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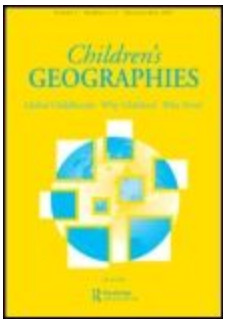

Does children's independent mobility matter? Insights into escorting practices in a developing country

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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 (Freudendal-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

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

Recent studies attempted to explain children's independent mobility by analysing factors that directly or indirectly control or support their independent mobility. Among various factors, children's age, gender, and maturity are widely used indicators in the area of demographic milieu (Alparone and Pacilli 2012; Valentine and McKendrck 1997; Brown et al. 2008; Barker et al. 2009). Other biological factors such as body mass index (BMI) are also considered to be inversely associated with children's daily physical activity and active mobility (Larouche et al. 2016; Schoeppe et al. 2013). Also, characteristics of the physical and living environments that constitute children's backdrop of everyday life significantly influence their geographical boundaries of mobility (Carver et al. 2014). The perception of children and their parents about the surrounding environment and danger is also important to autonomous mobility (Alparone and Pacilli 2012; Carver, Timperio, and Crawford 2008). The "fear" of potential risk generally restricts children's independent mobility (Carver, Timperio, and Crawford 2008; Alparone and Pacilli 2012), and the ontology of "fear" is not only rooted in the parental perspective but also children (Valentine and McKendrck 1997). Fear could be related to danger on the street (Timperio et al. 2004), strangers (Timperio et al. 2004; Carver, Timperio, and Crawford 2008; Lopes, Cordovil, and Neto 2014), risk of violence (Carver, Timperio, and Crawford 2008; Valentine and McKendrck 1997), and fear from space (Valentine and McKendrck 1997). All factors associated

with children's independent mobility patterns are dynamic, interdependent, and vary depending on the context, scale, and time (Alparone and Pacilli 2012). For example, when most of the studies highlighted parents' and children's "fear" of "stranger danger" as one of the potential risks for the children, paradoxically, according to Gardner (2011) the relationship with strangers could be an important factor to form a natural neighbourhood. The perception of traffic danger leads parents to drive their children to school, causing an increase in the number of vehicular traffic around the school, making school precincts more dangerous and causing traffic congestion around schools (Lam and Loo 2014). Hence, investigating children's independent mobility is challenging due to the complex relationships of children's mobility with socio-demographic, environmental and psychological factors, as well as the built environment of a city.

Given the importance to understand children's independent mobility in transport planning in different socio-demographic contexts, several studies were conducted in the context of developed countries (e.g., the USA, Canada, UK, Australia, New Zealand, Denmark, Finland, Germany, and Switzerland), where children's independent mobility behaviour was analysed from multi-dimensional perspectives (Babey et al. 2009; Schoeppe et al. 2014; Boarnet et al. 2005; Christensen et al. 2011; McMillan 2005; Brown et al. 2008; Milne 2009; Kyttä, Broberg, and Kahila 2012; Mikkelsen and Christensen 2009; Mitchell, Kearns, and Collins 2007; Borghese and Janssen 2018; Lin et al. 2017). The findings from developed countries with little or no adjustment considering the context of developing countries often face numerous shortcomings due to the differences in (i) socioeconomic composition (e.g., income, age and gender distribution, household responsibilities, family structure); (ii) dependency and freedom culture (e.g., level of dependency of children on parents, elderly people, peer, neighbour, caregiver and friends and, level of freedom allowed to children); (iii)

neighbourhood facilities (e.g., availability of school, playing facilities within walking distance, mobility facilities, safety and security, law enforcement); (iv) social norms (e.g., level of interaction with family members and outsiders); and (v) transportation facilities (e.g., car ownership level, school transport facilities, public transport facilities, paratransit) (Cervero 2013; Torche 2019; Sharmin, Kamruzzaman, and Haque 2020; Malone and Rudner 2011). Thus, a significant difference in children's mobility behaviour and escorting type can be observed between developed and developing countries. Only a few studies on understanding children's mobility behaviour were conducted in developing countries, particularly in Asia and Africa (Malone and Rudner 2011; Behrens and Muchaka 2011; Lam and Loo 2014). Evidence from those studies showed that children from developing countries are less likely to be independently active than children from developed countries. For example, the rate of car dependency in Cape Town increased from 1975 to 2010, causing a decline in the use of non-motorized modes (walking and cycling) for school trips (Behrens and Muchaka 2011; Malone and Rudner 2011). Therefore, it is imperative to emphasize studies of children's mobility behaviour in developing countries to formulate context-specific policies to promote children's independent mobility. The purposes of this study were two-fold. First, to develop an econometric model1 to understand the escorting practices of parents, residing in a developing country. Second, to identify potential factors either

