The effect of the social and physical environment on children's independent mobility to neighborhood destinations

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Abstract

Background: Relationships between context-specific measures of the physical and social environment and children's independent mobility to neighborhood destination types were examined. **Methods:** Parents in RESIDE's 4th survey reported whether their child (8-15 years; n=181) was allowed to travel without an adult to school, friend's house, park and local shop. Objective physical environment measures were matched to each of these destinations. Social environment measures included neighborhood perceptions and items specific to local independent mobility. **Results:** Independent mobility to local destinations ranged from 30-48%. Independent mobility to a local park was less likely as the distance to the closest park (small and large size) increased and less likely with additional school grounds (p<0.05). Independent mobility to school was less likely as the distance to the closest large park increased and if the neighborhood was perceived as unsafe (p<0.05). Independent mobility to a park or shops decreased if parenting social norms were unsupportive of children's local independent movement (p<0.05). **Conclusions:** Independent mobility appears dependent upon the specific destination being visited and the impact of neighborhood features varies according to the destination examined. Findings highlight the importance of access to different types and sizes of urban green space for children's independent mobility to parks.

Key words: Child, Independent travel, Built environment, Social environment.

Introduction

Children's independent mobility, defined as the license and ability to move around the neighborhood unaccompanied by adults,[1] is increasingly being investigated due to a strong association with beneficial health behaviors, such as active travel and physical activity.[2,3] Moreover, independent mobility provides additional psychosocial benefits by allowing children the opportunity to socially interact with friends and the local community.[2,4] Independently mobile children are also more likely to develop mapping and way-finding abilities[5,6] and learn how to interact with and navigate their local built and natural environments.[7] Despite the many benefits of independent mobility, studies from various countries report a rapid decline in the 1970-1980's to the current low levels.[2,8-10] For example, since 2002 only about 40% of UK children 7-13 years have been allowed to commute to school unaccompanied.[11] Children are increasingly now driven to school and leisure activities.[8,11] This trend is partly attributed to an increased number of cars in households, a rise in households where both parents work, increased distances between home and school, and a shift from free play in the neighborhood to organized activities outside the neighborhood where children are escorted, predominantly by car.[8]

A number of demographic, social and physical environment factors are associated with children's independent mobility. More independent mobility appears to be strongly associated with being male and older (vs. female and younger)[1,4,6,12] and having siblings and friends.[4,13-15] Parents oversee their children's travel behavior[16] and thus their perceptions of the social and physical environment impact on their children's freedom to travel independently. "Traffic danger" and "stranger danger" are two main reasons why parents restrict their child's independent mobility.[1,8,15] However, children living in neighborhoods with well connected, low traffic streets have higher overall independent mobility.[17] Broader

community social constructs such as collective efficacy (i.e., mutual trust and the shared willingness of residents to intervene for the public good),[18] and perceptions of social and physical disorder (e.g., vandalism, graffiti, evidence of drug and alcohol use) may also play a role in parent's willingness to grant their children mobility licenses.[15] To date, studies of the environmental correlates of independent mobility have been limited by the lack of objective and context-specific measures of the physical and social environment.[6,19]

The majority of studies of children's independent mobility focus on one type of destination, travel to or from school.[2] There are fewer studies examining children's independent mobility to leisure activities (e.g., going to the park, visiting friends)[8] and destinations such as local shops.[20] Promoting active travel to these types of activities has been identified as a viable strategy to increase children's physical activity.[21] A recent study reported that the physical environment was correlated with non-school walking journeys (e.g., friends' houses, shops, parks, places of worship and clubs) but not walking to school, highlighting that the physical environment may be more important for discretionary journeys compared with school journeys. [22,23] There appear to be no studies to date that have investigated neighborhood factors associated with independent mobility to specific destination types, nor how the quality of neighborhood environments influences the type of destination a child visits independently. This research requires the use of context-specific measures of the behavior and the environments[19] and is important for a consistent evidence base to inform the development of more targeted independent mobility interventions. The aim of this study was to use a social-ecological model [24] to examine the relationship between context-specific measures of the physical and social environment and children's independent mobility to and from each of the following local destinations: school (a non-discretionary destination), friend's house, park, local shop (discretionary destinations), and overall. We hypothesized that destination-specific features of the physical environment (e.g., presence,

type and distance to parks) would be associated with independently mobility to that

particular destination (i.e., a local park).

