Impact of Street Design on Children's Independent Mobility

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Abstract

Like many other developing countries of the world, in Bangladesh, critical child issues such as health and disease, hunger, poverty, child labor, and illiteracy dominates the discussion of child problems. This tendency is responsible for the near complete exclusion of school-going urban children from the sphere of research. Some recent findings revealed that in the realm of unprecedented rate of urbanization, this specific population of urban children of Bangladesh has distinctive problems of their own. Lack of independent mobility and little or no provisions for playing outdoors are two such conditions proven to be unsupportive, if not harmful, for the proper development of the child. Design characteristics of the street have attracted attention for both their contribution to the problem and their potential as a solution, but few studies actually examined the impact of characteristic features of neighborhood streets on independent mobility of children.

Dhaka, the ninth largest and the fastest growing mega city of the world by population, provided a unique setting for a research on children's independent mobility. The study was conducted with over 60 school-going children of Dhaka, aged 7 to 11 years of age. Four dependent variables were determined to calculate the level of independent mobility of children and four specific street design characteristics were employed as independent variables (two additional for dead-end streets). Six socio-demographic and four built-environment variables of independent mobility were also considered.

Street type and street width were found to have significant relationships with the independent time of children. The number of streets to cross negatively influenced regular independent distance, but no significant relationship was found between street design and occasional maximum independent distance of a child. Both street type and number of street crossings influenced autonomy of children in their school trips.

Impact of Street Design on Children's Independent Mobility

The modern world passed a historic demographic threshold as the total urban population of the world surpassed its rural population for the first time (United Nations, 2008), and this global urbanizing trend is believed to be continuing in greater rates. According to a number of studies, this unprecedented era of urbanization has contributed in the sharp decline of children's autonomy of movement all over the world. Today, only very few children circulate freely in their neighborhoods, discover its secrets, and meet and play with other children in open spaces (Prezza, Pilloni, Morabito, Sersante, Alparone, & Giuliani, 2001). With an annual growth rate of 5.6 percent, Dhaka in Bangladesh is the world's fastest growing mega city (United Nations, 2008). Although this unprecedented growth affects all citizens of Dhaka, children are the most affected because they have the least power (Islam, 2008).

Historically, the global decrease of IM (independent mobility) of children has been very poorly recorded (Hillman & Adams, 1992). The most famous amongst such records, conducted by Hillman and Adams In the United Kingdom, found that the percentage of 7-8 year olds going to school on their own dropped from 80 percent in 1970 to 10 percent in 1990 (1992). Decreases of freedom of movement of children had been reported in Italy (Giuliani, Alparone, & Mayer, 1997), Australia (Salmon, Timperio, Cleland, & Venn, 2005), and many other parts of the world as well. All these historical studies are remarkably unanimous in their conclusions; however, similar research regarding reduction of children's IM is limited in the developing nations.

It has been widely documented that children benefit from playing outdoors and moving around freely, which facilitates development of their physical, social, and cognitive competencies (Christensen & O'Brien, 2003). Huttenmoser (1995) showed that children who can play out of danger from street traffic in their living surroundings clearly differ from those children in terms of social and motor development and independent behavior. Another more recent study had also claimed that in 7-11 year old children, autonomy of movement in the neighborhood was associated with pro-social behavior (Mayer, Giuliani, & Alparone, 2000). It is now firmly established that lack of independent mobility is associated with childhood obesity (Whitzman, Romero, Duncan, Curtis, Tranter, & Burke, 2010; van Oel, 2009). The decline in children's independent mobility increases the time that parents use for chauffeuring (Mattson, 2002). One of the major consequences of lack of children's IM is car dependency, which is responsible for an increase in the level of motorized traffic and pollution (Tranter & Doyle, 1996; U.S. Agency of Environmental Peotection, 2003).

Very few studies in the related field had examined the correlation between street design and children's level of independent mobility. Residential streets, being a key component of the built environment, must be examined from the perspective of children's IM. Although few studies have focused on children, they have found a positive relationship between street connectivity and children biking or walking to school (Braza, Shoemaker, & Seeley, 2004; Falb, Kanny, Powell, & Giarrusso, 2007). There are also studies that have found that more connectivity is associated with lower rates of walking or riding to destinations (Timperio, Crawford, Telford, & Salmon, 2004). Such disarray of findings suggests a need for further investigation on the topic. Variables having high correlation with independent mobility in a developed nation may act differently in a developing nation. For instance, presence of bike lanes as an important street variable for children's independent mobility (Boarnet, Anderson, Day, McMillan, & Alfonzo, 2005 ; Fotel & Thomsen, 2004) is not at all an applicable a variable in the urban context of Dhaka.

