

Does children's independent mobility matter? Insights into escorting practices in a developing country

Abstract

Understanding children's mobility behaviour and parents escorting practices are important to developing a children-friendly society. Both in developed and developing countries, children's independent mobility is decreasing, and increasingly, they are chauffeured by their parents or under surveillance to school or other potential activity locations. Only a few studies on understanding children's mobility behaviour have focused on developing countries. In this study, we attempted to develop an econometric model to understand escorting practices in a developing country. A multinomial logit (MNL) model is developed using travel diary data of 398 elementary school-going children, inhabiting in Chattogram City Corporation (CCC) area of Bangladesh. We have considered different combinations of environmental (both school and neighbourhood environment), socio-cultural, household, and personal factors to explain children's independent mobility behaviour for both school and discretionary trip purposes. The findings suggested that children's individual (e.g., education level) and parents' sociodemographic (e.g., income, access to cars, mother's education level) facilities available at school, and built-environmental factors (e.g., commercial density, road density, land use mix and proximity to open spaces) are significantly associated with parent's choice for chauffeuring their children in CCC area. Results will be useful to planners and policy makers for formulating effective measures to promote children's independent mobility and will be a guideline for urban planners to include children's mobility demand for the neighbourhood as well as city design.

Keywords: Children; independent mobility; escorting type; developing country; Chattogram; Bangladesh

Background

Mobility is a complex concept that has different meanings, practices, functions, and justification to shape the way of movement through urban spaces (Cuzzocrea and Mandich 2015). It is considered to be an essential element in everyday life (Freudenthal-Pedersen 2016), playing an indispensable role in developing relationships among family members as well as experiencing a city through the lens of a safe circle — a reflection of self-belongingness (Cuzzocrea and Mandich 2015). However, recent mobility studies are not only limited to normative analysis of historical and contemporary mobility patterns but also focused on mobility capabilities and justice, which deal with the mobility right and sustainable movement (Sheller 2014; Bergmann and Sager 2008). Among a wide range of topics gets by the mobility regime, understanding children's mobility is an important part of drawing a complete picture of the overall well-being of the society (Sheller 2014; Waygood et al. 2017). The sustainable development goals (SDGs), adopted by United Nations member countries in 2015, highlighted the importance to take initiatives to ensure child-friendly cities, aiming to make cities and human settlements inclusive, safe, resilient, and sustainable (Khan, Razzak, and Wärnberg 2022). However, contemporary urban-transport policies in many cities overlooked the importance of children's mobility as a complementary part of sustainable development (Banister 2008). "Value of time" oriented transport policies are more focused on adults than children, which overlooked children's right to autonomy (Waygood et al. 2017). As a result, children's lives become socially excluded and isolated, which are frequently compared with life in a glasshouse (Kyttä 2003; Cass, Shove, and Urry 2005). Several studies highlighted that children's independent mobility is decreasing and increasingly, they are chauffeured by their parents or under surveillance to school or other potential activity locations (Waygood et al. 2017; Carroll

1
2
3 et al. 2015; Drianda, Kinoshita, and Said 2015; Lopes, Cordovil, and Neto 2014; Witten
4
5 et al. 2013; Malone 2007). The increasing dependence of children on their parents for
6
7 the mobility purposes has direct or indirect impacts on their health, cognitive
8
9 knowledge, analytical skills, competence development, psychological growth social-
10
11 cultural-spatial relation development (Mackett et al. 2005; Lopes, Cordovil, and Neto
12
13 2014; Carver et al. 2014).

14
15
16
17 Recent studies attempted to explain children's independent mobility by
18
19 analysing factors that directly or indirectly control or support their independent
20
21 mobility. Among various factors, children's age, gender, and maturity are widely used
22
23 indicators in the area of demographic milieu (Alparone and Pacilli 2012; Valentine and
24
25 McKendrick 1997; Brown et al. 2008; Barker et al. 2009). Other biological factors such
26
27 as body mass index (BMI) are also considered to be inversely associated with children's
28
29 daily physical activity and active mobility (Larouche et al. 2016; Schoeppe et al. 2013).
30
31 Also, characteristics of the physical and living environments that constitute children's
32
33 backdrop of everyday life significantly influence their geographical boundaries of
34
35 mobility (Carver et al. 2014). The perception of children and their parents about the
36
37 surrounding environment and danger is also important to autonomous mobility
38
39 (Alparone and Pacilli 2012; Carver, Timperio, and Crawford 2008). The "fear" of
40
41 potential risk generally restricts children's independent mobility (Carver, Timperio, and
42
43 Crawford 2008; Alparone and Pacilli 2012), and the ontology of "fear" is not only
44
45 rooted in the parental perspective but also children (Valentine and McKendrick 1997).
46
47 Fear could be related to danger on the street (Timperio et al. 2004), strangers (Timperio
48
49 et al. 2004; Carver, Timperio, and Crawford 2008; Lopes, Cordovil, and Neto 2014),
50
51 risk of violence (Carver, Timperio, and Crawford 2008; Valentine and McKendrick
52
53 1997), and fear from space (Valentine and McKendrick 1997). All factors associated
54
55
56
57
58
59
60

1
2
3 with children's independent mobility patterns are dynamic, interdependent, and vary
4
5 depending on the context, scale, and time (Alparone and Pacilli 2012). For example,
6
7 when most of the studies highlighted parents' and children's "fear" of "stranger danger"
8
9 as one of the potential risks for the children, paradoxically, according to Gardner (2011)
10
11 the relationship with strangers could be an important factor to form a natural
12
13 neighbourhood. The perception of traffic danger leads parents to drive their children to
14
15 school, causing an increase in the number of vehicular traffic around the school, making
16
17 school precincts more dangerous and causing traffic congestion around schools (Lam
18
19 and Loo 2014). Hence, investigating children's independent mobility is challenging due
20
21 to the complex relationships of children's mobility with socio-demographic,
22
23 environmental and psychological factors, as well as the built environment of a city.
24
25
26
27

28
29 Given the importance to understand children's independent mobility in transport
30
31 planning in different socio-demographic contexts, several studies were conducted in the
32
33 context of developed countries (e.g., the USA, Canada, UK, Australia, New Zealand,
34
35 Denmark, Finland, Germany, and Switzerland), where children's independent mobility
36
37 behaviour was analysed from multi-dimensional perspectives (Babey et al. 2009;
38
39 Schoeppe et al. 2014; Boarnet et al. 2005; Christensen et al. 2011; McMillan 2005;
40
41 Brown et al. 2008; Milne 2009; Kyttä, Broberg, and Kahila 2012; Mikkelsen and
42
43 Christensen 2009; Mitchell, Kearns, and Collins 2007; Borghese and Janssen 2018; Lin
44
45 et al. 2017). The findings from developed countries with little or no adjustment
46
47 considering the context of developing countries often face numerous shortcomings due
48
49 to the differences in (i) socioeconomic composition (e.g., income, age and gender
50
51 distribution, household responsibilities, family structure); (ii) dependency and freedom
52
53 culture (e.g., level of dependency of children on parents, elderly people, peer,
54
55 neighbour, caregiver and friends and, level of freedom allowed to children); (iii)
56
57
58
59
60

1
2
3 neighbourhood facilities (e.g., availability of school, playing facilities within walking
4 distance, mobility facilities, safety and security, law enforcement); (iv) social norms
5 (e.g., level of interaction with family members and outsiders); and (v) transportation
6 facilities (e.g., car ownership level, school transport facilities, public transport facilities,
7 paratransit) (Cervero 2013; Torche 2019; Sharmin, Kamruzzaman, and Haque 2020;
8 Malone and Rudner 2011). Thus, a significant difference in children's mobility
9 behaviour and escorting type can be observed between developed and developing
10 countries. Only a few studies on understanding children's mobility behaviour were
11 conducted in developing countries, particularly in Asia and Africa (Malone and Rudner
12 2011; Behrens and Muchaka 2011; Lam and Loo 2014). Evidence from those studies
13 showed that children from developing countries are less likely to be independently
14 active than children from developed countries. For example, the rate of car dependency
15 in Cape Town increased from 1975 to 2010, causing a decline in the use of non-
16 motorized modes (walking and cycling) for school trips (Behrens and Muchaka 2011;
17 Malone and Rudner 2011). Therefore, it is imperative to emphasize studies of children's
18 mobility behaviour in developing countries to formulate context-specific policies to
19 promote children's independent mobility. The purposes of this study were two-fold.
20 First, to develop an econometric model to understand the escorting practices of
21 parents, residing in a developing country. Second, to identify potential factors either
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48