[1] Econometric models are used to estimate the influence of various independent variables on a dependent variable, assuming that each decision-maker is an economic agent. These are based on mathematical, economic, and statistical concepts (Maddala and Lahiri 1992; Wooldridge 2015).

supporting or inhibiting children's independent mobility at a very early stage. The study focused on elementary school-going children, inhabiting Chattogram City Corporation (CCC) area in Bangladesh. The existing urban and transport development policies in Bangladesh less prioritize children's mobility demand. While considering children as active agents in the decision-making process is imperative to make a child-friendly city (UNICEF 2022), overlooking their demand hinders the sustainable urban development in Bangladesh. Hence, this study is an attempt to shed a light on this emerging fact to reinforce the importance of children's mobility at the city scale to rethink, reshape, and rebuilt the cityscape as per children's needs.

Materials and methods

Study area

Chattogram City Corporation (CCC), located in the south-eastern region of Bangladesh, was selected as the study area (Figure 1). It is the second-largest city and the commercial hub of the country. About 4 million people inhabit within 177 km^2 area of CCC. Administratively, CCC is divided into 41 wards (the smallest administrative unit) (Zannat et al. 2021). About 60% of the total urban population in Bangladesh inhabits four major cities such as Dhaka, Chattogram, Khulna, and Rajshahi (Rana and Parves 2011). Like other major cities in the country, Chattogram city has been growing at an alarming rate, fuelled primarily by rural-urban migration. (Zannat, Raja, and Adnan 2019). The city was ranked as the tenth fastest-growing city in the world in 2010 (Mia et al. 2015). The major development policies of the city predominantly considered adults' daily mobility. The city planning policies lack focus on children's mobility. For example, the Strategic Urban Master Plan (SUTMP) developed to improve mobility in Chattogram overlooks the vision to make the city children friendly. Reportedly, there is

a lack of policy in SUTMP (2019-2030) to improve children's independent mobility in CCC (Sakaki 2018). This can be a potential reason for the increasing accident rates and causalities of school-going children (Zvobgo 2019). In this study, we selected the elementary school-going children residing in the CCC area to understand their escorting type and mobility behaviour, accounting for different individual and household sociodemographic and built environmental factors.

Data

Primary data

A travel diary survey was conducted from 15 April 2019 to 29 April 2019 to acquire relevant data. The survey was designed to record children's travel patterns within a week (both weekdays and weekends). The respondents included parents of the elementary school-going children, who were asked about their children's mobility patterns. We selected the elementary school-going children because at this stage children attempt to establish a relationship with their surroundings activity environment (Loukaitou-Sideris 2003). The contact information of parents was collected from school authorities. Authorities of a total of 65 (out of 215) Government Elementary schools in the CCC area were approached. Among them, 22 schools granted permission and shared parents' details and contact information. The selected Government Elementary schools were located both in high-income and low-income neighbourhoods to avoid geographical and socioeconomic biases among the participants. Parents of a total of 398 school-going children participated in a weeklong telephone interview survey. Table 1 shows a comparison of the household characteristics (e.g., household size and income) in the sample with the corresponding urban population (census). The survey form comprised of three subsections: household socio-demographics (e.g., household income,

parents' education, occupation, access to cars[2] (includes both car ownership and have access to office-provided car transport), housing condition, ethnicity, number of elementary schools going children in the household, location of household at the ward level)), children's socio-demographics (e.g., study level, gender), and trip-related information (e.g., departure time, trip purpose, mode choice, accompaniment type). Parents were contacted every day in the evening of the surveying week. Interviewers ensured the parents that the collected information will be only used for research purposes. School authorities informed the parents beforehand about the research and interview. We used the telephone interview survey technique as it allowed us to cover a wider geographical area in CCC in comparison with the face-to-face interview. Also, it was easier for the respondents to recall their children's everyday mobility as they were contacted in the evening and were asked about the trips made by their children on the same day. Therefore, the collected data was as reliable as the face-to-face interview. Further, to achieve greater accuracy and avoid biases in the cross-sectional study, the data was collected for seven consecutive days, including both working days and weekends. Therefore, the model developed using the collected data provided a more accurate inference of model parameters and has a greater capacity for capturing the heterogeneity associated with the socio-demographic conditions of the respondents. The school authorities also provided additional information about the physical (e.g., playing equipment) and functional (e.g., extracurricular activities) facilities available within the school for children's extra-curricular activities.

