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

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ABSTRACT

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, on e-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.

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 Belton, 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?

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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 afterschool journey accounted for 34% of daily MVPA (Southward et al., 2012). 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 after school (Gao et al., 2015).

Children perceive different opportunities for play in the local urban environment as a function of objective urban design characteristics (Holt et al., 2008). Intersection density, residential density and built coverage ratio are all positively associated with children's walking although bicycling may not follow walking patterns (Moran et al., 2016). The facilities-induced increase in child outdoor activity carries modest evidence so far, as uncovered in a study in Utah (Gallimore et al., 2011). On the other hand, the inhibiting effects of lower urban densities and suburban road layouts with low connectivity, have had direct impact on active travel rates by middle-school students across the United States (Schlossberg et al., 2006).

It is suggested that the environment may induce activity (Broberg et al., 2013) although the evidence remains partial and fragmented. Benefits of vegetation include fewer behavioral problems in children (Markevych et al., 2014; Flouri et al., 2014) and positive relations to health-related quality of life (McCracken et al., 2016). MVPA is associated with vegetation (Matisziw et al., 2016; Remmers et al., 2016).

Greater parental controls on children's travel leads to less active transport 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 record 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 1).

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 4provides 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	0.366	−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
10 Mean distance									

Table 2
School district descriptive data.

	House price (RMB/m^2)(length)	Ped. streets (length)	Motor-way (m^2)	Play space (n)	Inter-sections (n)	Open gates (n)	Closed gates (n)	Shops (n)	Bus stops (m)	Mean distance
High intersection density (ID) or low motorway length (ML)										
Gangxia	41,841	15,526	2778	14,380	357	0	0	76	0	688
Anle	44,457	14,969	3721	3092	365	29	2	75	7	451
Shuiwei	55,578	12,296	6033	17,657	445	14	10	36	4	477
Jingbei	40,293	14,289	2624	5296	273	26	13	68	4	405
Fenggang	54,378	9726	1381	6113	185	84	9	45	3	1156
Jingxuan	19,765	11,617	1915	2936	199	3	3	60	7	770
Huanggang	45,503	5287	2619	1589	179	1	2	26	2	1216
Baimang	12,668	6536	1265	773	115	1	1	32	3	2084
Medium or mixed ID and ML										
Xinanhu	46,303	8416	3370	9495	172	10	17	39	6	440
Huaqiao	69,691	107	2458	15,434	114	20	7	6	3	690
Liuxian	34,474	4312	1868	8993	87	13	2	19	2	2050
Pingshan	46,741	8980	2622	4413	83	7	3	28	2	767
Yuanlingsh	49,935	11,311	5349	12,162	206	17	4	28	6	457
Bibo	51,734	6026	2394	9555	66	6	4	19	4	615
Baocheng	50,321	5994	3108	4107	90	14	2	12	4	591
Cuizhuwai	61,781	5871	2421	2288	58	11	10	33	7	362
Low ID high ML										
Shenzhen	47,446	7047	4144	2505	20	7	20	46	5	364
Liyuan	60,888	6953	3843	4512	110	40	12	18	7	665
Beishida	74,790	2220	2569	9217	33	7	5	29	5	358
Tanglang	7516	720	2143	459	12	1	5	11	5	1962
Liyuanbei	98,094	4899	4184	5821	59	21	25	11	8	223
Jingpeng	61,310	4936	4551	12,931	64	6	35	19	1	685
Binhai	84,231	2535	4174	12,220	40	3	15	15	6	685
Tianjian	84,231	1625	4054	13,316	32	8	19	7	8	467

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
School leaving behavior distributions across schools.

