

Factors affecting children's journeys to school: a joint escort-mode choice model

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Abstract A child's mode of travelling to school is influenced by, or dependent on, parental choices. Thus, an increasing proportion of car trips may reflect parental choices and constraints. Whether a parent can escort their children to school may depend on their scheduling and spatial constraints, e.g., work schedule and job location in relation to home and school locations. This research aims to understand the effect of household bundling constraints on a child's escort-mode choice. In this study, school trip data are drawn from the 2001 SCAG (Southern California Association of Governments) Post Census Regional Household Travel Survey. The study area is the five-county Los Angeles region. Our findings show that the parents', especially the mother's, increased working hours and more distant job locations result in an increased likelihood of several alternative escort-mode choices. Mothers who work longer hours and further away from home are less likely to chauffeur their children. These trips have been substituted by alternative escort choices such as independent travel and being escorted by fathers, or alternative mode choices such as active commuting and busing. The effect of increased working hours may be offset by the option of flexible working hours, which allows parents to arrange more escort trips. This study elucidates an important aspect in explaining children's changing mode choice in journeys to school and sheds light on current policy efforts in reducing children's car dependency.

Keywords Children · Escort choice · Mode choice · Parental employment · School trip · Work arrangement

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Introduction

In the United States, the proportion of children aged between 6 and 12 years who travel to school by private vehicle has increased from 15 % in 1969 to 50 % in 2001 (NHTS Brief 2008). Children's rising car use for travelling to school can lead to the loss of important opportunities for physical exercise outside the classroom (Tudor-Locke et al. 2001). While this serious concern has aroused keen academic interest in school transportation studies, most have focused on mode choice (DiGuiseppi et al. 1998; Ewing et al. 2004; McMillan 2005, 2007; McDonald 2008a; Müller et al. 2008; Black et al. 2001; Schlossberg et al. 2006; Babey et al. 2009; Zhu and Lee 2008; Davison et al. 2008; He 2011). However, relatively little is known regarding the escort choice decision (He 2013). Even in research on escort choice, the decisions of escort and travel mode are usually modelled as separate decisions, rather than being considered as a joint escort-mode choice.

A child's travel mode during school trips is influenced by the parent's escort decision. Research focusing on Japan revealed that the child's travel mode and whether the child is escorted by a parent (or other caregiver) are closely related: even though Japan has an extensive public transport system, children escorted by parents are more likely to be transported by car (Waygood 2009). Following this line of research we postulate that, in the United States, children who are escorted to school may be more likely to be dropped off or picked up by car, whereas those who travel independently are more likely to walk, cycle or take the bus.

To study the escort-mode joint decision, it is important to consider intra-household bundling constraints. These can be defined as scheduling and spatial constraints, which determine whether a household member is able to join another member during an activity. Applying this concept to school trips, whether a parent can escort their children to school may depend on the parent's scheduling and spatial constraints, e.g., work schedule and job location. As part of general parental responsibilities, the parent decides whether the child is escorted to school or travels alone. Thus, an increasing proportion of car trips may reflect parental choices and constraints.

The effects of intra-household bundling have only recently been addressed. It has been shown that parental employment and flexibility of working hours are significant factors in the escort and/or mode choice of children's school trips (McDonald 2008a; Vovsha et al. 2004; Vovsha and Petersen 2005; Yarlagadda and Srinivasan 2008). However, spatial constraints, which may also affect joint trip making, have rarely been taken into account. The child may attend a non-neighbourhood school, resulting in a longer travel distance that makes walking or cycling trips less feasible. Attendance at non-neighbourhood schools is increasingly likely in the US due to open enrollment policies. In some cases, students may be able to transfer to districts where their parents work. Therefore, although the student attends a non-neighbourhood school that is further from home than a neighbourhood school, it can be closer to the parent's work location, which in turn facilitates parental pick-up and drop-off duties. This paper examines the effect of the spatial (dis)coordination and time (de)synchronisation between parents and children on a child's travel.

The effect of intra-household spatial and temporal coordination on escort-mode choice may vary across different household structures because of unequal chauffeuring responsibility. For this reason, five types of households are defined in this study, including two types of two-parent households (i.e., dual-earner, non dual-earner), two types of single-parent households (i.e., father-headed, mother-headed), and no-parent households (i.e., other-headed). In this research, the group of primary interest is the dual-earner household,

because only for this household structure can the father's and mother's employment status and job locations be identified at the same time, which enables their respective effect on escort-mode choice to be estimated.

