school

		B	Std. Error	Wald	Sig.
walk with parents/elder siblings	Intercept	9.244	4.219	4.800	.028
	HOUSHLDCAR	.394	.776	.258	.612
	[MOTOR=1.00]	.373	.743	.251	.616
	[SAFE=1.00]	**2.043**	**1.224**	**2.787**	**.095**
	[PARFEELWAK=.00]	.744	.891	.697	.404
	[DRIVELIC=1.00]	**1.209**	**.664**	**3.319**	**.068**
	[KIDSNU=1.00]	-.481	.812	.350	.554
	[KIDGEN=1.00]	**-1.816**	**.684**	**7.038**	**.008**
	KIDAGE	**-1.471**	**.436**	**11.377**	**.001**
	[DADTRVLMOD=1.00]	.456	.717	.404	.525
	[MIXU=.00]	1.463	1.049	1.942	.163
	[NOPAV=.00]	**3.078**	**1.294**	**5.661**	**.017**
	[PAVWIDTH=2.00]	**2.505**	**1.010**	**6.149**	**.013**
	[PAVWIDTH=3.00]	1.203	.858	1.969	.161

Table 6.3: Continued

driven by parents	Intercept	-25.953	6.067	18.299	.000
	HOUSHLDCAR	**2.709**	**.988**	**7.513**	**.006**
	[MOTOR=1.00]	**1.986**	**.998**	**3.955**	**.047**
	[SAFE=1.00]	**21.150**	**.880**	**578.261**	**.000**
	[PARFEELWAK=.00]	**4.795**	**1.009**	**22.602**	**.000**
	[DRIVELIC=1.00]	-.596	.910	.430	.512
	[KIDSNU=1.00]	**2.548**	**.984**	**6.709**	**.010**
	[KIDGEN=1.00]	**-1.629**	**.889**	**3.360**	**.067**
	KIDAGE	-.131	.548	.058	.810
	[DADTRVLMOD=1.00]	-.953	.925	1.060	.303
	[MIXU=.00]	**2.479**	**1.219**	**4.135**	**.042**
	[NOPAV=.00]	-.056	1.337	.002	.967
	[PAVWIDTH=1.00]	**4.125**	**1.732**	**5.674**	**.017**
	[PAVWIDTH=2.00]	.164	1.143	.021	.886
	[PAVWIDTH=3.00]	-.800	1.045	.586	.444
school bus	Intercept	1.742	5.994	.085	.771
	HOUSHLDCAR	**1.883**	**.951**	**3.922**	**.048**
	[MOTOR=1.00]	**2.290**	**.982**	**5.437**	**.020**
	[SAFE=1.00]	-1.541	1.558	.978	.323
	[PARFEELWAK=.00]	**8.328**	**1.317**	**39.989**	**.000**
	[DRIVELIC=1.00]	.071	.864	.007	.934
	[KIDSNU=1.00]	**1.897**	**1.019**	**3.465**	**.063**
	[KIDGEN=1.00]	**-3.267**	**.974**	**11.244**	**.001**
	KIDAGE	-.630	.547	1.328	.249
	[DADTRVLMOD=1.00]	1.472	.923	2.544	.111
	[MIXU=.00]	**4.810**	**1.315**	**13.373**	**.000**
	[NOPAV=.00]	**-2.898**	**1.325**	**4.782**	**.029**
	[PAVWIDTH=1.00]	2.165	1.827	1.405	.236
	[PAVWIDTH=2.00]	1.171	1.157	1.025	.311
	[PAVWIDTH=3.00]	-1.723	1.093	2.486	.115

Note: the reference category is: walk with friends/alone; variables are significant at $p \leq 0.05$
$0.1 > p > 05$ is defined as modest relationship

Parental negative perception of safety in the neighbourhood (SAFE; p=.095<0.1) makes parents walk with their children more after adding built environment into the model. The presence of only one person in a household who holds a driving licence (DRIVELIC; p=0.068<0.1), children's age (KIDAGE; p=.001<.05) and gender (KIDGEN; p=.008<.05) impacts on children's trip to school the same as the previous model. There is only a slight decrease in the impact of children's age on children's travel mode in the current model.