Methods

Sample and procedure

The sample included parents participating in the RESIDential Environments Project

(RESIDE). RESIDE commenced in 2003, and is a longitudinal natural experiment of 1813

people building homes in 73 new housing developments across metropolitan Perth, Western

Australia.[25] Details of the RESIDE study recruitment and design are described elsewhere.[25]

Briefly, participants moving to a development were invited to participate by the state water

authority following a land transfer transaction. The following eligibility criteria were

applied: English proficiency; ≥18 years; intention to relocate by December 2005; and

willingness to complete surveys four times over seven years. Participants were recruited by

telephone and one adult from each household randomly selected. Participants were

surveyed four times: before relocation (T1 - n=1813); then approximately one (T2 - n=1467),

three (T3 - n=1230) and seven (T4 – n=565) years after moving house. This sample was

selected from all parents (n=305) who provided data on their children's independent travel at

the fourth time point (i.e., T4, Feb 2011-Mar 2012). A total of 181 children who were aged 8-

15 years were included. If there were more than one child within this age range in the

household, the youngest was included. This age range was selected because it represents

when children may be given licenses to move independently around their neighborhood.[1] The

University of Western Australia's Human Research Ethics Committee provided ethics

approval.

Measures

Independent mobility measure: Parents reported whether their child was allowed to walk or cycle alone or with other children (without an adult) to or from four neighborhood destinations: school; friends or family house; park, oval or sporting field; and local shop (e.g., deli, newsagent).[26] Children who were independently mobile to ≥3 destinations were coded as having 'overall' independent mobility.

Physical environment measures: Geographic Information Systems (GIS) software was used to calculate objective measures of the physical environment within a 1600m road network buffer around each participant's home.[27] Objective measures of the neighborhood environment were matched to three (park, school and shop) of the four destinations of interest (this was not possible for 'friend's house' as an address was not recorded).

Park-related variables were derived from a spatial public open space layer developed for the Perth metropolitan area in 2011 (n=3463 parks)[28] and included distance (m) to closest park by size category (pocket ≤0.3 hectares (ha), small >0.3-≤0.5 ha, medium >0.5-≤1.5 ha, large >1.5 ha),[28] count of parks, count of school grounds (ovals, sport and play spaces owned/adjacent to school), presence of playground at closest park, and an attractiveness score of closest park (derived from objective measures of park attributes such as the presence of irrigated lawns, walking paths, trees, sporting facilities, amenities, water features, lighting).[29] Park attributes were determined by remote sensing methods (Google Earth) using the Public Open Space Desktop Auditing Tool (POSDAT), which has been shown to be a valid and reliable tool for assessing park quality.[30] We hypothesized that larger parks have more attributes and thus children are more likely to independently travel to these destinations compared with smaller parks.

School-related variables including count of primary schools and the presence of secondary schools were determined using GIS (data provided by the Western Australian Department of Education and Department of Planning). We calculated the presence of shops for daily living (i.e., deli, general store, supermarket, produce market, gasoline station, shopping center) using data from a commercial electronic database of services and stores (Sensis Pty Ltd).[27] Traffic exposure was calculated using the Western Australian Main Roads 'road function' which is a measure of traffic volume (number of vehicles/day).[31] The ratio of the total length of heavy road volume types by the total length of all road volume types was determined.