49
50
51 ¹ Econometric models are used to estimate the influence of various independent variables on a
52 dependent variable, assuming that each decision-maker is an economic agent. These are
53 based on mathematical, economic, and statistical concepts (Maddala and Lahiri 1992;
54 Wooldridge 2015).
55
56
57
58
59
60

1
2
3 supporting or inhibiting children's independent mobility at a very early stage. The
4
5 study focused on elementary school-going children, inhabiting Chattogram City
6
7 Corporation (CCC) area in Bangladesh. The existing urban and transport development
8
9 policies in Bangladesh less prioritize children's mobility demand. While considering
10
11 children as active agents in the decision-making process is imperative to make a child-
12
13 friendly city (UNICEF 2022), overlooking their demand hinders the sustainable urban
14
15 development in Bangladesh. Hence, this study is an attempt to shed a light on this
16
17 emerging fact to reinforce the importance of children's mobility at the city scale to
18
19 rethink, reshape, and rebuilt the cityscape as per children's needs.
20
21
22
23
24

25 **Materials and methods**

26 *Study area*

27
28
29
30
31 Chattogram City Corporation (CCC), located in the south-eastern region of Bangladesh,
32
33 was selected as the study area (Figure 1). It is the second-largest city and the
34
35 commercial hub of the country. About 4 million people inhabit within 177 km² area of
36
37 CCC. Administratively, CCC is divided into 41 wards (the smallest administrative unit)
38
39 (Zannat et al. 2021). About 60% of the total urban population in Bangladesh inhabits
40
41 four major cities such as Dhaka, Chattogram, Khulna, and Rajshahi (Rana and Parves
42
43 2011). Like other major cities in the country, Chattogram city has been growing at an
44
45 alarming rate, fuelled primarily by rural-urban migration. (Zannat, Raja, and Adnan
46
47 2019). The city was ranked as the tenth fastest-growing city in the world in 2010 (Mia
48
49 et al. 2015). The major development policies of the city predominantly considered
50
51 adults' daily mobility. The city planning policies lack focus on children's mobility. For
52
53 example, the Strategic Urban Master Plan (SUTMP) developed to improve mobility in
54
55 Chattogram overlooks the vision to make the city children friendly. Reportedly, there is
56
57
58
59
60

1
2
3 a lack of policy in SUTMP (2019-2030) to improve children's independent mobility in
4
5 CCC (Sakaki 2018). This can be a potential reason for the increasing accident rates and
6
7 causalities of school-going children (Zvobgo 2019). In this study, we selected the
8
9 elementary school-going children residing in the CCC area to understand their escorting
10
11 type and mobility behaviour, accounting for different individual and household
12
13 sociodemographic and built environmental factors.
14
15
16
17
18

19 ***Data***

20 *Primary data*

21
22 A travel diary survey was conducted from 15 April 2019 to 29 April 2019 to acquire
23
24 relevant data. The survey was designed to record children's travel patterns within a
25
26 week (both weekdays and weekends). The respondents included parents of the
27
28 elementary school-going children, who were asked about their children's mobility
29
30 patterns. We selected the elementary school-going children because at this stage
31
32 children attempt to establish a relationship with their surroundings activity environment
33
34 (Loukaitou-Sideris 2003). The contact information of parents was collected from school
35
36 authorities. Authorities of a total of 65 (out of 215) Government Elementary schools in
37
38 the CCC area were approached. Among them, 22 schools granted permission and shared
39
40 parents' details and contact information. The selected Government Elementary schools
41
42 were located both in high-income and low-income neighbourhoods to avoid
43
44 geographical and socioeconomic biases among the participants. Parents of a total of 398
45
46 school-going children participated in a weeklong telephone interview survey. Table 1
47
48 shows a comparison of the household characteristics (e.g., household size and income)
49
50 in the sample with the corresponding urban population (census). The survey form
51
52 comprised of three subsections: household socio-demographics (e.g., household income,
53
54
55
56
57
58
59
60

1
2
3 parents' education, occupation, access to cars² (includes both car ownership and have
4 access to office-provided car transport), housing condition, ethnicity, number of
5 elementary schools going children in the household, location of household at the ward
6 level)), children's socio-demographics (e.g., study level, gender), and trip-related
7 information (e.g., departure time, trip purpose, mode choice, accompaniment type).
8 Parents were contacted every day in the evening of the surveying week. Interviewers
9 ensured the parents that the collected information will be only used for research
10 purposes. School authorities informed the parents beforehand about the research and
11 interview. We used the telephone interview survey technique as it allowed us to cover a
12 wider geographical area in CCC in comparison with the face-to-face interview. Also, it
13 was easier for the respondents to recall their children's everyday mobility as they were
14 contacted in the evening and were asked about the trips made by their children on the
15 same day. Therefore, the collected data was as reliable as the face-to-face interview.
16 Further, to achieve greater accuracy and avoid biases in the cross-sectional study, the
17 data was collected for seven consecutive days, including both working days and
18 weekends. Therefore, the model developed using the collected data provided a more
19 accurate inference of model parameters and has a greater capacity for capturing the
20 heterogeneity associated with the socio-demographic conditions of the respondents. The
21 school authorities also provided additional information about the physical (e.g., playing
22 equipment) and functional (e.g., extracurricular activities) facilities available within the
23 school for children's extra-curricular activities.
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57

58 ² In Bangladesh, it is a common practice that household members have access to cars provided
59 by offices (both private and public organizations) for their employees.
60

Secondary data

This study also used a range of secondary data to investigate the association between escorting type and various built environment indicators. We used “4D” built environment indicators originally developed by Cervero and Kockelman (1997). “4D” variables include density, diversity, design, and destination accessibility. Spatial information on different physical features such as building density, road density, public facilities (e.g., schools, parks), and structural use was collected at the city scale from Chattogram Development Authority (CDA) (Sakaki 2018). A summary of the selected built environment factors is given in Table 2. This study used grided population density data collected from WorldPop (Bondarenko et al. 2020). To understand the state of land use mix, a dissimilarity index was developed following a methodology by Cervero and Kockelman (1997). The dissimilarity index was calculated at 300 m resolution using the following equation (Ma and Chen 2013):

$$Dissimilarity = \left\{ \left[\sum_j^k \sum_1^8 (X_i/8) \right] / K \right\} \quad (1)$$

where, K = number of actively developed grid-cells in the larger geographic area; and $X_i = 1$ if abutting grid cells have different land uses. Otherwise, $X_i = 0$. Dissimilarity index ranges from 0 to 1, where 0 represents no variability of land use (total homogeneity) and 1 represents the highest variability (total heterogeneity) (Ma and Chen 2013). Land cover data used to calculate dissimilarity index includes five categories built-up, waterbody, vegetation, agricultural land, and fallow land (Abdullah et al. 2019).

Modelling framework

To understand children's mobility behaviour, different studies adopted qualitative approaches (Witten et al. 2013; El-Dorghamy and Mosa 2016; Pacilli et al. 2013; Nansen et al. 2015), quantitative approaches (Stone et al. 2014; Larouche et al. 2016; Carver et al. 2014; Carroll et al. 2015; Carlson et al. 2015; Babey et al. 2009; Timperio et al. 2004) or a combination of both (Boarnet et al. 2005; Tranter and Pawson 2001).