Only two built environment variables were significant in second model. In neighbourhoods with narrow pavements (less than 1 metre width) (PAVWIDTH; $p=.017<.05$) parents are more likely to chauffer their children to school. The same result is true in neighbourhoods where the proportion of street segments without mixed land use increased (MIXU; $p=.048<.05$). This produced a consistent result with popular policies such as Smart Growth that assumes that the presence of mixed land use makes the neighbourhood conducive for pedestrians. Studies that focus on children's travel also confirmed the influence of land use on increasing the number of children walking to school (Van Dyck et al., 2009; Dissanayake et al., 2009).

Among non-urban form variables, the number of cars in household (HOUSHLDCAR; $p=.006<.05$) and parental concerns about personal safety in the neighbourhood (SAFE; $p=.00<.05$) remained significant with a decrease in the impact on children's transportation to school after entering built environment variables to the model. Parents who do not encourage their children to walk to school (PARFEELWAK; $p=.00<.05$) and the number of children in a household (KIDSNU; $p=.01<.05$) also remained significant with a slight increase in impact. In this model, female children (KIDGEN; $p=.067 <0.1$) are more likely to be driven than males. Finally, children's fear of motorcycles (MOTOR; $p=.047<0.05$) that are riding on the pavements became significant and increased the probability of being driven by cars.

In the third model, the presence of pavements decreases (NOPAV; $p=.029<0.05$) the use of a school bus to school. The proportion of street segments without mixed land use (MIXU; $p=.00<0.05$) increases the use of a school bus to school. Pavement width does not have any effect on choosing a school bus for the children's transportation mode over walking to school.

Only the number of cars in a household (HOUSHLDCAR; $p=.048<.05$), parental feeling about walking to school (PARFEELWAK; $p=.00<0.05$) and children's gender (KIDGEN; $p=.001<0.05$) remained significant in this model in comparison with the basic model. The result also showed that female children are more likely to use a school bus than male children. Interestingly, an increase in the number of cars in a household also increased the probability of choosing a school bus over walking to school, which is an unexpected result. Increasing the number of cars in a household can be considered as increasing the monthly household income and they can afford to send their children to school by school bus.

Households with more than one child are more (KIDSNU; $p=.063<0.05$) likely to send their children to school by school bus. An increase in the number of children in a household makes parents look for other transportation options, especially if the children were not of the same sex. This is due to the absence of co-educational schools in Iran and male and female schools are not always located next to each other. In addition, children's fear of motorcycles (MOTOR; $p=.02<0.05$) that are riding on pavements makes their parents send them by school bus. Other variables were no more significant after entering the built environment variables.

In summary, an increase in the number of cars in a household, children's fear of motorcycles, parental concerns of safety in a neighbourhood, increase in the number of children in a household, being a female child, lack of mixed land use in street segments, presence of pavements and narrow pavements increase the probability of choosing motorized modes for children to go to school over their independent walking to school.

6.3.4 Built environment model (Expanded model) (Children's transportation back home)

Parental concerns about safety in the neighbourhood, presence of only one person who holds a driving licence in a household, being a female child, decreasing the children's age, presence of pavements and narrow pavements makes parents walk with their children to school instead of allowing them to walk on their own. In the expanded model, which examines the children's transportation back home, the presence of pavements and pavement width no longer had an effect on the model (Table 6.4).

In the comparison between children walking with an adult and their walking on their own back home, children's fear of being abducted or harassed by strangers on the street (STRANG; $p=0.081<0.1$) is the only variable from the basic model that remains significant. Parental feeling about children's walking back home on their own (PARFEELWAK; $p=0.098<0.1$) and children' age (KIDAGE; $p=0.019<0.05$) became significant after entering built environment variables. Only increasing the number of lanes of traffic on the street (TRAFLANE; $p=.00<0.05$) will increase the children's walking with an adult over their walking on their own back home. Width of streets, lack of separation between pedestrians and traffic and lack of mixed land use did not affect the model.