This study defined IM in terms of four dependent variables. The definition which was adopted was given by Prezza and colleagues (2010), who identified Independent Mobility (IM) as the frequency with which children play and move around outdoors by themselves. This study introduced a unique approach to defined IM in terms of freedom of time, freedom of distance, and freedom in school trips. DAIT (Daily Average Independent Time) is the 'time' component of independent mobility. Regular Independent Mobility Distance (RIMD) is the maximum distance a child visits on a regular basis without adult supervision. Maximum Independent Mobility Distance (MIMD) represents the maximum occasional independent distance. One categorical data, Home School Travel Mode (HSTM), represents the autonomy of a child in home-school travel. This variable was considered given the global concern for children's freedom in school trips in numerous projects like the SR2S (Safe Route to School) adopted in California (Boarnet, Anderson, Day, McMillan, & Alfonzo, 2005). Six specific street design characteristics were employed as independent variables. Six socio-demographic and four built-environment variables of independent mobility were also considered, given their significance on IM in previously conducted research. The socio-demographic and other built-environmental variables in the regression analysis helped to identify the true role of street design on children's IM with a holistic background.

Method

Participants

Sixty school-going children of Dhaka aged 7 to 11 (16 girls and 44 boys) volunteered in this research. This is the age range when children are more likely to roam outdoors than during any other period of their childhood (Moore 1986, O'Brien, Jones and Rustin 2000). In one study (Prezza and Pacilli 2007), 8-10 years is defined appropriate as a "running point". Before this age, children are considered to be too young to be autonomous, whereas, after age 11, children are expected to be ready to be independent.

Sampling Strategy

The study adopted a two-phase cluster random sampling method. There is no available database of children of 7 to 11 years of age of Dhaka. So, instead of random sampling of children, sampling started with random picking of schools from an existing list. This list of all schools of Dhaka was retrieved from the website of Bangladesh Bureau of Educational Information and Statistics (BANBEIS, 2007). Four schools were randomly picked from the list and the researcher visited those schools.

Data Collection and Analysis

Four methods were adopted: questionnaire survey, mapping with satellite image, systematic direct observation, and child-led field trip. The mapping strategy was originally developed by Dr. Islam and Professor Robin C. Moore and was adopted successfully (2008). It was particularly advantageous because the data collected by this process were drawn in front of the child. The variables list, their respective data collection methods, and units/ coding are shown in Table 1. There were two additional street variables for separate regression for children living only in dead-end streets (dead-end depth and home-street face distance). For data analysis (mean calculation, linear regression, and binary logistic regression) SPSS Statistics 17.0 (released August 23, 2008) was used. The statistical regression model applied a three-staged method for investigation. At first, 'one to one' regression analysis investigated the "one to one" relationship between each measurement and a dependent variable (DAIT/ RIMD/ MIMD /HSTM). Second, regression analysis investigated the "group to one" relationship, and third, analysis investigated the "all to one" relationship with forwarded variables from the second stage.

Variable	Name of Variable	Variable Explanation	Data Collection Method	Type	Coding/Unit
Dependent Variables	DAIT	Daily Average Independent Time	Questionnaire	Scale	minute
	RIMD	Regular Independent Mobility Distance	Questionnaire, mapping and 'Path Tool' of Google Earth software	Scale	feet
	MIMD	Maximum Independent Mobility Distance	Questionnaire, mapping and 'Path Tool' of Google Earth	Scale	feet
	HSTM	Home School Travel Mode	Questionnaire	Categorical	1=independent, 0=dependent
Independent Street Design Variables	Street Type	Whether the street is dead-end or through traffic	Systematic direct observation	Categorical	1=dead-end, 0=through
	Street Width		Systematic direct observation	Scale	
	Street Level	City bus route was considered primary and a branching from primary was labeled secondary and so on	Systematic direct observation and Google Earth software	ordinal	1=primary, 2=secondary, 3=tertiary, 4=level 4
	Number of Crossings	How many streets are required to cross by a child on school trip (one way)	Map study in Google Earth	Scale	
Socio	Gender		Questionnaire	Categorical	1=boy, 0=girl
	Age		Questionnaire	Scale	
	Number of Sibling		Questionnaire	Scale	
	Eldest among Siblings	Whether the child is the eldest or not	Questionnaire	Categorical	1=yes, 0=no
	HHMI	House Hold Monthly Income	Questionnaire	Scale	
	Residency Duration	How long the family is living in the present address	Questionnaire	Scale	
Other Built Environment	Neighborhood Type	Whether the child lives in a colony or not	Systematic direct observation	Categorical	1=colony, 0=non-colony
	Presence of Play Ground	If there is any play ground in the neighborhood	Systematic direct observation	Categorical	1=available, 0=not available
	Home-School Distance		'Path Tool' of Google Earth	Scale	
	Building Storey	The floor number where the child lives in	Systematic direct observation	Scale	