Among different quantitative approaches, econometric models are widely used to understand children's mobility behaviour in conjunction with several behavioural theories (Carlson et al. 2015; Larouche et al. 2016; de Bruijn et al. 2005). In general, econometric models enable investigating relationships, hypothesis testing, and predicting the future (Wooldridge 2015). In this study, we applied a random utility framework to model escorting practices in the CCC area. Random utility theory suggests that individual decision is followed by rationality and complete information. In this study, decision-makers were the parents who choose each alternative escorting type with the highest utility, where the utility of an alternative i to a person n has the form:

$$u_n(i) = u(x_{in}, s_n) \quad (2)$$

where, x_{in} is the vector of the attribute of alternative i and s_n is the vector of characteristics of person n . McFadden (1973) proposed that this utility has a linear-in-parameters separable form:

$$u(x_{in}, s_n) = V(x_{in}, s_n)\beta + \varepsilon_{in} \quad (3)$$

where, V is the observed component of utility, β is the parameter vector that would be estimated using the available choice data. The unobserved variable ε_{in} expresses contribution of unobserved attributes to utility. Here, rationality is measured

by comparing with the sample. If there are additional factors influencing the observed behaviour of the individuals that cannot be explained within a random utility framework, those will be captured by the error term. Besides, the probabilistic nature of the adopted framework allowed us to test the assumptions related to the choice situation without making any deterministic interpretation. In our model, ε was assumed to be independent and identically distributed across alternatives and following a Type I Extreme Value distribution (Gumbel). Therefore, the choice probability of children's mobility behaviour (independent mobility/accompanied by parents/accompanied by caregiver/accompanied by siblings or friends) was estimated using the multinomial logit model (McFadden 1973). The choice probabilities for each alternative mobility type i in MNL model can be expressed as (for detail see (Train 2009)):

$$P_n(i) = \frac{e^{V_{in}}}{\sum_{j=1}^J e^{V_{in}}} \quad (4)$$

Here, the distribution of the error term can be expressed as:

$$f(\varepsilon_{n,j}) = \mu e^{-\mu(\varepsilon_{n,j} - \eta)} e^{-e^{-\mu(\varepsilon_{n,j} - \eta)}} \quad (5)$$

$$F(\varepsilon_{n,j}) = e^{-e^{-\mu(\varepsilon_{n,j} - \eta)}} \quad (6)$$

For the MNL estimation, location parameter $\eta = 0$, scale parameter $\mu = 1$, mean $\eta + \frac{\gamma}{\mu} = \gamma$ which is the Euler constant and variance $\frac{\pi^2}{6\mu^2} = \frac{\pi^2}{6} \sim 1.6449$.

Modelling issues

A multinomial logistic regression model was developed to understand the factors influencing parents' chauffeuring choices for their elementary school-going children.

1
2
3 The MNL model was established using the “Apollo” package R, applying the Maximum
4 Likelihood Estimation with the BFGS optimization algorithm (Hess and Palma 2019).
5
6 Model estimation was done considering the weeklong mobility pattern of children. The
7
8 MNL model included parents’ chauffeuring choice type as a dependent variable and
9
10 sociodemographic, built environment, and trip-related factors as independent variables.
11
12 Though income and car ownership are generally correlated, we used “access to car” as
13
14 an alternative to car ownership. Most of the independent variables were incorporated
15
16 into the model as dummy variables. The number of students studying in schools and
17
18 built environment attributes was included in the model as continuous variables. Both
19
20 school and non-school trips were incorporated into the model estimation. Given the
21
22 differences in the share of household income in the sample and the census, the samples
23
24 were weighted to match the census shares before the model estimation to increase the
25
26 representativeness. The addition of weightage has improved the model log-likelihood
27
28 and subsequently the goodness-of-fit (measured by adjusted rho-square). The majority
29
30 of the studies measured the influence of the neighbourhood built environment on
31
32 children’s independent mobility using subjective perception (Ghekiere et al. 2017).
33
34 However, to avoid subjective bias, in this study, we measured objectively the
35
36 association between the built environment and escorting practices of children’s
37
38 mobility.
39
40
41
42
43
44
45
46
47

48 **Results**

49 ***Summary statistics***

50
51 A summary of the socio-demographic characteristics of the children and their
52
53 households are given in supplementary document (Table S1 and Table S2). Of the 398
54
55 respondents (parents of school-going children), about 41% were from the middle-
56
57 income group, who lived in rented houses. The majority of them (95%) did not have
58
59
60

1
2
3 access to cars. With respect to the education level, about 39% of fathers and 54% of the
4
5 mothers completed primary studies. A substantial proportion of fathers (24%) were
6
7 university graduates, while only 7% of mothers completed their graduations. Fathers
8
9 were mostly employed in the formal job sectors, whereas mothers were mainly
10
11 housewives. In terms of the mode choice of school-going children, most of them walked
12
13 for school trips and were accompanied by their parents.
14
15

16 17 18 *MNL model results* 19

20
21 Results of the MNL model are summarized in Table 3, which shows the estimated
22
23 alternative-specific constants (ASCs) for independent and dependent mobility
24
25 (accompanied by parents/caregiver/peer) of children, where independent mobility was
26
27 used as a base. The values of the ASCs indicate that all else being equal, parents had the
28
29 highest utility if they accompanied their children's movement compared to their
30
31 children's independent movement. This is an indication of increasing dependent
32
33 mobility practice at an early stage.
34
35

36
37 Three variables were used to capture heterogeneity associated with the
38
39 household socio-demographics such as "access to car", household income
40
41 (<10,000BDT), and education level of the children's mother. A positive coefficient is a
42
43 sign of potential access to cars, indicating that the propensity to move independently
44
45 was lower among the children having household access to cars. The statistical
46
47 insignificance of mobility with parents having access to cars was likely to be linked to a
48
49 common scenario in Bangladesh, i.e., multiple users of a car operated by a chauffeured
50
51 driver. This implies that sometimes children needed to rely on others (e.g., friends,
52
53 caregivers) due to the unavailability of cars when other household members had access
54
55 to cars. The household income (<10,000 BDT) shift in the escorting type of ASC
56
57
58
59
60

1
2
3 captured the preference of parents for their children's independent mobility. Such a
4
5 scenario may be attributed to the fact that in low-income households, both parents are
6
7 likely to go outside for earning and have a lower chance to accompany their children
8
9 during the movement. Mothers' education level was also associated with the escorting
10
11 type preferred by the parents for their children's mobility practice. Graduated mothers
12
13 were less likely to allow their children to move with their friends.
14
15

16
17 Among different socio-demographic variables, children's education level was
18
19 found to be a significant exogenous variable in predicting their mobility behaviour, due
20
21 to the association of children's education level with their age. Children studying below
22
23 standard III were more likely to travel with their parents and caregivers. The effect of
24
25 gender was also considered initially. However, since the effect was significantly not
26
27 different from zero, they were excluded in the final model.
28
29

30
31 From model estimates, a significant difference in escorting practice (in the CCC
32
33 area) can be observed, depending on the type of modes used for the movement and trip
34
35 purposes. Children travelling by non-motorized transport (walking, cycling) were more
36
37 likely to travel independently. Also, depending on the trip purposes, escorting practices
38
39 varied among the parents of school-going children. For home-to-school trips and
40
41 discretionary trips (both outbound and return), children were less likely to be escorted
42
43 by their friends.
44
45

46
47 To capture social influence on children's independent mobility, both school-
48
49 related and social attributes were considered in the model. Children studying in a school
50
51 with many students were more reliant on others for daily movements. Many students at
52
53 school remarked less chance among parents, teachers, and students to be known to each
54
55 other. In such a situation, it is intuitive that parents would be less likely to allow their
56
57 children to move alone for school and other discretionary trips. Also, if the schools were
58
59
60