Social environment measures: Parent-report measures of neighborhood problems included scales measuring poor neighborhood maintenance (e.g., littering and dumping of rubbish in public areas); social incivilities (e.g., using or selling drugs); graffiti and vandalism; property crime (e.g., household burglary); violent crime (e.g., domestic violence); and two single items of loitering teenagers in public places and dangerous or drink driving. All scales/items were rated on a four-point scale (1=not a problem, 4=significant problem) and then dichotomized, with respondents reporting one or more items in the scale as a 'moderate problem' classified as perceiving a problem. Details of these measures are reported elsewhere.[32]

A measure of how safe the neighborhood environment was for children to walk or cycle around the neighborhood without adult accompaniment was based on existing items[33] that captured parent perceptions of: parks unsafe; not enough footpaths (2 item sub-scale); too much traffic; (single item) and high level of crime risk or abduction make it difficult for children to safely move around their neighborhood without adult supervision (2 item sub-scale). The two sub-scales and the single item were rated on a five-point scale (1=strongly disagree, 4=strongly agree) and then dichotomized and combined into an 'unsafe

environment' scale (range 0-3; scores ≥1=unsafe environment). Single items (5 point Likert scale dichotomized to agree vs. disagree) were used to measure poor collective efficacy ('People in the neighborhood don't look out for children who move around the area without adult supervision'), and poor parenting social norms ('Parents shouldn't let primary school age children move to and from places without adult supervision').[33]

Statistical analyses

Logistic regression models adjusting for child age, gender and siblings, and parent age, gender and education, were used to separately examine the relationship between each objective physical environment and each parent perceived social environment variable and independent mobility to each of the four destinations and overall independent mobility. All physical and social environment variables significant at $p≤0.1$ were then included in a multivariable logistic regression model.

Results

The mean age of children was 10.7 (SD 2.1) years and 45% were boys. Overall, 22% of children did not have a sibling, 35% had a younger sibling (0-7 years), and 56% had an older sibling (8-17 years) (Supplementary Table 1). Thirty percent of children were independently mobile to and from school, 40% to a friend's or another family member's house, 48% to a park, oval or sporting field, 30% to the local shop and 29% to at least three of these local destinations (i.e., 'overall') (Table 1).

In multivariable models adjusting for child and parent socio-demographic and all physical and social environment variables significant at $p≤0.1$ (see Supplementary Table 2), parent perception of an unsafe neighborhood for children to move around independently significantly decreased the odds of being independently mobile to school (OR=0.25; 95% CI=0.09-0.70) and overall (OR=0.21; 95% CI=0.06-0.70) (Table 2). If parents perceived that

parenting social norms were unsupportive of independent mobility, the odds of their child's independent mobility to the local park (OR=0.64; 95% CI=0.42-0.97) and shop (OR=0.56; 95% CI=0.34-0.91) significantly decreased. None of the perceived neighborhood problems variables (e.g., social incivilities, violent crime, loitering teenagers in public places, dangerous or drink driving) retained significance in the multivariable models.

A number of objectively measured physical environment variables were significantly (p<0.05) associated with independent mobility to specific neighborhood destinations (Table 2); increasing access to local school grounds was associated with reduced independent mobility to the park (OR=0.77; 95% CI=0.62-0.96); increasing distance to the closest large sized park was associated with reduced independent mobility to the park and school (OR=0.86; 95% CI=0.77-0.95, OR=0.88; 95% CI=0.79-0.99, respectively), and increasing distance to the closest small sized park was associated with reduced independent mobility to the park (OR=0.85; 95% CI=0.76-0.96). A sensitivity analysis (results not shown) to determine if there were any changes in the effects of physical environment variables before and after adjusting for the social environment variables revealed that there was no change and that the same physical environment variables were independently associated with independent mobility regardless of adjustment for social environment variables.

Discussion

This study examined the effect of physical and social environment features on children's independent mobility to a number of local destinations (school, park, local shop and friend's house). After adjustment for child and parent socio-demographic variables, parent perceived context-specific measures of the social environment (i.e., neighborhood safety and parenting social norms related to children's independent movement in the neighborhood) were consistently associated with independent mobility to each destination,

except a friend's house. Objective neighborhood physical environment features were associated with independent mobility but were dependent on the destination of interest.