In the second model, the comparison between being driven by parents and walking back home independently, only one person in a household who holds a driving licence (DRIVELIC; $p=0.01<0.05$) has the same effect on children's school travel mode back home as the basic model with a slight increase in the impact. Children's fear of being abducted or harassed (STRANG; $p=0.016,0.05$) makes parents pick them up in the afternoon. Younger children (KIDAGE; $p=0.056<0.1$) are more likely to be driven back home by parents than elder ones. The absence of mixed land use (MIXU; $p=0.007<0.05$), lack of separation between pedestrians and traffic (NOSEPPAV;

$p=0.007<0.05$), and increase in the lanes of traffic (TRFLANE; $p=.00<0.05$) in a neighbourhood, makes parents pick up their children by car in the afternoon. Surprisingly, the width of streets does not have any effect on the likelihood of using private car over walking for children's travel mode back home.

Table 6. 4: Association between non-urban form and urban form variables with travel modes of children from school.

		B	Std. Error	Wald	Sig.
walk with parents/elder siblings	Intercept	-13.982	2.718	26.457	.000
	[PARFEELWAK=.00]	**.819**	**.491**	**2.787**	**.095**
	[DRIVELIC=1.00]	.597	.454	1.726	.189
	[STRANG=1.00]	**.735**	**.421**	**3.045**	**.081**
	KIDAGE	**-.599**	**.257**	**5.461**	**.019**
	[MIXU=.00]	.668	.833	.642	.423
	[NOSEPPAV=.00]	-.710	.818	.754	.385
	[TRFLANE=1.00]	**19.208**	**.850**	**510.465**	**.000**
	[STWIDTH=1.00]	-16.827	3591.332	.000	.996
	[STWIDTH=2.00]	.877	1.088	.650	.420
	[STWIDTH=3.00]	.250	1.072	.055	.815
	[STWIDTH=4.00]	-.221	1.151	.037	.848
driven by parents	Intercept	-12.531	5.498	5.196	.023
	[PARFEELWAK=.00]	**5.993**	**1.197**	**25.067**	**.000**
	[DRIVELIC=1.00]	**-3.128**	**1.207**	**6.710**	**.010**
	[STRANG=1.00]	**-2.005**	**.830**	**5.830**	**.016**
	KIDAGE	**-.998**	**.523**	**3.646**	**.056**
	[MIXU=.00]	**2.876**	**1.061**	**7.347**	**.007**
	[NOSEPPAV=.00]	**-3.404**	**1.271**	**7.168**	**.007**
	[TRFLANE=1.00]	**18.627**	**1.219**	**233.307**	**.000**
	[STWIDTH=1.00]	2.951	2.121	1.935	.164
	[STWIDTH=2.00]	2.358	1.685	1.959	.162
	[STWIDTH=3.00]	-1.713	1.497	1.309	.253
	[STWIDTH=4.00]	.046	1.580	.001	.977
school bus	Intercept	7.001	3.829	3.343	.067
	[PARFEELWAK=.00]	**5.487**	**.883**	**38.622**	**.000**
	[DRIVELIC=1.00]	-.666	.611	1.190	.275
	STRANG=1.00]	-.717	.626	1.309	.253
	KIDAGE	**-1.172**	**.379**	**9.577**	**.002**
	[MIXU=.00]	**1.958**	**.920**	**4.527**	**.033**
	[NOSEPPAV=.00]	**-1.930**	**.994**	**3.766**	**.050**
	[TRFLANE=1.00]	2.736	1.722	2.524	.112
	[TRFLANE=2.00]	**3.579**	**1.504**	**5.662**	**.017**
	[STWIDTH=1.00]	.149	1.505	.010	.921

Table 6.4: Continued

[STWIDTH=2.00]	1.280	1.247	1.053	.305
[STWIDTH=3.00]	-1.893	1.217	2.417	.120
[STWIDTH=4.00]	**-2.442**	**1.405**	**3.020**	**.082**

Note: the reference category is: walk with friends/alone; variables are significant at $p \leq 0.05$
$0.1 > p > 05$ is defined as modest relationship

In the last model, only the negative perception of parents about children walking (PARFEELWAK; p=.00<0.05) remains significant with a dramatic increase in the impact on the model. In this model, younger children are also more likely to take a school bus back home (Table 6.5).