1
2
3 facilitated with playing equipment, children were more likely to travel with their
4
5 friends. Though all the schools selected for this study were government primary
6
7 schools, facilities for children varied from school to school, depending on the location
8
9 of schools and governing authority. The type of school is also an indicator of
10
11 neighbourhood type and socio-economic status of the parents. Literacy rates at home
12
13 locations (ward-wise aggregate literacy rate) were also positively associated with
14
15 children's independent movements with their friends. Higher literacy insinuates a better
16
17 social and living environment which anticipates better safety.
18
19
20

21
22 Different built environment factors such as ward-wise commercial density, road
23
24 density, average elevation, proximity to parks, and land use type were considered in this
25
26 work. The influence of other built environment factors (Table 2) was also tested,
27
28 however, not included in the final model as their influence was not statistically different
29
30 from zero. The inclusion of built environment factors improved the model's
31
32 performance. Most of the estimated coefficients agreed with the hypothesis.
33
34 Commercial density and road density were negatively associated with children's
35
36 independent mobility. Estimated coefficients suggested that when children's
37
38 neighbourhood was in a high-density commercial area (where road density is also high),
39
40 they were more likely to travel with their parents or caregiver due to the concern
41
42 regarding traffic accidents. However, if the home location was characterised by a
43
44 balanced residential and commercial development, children were more likely to travel
45
46 with friends or caregivers other than their parents. On the other hand, if the home
47
48 location was in proximity to parks and green areas, children were more likely to travel
49
50 with their parents and less likely to travel with their caregivers. In the CCC area, most
51
52 of the parks and green spaces were located close to affluent neighbourhoods. Affluent
53
54 parents were less likely to allow their children to move independently. Such a scenario
55
56
57
58
59
60

1
2
3 was also observed in households with access to cars and characterized by higher income
4
5 levels. The influence of land elevation was also estimated. In the hilly CCC area,
6
7 children living in higher elevation lands (i.e., affluent areas) were more likely to travel
8
9 with their caregivers.
10
11
12

13 **Discussion**

14
15
16 The United Nations' Sustainable Development Goals (SDGs) promote children's
17
18 independent mobility to allow the implementation of active transportation as a safe,
19
20 affordable, accessible, and sustainable mode of transport (de Sa et al. 2015). According
21
22 to Piaget's theory of cognitive development of children, knowledge and growth of
23
24 intelligence evolves through a complex interaction between individual and environment
25
26 (social as well as the physical environment) (Valentine and McKendrick 1997). The
27
28 current study considered different combinations of environmental (both school and
29
30 neighbourhood environment), socio-cultural, and personal factors to explain children's
31
32 independent mobility behaviour for both school and discretionary trip purposes. We
33
34 attempted to provide a comprehensive understanding of parents' escorting preference
35
36 for their children's movement focusing on a developing country. The findings from the
37
38 CCC area suggested that significant heterogeneity existed in the children's mobility
39
40 behaviour while studying in government elementary school.
41
42
43
44
45

46
47 In line with other studies, household socio-demographic variables such as
48
49 household monthly income and access to cars played an important role in understanding
50
51 parents' choices for chauffeuring their children's daily movement. This can be
52
53 attributed to households' economic status which determines the proportion of income
54
55 spent on transport, caregiving, and the amount of free time available for parents to
56
57 escort their children. However, the insignificant influence of access to cars on children's
58
59
60

1
2
3 chauffeuring choices in the CCC area distinguished the difference between developed
4 and developing countries. Higher dependency on private vehicles, particularly car use is
5 apparent in a developed country where fewer children are involved in active transport or
6 using public transport (de Sa et al. 2015). A lower car ownership rate in Bangladesh as
7 well as among the recruited respondents (4.52% of the total respondents) approved a
8 lower car use rate for educational trips, which also complies with the study of Loo and
9 Lam (2015). Also, more than 75% of the total respondents (children) used walking for
10 daily movement, which reinforced their reliance on active mode for trip purposes (Table
11 S2, supplementary document).
12
13
14
15
16
17
18
19
20
21
22

23
24 Besides households' socio-demographic properties, demographical
25 characteristics of children stood out to be significant factors in defining their mobility
26 behaviour and corresponding chauffeuring type in the CCC area. Though gender is a
27 significant determinant in other child mobility studies (McMillan et al. 2006), in the
28 CCC area, the influence of gender on children's chauffeuring choices was not
29 significantly different from zero. Similar to the other studies (Alparone and Pacilli
30 2012; Schoeppe et al. 2014; Prezza et al. 2001), findings from this study exhibited
31 children's age and level of maturity as significant determinants of parents' choice of
32 chauffeuring type for their children. This finding is intuitive as parents were afraid of
33 potential risks to their children, caused by strangers and vehicular traffic. Also, it is
34 empirically proven that for safety reasons younger children are accompanied by their
35 parents either in cars or under surveillance (Drianda, Kinoshita, and Said 2015; Fyhri
36 and Hjorthol 2009; Carroll et al. 2015). This safety concern reduces children's
37 independent mobility and excludes them to interact with their surroundings and develop
38 social and environmental relations (Valentine and McKendrick 1997), resulting in
39 disconnection or lack of interactions with their surrounding environment and space
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

(Malone 2007; Karsten and Van Vliet 2006). This study also noted that there is a social trend to control children, monitor and look after them every time to become the “good parent” in the culture imposing restrictions on children’s mobility patterns (Sergeyeva and Laktukhina 2016; Valentine and McKendrick 1997). The avoidance of friends from discretionary trip movement noted an increasing number of organized leisure activities often in an institutionalized structure. Various incidences in Bangladesh associated with children’s drug addiction and dropping out of school might be the potential reasons for parents’ preference to escort their children by themselves or by their caregivers (Ahad et al. 2017). This highlights the negligence of peer-peer learning in the process of children’s upbringing. Consequently, children face multiple threats (health, social, psychological, cultural, and environmental) during their childhood and adulthood (Drianda, Kinoshita, and Said 2015; Malone 2007), making them less resilient to the potential risk associated with their everyday life (Lopes, Cordovil, and Neto 2014; Malone 2007). This is because childhood is not completely biological and adulthood is not merely physical maturity, they are both socially constructed and developed (Valentine and McKendrick 1997; Barker et al. 2009). Malone (2007) called this confined generation of children a bubble-wrap generation who are more confined in indoor activity (Karsten and Van Vliet 2006; Carver, Timperio, and Crawford 2008). This study further observed that within the seven days of the survey (including both working days and weekends), only 5% of children were involved in out-of-home activities other than school. Therefore, it is high time to think about children’s independent mobility in the CCC area to protect them from being confined generation. Instead of confining younger children’s movement for the perceived safety, alternative approaches (e.g., walking school, out of school activity, way-finding games, or unorganized activities monitored remotely without interfering in children’s interaction

1
2
3 activity) need to be practised that would increase their independence in moving freely
4
5 and increase interaction with the neighbourhood environment.
6

7
8 Various studies highlighted the importance of unsupervised, informal and
9
10 random leisure activities for children's cognitive development (Mackett et al. 2005;
11
12 Fyhri et al. 2011; Fyhri and Hjorthol 2009), as it involves more physical exercise and
13
14 psychological work well connected with their (children) fellows. However, this study
15
16 observed that in the CCC area, children's movement was very limited during their
17
18 school trips (95% of the total recorded trips within a week), which were mostly
19
20 accompanied by their parents (60% of the total trips). Children spend their maximum
21
22 day time under adult supervision (parents and caregivers at home and teachers at
23
24 school) and this way of growing up is less support for children's independent mobility
25
26 and cognitive development (Drianda, Kinoshita, and Said 2015). Such supervised
27
28 activities have two-fold impacts on the children. Firstly, as most of the organized
29
30 activities are institutionalized, children's mobility pattern becomes hopping from island
31
32 to island which corresponds to their parent's mobility pattern (Fyhri and Hjorthol 2009).
33
34 Specifically, in terms of mode choice, this circumstance precludes the formation of a
35
36 holistic image of the city among children (Karsten and Van Vliet 2006). Secondly,
37
38 children's mobility pattern is muddled with the adult's movement pattern and
39
40 considered children's mobility invisible (Fotel and Thomsen 2003) or relatively
41
42 immobile (Elliott and Urry 2010). Therefore, it is important to bring changes in
43
44 children's confined home and school-oriented activity patterns. This 'spatial'
45
46 disconnection and lack of communication are described to be sinuous of social
47
48 exclusion (Cass, Shove, and Urry 2005). Measures need to be taken to increase
49
50 interactions and communication of children with friends, neighbours or with outsiders.
51
52 This is because, interaction and communication are imperative to develop a sense of
53
54
55
56
57
58
59
60