Table 1. Variables and their respective data collection methods

<table>
<tr><th colspan="4">Model DAIT-FINAL(Forward): All Entered Variables</th><th>Adjusted R Square</th><th>Model Significance</th></tr>
<tr><td rowspan="12">Forwarded Significant Variables</td><td rowspan="2">Street Type</td><td>Coefficient (B)</td><td>41.630</td><td rowspan="12">0.594 (59.4% of variation of MIMD can be explained by the variation of independent variables)</td><td rowspan="12">0.000 (highly significant at p<0.001 level)</td></tr>
<tr><td>Significance</td><td>0.000**</td></tr>
<tr><td rowspan="2">Gender</td><td>Coefficient (B)</td><td>43.277</td></tr>
<tr><td>Significance</td><td>0.000**</td></tr>
<tr><td rowspan="2">Accessible Open Availability</td><td>Coefficient (B)</td><td>39.538</td></tr>
<tr><td>Significance</td><td>0.002**</td></tr>
<tr><td rowspan="2">Home-School Distance</td><td>Coefficient (B)</td><td>-0.130</td></tr>
<tr><td>Significance</td><td>0.000**</td></tr>
<tr><td rowspan="2">HHMI (Monthly House Hold Income)</td><td>Coefficient (B)</td><td>-0.002</td></tr>
<tr><td>Significance</td><td>0.003**</td></tr>
<tr><td rowspan="2">Street Width</td><td>Coefficient (B)</td><td>-1.769</td></tr>
<tr><td>Significance</td><td>0.030*</td></tr>
</table>

N=60, **p<0.01, *p<0.05

Table 2. Final Regression Model for DAIT

<table>
<tr><th colspan="4">Model RIMD-FINAL (Forward): All Entered Variables</th><th>Adjusted R Square</th><th>Model Significance</th></tr>
<tr><td rowspan="8">Forwarded Significant Variables</td><td rowspan="2">Number of Sibling</td><td>Coefficient (B)</td><td>348.216</td><td rowspan="8">0.279 (27.9% of variation of MIMD can be explained by the variation of independent variables)</td><td rowspan="8">0.000 (highly significant at p<0.001 level)</td></tr>
<tr><td>Significance</td><td>0.001**</td></tr>
<tr><td rowspan="2">Gender</td><td>Coefficient (B)</td><td>735.682</td></tr>
<tr><td>Significance</td><td>0.001**</td></tr>
<tr><td rowspan="2">Age</td><td>Coefficient (B)</td><td>-19.712</td></tr>
<tr><td>Significance</td><td>0.005**</td></tr>
<tr><td rowspan="2">Number of Crossing on RM</td><td>Coefficient (B)</td><td>-201.643</td></tr>
<tr><td>Significance</td><td>0.050*</td></tr>
</table>

N=60, **p<0.01, *p<0.05

Table 3. Final Regression Model for RIMD

Results

In "one to one" regression between street design variables and DAIT, only street type was found to have significant relationship ($p<0.001$ level). In group to one, street type and street width were significant and forwarded. Street type was highly significant for DAIT ($p<0.001$ level), and street width was significant at the 5 percent level ($p<0.05$ level). Gender and HHMI (Household Monthly Income) were highly significant ($p<0.01$ level) in their respective individual models. The number of siblings was significant at $p<0.05$ level. In the forward selection model for all socio-demographic variables, gender and HHMI were highly significant ($p<0.01$ level) and forwarded. In the individual models, three built-environment variables—availability of accessible open, home school distance, and building level—were significant at $p<0.05$ level. In the forward selection model, accessible open and home school distance were forwarded with high level of significance ($p< 0.01$ level). A total of six variables were forwarded for having significant relationship with DAIT. All these selected variables are again run in the final model with 'forward selection' to identify the most significant variables (Table 2).

For RIMD, from the individual models only street type was significant at $p<0.05$ level. Only street type was forwarded with a significance of $p< 0.05$ level. In the group model, gender and number of siblings were forwarded with high significance. Age was not significant individually but forwarded in this model with a significance of $p<0.05$ level. The Final forwarded model for RIMD is shown in Table 3.

For MIMD, individually only street type was significant at p<0.05 level. In the group model, once again only street type was forwarded among the street variables. The final forwarded model is shown in Table 4.

