Local environment and social factors in primary school children’s afterschool commute in China

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A B S T R A C T

The rapid decline in young children’s active commutes to and from school has prompted investigations into ways to raise activity levels. The period after school is recognized as very important in the daily activity regime of primary school children. In this study, we examine the relative effects of local environmental factors and socio-economic status on children’s after-school commute mode choice. Environmental factors are pedestrian priority streets, street intersection density, motorways, shops, and play spaces. Property values are used as a proxy for income. Twenty-four school districts are selected using intersection density and motorway length as criteria. All children’s exit behaviors were film-recorded on October weekdays and extracted as four choices–alone, in a group of children, on foot with a parent or guardian, or a bike driven by an adult. A multinomial logistic regression reveals that gated communities, higher priced housing, motorways and bus stops are associated with children accompanied by adults. The presence of pedestrian streets is associated with children travelling alone and in groups. Greater travel distance is also associated with parents accompanying children on foot or on e-bike. The amount of play space is associated with children leaving school in groups. Overall, social and environmental factors are influential in the independent travel of primary school children after the school day ends in south China.

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1. Introduction

With concerns about rising sedentariness of urban populations worldwide, and the consequent negative health impacts, there has been particular focus on childhood. The promotion of active commuting by children from school confronts a dramatic drop in such behaviors across the world (Arundell et al., 2016). Reversing the trend to motorized travel and greater sedentariness among children is particularly important since early habits have long-term consequences in behavior and health outcomes (Wickel and Beltion, 2016). Modest associations between activity and facility provision, geography and environmental factors have been uncovered in a small number of studies of school children’s activity after school (Flouri et al., 2014; Markevych et al., 2014; Broberg et al., 2013). A comprehensive picture of the environment as an independent facilitating force for afterschool activity has yet to emerge. Other studies have focused on the social context for after-school activity (Veitch et al., 2006; Weir et al., 2006). Children from the middle classes in China have access to supplemental education after school hours, much of it related to performance in the regular curriculum. On the other hand, the primary school district in China is conceived as a non-motorized environment where it is imagined children will commute actively and on their own from home. The attraction represented by the local environment for active commutes and higher levels of activity in general needs more examination. Such study is also necessary to help situate environmental interventions in relation to social practices in favor of afterschool education.

This paper is concerned with the leaving routines of primary school children that announce their subsequent afternoon activities. In general, we can observe how the leaving behaviors—alone, with friends or classmates, with guardians or on motorized transport—are related to several environmental variables that are typical candidates for explaining active transport: street provisions and layout, availability of play space, permeability of the urban fabric on foot, local shops, bus services and road traffic. Since these factors vary remarkably across residential habitats, we might expect to uncover any latent relations with the travel behavior of children in a cross-sectional study of school environments. At the same time, what is the importance of environmental variables relative to the lifestyle changes that accompany rising incomes and property acquisition? Is enhancing further the playability of a local habitat worth it, as measured in increased activity levels, independent of social controls?
Our hypotheses are as follows:

1. The abundance of pedestrian-priority streets is positively associated with children travelling alone and with schoolmates.
2. The amount of play space is positively associated with travel in groups.
3. The number of local shops is associated with children’s travel without adults.
4. The number of bus stops is associated with travel with parents and guardians.
5. The number of control gates on residential communities is associated with travel with parents.

2. Literature review

The contribution of the school journey to daily physical activity is substantial in young children, with such activity measured using accelerometers positively associated with meeting the daily recommended levels of moderate-to-vigorous physical activity (MVPA) in an American study (Arundell et al., 2015). In a comparable British study, the after-school period and weekends were also the most active periods for second and third graders in a study in Texas (Lee et al., 2016). Studies tend to agree that the afterschool period is most important in contributing to children’s activity levels. For example, active commutes were found to be equivalent to 24 min of moderate-to-vigorous activity among fifth graders in South Carolina (Sirard et al., 2005). In Hong Kong, 56% of daily steps by primary school children took place with travel by children (McDonald et al., 2010). Higher income households have more cars and the private car is strongly associated with lower rates of active transport among children (Steinbach et al., 2012).

3. Materials, methods, and data

All the primary schools in Shenzhen (n = 356) were stratified by two physical measures: street intersection density (ID) and motorway length (ML), following evidence in the literature. Districts (n = 24) were selected with stratified sampling in the following way: Both ID and ML were derived from a GIS, where motorways have four traffic lanes. ID and ML were standardized on their measures to give them equal weight in the selection. ID scores were then reduced by ML scores and ordered over all schools. From each of the three strata in the ordered population of schools – 119, 119 and 118 schools respectively from top to bottom – 8 were randomly selected.