Among the built environment variables, lack of mixed land use (MIXU; p=0.033<0.05) and absence of separation between traffic and pedestrians (NOSEPPAVE; p=0.05<0.05) increased choosing the school bus for children back home over walking on their own. An increase in the proportion of streets that have more than 4 lanes for traffic (TRAFLANE; p=0.013<0.05) increase taking a school bus in the afternoon. The findings produced a contrasting result, an increase in the width of the streets increased taking a school bus back home if it is less than 12 metres. Increasing the proportion of street segments in which the width of the streets were 12 metres (STWIDTH; p=0.082<0.1) decreases the probability of taking a bus.

The results showed that as the percentage of street segment with more than 2 traffic lanes increased, children's walking rates decreased. The same result was found for street width, an increase in the width of the street segment impacted negatively on the probability of walking to and from school. These results are consistent with the popular concepts such as New Urbanism and Livable communities, which suggest that neighbourhoods with narrower streets are pedestrian friendly (it leads to traffic calming) and pedestrians feel safer and more comfortable in such environments.

However, the results of this study indicated that narrower streets decrease the perception of traffic safety, because it is impossible to provide complete pavements due to insufficient width. Moreover, narrow streets without any pavements had no influence on the likelihood of children walking to school. The coefficient is very small in this model, indicating that the level of influence of this urban form factor is limited. This may be explained by the fact that insufficient width of street slows down the traffic or decreases the number of vehicles driving on that street.

Other studies showed that streetlights affect children walking, especially on their own (Johansson, 2003); however, the result of this study showed that streetlights had no impact on the likelihood of children walking to and from school with/without an adult. This may be explained by the fact that government primary schools in Iran are only half day (7:45 am to 12:30 pm), as such children go to school in the day time and do not need to use streetlights.

Interestingly, the increase in the proportion of street segments with speed bumps does not impact on children walking to and from school. Again the result does not match the hypothesis about walking behaviour and improving the traffic safety, which suggests that speed bumps used as traffic calming increase the probability of walking. In this study, speed bumps are present in nearly all street segments; however, the likelihood of children walking is different across different areas.

The findings are consistent with the results of popular policies such as Smart Growth, which assume that the presence of mixed land use facilitates the neighbourhood for pedestrians by putting more destinations within a neighbourhood; however, they did not focus on children pedestrians and their travel to school (Ye et al., 2005; Handy 2005). Another unexpected result is that block does not affect the model. In terms of block length, it is always assumed that a shorter walking distance promotes walking more (Falb et al., 2007). Shorter block length does not always provide a shorter distance; however, it may give the perception of a shorter distance by providing a variety of destinations along a walking route. It also increases the perception of safety in a neighbourhood (Crane & Crepeau, 1998; Mitra & Buliung, 2011).

Another unexpected result was that the presence of first floor windows did not affect the model. Due to the construction regulations in Tehran, all buildings must be built in the northern part of the site. Therefore, in almost all blocks (within all areas) at least 50% of the houses have first floor windows facing the street; however, it did not increase the perception of safety in the neighbourhood. This may be explained by the cultural norms in Iranian society. Although 50% of buildings have first floor windows facing the street, the glass is not clear or they are covered by a thick curtain. As such, the presence of these windows does not increase the safety on the street (Figure 6.1 and Figure 6.2).

These differences in outcomes can be explained as follows. First, the urban design measurement tools were built from literature reviews and policies about children's active commuting to school. Although this information is helpful, they have some limitations and biases as well, which may not have be given or reported in the measurement or analysis (McMillan, 2003). Current policies target the revitalizing of the urban areas to be more "walk able" by using advanced infrastructure improvements. However, elements that may prevent walking, may have different features or meaning across different socio-economic areas. For example, block size is bigger in high-income areas and mixed land use is absent in most parts of them, therefore, the distance between the origin and destination is greater in these areas. While the number of abandoned buildings in all areas was few, there are so many construction sites across different areas, which may negatively influence a child's trip to school on foot.