1
2
3 safety, otherwise, children would feel lonely and less secure even within their
4
5 community (Pacilli et al. 2013), and this fact, is often overlooked or undermined
6
7 (Carver, Timperio, and Crawford 2008).
8
9

10 Several studies also reported that children's independent mobility provides the
11
12 opportunity to interact with the environment which in return develops social relations
13
14 and a sense of community (Carver et al. 2014; Kytta 2003). Besides, children are active
15
16 learners, and their learning process is dependent on their daily experiences with their
17
18 surroundings. However, parallel to other contemporary studies, it is clear in this study
19
20 that due to the unplanned development and labyrinth of a modern city it was difficult for
21
22 a child to find a suitable place for them that often requires the supervision of elders to
23
24 reach their potential destination. The result from this study indicated that activity places
25
26 in proximity to home (accessible by active mode) were considered to be safe for
27
28 children as parents can keep their eye on their children's movement (Prezza et al. 2001).
29
30 Further, findings from this study also reinforce that commercialization, higher street
31
32 density, and homogenous land use development inhibited children's independent
33
34 movement. On the contrary, proximity to parks or open spaces did not encourage the
35
36 independent movement of children or escorting with friends, which does not comply
37
38 with the hypothesis. This can be attributed to an unorganized spatial distribution of open
39
40 spaces and their inaccessibility. Therefore, it is important to think about the inclusion of
41
42 children's mobility demand in the neighbourhood as well as in city design. Besides,
43
44 having more playing facilities at school, children engage for a longer duration with their
45
46 friends which may also help the children to have a special bonding with their friends.
47
48 Parents become familiar with the other children and consequently, become willing to
49
50 rely on children's movements with their friends (Page et al. 2010).
51
52
53
54
55
56
57
58
59
60

Conclusion

Children's mobility has similar significance to adults' mobility in the city as they are often interdependent with each other and have a substantial contribution to shaping the city. This study attempted to highlight the importance of children's mobility from a developing country perspective. The effects on the parents' choice of escorting were estimated by establishing a comprehensive MNL model using panel data. The results reflected different escorting preferences of various socio-economic groups and potential factors affecting such behaviour. Though the study proposed a comprehensive framework to analyse children's mobility behaviour, there is potential room for future research. This study only considered the mobility behaviour of children residing in urban areas. It would be worth considering similar research focusing on rural areas since changes in children's mobility behaviour are expected to be different. Also, the scope of this study was limited to analysing the influence of socio-demographic and built environment factors on individual parental behaviour in accompanying their children. However, parents' and children's perceptions about their neighbourhood or school precinct are important determinants in understanding children's independent mobility which can be incorporated in future research with a more advanced modelling approach. Further, new technology such as GPS, and mobile phones can be used along with the travel diary survey data to get a more comprehensive scenario of children's and their parents' mobility behaviour. This is an important shortcoming of this work given Bangladesh is a developing country and has some social restrictions on to use of digital devices. For further analysis of children's travel behaviour, along with out-of-home activity, in-home activity data can be used to understand children's daily activity type and duration choice to elucidate the satiation and baseline preference of children's daily activity pattern.

Nevertheless, the findings of this research can be used as a starting point to develop a framework for the inclusion of children's mobility demand in transport policies and planning at the city scale. Eventually, the outcome of the research will be useful to urban planners and policymakers for predicting children's mobility behaviour in different future urban scenarios to formulate effective measures to promote children's independent mobility.

References

- Abdullah, Abu Yousuf Md, Arif Masrur, Mohammed Sarfaraz Gani Adnan, Md Baky, Abdullah Al, Quazi K Hassan, and Ashraf Dewan. 2019. "Spatio-temporal patterns of land use/land cover change in the heterogeneous coastal region of Bangladesh between 1990 and 2017." *Remote Sensing* 11 (7):790.
- Ahad, Md Abdul, Mitu Chowdhury, Indrajit Kundu, Nishith Tanny, and M Wakilur Rahman. 2017. "Causes of drug addiction among youth in Sylhet city of Bangladesh." *IOSR Journal Of Humanities And Social Science (IOSR-JHSS)* 22 (5):27-31.
- Alparone, Francesca Romana, and Maria Giuseppina Pacilli. 2012. "On children's independent mobility: the interplay of demographic, environmental, and psychosocial factors." *Children's Geographies* 10 (1):109-22.
- Babey, Susan H, Theresa A Hastert, Winnie Huang, and E Richard Brown. 2009. "Sociodemographic, family, and environmental factors associated with active commuting to school among US adolescents." *Journal of public health policy* 30 (1):S203-S20.
- Banister, David. 2008. "The sustainable mobility paradigm." *Transport policy* 15 (2):73-80.
- Barker, John, Peter Kraftl, John Horton, and Faith Tucker. 2009. "The road less travelled—new directions in children's and young people's mobility." *Mobilities* 4 (1):1-10.
- BBS. 2011. "Bangladesh Population and Housing Census " In.
- Behrens, Roger, and Patrick Muchaka. 2011. "Child independent mobility in South Africa: The case of Cape Town and its hinterland." *Global Studies of Childhood* 1 (3):167-84.
- Bergmann, Sigurd, and Tore Sager. 2008. *The ethics of mobilities: rethinking place, exclusion, freedom and environment*: Ashgate Publishing, Ltd.
- Boarnet, Marlon G, Craig L Anderson, Kristen Day, Tracy McMillan, and Mariela Alfonso. 2005. "Evaluation of the California Safe Routes to School legislation: urban form changes and children's active transportation to school." *American journal of preventive medicine* 28 (2):134-40.
- Bondarenko, Maksym, David Kerr, Alessandro Sorichetta, and Andrew Tatem. 2020. "Census/projection-disaggregated gridded population datasets for 189 countries in 2020 using Built-Settlement Growth Model (BSGM) outputs."
- Borghese, Michael M, and Ian Janssen. 2018. "Development of a measurement approach to assess time children participate in organized sport, active travel,