Objectively measured context-specific features of the physical environment were associated with children's independent mobility and varied according to the destination examined. Previous studies show that living nearer a park is positively associated with independent mobility [4,12,13] and our findings support this; independent mobility to a local park decreased as the distance to both the closest small and large sized park increased, even after adjustment for all other factors. Our findings also suggest that access to both small and larger sized local parks is important for encouraging children's independent mobility. To date, the influence of park size has been primarily limited to adult physical activity outcomes,[34] or considered in the context of recreational planning and public open space strategies. [35] Most public open space planning guidelines acknowledge the importance of providing different sized parks within local catchment areas,[36] however the influence of park proximity and size on children's independent travel remains relatively unknown. Further research is warranted to guide urban green planners and developers on the importance of access, size and attributes of local parks for children's independent mobility, physical activity and other health and development outcomes.

Our findings highlight the need to consider the social and physical environment influences on independent travel to school and individual discretionary destinations (friend's house, park, shops) separately.[22] Somewhat counter intuitively, increased availability of local school grounds was associated with reduced independent mobility to a local park. It may be that parents are less inclined to allow their children to travel independently to the local park if there is a more familiar or child orientated school oval or playground nearby. These findings indicate the need for school grounds to be accessible out of school hours as they provide an important local destination that children can independently travel to and from.

Unfortunately this appears at odds with trends, particularly in Australia, towards fencing off and gating of school grounds.[37]

A number of studies have examined objectively measured physical environment correlates of active travel to school.[38,39] We observed that independent mobility to school decreased with increasing distance to the closest large sized park. It is likely that having destinations such as parks en route to and from school provides children with safe places to stop and play as well as cut-throughs away from the main roads thus reducing their exposure to traffic.[13,17,40] Future studies should explore the multiple built influences on children's independent mobility when more than one destination is visited in a single trip.

In the final multivariate model the only factor significantly associated with independent mobility to a friend's house was child age. It is possible that the other variables may have been statistically significant had we had a larger sample size and hence, they could be considered in future studies. However, it is also possible that independent travel to a friend's house involves a child travelling to a familiar local destination (i.e., one regularly visited) along a familiar route and in a familiar neighborhood. Thus parents may have fewer concerns. Moreover, compared with other destinations, parents can generally easily confirm whether or not their child has arrived safely and this may help to alleviate some of their concerns about the environment being unsafe and poor social norms amongst parents about allowing children to independently travel.

Aspects of the social environment were also important for children's independent mobility. In the final models only context-specific measures of how safe the neighborhood was for children to move independently and unsupportive parenting social norms about children children's independent movement were associated with reduced independent mobility to each of the destinations (except friend's house) and overall. Parent perceptions of neighborhood safety including safety from traffic and stranger danger are significantly

associated with children's physical activity,[41,42] active school transport [38] and overall independent mobility.[41,43] [44] Our findings confirm that parents who perceive the neighborhood environment as unsafe for children to move around independently are less likely to grant their children licenses to independently travel to a number of different local destinations.

While it appears parent's increased concerns about traffic danger may correspond to evidence of children being at greater risk from traffic accidents,[45] concerns about stranger danger have been shown to be substantially unfounded [46] and largely fuelled by a pervasive culture of parental fear and over-protection.[47] Moreover, parent's perceptions of neighborhood safety may contribute to a social norm that parents shouldn't allow their children (especially those still attending primary school) to move to and from places without adult supervision (i.e., that responsible parenting equates to constant supervision of children).[12] These social norms can be reinforcing and may supersede any benefits arising from a positive collective efficacy surrounding children moving around the neighborhood independently. Strategies aimed at improving the quality of the local physical environment as well as community level indicators such as sense of community and social capital,[12,48] may improve parent perceptions of the local neighborhood and its residents and increase children's opportunities to develop independent mobility.