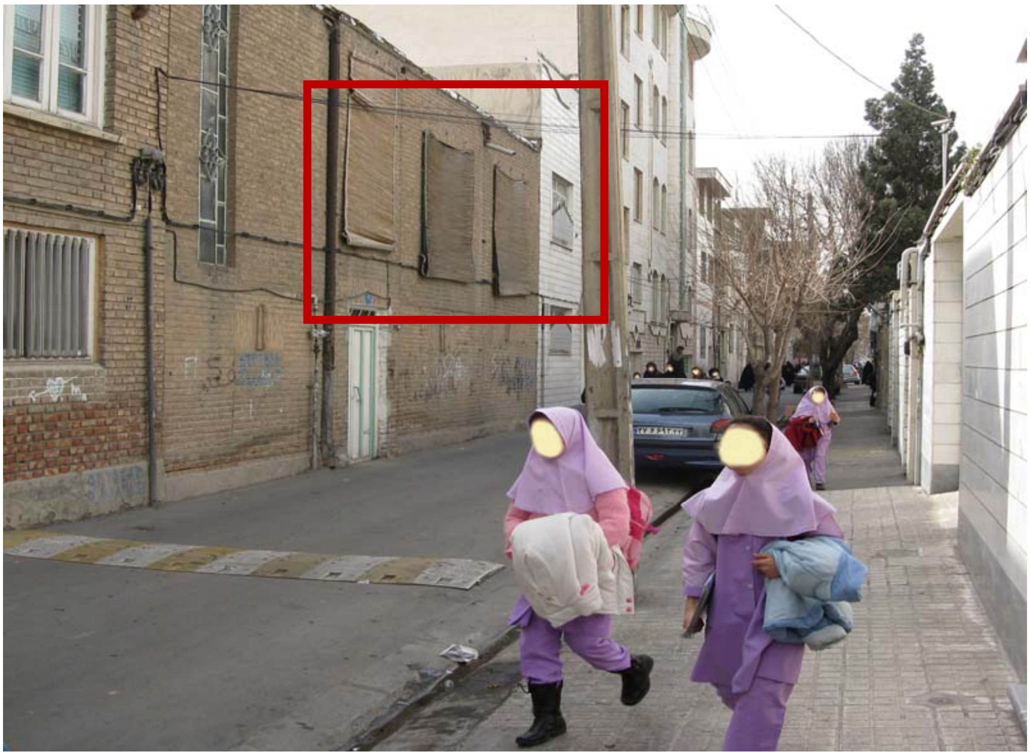

Figure 6. 1: the first floor windows are covered with curtains

Figure 6. 2: The first floor windows are not clear glass, so they cannot be seen through.

In low-income areas, parents indicated that construction sites have blocked the pavements; therefore, children have to walk on the street. In high-income areas and middle-income areas, parents complained about the presence of foreigner workers in construction sites who potentially might sexually abuse female children. Future studies need to correct the urban measurement tools to be more context sensitive across different income areas.

Second, the outcomes may also be due to a lack of variation in the urban environment and traffic safety variables in the observed neighbourhoods. Although there were nine neighbourhoods in the sample, they were selected from only three different socio-economic areas. Urban form and traffic safety variables across different neighbourhoods within the same income area may vary to a limited extent and across different socio-economic areas may have more variations. However, they may not affect the walking rate of children to and from school (especially with an adult). For example, the school with the highest walking rate had many construction sites or incomplete pavement networks (McMillan, 2003). These particular issues will be addressed more analytically with a detailed discussion later in this chapter.

6.3.5 Model improvement test

A model improvement test was carried out to decide if the addition of built environment variables in the model significantly increased the models' ability to predict the likelihood of children walking to and from school. The models that included all the variables (built environment model) were compared to the non-urban form models by looking at "model fitting information" and "Pseudo R-square". The Initial Log Likelihood Function, (-2 Log Likelihood or -2LL) is a statistical measure that shows whether the independent variables have a relationship to the dependent variable. If the ability of the model to predict the dependent variable accurately improves, the log likelihood measure will decrease. Later, the strength of the relationship between the dependent variable and the independent variables, analogous to the R^2 measures in multiple regression.

The results in Table 6.5 show that the built environment variables influenced the non-urban form models, but not significantly. We can see that Cox and Snell, Nagelkerke and McFadden R^2 (0.484) measures are modest. However, adding built environment variables to the model has improved it (0.527) substantively. It supports the hypothesis that built environment variables, which represent traffic safety and neighbourhood safety, are contributing factors in choosing children's transportation to and from school. However, the amount of influence that the effect of traffic safety has on child's mode choice was modest as the odds ratio describe in the next section.