- 1
2
3 outdoor active play, and curriculum-based physical activity." *BMC Public*
4 *Health* 18 (1):1-10.
- 5 Brown, Belinda, Roger Mackett, Yi Gong, Kay Kitazawa, and James Paskins. 2008.
6 "Gender differences in children's pathways to independent mobility." *Children's*
7 *Geographies* 6 (4):385-401.
- 8 Carlson, Cynthia, Semra Aytur, Kevin Gardner, and Shannon Rogers. 2015. "The
9 importance of the "local" in walkability." *Buildings* 5 (4):1187-206.
- 10 Carroll, Penelope, Karen Witten, Robin Kearns, and Phil Donovan. 2015. "Kids in the
11 City: children's use and experiences of urban neighbourhoods in Auckland, New
12 Zealand." *Journal of Urban Design* 20 (4):417-36.
- 13 Carver, Alison, Jenna R Panter, Andrew P Jones, and Esther MF van Sluijs. 2014.
14 "Independent mobility on the journey to school: A joint cross-sectional and
15 prospective exploration of social and physical environmental influences."
16 *Journal of Transport & Health* 1 (1):25-32.
- 17 Carver, Alison, Anna Timperio, and David Crawford. 2008. "Playing it safe: The
18 influence of neighbourhood safety on children's physical activity—A review."
19 *Health & place* 14 (2):217-27.
- 20 Cass, Noel, Elizabeth Shove, and John Urry. 2005. "Social exclusion, mobility and
21 access." *The sociological review* 53 (3):539-55.
- 22 Cervero, Robert. 2013. "Linking urban transport and land use in developing countries."
23 *Journal of transport and land use* 6 (1):7-24.
- 24 Cervero, Robert, and Kara Kockelman. 1997. "Travel demand and the 3Ds: Density,
25 diversity, and design." *Transportation research part D: Transport and*
26 *environment* 2 (3):199-219.
- 27 Christensen, Pia, Miguel Romero Mikkelsen, Thomas Alexander Sick Nielsen, and
28 Henrik Harder. 2011. "Children, mobility, and space: using GPS and mobile
29 phone technologies in ethnographic research." *Journal of Mixed Methods*
30 *Research* 5 (3):227-46.
- 31 Cuzzocrea, Valentina, and Giuliana Mandich. 2015. "Fragments of "Cultures of
32 Mobility": Everyday Movement of Parents with Children in Cagliari, Southern
33 Italy." *City & Society* 27 (1):51-69.
- 34 de Bruijn, Gert-Jan, Stef PJ Kremers, Herman Schaalma, Willem Van Mechelen, and
35 Johannes Brug. 2005. "Determinants of adolescent bicycle use for transportation
36 and snacking behavior." *Preventive medicine* 40 (6):658-67.
- 37 de Sa, Thiago Herick, Leandro Martin Totaro Garcia, Grégoire Iven Mielke, Fabiana
38 Maluf Rabacow, and Leandro Fórniás Machado de Rezende. 2015. "Changes in
39 travel to school patterns among children and adolescents in the São Paulo
40 Metropolitan Area, Brazil, 1997–2007." *Journal of Transport & Health* 2
41 (2):143-50.
- 42 Drianda, Riela Provi, Isami Kinoshita, and Ismail Said. 2015. "The Impact of Bandung
43 City's Rapid Development on children's Independent Mobility and Access to
44 Friendly Play Environments." *Children & Society* 29 (6):637-50.
- 45 El-Dorghamy, Ahmed, and Ahmed Ibrahim Mosa. 2016. "Exploring children's travel to
46 school in upgraded informal settlements: A qualitative case study of Ezbet El-
47 Haggana." *Transportation research procedia* 14:1277-86.
- 48 Elliott, Anthony, and John Urry. 2010. *Mobile lives*: Routledge.
- 49 Fotel, Trine, and Thyra Uth Thomsen. 2003. "The Surveillance of Children's Mobility."
50 *Surveillance & Society* 1 (4).
- 51 Freudendal-Pedersen, Malene. 2016. *Mobility in daily life: between freedom and*
52 *unfreedom*: Routledge.
- 53
54
55
56
57
58
59
60

- 1
2
3 Fyhri, Aslak, and Randi Hjorthol. 2009. "Children's independent mobility to school,
4 friends and leisure activities." *Journal of Transport Geography* 17 (5):377-84.
5 Fyhri, Aslak, Randi Hjorthol, Roger L Mackett, Trine Nordgaard Fotel, and Marketta
6 Kytta. 2011. "Children's active travel and independent mobility in four
7 countries: Development, social contributing trends and measures." *Transport*
8 *policy* 18 (5):703-10.
9
10 Gardner, Paula J. 2011. "Natural neighborhood networks—Important social networks in
11 the lives of older adults aging in place." *Journal of Aging Studies* 25 (3):263-71.
12 Ghekiere, Ariane, Benedicte Deforche, Alison Carver, Lieze Mertens, Bas de Geus,
13 Peter Clarys, Greet Cardon, Ilse De Bourdeaudhuij, and Jelle Van Cauwenberg.
14 2017. "Insights into children's independent mobility for transportation cycling—
15 Which socio-ecological factors matter?" *Journal of Science and Medicine in*
16 *Sport* 20 (3):267-72.
17
18 Hess, Stephane, and David Palma. 2019. "Apollo: A flexible, powerful and
19 customisable freeware package for choice model estimation and application."
20 *Journal of choice modelling* 32:100170.
21
22 Karsten, Lia, and Willem Van Vliet. 2006. "Children in the city: Reclaiming the street."
23 *Children Youth and Environments* 16 (1):151-67.
24
25 Khan, Uzma Rahim, Junaid Razzak, and Martin Gerdin Wärnberg. 2022. "Association
26 of adolescents' independent mobility with road traffic injuries in Karachi,
27 Pakistan: a cross-sectional study." *BMJ open* 12 (3):e057206.
28
29 Kytta, A Marketta, Anna K Broberg, and Maarit H Kahila. 2012. "Urban environment
30 and children's active lifestyle: SoftGIS revealing children's behavioral patterns
31 and meaningful places." *American Journal of Health Promotion* 26 (5):e137-
32 e48.
33
34 Kytta, Marketta. 2003. *Children in outdoor contexts: affordances and independent*
35 *mobility in the assessment of environmental child friendliness*: Helsinki
36 University of Technology.
37
38 Lam, Winnie WY, and Becky PY Loo. 2014. "Determinants of children's independent
39 mobility in Hong Kong." *Asian transport studies* 3 (2):250-68.
40
41 Larouche, Richard, Michelle Stone, Ron N Buliung, and Guy Faulkner. 2016. "I'd
42 rather bike to school!": Profiling children who would prefer to cycle to school."
43 *Journal of Transport & Health* 3 (3):377-85.
44
45 Lin, En-Yi, Karen Witten, Melody Oliver, Penelope Carroll, Lanuola Asiasiga, Hannah
46 Badland, and Karl Parker. 2017. "Social and built-environment factors related to
47 children's independent mobility: the importance of neighbourhood cohesion and
48 connectedness." *Health & place* 46:107-13.
49
50 Loo, BPY, and WWY Lam. 2015. "Does neighbourhood count in affecting children's
51 journeys to schools?" *Children's Geographies* 13 (1):89-113.
52
53 Lopes, F, R Cordovil, and C Neto. 2014. "Children's independent mobility in Portugal:
54 effects of urbanization degree and motorized modes of travel." *Journal of*
55 *Transport Geography* 41:210-9.
56
57 Loukaitou-Sideris, Anastasia. 2003. "Children's common grounds: a study of intergroup
58 relations among children in public settings." *Journal of the American Planning*
59 *Association* 69 (2):130-43.
60
61 Ma, Yin-Shan, and Xueming Chen. 2013. "Geographical and Statistical Analysis on the
62 Relationship between Land-Use Mixture and Home-Based Trip Making and
63 More: Case of Richmond, Virginia." *Journal of Urban and Regional Analysis* 5
64 (1):5.