The study aimed at a 100% sample of students at the schools. Up to 5 video cameras were positioned on all pathways near each school, depending on the number of clear egress pathways, to film the students’ departure from school over the departure hour. The film was examined by assistants to extract all primary school children in the sample, the child’s sex, and whether they were leaving on foot alone, with other children, with an adult, and on e-bike driven by an adult. The coding was undertaken by the assistant operating the camera and independently verified. There were no discrepancies in the four-category coding.

Pedestrian streets and play spaces were identified in site visits. Play spaces included paved areas not primarily used for movement, vacant land, playgrounds, and parks. The first and second authors jointly coded the play spaces, which were measured as area within 400 m of the school. Local shops and bus stops were counted within 400 m radius of the school entrance. After eliminating non-urban land from the districts, mean Euclidean distance was generated for each of the districts from each residential building centroid to the school entrance.

Gated communities and average house price were the social indicators. Open gates to communities—those without security control—were counted along with closed gates—those requiring a key card or personal identification. House prices were extracted from a popular online property listing service and reduced to price per square meter.

A correlation matrix was generated for the explanatory variables (Table 2).

Ethical approval was obtained from the Bio-Medical Research Ethics Board of Peking University (no. 2015063).

4. Results

School districts varied in quantities of space for play, street network density, number of closed gate communities, and house price, among other factors (Table 2). Distribution by leaving behavior also varied considerably over the school districts (Table 3).

Table 4 provides the relationships between independent variables and travel choices. Because of the important differences in the local environments of the school districts and the school populations, the latter were standardized. Longer commute distance is associated with the use

| Table 1 | Correlation matrix for independent variables. |
|---------|-----------------------------------------------|
|         | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 1 House price | −0.292 | 0.465 | 0.460 | −0.216 | −0.011 | 0.622 | −0.372 | 0.324 | −0.611 |
| 2 Pedestrian street | 0.140 | −0.018 | 0.850 | 0.356 | −0.320 | 0.868 | −0.016 | −0.277 |
| 3 Motorway | 0.506 | 0.276 | 0.392 | 0.489 | −0.116 | 0.170 | −0.437 |
| 4 Play space | 0.230 | 0.189 | 0.238 | −0.150 | 0.068 | 0.240 |
| 5 Intersections | 0.268 | −0.280 | 0.745 | 0.044 | −0.184 |
| 6 Open gates | −0.023 | 0.241 | −0.409 | −0.256 |
| 7 Closed gates | −0.234 | 0.224 | −0.363 |
| 8 Shops | 0.062 | −0.261 |
| 9 Bus stops | −0.444 |
of e-bikes ($r = 0.483$), but negatively associated with walking with parents ($r = -0.514$). E-bikes are negatively related to closed gate communities. This result is not surprising since e-bikes are in greater use in traditional communities which are typically not accessible by car.

Both open and closed gate communities are associated with children travelling with parents. Open gate communities are mostly those built between 1982 and 2000, and are generally of lower market value than closed gate communities built after 2000. While the presence of both favors travel with parents and guardians, the effect is markedly stronger in the case of closed gate communities. House price is associated with walking with parents ($r = 0.573$), and negatively related to walking with friends ($r = -0.416$). There are also differences in leaving

Table 3

| 2 or more children without adult | Single child travelling alone | Child/children walks with adult | Child on e-bike driven by adult | Total N |
|--------------------------------|-------------------------------|--------------------------------|-------------------------------|--------|
| % n1                          | % n2                          | % n3                          | % n4                          |        |
| Gangxia                       | 46.5                          | 25.9                          | 27.6                          | 4.3    |
| Anle                          | 37.3                          | 19.9                          | 23.3                          | 14.7   |
| Shuiwei                       | 42.0                          | 26.2                          | 22.8                          | 8.6    |
| Jingbei                       | 36.9                          | 22.4                          | 23.0                          | 21.7   |
| Fenggang                      | 44.8                          | 25.8                          | 16.8                          | 21.7   |
| Jiangxuan                     | 40.4                          | 26.3                          | 245                           | 22.5   |
| Huanggang                     | 46.0                          | 20.2                          | 18.4                          | 18.8   |
| Baiming                       | 38.4                          | 28.0                          | 223                           | 18.2   |
| Xianhu                       | 50.1                          | 30.7                          | 238                           | 16.4   |
| Haqiao                       | 47.9                          | 17.0                          | 254                           | 59.1   |
| Liuxian                       | 49.5                          | 12.9                          | 299                           | 12.7   |
| Pinghao                       | 50.6                          | 18.5                          | 176                           | 19.6   |
| Yuedingshiyuan               | 34.9                          | 27.7                          | 284                           | 33.9   |
| Bibo                          | 36.2                          | 23.0                          | 231                           | 31.9   |
| Baocant                       | 30.0                          | 26.7                          | 223                           | 28.0   |
| Shenzhen                     | 40.4                          | 32.7                          | 207                           | 25.2   |
| Beishida                      | 34.9                          | 27.7                          | 284                           | 33.9   |
| Cuizhunxiyuan                | 43.1                          | 15.2                          | 165                           | 37.2   |
| Beishida                      | 34.9                          | 27.7                          | 284                           | 33.9   |
| Huaqiao                       | 47.9                          | 17.0                          | 254                           | 59.1   |
| Shenzhen                     | 40.4                          | 32.7                          | 207                           | 25.2   |
| Beishida                      | 34.9                          | 27.7                          | 284                           | 33.9   |
| Total                         | 8401                          | 5556                          | 5798                          | 1999   |