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

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):

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

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:

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

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:

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

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)):

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

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

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

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

For the MNL estimation, location parameter η =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.

The MNL model was established using the "Apollo" package R, applying the Maximum Likelihood Estimation with the BFGS optimization algorithm (Hess and Palma 2019). Model estimation was done considering the weeklong mobility pattern of children. The MNL model included parents' chauffeuring choice type as a dependent variable and sociodemographic, built environment, and trip-related factors as independent variables. Though income and car ownership are generally correlated, we used "access to car" as an alternative to car ownership. Most of the independent variables were incorporated into the model as dummy variables. The number of students studying in schools and built environment attributes was included in the model as continuous variables. Both school and non-school trips were incorporated into the model estimation. Given the differences in the share of household income in the sample and the census, the samples were weighted to match the census shares before the model estimation to increase the representativeness. The addition of weightage has improved the model log-likelihood and subsequently the goodness-of-fit (measured by adjusted rho-square). The majority of the studies measured the influence of the neighbourhood built environment on children's independent mobility using subjective perception (Ghekiere et al. 2017). However, to avoid subjective bias, in this study, we measured objectively the association between the built environment and escorting practices of children's mobility.

Results

Summary statistics

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

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

MNL model results

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

Three variables were used to capture heterogeneity associated with the household socio-demographics such as "access to car", household income (<10,000BDT), and education level of the children's mother. A positive coefficient is a sign of potential access to cars, indicating that the propensity to move independently was lower among the children having household access to cars. The statistical insignificance of mobility with parents having access to cars was likely to be linked to a common scenario in Bangladesh, i.e., multiple users of a car operated by a chauffeured driver. This implies that sometimes children needed to rely on others (e.g., friends, caregivers) due to the unavailability of cars when other household members had access to cars. The household income (<10,000 BDT) shift in the escorting type of ASC

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

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

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

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

facilitated with playing equipment, children were more likely to travel with their friends. Though all the schools selected for this study were government primary schools, facilities for children varied from school to school, depending on the location of schools and governing authority. The type of school is also an indicator of neighbourhood type and socio-economic status of the parents. Literacy rates at home locations (ward-wise aggregate literacy rate) were also positively associated with children's independent movements with their friends. Higher literacy insinuates a better social and living environment which anticipates better safety.

Different built environment factors such as ward-wise commercial density, road density, average elevation, proximity to parks, and land use type were considered in this work. The influence of other built environment factors (Table 2) was also tested, however, not included in the final model as their influence was not statistically different from zero. The inclusion of built environment factors improved the model's performance. Most of the estimated coefficients agreed with the hypothesis. Commercial density and road density were negatively associated with children's independent mobility. Estimated coefficients suggested that when children's neighbourhood was in a high-density commercial area (where road density is also high), they were more likely to travel with their parents or caregiver due to the concern regarding traffic accidents. However, if the home location was characterised by a balanced residential and commercial development, children were more likely to travel with friends or caregivers other than their parents. On the other hand, if the home location was in proximity to parks and green areas, children were more likely to travel with their parents and less likely to travel with their caregivers. In the CCC area, most of the parks and green spaces were located close to affluent neighbourhoods. Affluent parents were less likely to allow their children to move independently. Such a scenario

was also observed in households with access to cars and characterized by higher income levels. The influence of land elevation was also estimated. In the hilly CCC area, children living in higher elevation lands (i.e., affluent areas) were more likely to travel with their caregivers.