Table 6. 5: Model fitting information: the comparison between non-urban form and built environment models.

		Pseudo R-Square					
		Cox and Snell	McFadden	2Log Likelihood	Chi-Square	df	Sig.
Children transportation to school	Basic model	0.72	**0.484**	**296.3**	277.8	45	0
	Expanded model	0.75	***0.527***	***271.8***	302.4	45	0
Children transportation back home	Basic model	0.576	**0.327**	**384**	187	21	0
	Expanded model	0.652	***0.403***	***341.2***	229.8	36	0

6.3.6 Odds ratio

6.3.6.1 Odds ratio (Children's transportation to school)

In the comparison of walking relative to other transportation alternatives in children walking to school, some of the variables that were significant in the non-urban models remained significant in the built environment models. However, there were some differences in the magnitude of coefficients and the level of significance. Moreover, the coefficient and the level of significance only highlight the relationships and link the variable values to the different outcomes. Therefore, odds ratios were calculated to determine the magnitude of the impact of each variable on parental decision-making about children's trip to school on foot, and to see the change in the magnitude of impact when built environment variables were added in the basic models (non-urban form) (Table 6.6).

Table 6.6: Comparison between basic model and expanded model to see the magnitude of impact of non-urban form variables on children's transportation modes to school after adding built environment variables to the models

		Basic model	Expanded model
Children's travel mode to school	Independent variables	Exp (B)	Exp (B)
walk with parents/elder siblings	[SAFE=1.00]	4.168	**7.712**
	[DRIVELIC=1.00]	3.315	**3.349**
	[KIDGEN=1.00]	0.141	**0.163**
	KIDAGE	0.359	**0.23**
Driven by parents	HOUSHLDCAR	18.835	**15.017**
	[SAFE=1.00]	3.90E+07	**1.53**
	[PARFEELWAK=.00]	76.991	**120.908**
	[KIDSNU=1.00]	9.019	**12.782**
	[KIDGEN=1.00]	0.381	**0.196**
Take school bus	HOUSHLDCAR	5.995	**6.572**
	[PARFEELWAK=.00]	1532.529	**4137.9**
	[KIDSNU=1.00]	3.352	**6.664**
	[KIDGEN=1.00]	0.14	**0.038**

Adding the built environment variables into the non-urban form models changed the impact of some influential variables on choosing the children's transportation mode to school (Table 6.6). In the model comparing the preference of children walking with an adult over walking on their own to school, entering urban form variables did not significantly change the impact of the children's age (KIDAGE; .23<.359) and gender (KIDGEN; 0.163>0.141) or the number of persons in a family who hold a driving licence (DRIVELIC; 3.349>3.315). However, the magnitude of the impact of the negative perception of parents about neighbourhood safety (SAFE; 7.712>4.168) on the preference for escorting children walking to school over allowing them to walk on their own increased 85% after entering urban form variables into the models. This showed that the absence of pavements or presence of narrow pavements negatively affects the parental perception of safety in a neighbourhood and makes them escort their children walking to school.

Comparing the odds ratio indicates that the impact of the negative perception of parents about their children's autonomous walking to school on choosing motorized modes over walking to school will be increased tremendously in built environment models (PARFEELWAK; r=120.908>76.991). This may be explained by the fact that the majority of families do not believe in the importance of interaction between children while walking to school in groups.

Increasing the number of children in a household (KIDSNU; r=12.782>9.019) was also more effective in the extended model to increase the preference of sending children to school by private car or school bus relative to walking. In the basic model, parents were more likely to send their female children to school by motorized modes. However, after adding the built environment variables the impact of children's gender (KIDGEN; 0.196<0.381) on parental decision making about their children's trip to school decreased. In other words, parental concerns about safety (traffic and personal) in a neighbourhood are almost the same for both male and female children in their trip to school. The impact of the number of cars in a household is still great in the extended models; however, it decreased slightly after adding urban form variables in preference to sending children to school by private car (HOUSHLDCAR; 15.017<18.835). This showed that the presence of narrow pavements and lack of mixed land use makes parents want to chauffer their children to school even if there is only one car in the household.