Table 2

School district descriptive data.

| House price (RMB/m²) | Ped. streets (length) | Motor-way (m²) | Play space (n) | Inter-sections (n) | Open gates (n) | Closed gates (n) | Shops (n) | Bus stops (m) | Mean distance |
|----------------------|-----------------------|----------------|---------------|-------------------|----------------|-----------------|-----------|--------------|--------------|
| Gangxia              | 41,841                | 15,526         | 14,380        | 357               | 9              | 0               | 76        | 688          |              |
| Anle                 | 44,457                | 14,969         | 3721          | 3092              | 365            | 29              | 2         | 75           | 451          |
| Shuiwei              | 55,578                | 12,296         | 6033          | 7,657             | 445            | 14              | 10        | 36           | 477          |
| Jingbei              | 40,293                | 14,284         | 2624          | 5,296             | 167            | 273             | 3         | 68           | 41           |
| Fenggang             | 54,378                | 9726           | 1381          | 6113              | 185            | 84              | 9         | 45           | 1156         |
| Jiangxuan            | 19,765                | 11,617         | 1915          | 2936              | 199            | 3               | 3         | 60           | 770          |
| Huanggang            | 45,503                | 5287           | 2619          | 1589              | 179            | 1               | 2         | 26           | 1216         |
| Baimang              | 12,668                | 6536           | 1265          | 773               | 115            | 1               | 1         | 32           | 2084         |

| Medium or mixed ID and ML |                     |                |                |                  |                |                  |          |              |              |
|--------------------------|---------------------|----------------|----------------|-----------------|----------------|-----------------|----------|-------------|--------------|
| Xinhua                   | 46,303              | 8416           | 3370           | 9495             | 172            | 10              | 17       | 39          | 440          |
| Huaxiao                  | 69,691              | 107            | 2458           | 15,434           | 114            | 20              | 7        | 6           | 690          |
| Liuxian                  | 34,474              | 4312           | 1808           | 8993             | 87             | 13              | 2        | 19          | 2050         |
| Yingcheng               | 46,741              | 8980           | 2622           | 4413             | 83             | 7               | 3        | 28          | 767          |
| Yuelingshi               | 49,935              | 11,311         | 5349           | 12,162           | 206            | 17              | 4        | 28          | 457          |
| Bibo                     | 51,734              | 6026           | 2394           | 9555             | 66             | 6               | 4        | 19          | 615          |
| Baocant                  | 50,321              | 5994           | 3108           | 4107             | 90             | 14              | 2        | 12          | 591          |
| Cuizihuai                | 61,761              | 5871           | 2421           | 2288             | 58             | 11              | 10       | 33          | 362          |

| Low ID high ML           |                     |                |                |                  |                |                  |          |              |              |
| Shilou                   | 47,446              | 7047           | 4144           | 2505             | 20             | 7               | 20       | 46          | 364          |
| Liuxian                  | 60,888              | 6953           | 3843           | 4512             | 110            | 40              | 12       | 18          | 665          |
| Beishida                 | 74,990              | 2220           | 2569           | 9217             | 33             | 7               | 5        | 29          | 358          |
| Langling                 | 7516                | 720            | 2143           | 459              | 12             | 1               | 5        | 11          | 1962         |
| Liuyangbei               | 98,094              | 4893           | 1418           | 5821             | 59             | 21              | 25       | 11          | 223          |
| Jingpeng                 | 61,310              | 4936           | 4551           | 12,391           | 64             | 6               | 35       | 19          | 685          |
| Binhai                   | 84,231              | 2535           | 4174           | 12,220           | 40             | 3               | 15       | 15          | 685          |
| Tianjian                 | 84,231              | 1625           | 4054           | 13,316           | 32             | 8               | 19       | 7           | 467          |

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behavior by sex. Although 56% of all the students at the 24 schools are male, 61% of those travelling alone are male. Males and females are equally likely to be leaving in a group. Males are slightly less likely to be accompanied by a guardian (54%) but are as likely to be driven by a parent on an e-bike (56%).