Discussion

The United Nations' Sustainable Development Goals (SDGs) promote children's independent mobility to allow the implementation of active transportation as a safe, affordable, accessible, and sustainable mode of transport (de Sa et al. 2015). According to Piaget's theory of cognitive development of children, knowledge and growth of intelligence evolves through a complex interaction between individual and environment (social as well as the physical environment) (Valentine and McKendrck 1997). The current study considered different combinations of environmental (both school and neighbourhood environment), socio-cultural, and personal factors to explain children's independent mobility behaviour for both school and discretionary trip purposes. We attempted to provide a comprehensive understanding of parents' escorting preference for their children's movement focusing on a developing country. The findings from the CCC area suggested that significant heterogeneity existed in the children's mobility behaviour while studying in government elementary school.

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

chauffeuring choices in the CCC area distinguished the difference between developed and developing countries. Higher dependency on private vehicles, particularly car use is apparent in a developed country where fewer children are involved in active transport or using public transport (de Sa et al. 2015). A lower car ownership rate in Bangladesh as well as among the recruited respondents (4.52% of the total respondents) approved a lower car use rate for educational trips, which also complies with the study of Loo and Lam (2015). Also, more than 75% of the total respondents (children) used walking for daily movement, which reinforced their reliance on active mode for trip purposes (Table S2, supplementary document).

Besides households' socio-demographic properties, demographical characteristics of children stood out to be significant factors in defining their mobility behaviour and corresponding chauffeuring type in the CCC area. Though gender is a significant determinant in other child mobility studies (McMillan et al. 2006), in the CCC area, the influence of gender on children's chauffeuring choices was not significantly different from zero. Similar to the other studies (Alparone and Pacilli 2012; Schoeppe et al. 2014; Prezza et al. 2001), findings from this study exhibited children's age and level of maturity as significant determinants of parents' choice of chauffeuring type for their children. This finding is intuitive as parents were afraid of potential risks to their children, caused by strangers and vehicular traffic. Also, it is empirically proven that for safety reasons younger children are accompanied by their parents either in cars or under surveillance (Drianda, Kinoshita, and Said 2015; Fyhri and Hjorthol 2009; Carroll et al. 2015). This safety concern reduces children's independent mobility and excludes them to interact with their surroundings and develop social and environmental relations (Valentine and McKendrck 1997), resulting in disconnection or lack of interactions with their surrounding environment and space

(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 McKendrck 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 McKendrck 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

activity) need to be practised that would increase their independence in moving freely and increase interaction with the neighbourhood environment.

Various studies highlighted the importance of unsupervised, informal and random leisure activities for children's cognitive development (Mackett et al. 2005; Fyhri et al. 2011; Fyhri and Hjorthol 2009), as it involves more physical exercise and psychological work well connected with their (children) fellows. However, this study observed that in the CCC area, children's movement was very limited during their school trips (95% of the total recorded trips within a week), which were mostly accompanied by their parents (60% of the total trips). Children spend their maximum day time under adult supervision (parents and caregivers at home and teachers at school) and this way of growing up is less support for children's independent mobility and cognitive development (Drianda, Kinoshita, and Said 2015). Such supervised activities have two-fold impacts on the children. Firstly, as most of the organized activities are institutionalized, children's mobility pattern becomes hopping from island to island which corresponds to their parent's mobility pattern (Fyhri and Hjorthol 2009). Specifically, in terms of mode choice, this circumstance precludes the formation of a holistic image of the city among children (Karsten and Van Vliet 2006). Secondly, children's mobility pattern is muddled with the adult's movement pattern and considered children's mobility invisible (Fotel and Thomsen 2003) or relatively immobile (Elliott and Urry 2010). Therefore, it is important to bring changes in children's confined home and school-oriented activity patterns. This 'spatial' disconnection and lack of communication are described to be sinuous of social exclusion (Cass, Shove, and Urry 2005). Measures need to be taken to increase interactions and communication of children with friends, neighbours or with outsiders. This is because, interaction and communication are imperative to develop a sense of

safety, otherwise, children would feel lonely and less secure even within their community (Pacilli et al. 2013), and this fact, is often overlooked or undermined (Carver, Timperio, and Crawford 2008).