Overall, our findings highlight that the social environment (e.g., parent perceived safety and social norms) influences children's independent mobility regardless of the destination being visited. Programs aimed at educating parents about the real (from actual crime data) versus perceived safety concerns about children travelling independently around the neighborhood are required.[49] These programs should also emphasize the child benefits derived from developing independence and address the issues of parental peer pressure to constantly supervise children and an underlying risk-averse culture. [50-52] Whole of

community approaches to improve sense of community and social capital may help to reverse social norms associated with the restriction of children's independent mobility by creating neighborhoods where people look out for children and support the development of their independence.[50,53] Our findings also highlight that the physical environment is associated with independent mobility to neighborhood destinations even after adjusting for socio-demographic and social environment factors. Our study appears to be one of the first to observe that the influence of objectively-measured physical environment on children's independent mobility is specific to the destination being visited. For example, access to different types (parks and school grounds) and sizes (small and large) of urban green spaces was associated with children's independent mobility to a park. A combined strategies approach is required to provide children with access to a variety of safe neighborhood destinations, allay parent safety concerns and educate children about safely navigating their neighborhoods independently.

Study Limitations: The generalizability of the findings may have been compromised because RESIDE participants live in relatively new housing developments on the urban fringe and thus may not be representative of all parents and children. This study relied on parent-report measures of independent mobility and the social environment. Future studies should consider including child-report measures of independent mobility and their perceptions of the environment as well as objective measures of the social environment (e.g., crime rates and child-related offences). Furthermore, our study did not include all features of the perceived social environment considered important for children's independent mobility. Future empirical studies should also measure the influence of peers, parent level of local walking, dog ownership, parent and child perceptions of appropriate destinations and the value of these local destinations.[54-56] However, context-specific and objectively measured physical environment features were strengths of this study. Another strength of this study was

its investigation of the social and physical environment features associated with independent mobility to a number of different local destinations. Future studies should use Global Position Systems (GPS) to objectively measure destinations children visit along with a self-report measure (SMS or an app) to determine if the travel has been unaccompanied by adults.[57,58]

While this study appears to among the first studies to empirically investigate the physical (and social) environment factors associated with children's independent mobility to a friend's house and local shop, no objectively measured physical environment variables in the final models were significantly associated with independent mobility to these destinations. This may be due to a lack of a context-specific measure for friend's house (e.g., distance to closest friend's house) and the sample size. Future studies should include objective measures of street connectivity, traffic exposure and intersection crossings and investigate the relative influence of social and physical environment factors on independent mobility to different local destinations (stratified by gender) using context-specific objective measures and larger sample sizes.

Conclusion

Parent perceptions of neighborhood safety and parenting social norms were consistently associated with independent mobility to all of the specific destinations examined, except a friend's house. Associations between objective physical environment features and independent mobility were dependent on the destination of interest and remained significant after adjusting for social environment factors. Access to different sized parks as well as school grounds were associated with independent mobility to a park, highlighting that access to different types of urban green spaces is important for children's independent mobility to key non-school destinations and that the influence of physical environment factors on

children's independent mobility is specific to the destination being visited. Future research should examine correlates of independent mobility to individual destinations other than school using objective context-specific measures of the physical and social environment. Further evidence of the influence of the physical environment on children's independent mobility to specific destinations when more than one destination is visited in a single commute is also required.

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Table 1: Physical and social environment and independent mobility characteristics of sample