Before we run the multinomial logistic regression (MNL), we calculate variance inflation factor (VIF), particularly in light of the correlation matrix in Table 1. First we run an ordinary least square regression that has $X_i$ as a function of all the other explanatory variables. If $i = 1$, for example, the equation is as follows:

$$X_1 = \alpha_2 X_2 + \alpha_3 X_3 + ... + \alpha_k X_k + \epsilon$$

where $\alpha_k$ is a constant and $\epsilon$ is the error term. Then we calculate the VIF factor for $\hat{\beta}_i$ with the following formula:

$$VIF_i = \frac{1}{1-R_i^2}$$

where $R_i^2$ is the coefficient of determination of the regression equation in step one. The result is in Table 5. Again we can observe that pedestrian streets and shops have particularly high values but are retained in the MNL for their informative value, but without an attempt at estimating coefficient of determination of this model.

In order to proceed with the MNL, we need to standardize all numeric variables. Variables are rescaled to a mean of zero and standardization of 1. Z-score standardization is applied as follows:

$$X_{\text{changed}} = \frac{X - \mu}{\sigma}$$

where $\mu$ is mean of variable $X$, $\sigma$ is the standard deviation of variable $X$.

Residual deviance of the model is 23,708.83 with a degree of freedom of 36. The $p$-value of null hypothesis is $\sim 0.001$, allowing us to reject the null hypothesis of the model. The Likelihood Ratio Test (LRT) for the whole model is highly significant so we can be sure of the contribution of the variables ($\chi^2 = 700.980; p = 0.000$).

It is clear that both environmental and social variables act to promote or discourage after-school activity (Table 6). Again, children leaving with parents is more likely as a function of higher house price. Children are less likely to be accompanied by adults when the local environment has many pedestrian streets, although pedestrian streets did not achieve significance in relation to choice (Table 4). Parents are more likely to accompany children or to use the e-bike to transport them when there is a heavier presence of motorways, or a car-oriented environment, consistent with the correlational analysis. Greater travel distance within the school district leads to a greater likelihood of parents accompanying children or taking them elsewhere on e-bike. Although play space was not a significant variable in the bivariate analysis, more play space means parents are less likely to accompany children when compared with the choice of children leaving as a group.

### 5. Discussion

The decline in active commuting by school children, especially the youngest, is a worldwide phenomenon. In the U.S., in 1969, 90% of primary school children living within one mile of school walked or bicycled, compared with 31% in 2003 (BTS, 2003). Arundell et al. (2016) found that in 16 studies from the U.S., U.K., Canada, Australia and Portugal, elementary school children were spending 41%–51% of the afterschool period in sedentary activity. Since it was already noted here that the active commute is highly associated with higher activity levels (Southward et al., 2012), it is clear that the promotion of active commuting by school children is imperative. Studies in China are very scarce but important because the country already has the highest absolute number of obese individuals in the world (NCD Risk Factor Collaboration, 2016).

In this study, play space was broadly defined, given that primary school children have a tendency to invent their own play when they are without adults. Such opportunity is significantly associated with children leaving as a group when compared with children accompanied by an adult. Similarly, children were more likely to travel alone in environments with many pedestrian streets. Those districts have more traditional environments, composed of high density, mixed use buildings and a dense network of narrow streets.

Residential community and socio-economic status have great importance in the degree of independence of a young child in a Chinese city. The highest levels of activity are observed in children inhabiting urban villages, with the most precarious social infrastructure and lowest incomes. Most of the children not residing in open-gate or closed-gate communities reside in urban villages. A relative lack of opportunity to access cram schools means they have more access to the local environment and have higher levels of physical activity.

The contemporary Chinese practice of making compact primary school districts where through car traffic is minimized, has clear positive impact on the tendency of young children to travel independently after school. Walking alone or in a group of students makes up 62.4% of the total, much higher than comparable measures from the West. However,
the increasing number of internal roads for motor vehicles, to cater for burgeoning car ownership, has a clear dampening effect on children travelling alone or in groups after school. The provision of play facilities has much less impact on independent travel by children than a non-motorized environment.

Given these results, other environmental variables should be explored. Also, the impact of social context on afterschool activity needs more exploration, particularly given the wide range of experiences across regional contexts, as noted above. Finally, we need to know more about how these young children are using their unsupervised after-school time.

6. Conclusion

In this study in urban China, higher social status is negatively associated with independent travel and play of primary school children in the critical afterschool period. Highest levels of independent child behavior, singly and in groups, are associated with communities without gates or walls.

Motorways are associated with parents accompanying children or using an e-bike, when compared with children travelling alone or in groups. Greater travel distance increases the likelihood of using the e-bike. Pedestrian streets are associated with walking alone.

Transparency document

The Transparency document associated with this article can be found, in online version.

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