This research presents a first attempt at bringing together both scheduling and spatial variables that are derived from parents' working arrangements and workplaces to model escort-mode decisions about school trips. The data are drawn from the 2001 SCAG (Southern California Association of Governments) Post Census Regional Household Travel Survey (RHTS). We focus on children aged between 5 and 18 years, the age range for primary and secondary schooling in the United States. The findings from this study will help to explain children's changing mode choice of travel for school trips and may shed light on current efforts to reduce children's car dependency.

Theoretical framework and empirical research

Time geography

This paper adopts a time-geography framework (Hägerstrand 1970), which centres around the spatial and temporal constraints on the movement of individuals. According to this theory, constraints can be categorised into three types: individual; bundling; and societal. Individual constraints refer to biological and physiological necessities; bundling constraints refer to when, where and for how long must an individual join others; and societal constraints refer to accessibility to specific domains at specific times determined by rules, laws and economic barriers (Hägerstrand 1970; Pred 1977). Although the joint school trip involves all three types of constraint, its realisation depends heavily on *bundling* and *societal* constraints. Bundling constraints emphasise both temporal synchronisation and spatial coordination between the parent and the student, and societal constraints address institutional rules such as the daily school schedule. Changes such as the provision of childcare or having flexible start times at school could relax the time and space constraints on parents. However, institutional change is difficult and takes place over a period of time. We, therefore, consider institutional constraints as exogenous to the household, and focus on *bundling* constraints, such as parental work arrangements and workplace locations, which are choices made by the household.

Previous research related to intra-household temporal synchronisation and spatial coordination

Until recently, previous studies of household interactions have focused mainly on the household head. Vovsha and Petersen (2005) examined household interactions between adults and children regarding their joint trip decision-making. Using data from the Atlanta region, they combined both to and from school trips and defined three escorting decisions (i.e., ridesharing with a household member who is going the same way for a mandatory activity, pure escorting by a household member who has no mandatory activity on the journey, and no escort) each way. Their results showed that part-time workers and non-workers were significantly more likely to escort their children: but for trips to school only. The authors suggested that their model would be enhanced by explicitly including an additional variable—flexible working hours. One drawback of Vovsha and Petersen's (2005) model is that they used only car trips.

McDonald (2008a) tested whether the parents' work schedule affects children's mode choice of travelling to school. Using a US national sample, McDonald found that the mother's work status and commute patterns can affect the probability of children's non-motorised travel. Mothers were the most frequent travel companion to their children during their school trips and these trips were mostly by car; non-household members were also very often found on school trips, but usually for trips on the school bus. Mothers who were employed and travelled to work in the morning were associated with a 7.7 % decrease in their children's non-motorised travel to school. This study suggested that a relationship existed between parental time constraint and children's walking and cycling to school. While the findings are interesting, the decision is limited to the mode choice level and does not link mode choice with escort choice.

Yarlagadda and Srinivasan (2008) used an escort-mode choice model to study the effect of household interactions. For some modes (i.e., cycle, drive, school bus and transit), the escorting decisions were not differentiated. Only walking and being a passenger were split by the escorting arrangement (i.e., walked alone, walked by mother, chauffeured by mother, chauffeured by father, and chauffeured by other). They found that the father's and mother's employment status and work schedules had a significant impact on children's private vehicle use. Working mothers were more likely to drop off their children, whereas working fathers were less likely to drop off their children. The association between parents' work commitments and children being chauffeured was not found in pick-up trips, suggesting less temporal overlaps between work–school end times than the overlaps for start times.

Despite their attempts to include parents' work schedules in school trips, the focus of these studies was on time synchronisation. Spatial coordination among household members (i.e., the distance from the parents' work place to school, deviation of the school trip from the parent's commuting trip) is not considered. We know that scheduling and joint trip decisions are influenced by factors along both the time and space dimensions. We expect that as distance between school and parental workplace increases, the likelihood that parents escort their children will decrease, which will affect the mode choice. Thus, we include both space and time constraints in our models.

Methodology

Space and time constraints

Under the time geography framework, school trips are subject to the space and time constraints that are anchored around home, school and workplace. Although there may be other constraints due to maintenance and discretionary activities, they may not affect school trips, with respect to the departure time, trip duration, mode choice and escort choice in the long run, because these choices are rather routine: they are contingent upon the fixed location of the next mandatory activities and the largely fixed time budget that is determined mainly by the institutional starting time at school and at work as well as by intra-household coordination.