	N (%) or mean (SD)
Social environment factors	
Poor neighborhood maintenance	70 (38.7)
Social incivilities	46 (25.4)
Graffiti and vandalism	44 (24.3)
Property crime	34 (18.8)
Loitering teenagers in public places	25 (13.8)
Dangerous or drink driving	28 (15.5)
Violent crime	14 (7.7)
Unsafe environment for children to independently move around neighborhood	62 (34.3)
Poor collective efficacy for children to independently move around neighborhood	64 (35.4)
Parenting social norm doesn't support children to independently move around neighborhood	84 (46.4)
Physical environment factors	
Count of primary schools, mean (SD)	1.5 (1.2)
Presence of Secondary school	71 (39.2)
Count of school grounds, mean (SD)	2.7 (2.0)
Count of parks, mean (SD)	13.6 (5.8)
Distance to closest park (any size category) (m), mean (SD)	214.8 (258.6)
Distance to closest pocket size park (m), mean (SD)	920.2 (521.6)
Distance to closest small size park (m), mean (SD)	511.2 (396.0)
Distance to closest medium size park (m), mean (SD)	728.9 (514.7)
Distance to closest large/district size park (m), mean (SD)	595.1 (467.8)
Attractiveness score of closest park, mean (SD)	37.6 (14.2)
Presence of playground at closest park	101 (55.8)
Presence of shops for daily living (convenience stores)	80 (44.2)
Traffic exposure	16.7 (10.0)

	N (%) or mean (SD)
Independent Mobility	
Independently mobile to and from:	
School	54 (30)
Friends/family house	72 (40)
Park/oval/sporting field	87 (48)
Local shop	55 (30)
Overall Independent Mobility[a]	53 (29)

[a] Independently mobile to and from three or all four of the destinations

Table 2: Multivariate models of the socio-demographic, social and physical environment factors associated with independent mobility to specific destinations and overall

	School	Friends or family house	Park/oval or sporting field	Local shop	Overall Independent Mobility[a]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Socio-demographic factors					
Child age	**1.61 (1.28-2.02)***	**2.02 (1.58-2.58)***	**1.94 (1.48-2.56)***	**2.64 (1.91-3.64)***	**2.45 (1.82-3.30)***
Child gender (Ref=girl)	0.76 (0.34-1.67)	1.61 (0.73-3.58)	**3.78 (1.53-9.32)***	2.40 (0.94-6.10)*	2.10 (0.83-5.30)
Parent age	0.94 (0.87-1.02)	0.99 (0.92-1.06)	0.98 (0.90-1.07)	1.02 (0.93-1.12)	1.00 (0.91-1.09)
Parent gender (Ref=male)	1.64 (0.65-4.12)	1.23 (0.53-2.87)	1.16 (0.46-2.95)	1.83 (0.65-5.17)	1.87 (0.68-5.14)
Parent education (Ref=Bachelor degree or higher)	1.00	1.00	1.00	1.00	1.00
Trade/Certificate/Diploma	2.56 (0.92-7.13)*	1.00 (0.40-2.56)	1.82 (0.63-5.26)	1.11 (0.37-3.31)	0.70 (0.24-2.06)
Secondary school	1.87 (0.65-5.33)	0.67 (0.24-1.83)	1.00 (0.32-3.23)	0.53 (0.16-1.79)	0.33 (0.10-1.12)*
Older sibling of same gender	**2.63 (1.09-6.32)***	-	-	**6.17 (2.07-18.34)***	**2.77 (1.02-7.52)**
Number of older siblings (Ref=none)	-	1.00	1.00	-	-
one		2.24 (0.94-5.35)*	**7.29 (2.57-20.68)***		
≥two		0.75 (0.22-2.60)	0.98 (0.27-3.53)		

	School	Friends or family house	Park/oval or sporting field	Local shop	Overall Independent Mobility[a]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Physical environment factors					
Count of Primary schools	-	-	-	1.59 (0.89-2.84)	-
Presence of Secondary schools	1.46 (0.62-3.46)	-	-	-	-
Count of school grounds	1.10 (0.90-1.36)	-	**0.77 (0.62-0.96)****	1.05 (0.77-1.42)	-
Distance to closest small size park (100m), mean (SD)	-	-	**0.85 (0.76-0.96)*****	-	-
Distance to closest large/district size park (100m), mean (SD)	**0.89 (0.79-0.99)****	-	**0.86 (0.77-0.95)*****	0.93 (0.83-1.04)	-
Attractiveness score of closest park	1.01 (0.98-1.05)	-	-	-	1.03 (0.99-1.07)
Presence of shops for daily living (convenience stores)	-	0.52 (0.23-1.19)	-	-	-
Social environment factors					
Social incivilities	-	-	0.63 (0.20-2.01)	-	-
Loitering teenagers in public places	-	0.54 (0.14-2.11)	0.44 (0.10-1.92)	-	-
Dangerous or drink driving	0.34 (0.09-0.70)	-	-	-	-