	2 or more children without adult		Single child travelling alone		Child/children walks with adult		Child on e-bike driven by adult		Total N
	%	n_1	%	n_2	%	n_3	%	n_4	
Gangxia	46.5	496	25.9	276	23.3	248	4.3	46	1066
Anle	37.3	438	19.9	233	28.1	330	14.7	172	1173
Shuiwei	42.0	365	26.2	228	23.2	202	8.6	75	870
Jingbei	36.9	379	22.4	230	23.3	239	17.4	179	1027
Fenggang	44.8	291	25.8	168	21.7	141	7.7	50	650
Jingxuan	40.4	377	26.3	245	22.5	210	10.8	101	933
Huanggang	46.0	420	20.2	184	18.8	171	15.0	137	912
Baimang	38.4	306	28.0	223	18.2	145	15.4	122	796
Xinanhu	50.1	389	30.7	238	16.4	127	2.8	22	776
Huaqiaocheng	27.2	406	17.0	254	50.1	747	5.7	85	1492
Liuxian	49.5	379	12.9	99	12.7	97	24.9	191	766
Pingshan	50.6	481	18.5	176	19.6	186	11.4	108	951
Yuanlingshiyan	34.9	357	27.7	284	33.9	347	3.5	36	1024
Bibo	36.2	364	23.0	231	31.9	321	8.9	90	1006
Baocheng	30.0	251	26.7	223	28.0	234	15.3	128	836
Cuizhuwaiguoyu	40.4	249	32.7	202	25.2	155	1.8	11	615
Shenzhen	20.9	122	13.3	789	57.4	336	8.4	49	585
Liyuan	34.4	284	20.2	167	39.0	323	3.9	41	828
Beishida	43.1	469	15.2	165	37.2	405	15.2	165	1087
Tanglang	61.9	433	16.4	115	16.9	118	4.8	34	700
Liyuanbei	33.7	358	37.0	393	3.9	41	3.9	41	1062
Jingpeng	34.3	137	23.3	93	36.3	145	6.1	24	399
Binhai	41.1	476	21.0	244	30.8	357	7.1	82	1159
Tianjian	38.4	174	21.2	96	38.2	173	2.2	10	453
Total		8401		5556		5798		1999	21,754

Table 4
Bivariate analysis of factors and school leaving behavior.

Factors	Leaving behavior children		With parents		Child alone		E-bike	
	(39.9%)	p	(28.7%)	p	(22.5%)	p	(8.8%)	p
House price	−0.416	0.043	0.573	0.003	0.004	0.985	−0.473	0.020
Pedestrian streets	−0.002	0.993	−0.292	0.166	0.389	0.061	0.212	0.320
Motorways	−0.342	0.102	0.409	0.047	0.079	0.715	−0.345	0.099
Playgrounds	−0.105	0.626	0.235	0.268	0.041	0.850	−0.316	0.132
Intersections	0.006	0.979	−0.220	0.301	0.252	0.235	0.205	0.336
Open gates	−0.394	0.057	0.373	0.073	0.073	0.734	−0.156	0.467
Closed gates	−0.275	0.193	0.510	0.011	−0.107	0.618	−0.498	0.013
Shops	0.047	0.826	−0.236	0.267	0.194	0.365	0.191	0.370
Bus stops	0.000	0.999	0.125	0.562	0.184	0.390	−0.451	0.027
Mean distance	0.479	0.018	−0.514	0.010	−0.254	0.287	0.483	0.017

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:

$$X_1 = \alpha_2 X_2 + \alpha_3 X_3 + \ldots + \alpha_k X_k + c_0 + e$$

where c_0 is a constant and e is the error term. Then we calculate the VIF factor for $\widehat{\beta}_i$ with the following formula:

$$\mathrm{VIF}_i = \frac{1}{1 - R_i^2}$$

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:

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

where μ is mean of variable X, σ 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 <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 ($\mathrm{Chi}^2 = 700.980$; $p = 0.000$).

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,

Table 5
VIF for environmental variables.

Variable	VIF
House price	2.620
Pedestrian streets	10.163
Motorways	6.743
Playgrounds	1.934
Intersections	7.616
Open gates	2.669
Closed gates	4.124
Shops	12.755
Bus stops	2.124
Mean distance	1.214
Sex	1.003

Table 6
Multinomial logistic regression (Exp(B)) of after-school commuting behavior[a].

	With parents ExpB	95% lower bound	95% upper bound	Child alone ExpB	95% lower bound	95% upper bound	Parent e-bike ExpB	95% lower bound	95% upper bound
House price	1.310***	1.205	1.424	1.055	0.968	1.150	1.036	0.915	1.173
Pedestrian streets	0.668***	0.572	0.781	1.398***	1.171	1.668	0.799*	0.620	1.031
Motorways	1.295***	1.136	1.477	0.892	0.777	1.023	1.511***	1.230	1.855
Playgrounds	0.873***	0.814	0.935	0.948	0.880	1.021	0.858***	0.769	0.956
Intersections	1.006	0.875	1.156	1.052	0.906	1.222	1.002	0.823	1.220
Open gates	1.315***	1.212	1.427	1.173***	1.074	1.281	0.713***	0.625	0.814
Closed gates	0.977	0.883	1.080	1.107*	0.994	1.234	0.707***	0.604	0.828
Shops	1.331***	1.116	1.587	0.721***	0.595	0.875	1.497***	1.119	2.004
Bus stops	1.014	0.941	1.092	1.118***	1.035	1.207	0.594***	0.528	0.669
Mean distance	1.281***	1.213	1.352	1.049	0.989	1.114	1.188***	1.087	1.299
Sex (m)	1.037	0.938	1.147	0.777***	0.698	0.866	1.024	0.880	1.191

*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.
[a] Children leaving in a group without parents or guardians is the reference.

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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