Several studies also reported that children's independent mobility provides the opportunity to interact with the environment which in return develops social relations and a sense of community (Carver et al. 2014; Kyttä 2003). Besides, children are active learners, and their learning process is dependent on their daily experiences with their surroundings. However, parallel to other contemporary studies, it is clear in this study that due to the unplanned development and labyrinth of a modern city it was difficult for a child to find a suitable place for them that often requires the supervision of elders to reach their potential destination. The result from this study indicated that activity places in proximity to home (accessible by active mode) were considered to be safe for children as parents can keep their eye on their children's movement (Prezza et al. 2001). Further, findings from this study also reinforce that commercialization, higher street density, and homogenous land use development inhibited children's independent movement. On the contrary, proximity to parks or open spaces did not encourage the independent movement of children or escorting with friends, which does not comply with the hypothesis. This can be attributed to an unorganized spatial distribution of open spaces and their inaccessibility. Therefore, it is important to think about the inclusion of children's mobility demand in the neighbourhood as well as in city design. Besides, having more playing facilities at school, children engage for a longer duration with their friends which may also help the children to have a special bonding with their friends. Parents become familiar with the other children and consequently, become willing to rely on children's movements with their friends (Page et al. 2010).

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.

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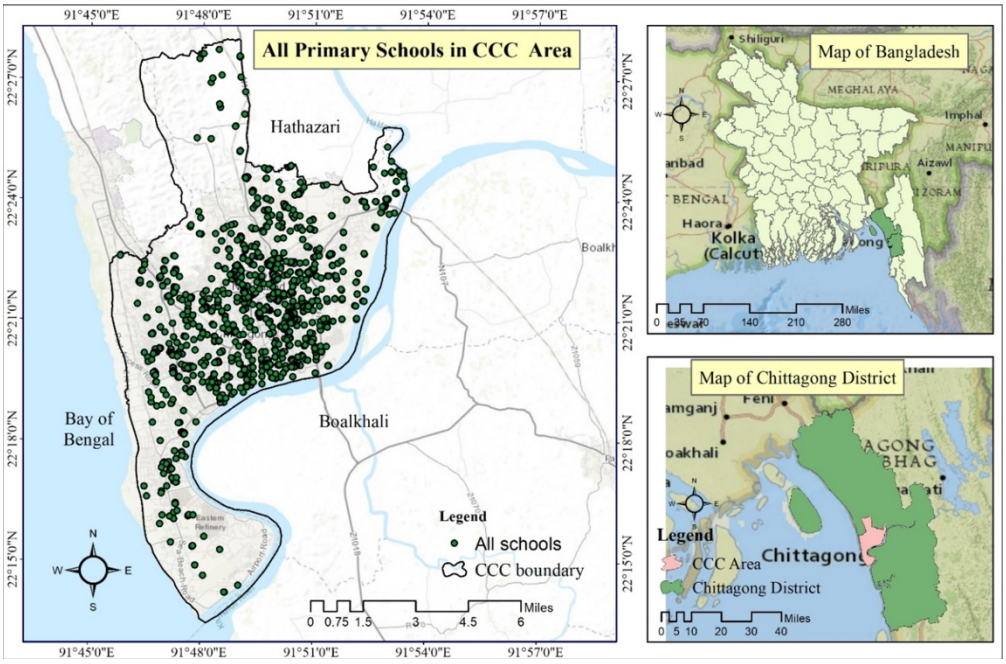

Figure 1: Location map of CCC area

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
Alternative specific constant		
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		
Household socio-demographics		
Access to car (==1)		
With parents	0.569909	0.6574
With friends	0.911344	1.5595*
With Caregiver	1.330435	1.574*
Income (<10,000BDT) (==1)		
With parents	-0.54936	-1.9594**
Graduated mother		
With friends	-1.04819	-1.5394*
Individual socio-demographics		
Studying below class three (==1)		
With parents	1.463966	4.5448***
With caregiver	1.428199	2.7455***
Trip characteristics		
Using NMT (==1)		
With parents	-4.93107	-4.6576***
With friends	-2.61149	-2.048**
With caregiver	-5.08326	-3.9186***
Education trip from home (==1)		
With friends	-0.71494	-3.785***
Return education trip to home (==1)		
With parents	0.199842	1.7769**

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

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

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

Table S2| Summary of children's profile

Parameters	**Boys** (% of the respondents)	**Girls** (% of the respondents)
Level of study		
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
Choice of chauffeuring type		
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
Mode choice		
Walking	76.34	77.44
Other	23.66	22.56
Trip purpose		
School trip	96.92	94.42
Non-school trip	3.08	5.58