	School	Friends or family house	Park/oval or sporting field	Local shop	Overall Independent Mobility[a]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Violent crime	-	0.38 (0.05-3.14)	-	-	-
Unsafe environment for children to independently move around neighborhood	**0.25 (0.09-0.70)***	0.45 (0.17-1.20)	0.63 (0.22-1.80)	0.37 (0.12-1.16)*	**0.21 (0.06-0.70)**
Parenting social norm doesn't support children to independently move around neighborhood	0.80 (0.54-1.19)	0.76 (0.52-1.12)	**0.64 (0.42-0.97)**	**0.56 (0.34-0.91)**	0.68 (0.43-1.07)*

IM=Independent Mobility; Ref=Reference category; *p≤0.1; **p≤0.05; ***p≤0.01

[a] Independently mobile to ≥three destinations

Supplementary Table 1: Socio-demographic characteristics of sample

	N (%) or mean (SD)
Parent age, mean (SD)	42.9 (5.8)
Parent gender (male)	57 (31)
Parent education level	
Secondary or less	58 (32)
Trade, apprenticeship or certificate/diploma	67 (37)
Bachelor degree or higher	56 (31)
Parent marital status	
Married or defacto	164 (91)
Single, widowed or separated/divorced	17 (9)
Child age, mean (SD)	10.7 (2.1)
Child gender (male)	82 (45)
Sibling status[a]	
Only child	40 (22)
Younger sibling (0-7 years)	64 (35)
Older sibling (8-17 years)	102 (56)
Older sibling (8-15 years)	80 (44)
Older sibling (16-17 years)	30 (17)
Number of older siblings[b]	
0	79 (44)
1	79 (44)
2+	23 (13)
Gender of older sibling[c]	
Male with older male sibling	23 (13)
Male with older female sibling	22 (12)
Female with older male sibling	42 (23)
Female with older female sibling	24 (13)
Older sibling same gender	47 (26)
Older sibling different gender	64 (35)

[a] Not mutually exclusive

[b] Only one child had 3 siblings

[c] Excludes only child (n=40)

Supplementary Table 2: Association between physical and social environment factors and independent mobility to specific destinations and overall

	School	Friends or family house	Park/oval or sporting field	Local shop	Overall Independent Mobility[a]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
PHYSICAL ENVIRONMENT					
Count of Primary schools	1.23 (0.90-1.68)	1.00 (0.72-1.38)	0.80 (0.57-1.11)	**1.54 (1.04-2.27)****	1.35 (0.92-1.97)
Presence of Secondary schools	**2.37 (1.13-4.99)****	1.17 (0.55-2.49)	1.25 (0.59-2.67)	1.81 (0.75-4.36)	1.77 (0.73-4.29)
Count of school grounds	1.18 (0.99-1.41)*	0.89 (0.74-1.06)	**0.83 (0.69-1.00)****	1.22 (0.99-1.51)*	1.10 (0.90-1.35)
Count of parks	1.03 (0.97-1.10)	1.00 (0.94-1.07)	0.98 (0.92-1.04)	1.02 (0.94-1.09)	0.99 (0.92-1.06)
Distance to closest pocket size park (100m), mean (SD)	1.00 (0.93-1.07)	1.03 (0.96-1.11)	0.97 (0.91-1.04)	1.01 (0.93-1.09)	1.03 (0.95-1.12)
Distance to closest small size park (100m), mean (SD)	0.97 (0.88-1.06)	0.94 (0.85-1.04)	**0.88 (0.80-0.98)****	1.05 (0.94-1.18)	1.00 (0.89-1.12)
Distance to closest medium size park (100m), mean (SD)	1.03 (0.96-1.10)	0.97 (0.90-1.05)	1.00 (0.93-1.08)	1.01 (0.93-1.10)	1.00 (0.92-1.09)
Distance to closest large/district size park (100m), mean (SD)	**0.88 (0.80-0.96)*****	0.96 (0.88-1.04)	**0.91 (0.84-0.99)****	0.92 (0.83-1.01)*	0.93 (0.84-1.03)
Attractiveness score of closest park	1.03 (1.00-1.06)*	1.02 (0.99-1.05)	1.02 (1.00-1.05)	1.03 (0.99-1.06)	1.03 (1.00-1.07)*