The home-school travel mode of the child was the only categorical dependent variable of the research with two possible measures, i.e. independent or dependent. Linear regression was not possible for a categorical measure, and a different statistical model was needed for regression of HSTM. This research applied a two-staged Binary Logistic Regression with ‘Backward Wald’ method. The final model (Table 5) forwarded significant findings for this research, as it kept two street variables (street type, number of crossings) as significant for HSTM. Gender has the highest significance (p<0.01) in the final table. Home-school distance is also significant for HSTM, and this association is negative as expected.

All regression models were repeated for children living only on dead-end streets (N=28) with two additional street variables mentioned before with no significant findings.

Results Summary

1. Street design characteristics have significant relationship with children’s IM in Dhaka.

2. Street type is highly significant (p=0.000) at p>0.001 and street width is significant (p=0.03) at p<0.05 level with DAIT in ‘all to one’ regression (R2 = 0.594). A respondent from a dead-end street is likely to spend 42 minutes more free time daily than one from a through street. For every one-foot increase of the width of the street, a respondent’s independent time is likely to be reduced by two minutes.

3. The number of crossings has negative significant (p=0.05) relation at p<0.05 with RIMD in ‘all to one’ regression (R2 = 0.279). For every additional street crossing, the independent regular distance of a respondent is likely to be reduced by 202 feet.

4. Street type (p=0.026) and number of crossings

Model MIMD-FINAL (Forward): All Entered Variables				Adjusted R Square	Model Significance
Forwarded Significant Variables	Gender	Coefficient (B)	1638.906	0.255 (25.5% of variation of MIMD can be explained by the variation of independent variables)	0.000 (highly significant at p<0.001 level)
		Significance	0.000**		
	Number of Sibling	Coefficient (B)	415.497		
		Significance	0.034*		

N=60, **p<0.01, *p<0.05

Table 4. Final Regression Model for MIMD

All Socio-Demographic Variables	Variables Selected by Backward Wald	Significance	B Value	Odds Ration Exp (B)
Street Type	Street Type	0.026*	Positive	14.603
Street Level	X			
Number of Crossing	Number of Crossing	0.016*	Negative	0.143
Gender	Gender	0.007**	Positive	163.285
HHMI	X			
Home-School Distance	Home-School Distance	0.015*	Negative	0.998

Table 5. Final Regression Model for HSTM

(p=0.016) have significant relation at $p<0.05$ with HSTM. If a child respondent lives on a dead-end street, he/she is 15 times more likely to be independent on home to school travel than a child respondent on a through street.

5. No street design variable is significant in ‘all to one’ regression with MIMD.

Discussion

The study validates the global concern over the decrease of independent mobility of children. One out of three children of this survey (33.3 percent) never spends even a minute of independent time outside the home per day. The situation for the girls is even worse. Empirical evidence is given by the research that a relationship exists between street design and children’s IM. Linear regression (bivariate and multivariate) analysis and binary logistic regression between street variables and independent mobility showed that children’s independent time (DAIT) is significantly related to street type and street width. The independent distance that a child travels on a regular basis has a significant relationship with the number of street crossings. Numbers of crossings and street types are also influential in determining the independence of a child’s school trips. However, this research has not found any significant relationship between any street variable and the occasional maximum independent distance (MIMD) of a child.

There is no evident solution for the problem of lack of open playground for Dhaka’s children in the intense battle for land. However, children living in the dense fabric of the urban Dhaka have found their own way out. Wherever a dead-end street was found, it was found with children playing on it. Dead-ends are found to be more than just mere streets in this research. They are the last resorts of play for the children of Dhaka. The negative relationship between number of street crossings and IM indicates that children are allowed more independence if they had to cross fewer streets in their everyday movement. While designing the streets, technical professionals such as traffic engineers are more concerned about cars, and connectivity is given priority over children’s safety and mobility. Out of the 24 children in the survey who travelled to school independently, 21 lived in houses within 2,500 feet of their schools. This finding implies that low home-school distance is helpful for autonomy of children in their school trips. This finding is further supported by the regression analysis, where home to school distance is found to have a negative relationship with HSTM (Home School Travel Mode) in the final forwarding model.

This study involved a sample of 60 children. A similar research design with a larger sample would be helpful to investigate such relationships with more confidence. Four indicators are used to define independent mobility of a child; but these variables are needed to be rated. For calculating the quality of independence, what should be given priority—time or distance? These questions need to be addressed in future research. After finding a positive relationship between dead-end street (street type) and independent mobility, this study was particularly interested in characteristic properties of dead-ends, such as the depth of the dead-end and the distance between the face of the street and the house of the respondent. But dealing with a very small sample size (N=28), this study failed to establish any relationship. But for a larger sample size, the same model may have different results. Research incorporating only dead-end children may be conducted in the future for such investigation. This study is helpful for realizing the importance of street design, but there may be other important variables (e.g. land use pattern around a street), which could not be accommodated within the scope of this research.

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