- 1
2
3 Mackett, Roger L, Lindsey Lucas, James Paskins, and Jill Turbin. 2005. "The
4 therapeutic value of children's everyday travel." *Transportation Research Part*
5 *A: Policy and Practice* 39 (2-3):205-19.
- 6 Maddala, Gangadharrao S, and Kajal Lahiri. 1992. *Introduction to econometrics*. Vol. 2:
7 Macmillan New York.
- 8 Malone, Karen. 2007. "The bubble-wrap generation: children growing up in walled
9 gardens." *Environmental Education Research* 13 (4):513-27.
- 10 Malone, Karen, and Julie Rudner. 2011. "Global perspectives on children's independent
11 mobility: a socio-cultural comparison and theoretical discussion of children's
12 lives in four countries in Asia and Africa." *Global Studies of Childhood* 1
13 (3):243-59.
- 14 McFadden, Daniel. 1973. "Conditional logit analysis of qualitative choice behavior."
15
- 16 McMillan, Tracy, Kristen Day, Marlon Boarnet, Mariela Alfonzo, and Craig Anderson.
17 2006. "Johnny walks to school—does Jane? Sex differences in children's active
18 travel to school." *Children Youth and Environments* 16 (1):75-89.
- 19 McMillan, Tracy E. 2005. "Urban form and a child's trip to school: the current literature
20 and a framework for future research." *Journal of planning literature* 19 (4):440-
21 56.
- 22 Mia, Md Aslam, Shamima Nasrin, Miao Zhang, and Rajah Rasiah. 2015. "Chittagong,
23 Bangladesh." *Cities* 48:31-41.
- 24 Mikkelsen, Miguel Romero, and Pia Christensen. 2009. "Is children's independent
25 mobility really independent? A study of children's mobility combining
26 ethnography and GPS/mobile phone technologies." *Mobilities* 4 (1):37-58.
- 27 Milne, Sue. 2009. "Moving into and through the public world: children's perspectives
28 on their encounters with adults." *Mobilities* 4 (1):103-18.
- 29 Mitchell, Hannah, Robin A Kearns, and Damian CA Collins. 2007. "Nuances of
30 neighbourhood: children's perceptions of the space between home and school in
31 Auckland, New Zealand." *Geoforum* 38 (4):614-27.
- 32 Nansen, Bjorn, Lisa Gibbs, Colin MacDougall, Frank Vetere, Nicola J Ross, and John
33 McKendrick. 2015. "Children's interdependent mobility: compositions,
34 collaborations and compromises." *Children's Geographies* 13 (4):467-81.
- 35 Pacilli, Maria Giuseppina, Iliara Giovannelli, Miretta Prezza, and Maria Lucia
36 Augimeri. 2013. "Children and the public realm: Antecedents and consequences
37 of independent mobility in a group of 11–13-year-old Italian children."
38 *Children's Geographies* 11 (4):377-93.
- 39 Page, Angie S, Ashley R Cooper, Pippa Griew, and Russell Jago. 2010. "Independent
40 mobility, perceptions of the built environment and children's participation in
41 play, active travel and structured exercise and sport: the PEACH Project."
42 *International journal of behavioral nutrition and physical activity* 7 (1):1-10.
- 43 Prezza, Miretta, Stefania Pilloni, Carmela Morabito, Cinzia Sersante, Francesca
44 Romana Alparone, and Maria Vittoria Giuliani. 2001. "The influence of
45 psychosocial and environmental factors on children's independent mobility and
46 relationship to peer frequentation." *Journal of community & applied social*
47 *psychology* 11 (6):435-50.
- 48 Rahman, H. Z. 2016. "Bangladesh 2016: Politics, Governance, and Middle Income
49 Aspirations Realities and Challenges " In. Dhaka, Bangladesh: : Power and
50 Participation Research Centre (PPRC).
- 51 Rana, Md, and Masud Parves. 2011. "Urbanization and sustainability: challenges and
52 strategies for sustainable urban development in Bangladesh." *Environment,*
53 *Development and Sustainability* 13 (1):237-56.
- 54
55
56
57
58
59
60

- 1
2
3 Sakaki, Shigeyuki. 2018. "Chittagong Strategic Urban Transport Master Plan: Corridor
4 Improvements Pre-Feasibility Study." In.: The World Bank.
- 5 Schoeppe, Stephanie, Mitch J Duncan, Hannah M Badland, Melody Oliver, and
6 Matthew Browne. 2014. "Associations between children's independent mobility
7 and physical activity." *BMC Public Health* 14 (1):1-9.
- 8 Schoeppe, Stephanie, Mitch J Duncan, Hannah Badland, Melody Oliver, and Carey
9 Curtis. 2013. "Associations of children's independent mobility and active travel
10 with physical activity, sedentary behaviour and weight status: a systematic
11 review." *Journal of Science and Medicine in Sport* 16 (4):312-9.
- 12 Sergeyeva, Olga, and Elena Laktukhina. 2016. Child in smart city: social studies review
13 of children's mobility. Paper presented at the Proceedings of the International
14 Conference on Electronic Governance and Open Society: Challenges in Eurasia.
- 15 Sharmin, Samia, Md Kamruzzaman, and Md Mazharul Haque. 2020. "The impact of
16 topological properties of built environment on children independent mobility: A
17 comparative study between discretionary vs. nondiscretionary trips in Dhaka."
18 *Journal of Transport Geography* 83:102660.
- 19 Sheller, Mimi. 2014. "The new mobilities paradigm for a live sociology." *Current*
20 *Sociology* 62 (6):789-811.
- 21 Stone, Michelle R, Guy EJ Faulkner, Raktim Mitra, and Ron N Buliung. 2014. "The
22 freedom to explore: examining the influence of independent mobility on
23 weekday, weekend and after-school physical activity behaviour in children
24 living in urban and inner-suburban neighbourhoods of varying socioeconomic
25 status." *International journal of behavioral nutrition and physical activity* 11
26 (1):1-11.
- 27 Timperio, Anna, David Crawford, Amanda Telford, and Jo Salmon. 2004. "Perceptions
28 about the local neighborhood and walking and cycling among children."
29 *Preventive medicine* 38 (1):39-47.
- 30 Torche, Florencia. 2019. *Educational mobility in developing countries: WIDER*
31 Working Paper.
- 32 Train, Kenneth E. 2009. *Discrete choice methods with simulation*: Cambridge university
33 press.
- 34 Tranter, Paul, and Eric Pawson. 2001. "Children's access to local environments: a case-
35 study of Christchurch, New Zealand." *Local environment* 6 (1):27-48.
- 36 UNICEF. 2022. "Child Friendly Cities Initiative." UNICEF, Accessed 11 June.
37 <https://childfriendlycities.org/>.
- 38 Valentine, Gill, and John McKendrick. 1997. "Children's outdoor play: Exploring
39 parental concerns about children's safety and the changing nature of childhood."
40 *Geoforum* 28 (2):219-35.
- 41 Waygood, Edward Owen Douglas, Margareta Friman, Lars E Olsson, and Ayako
42 Taniguchi. 2017. "Transport and child well-being: An integrative review."
43 *Travel behaviour and society* 9:32-49.
- 44 Witten, Karen, Robin Kearns, Penelope Carroll, Lanuola Asiasiga, and Nicola Tava'e.
45 2013. "New Zealand parents' understandings of the intergenerational decline in
46 children's independent outdoor play and active travel." *Children's Geographies*
47 11 (2):215-29.
- 48 Wooldridge, Jeffrey M. 2015. *Introductory econometrics: A modern approach*:
49 Cengage learning.
- 50 Zannat, Khatun E, KM Ashraful Islam, Dewan Salman Sunny, Tabassum Moury,
51 Rajsree Das Tuli, Ashraf Dewan, and Mohammed Sarfaraz Gani Adnan. 2021.
52 "Nonmotorized Commuting Behavior of Middle-Income Working Adults in a
53
54
55
56
57
58
59
60

1
2
3 Developing Country." *Journal of Urban Planning and Development* 147
4 (2):05021011.

5 Zannat, Khatun E, Debasish Roy Raja, and Mohammed Sarfaraz Gani Adnan. 2019.
6 "Pedestrian facilities and perceived pedestrian level of service (plos): A case
7 study of chittagong metropolitan area, Bangladesh." *Transportation in*
8 *developing economies* 5 (2):1-16.

9
10 Zvobgo, Julia. 2021. "Child road casualties double in Bangladesh ", Accessed 20 May.
11 [https://www.childinthecity.org/2019/04/01/child-road-casualties-double-in-](https://www.childinthecity.org/2019/04/01/child-road-casualties-double-in-bangladesh/)
12 [bangladesh/](https://www.childinthecity.org/2019/04/01/child-road-casualties-double-in-bangladesh/).