	School	Friends or family house	Park/oval or sporting field	Local shop	Overall Independent Mobility[a]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Presence of playground at closest park	1.01 (0.49-2.08)	0.70 (0.33-1.49)	1.16 (0.54-2.51)	1.11 (0.46-2.65)	1.15 (0.48-2.75)
Presence of shops for daily living (convenience stores)	0.78 (0.39-1.58)	0.48 (0.23-1.04)*	0.54 (0.26-1.14)	1.35 (0.59-3.08)	0.53 (0.22-1.24)
Traffic exposure	0.98 (0.95-1.02)	0.98 (0.94-1.02)	1.00 (0.96-1.04)	0.98 (0.94-1.03)	0.97 (0.93-1.01)
SOCIAL ENVIRONMENT					
Poor neighborhood maintenance	0.68 (0.33-1.40)	0.66 (0.31-1.41)	0.67 (0.31-1.43)	0.81 (0.35-1.91)	0.77 (0.32-1.82)
Social incivilities	0.56 (0.23-1.33)	0.48 (0.20-0.19)	0.42 (0.17-1.01)*	0.63 (023-1.71)	0.47 (0.17-1.30)
Graffiti and vandalism	0.77 (0.34-1.77)	0.77 (0.33-1.81)	0.96 (0.41-2.22)	1.79 (0.71-4.51)	1.29 (0.51-3.28)
Property crime	0.55 (0.21-1.42)	1.07 (0.41-2.76)	0.72 (0.28-1.91)	1.08 (0.38-3.11)	0.85 (0.29-2.50)
Loitering teenagers in public places	0.42 (0.13-1.36)	**0.27(0.08-0.91)**	**0.26 (0.08-0.81)**	0.69 (0.19-2.46)	0.42 (0.11-1.64)
Dangerous or drink driving	**0.29 (0.09-0.97)**	0.75 (0.26-2.17)	0.72 (0.26-2.02)	1.43 (0.45-4.54)	0.79 (0.23-2.66)
Violent crime	0.63 (0.15-2.58)	0.18 (0.03-1.17)*	0.41 (0.09-1.86)	0.96 (0.19-4.81)	0.50 (0.08-3.02)
Unsafe environment for children to independently move around neighborhood	**0.20 (0.08-0.51)***	**0.28 (0.12-0.69)***	**0.38 (0.17-0.88)**	**0.25 (0.08-0.73)**	**0.17 (0.05-0.54)***

	School	Friends or family house	Park/oval or sporting field	Local shop	Overall Independent Mobility[a]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Poor collective efficacy for children to independently move around neighborhood	1.15 (0.68-1.95)	1.42 (0.81-2.48)	1.07 (0.61-1.86)	1.44 (0.77-2.71)	1.59 (0.85-3.00)
Parenting social norm doesn't support children to independently move around neighborhood	**0.64 (0.45-0.90)****	**0.70 (0.49-0.99)****	**0.62 (0.43-0.88)*****	**0.54 (0.35-0.83)*****	**0.57 (0.37-0.87)*****

IM=Independent Mobility; *p≤0.1; **p≤0.05; ***p≤0.01; All models adjusted for child age, siblings and parent age, gender and education.

[a] Independently mobile to ≥three destinations