6.3.6.2 Odds ratio (Children transportation back home)

In the comparison of walking relative to other transportation alternatives for children in their walking back home, only a few of variables that were significant in the non-urban models remained significant in the built environment models. There were some slight differences in the magnitude of coefficients and the level of significance of these variables except one of them (parental negative perception about children walking back home). Table 6.7 shows the odds ratio calculation to compare the magnitude of impact of non-urban form variables in the basic models and after entering the urban form variables into the models.

Table 6. 7: Comparison between basic model and expanded model to see the magnitude of impact of non-urban form variables on children's transportation modes back home after adding built environment variables to the models

Children travel mode back Home		Basic model	Expanded model
		Exp(B)	Exp(B)
Walk with parents/elder siblings	[STRANG=1.00]	2.168	**2.086**
Driven by parents	[PARFEELWAK=.0]	50.804	**400.726**
	[DRIVELIC=1.00]	0.023	**0.044**
Taking school bus	[PARFEELWAK=.00	108.976	**241.494**

Only three non-urban form variables remained significant in the models after entering the built environment variables. Comparing the odds ratio indicated that children's negative perception about undesirable persons in the neighbourhood (STRANG; 2.086<2.168) is the only effective non-urban form barrier to decrease children's walking back home on their own relative to being escorted by adult. However, after entering built environment variables into the model the magnitude of the impact was almost imperceptible.

Increasing the number of persons in a household who hold a driving licence is another non-urban form of barrier for children in their independent walking back home over being driven by their parents. Even after adding built environment this variable still remained significant with a 90% increase in magnitude of impact (DRIVELIC; 0.044>0.023) on choosing driven by parents over walking on their own.

Parental negative perception about their children's walking back home makes them choose motorized modes for their children returning home over allowing them to walk on their own. Interestingly, after adding the built environment variables into the models, the magnitude of the impact increased dramatically (PARFEELWAK; 400.726>50.804). This means that the lack of mixed land use (commercial ground floor and residential buildings) in a neighbourhood, absence of separation between traffic and pedestrians, increase in lanes of traffic and wide streets increase the negative perception of parents about their children walking back home.

In comparing with the models that evaluated children's transportation to school, the influential variables after adding built environment into the models decreased. This may convey that parental concerns about neighbourhood safety (traffic and personal safety) causes them to be reluctant about allowing their children to walk back home. The characteristics of household and children did not play any role in choosing the mode of transportation from school. This may indicate that not all transportation alternatives are available to all children in the afternoon (i.e. households with only one car cannot drive their children back home if the father drives the car to work).

Interestingly, while there is much emphasis concerning traffic safety issues forcing parents to use motorized travel modes for their children or escorting them while on their trip to school, the neighbourhood safety variables had a significant impact compared to other influential factors. The most influential variable on preventing children walking to school independently, as reported by both parents and children, was clearly the presence of undesirable people in the neighbourhood, which is more related to the presence of construction sites in a block or some undesirable land-use which attracts this type of people (decreasing the odds of walking by over 20%).

It is very important to note that most of the built environment variables themselves influence children's walking to school moderately or had no impact, compared to the variables from the basic model. The absence of traffic signs to stop traffic, painted crosswalks and abundant buildings had even retained into models. However, the impact of pavement width was greater for each unit increase in pavement width, the odds of walking to and from school without an adult increased by approximately 45%. The results of the odds ratio proved that traffic safety and neighbourhood safety factors had a different degree of impact on a child's trip to school on foot.

6.4 Discussion

The results of the analysis support the hypothesis that traffic safety is important, but that it is not the only contributing factor to children's trip to school on foot. Other factors may be equally important, such as neighbourhood safety, socio-economic and socio-demographic factors. In addition, urban form variables can change the impact of parental perception about traffic safety and neighbourhood safety. The findings provide useful information to expand the knowledge concerning children walking to and from school, and highlight the importance of knowing about children's perception of barriers as well as their parents' perception regarding this issue.