13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For Peer Review Only

Does children's independent mobility matter? Insights into escorting practices in a developing country

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

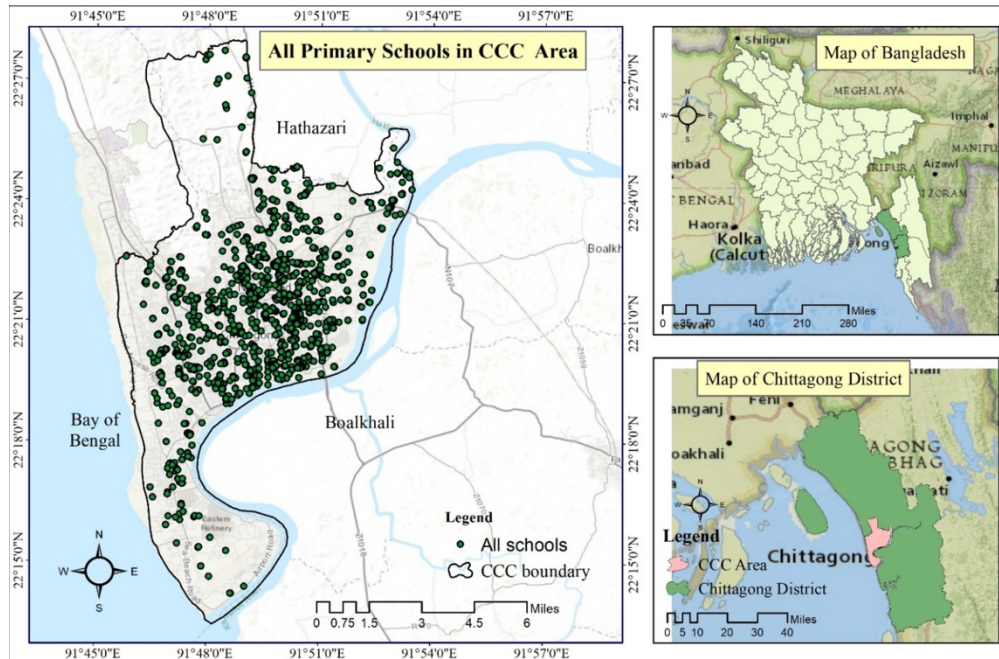


Figure 1: Location map of CCC area

446x292mm (300 x 300 DPI)

Table 1 Comparison between the sample and the census

Variable	Categories	Sample distribution (%)	Distribution* in urban population* (%)
Average household size		4.80	5.00
Monthly household income (BDT**)	Low income HH (0-25 K)	56.53	40
	Middle income HH (>25-40 K)	31.66	50
	High-income HH (more than 40 K)	11.81	10

* Census Data Bangladesh, 2011 (BBS 2011; Rahman 2016)

** 1 BDT = 0.012 USD

Table 2 Summary of built environmental factors considered in this study following the “4 D” concept

4Ds	Spatial factors	Description
Density	Population density	Measured per unit of area
	Residential density	Measured per unit of area
	Commercial density	Measured per unit of area
Diversity	Dissimilarity index	Dissimilarity index, ranging from 0 to 1 measured by land use mix
Design	Intersection density	Measured per unit of area
	Street density	Measured per unit of area
Destination accessibility	Proximity to school	Measured using Euclidean distance
	Proximity to parks and open spaces	Measured using Euclidean distance
	Proximity to CBD	Measured using Euclidean distance

Table 3 Final MNL model output and model fit

Parameter	Estimate	Robust t-ratio
<i>Alternative specific constant</i>		
Independent	0	NA
With parents	2.699114	1.9394**
With friends	-0.71881	-0.4613
With caregiver	-0.76666	-0.4046
Shift in escorting type ASC		
<i>Household socio-demographics</i>		
<i>Access to car (==1)</i>		
With parents	0.569909	0.6574
With friends	0.911344	1.5595*
With Caregiver	1.330435	1.574*
<i>Income (<10,000BDT) (==1)</i>		
With parents	-0.54936	-1.9594**
<i>Graduated mother</i>		
With friends	-1.04819	-1.5394*
<i>Individual socio-demographics</i>		
<i>Studying below class three (==1)</i>		
With parents	1.463966	4.5448***
With caregiver	1.428199	2.7455***
<i>Trip characteristics</i>		
<i>Using NMT (==1)</i>		
With parents	-4.93107	-4.6576***
With friends	-2.61149	-2.048**
With caregiver	-5.08326	-3.9186***
<i>Education trip from home (==1)</i>		
With friends	-0.71494	-3.785***
<i>Return education trip to home (==1)</i>		
With parents	0.199842	1.7769**

Does children's independent mobility matter? Insights into escorting practices in a developing country

Parameter	Estimate	Robust t-ratio
<i>Discretionary trip from home and return (==1)</i>		
With friends	-3.07105	-2.9438***
<i>School related attributes</i>		
<i>Number of students</i>		
With Parents	0.386622	1.1693
With friends	1.264178	3.2229***
With Caregiver	1.53131	2.9541***
<i>Having physical activity course</i>		
With parents	0.113873	0.38
<i>Having kid's facility (==1)</i>		
With friends	1.508908	3.1597***
<i>Social attributes</i>		
<i>literacy rate at home location</i>		
with friends	3.06E-05	2.011**
<i>Built-environmental attribute</i>		
<i>Commercial density of home location</i>		
With parents	0.004274	2.7996***
<i>Dissimilarity index at home location</i>		
With friends and care giver	3.641661	2.3653***
<i>Proximity to parks from home location</i>		
With parents	1.93E-04	2.3633***
With caregivers	-0.00101	-1.1005
<i>Road density</i>		
With parents and caregiver	0.080109	1.932**
<i>Average elevation</i>		
With caregiver	0.037819	1.4751*
LL (start)		-7650.959
LL (0)		-1107.372
LL (final)		-785.6922
Rho-square (0)		0.2905

Parameter	Estimate	Robust t-ratio
Adj. Rho-square (0)		0.2652
AIC		1627.38
BIC		1812.63

*** Estimates are significant at 98% level of confidence, ** Estimates are significant at 95% level of confidence,
* Estimates are significant at 90% level of confidence for one tail t-test

For Peer Review Only

Does children's independent mobility matter? Insights into escorting practices in a developing country

Table S1| Summary of household socio-demographic characteristics used in this work

Sample characteristics	Percentage of the respondents
<i>Housing type</i>	
Living in own house	32.41
Living in rented house	67.59
<i>Household Monthly Income</i>	
<10,000 BDT	15.83
10,000-25,000 BDT	40.70
25,000-40,000 BDT	31.66
>40,000 BDT	11.81
<i>Ethnicity</i>	
Local	62.82
Outside of Chattogram	37.18
<i>Number of Child in the household age <13 years</i>	
1	55.23
2	36.93
>2	7.84
<i>Access to car</i>	
Having access to Car	4.52
No access to Car	95.48
<i>Fathers' education level</i>	
Primary	38.69
Secondary	16.83
Higher secondary	13.07
University	23.87
Other	7.54
<i>Mothers' education level</i>	
Primary	54.27
Secondary	16.83

Higher secondary	8.29
University	6.78
Other	13.83
<i>Mothers' Occupation</i>	
Housewife	89.44
Working mother	10.56
<i>Father's occupation</i>	
Formal job	80.9
Informal job	19.1

Table S2| Summary of children's profile

Parameters	Boys (% of the respondents)	Girls (% of the respondents)
<i>Level of study</i>		
Nursery/Preschool	3.72	1.64
Standard I	15.35	12.02
Standard II	17.67	18.58
Standard III	20.93	17.49
Standard IV	24.65	25.14
Standard v	17.68	25.13
<i>Choice of chauffeuring type</i>		
Independent	16.74	19.67
Accompanied by parents	60.93	59.02
Accompanied by friends	16.28	15.85
Accompanied by caregiver	6.05	5.46
<i>Mode choice</i>		
Walking	76.34	77.44
Other	23.66	22.56
<i>Trip purpose</i>		
School trip	96.92	94.42
Non-school trip	3.08	5.58