The comparison of models shows that there are some contributing variables on children's school travel mode choice, which have not been considered in other studies, such as father's travel mode to work. However, this factor was no longer effective on children's trip to school on foot after urban form factors were taken into account. Urban form variables that related to traffic safety, such as traffic speed, lack of traffic signs and perceived distance did not have a significant impact on children's travel mode choices to school. However, children's perceptions of traffic speed influence their walking to school independently. Some other variables that present the perception that traffic safety strongly affects children walking to and from school include the presence and width of pavements. The only influential urban form variable that is related to personal safety in these models was the lack of mixed land use. This also impacted on traffic safety as well, by decreasing the distances between origins and destinations.

These initial results are very useful for policymakers and urban planners, as they indicate how elements of urban form that improve the traffic safety and personal safety in the neighbourhood should be used to address the fundamental concerns of parents and children about a child walking to school. Furthermore, it shows how these elements would be different if children want to walk to and from school on their own. For example, an element such as the presence of speed bumps to calm traffic may be useful around the schools but it is not enough if the street is narrow and impossible to provide pavements on both sides along the route. Moreover, the presence of completed pavements is not enough when they are too narrow (≤1.00 m) or there is not any separation between pedestrians and traffic. In addition, the presence of speed bumps is not effective when children have to cross streets with more than 4 lanes of traffic. This generated a consistent result with other studies that showed that children below 12 years old have a problem in perceiving the direction of moving traffic (Leden et al., 2006). The results also support that traffic safety is not the only influential factor to promote children walking to and from school. However, the hypothesis will be tested more in the next chapter.

Testing the model at different levels of geographic scale for the built environment variables was not initially intended but was a useful methodological exercise. The small neighbourhood sample size may be caused by the lack of results for traffic safety and neighbourhood safety. However, the lack of variation in the traffic safety variables across different neighbourhoods within each area (high-income, middle-income and low-income) is not considered a problem, because the objective of this study is to compare the critical variables in choosing children's mode of transportation to school across different income groups. However, to address different meanings of area level variables, parents and children were asked about the existing elements in the immediate school neighbourhood in the survey (open ended questions) and ad-hoc interviews were done if they did not answer the open-ended questions properly. Furthermore, some photos were taken to support the discussions and show the differences across the area.

Therefore, the new model includes the variables that present urban design and environmental safety (traffic and personal safety) from the perception of parents and children. This enables a better understanding of the characteristics of urban design that have an effect on children's travel mode to school. It is not entirely unexpected that when parents and children's perceptions of urban form barriers are added to the model that several changes occur in the results. Many variables that had been significant lost their significance and new variables became significant instead.

These changes emphasize the importance of people's perception (parents and children) when measuring urban design and traffic safety, particularly for walking. It also shows the elements in the physical environment that are considered as barriers or promoters to walking vary across different age groups. Some variations in the built environment that is important to pedestrians at finer grain than drivers may be less effective when data are aggregated. Moreover, the characteristics of the built environment may become exaggerated at the aggregated level (McMillan, 2003).

It also reveals that the characteristics of the urban design may become exaggerated when it is measured at the combination level (combination of blocks) and only averages are considered. For example, a school site may have an average of wide streets and narrow pavements yet a high walking rate as well, so the result that wider streets and narrower pavements increase children walking could be found, which is unexpected. Collecting data at the street segment level is more accurate and draws a clearer picture of the individual physical environment in analysis.

6.5 Conclusion

It is very important to take note that although some findings of this study do not support the results of previous studies, this does not mean that they are not correct or do not provide useful information. The results show that some factors that can promote walking for adults may not be considered as an effective element in choosing a child's school travel mode. Therefore, it highlights the importance of measuring urban form elements based on population specifics. In addition, the measurement should be sensitive to the socio-economic status of areas. Different elements may have different features across different areas. Moreover, a neighbourhood with more developed infrastructure may fit better to current urban design assessment.

This analysis was an initial stage for the complete testing model of children's walking to and from school. As the analytical framework indicated and the results show, traffic safety is a significant contributing factor in a child's trip to school on foot. However, there are some other factors besides traffic safety. It is important for urban planners and policymakers to consider the role of each factor in choosing active travel mode to school (especially walking without an adult) for children. Then, they can develop an effective policy improvement in the physical environment to promote walking to school among children. Modelling children's walking to school not only determines how traffic safety impacts on a child's trip to school on foot, but it also shows how these groups of factors relate to other influential factors regarding children walking to school. The next chapter presents these issues.