Although we do not have information on the starting time at work, we can include other institutional constraints at work such as the parents' working hours and whether they are entitled to flexible work schedules. Similarly, we do not know if the chauffeuring responsibility is pre-assigned between the parents by other mechanisms or other

considerations, which are not recorded in travel diaries; our goal here is to test whether the spouse who has less work-related constraints will be more likely to take up the duty.

It should be noted that some employment and location information (i.e., working hours, access to flexible working hours, workplace location) is available only for employed parents. Therefore, only *dual-earner* households provide adequate information with which to estimate the full model, in which the hypothesised relationship of intra-household temporal and spatial coordination can be fully tested and presented. For single working parent households, theoretically, we cannot estimate the intra-household coordination as in the case of dual-earner households. Nonetheless, we could still estimate the effect of parental work arrangements and locations by including the employed parent's work arrangement and location in the model. However, due to small valid samples from these households, several alternatives have too few observations such that the model would not converge unless we reduce the number of alternatives. Therefore, in the modelling part, we would not have the same choice set across different types of households, limiting the possibility of comparable estimation results. For this reason, we will present a statistical summary for all types of households and modelling results for dual-earner households only.

Study area and data

Our data source is the 2001 SCAG Post Census Regional Household Travel Survey (RHTS), covering six counties in the region: Los Angeles, Orange, Riverside, San Bernardino, Ventura and Imperial. The Los Angeles region is the second largest in the US, with a 2000 population of 16.5 million and approximately 5.4 million households. The survey resulted in 17,775 completed travel diaries (SCAG 2003). We exclude Imperial County, because it is not part of the developed portion of the region.

As noted above, we restrict our sample to school age children and school trips as identified by trip purpose, yielding 3172 school trips. Students in the Los Angeles Region have high car dependency and low usage of alternative modes. More than 60 % travelled to school by private vehicle, approximately 24 % on foot or by bicycle, and slightly more than 11 % by school bus; few students travelled by public transport (Fig. 1). Because trips undertaken by rail and express bus have a very small share of students in the region (three trips accounting for 0.09 %), they are removed from further analysis, leaving 3169 trips in total. We then combine mode choices into four categories: walking and cycling (active commuting); bus (school bus and local bus); passenger; and driving.

Household structure can play an important role in escort decisions. The 3169 school trips are from 2039 households, including 1491 two-parent households, 115 father-headed households, 418 mother-headed households, and 15 other types of households. Table 1 gives the share of school trips by type of escort and household structure. Approximately three quarters of all households are two-parent households, about 20 % are single mother, and the remainder is single father households. A little over half of all trips (about 53 %) involve parental escort, and of these, most are mother escorts. Nearly 40 % of all trips are non-escorted; the child either travels alone or with siblings. Comparing trips across household structure shows that parental escort accounts for nearly 60 % of trips in two parent households, while the majority of trips in single parent households are not escort trips. Students from father-headed households are nearly three times more likely to be escorted by the father (35.47 vs. 13.08 %) and over seven times more likely to be escorted by other household members (6.40 vs. .21 %). The table also indicates that single mothers receive less escort assistance from other household members compared to single fathers

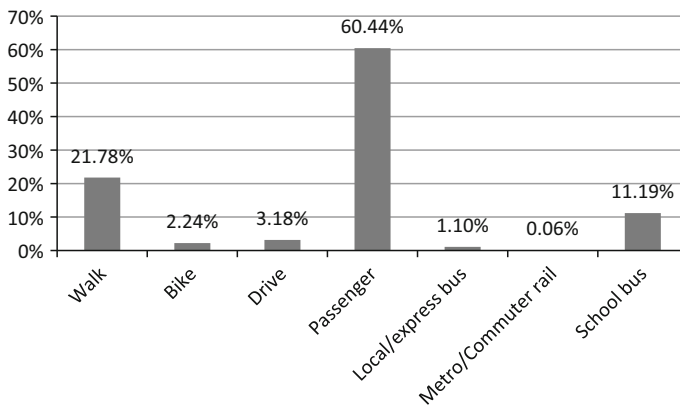


Fig. 1 Mode choice summary (N = 3172)

Table 1 Escort status by household structure

Escort status	All households	Household structure ^a		
		Two-parent	Father-headed	Mother-headed
Parent(s)				
Father and mother	1.6 %	2.2 %	N/A	N/A
Father	11.7 %	13.1 %	35.5 %	0.0 %
Mother	40.6 %	43.1 %	0.0 %	43.8 %
Others				
Other household member(s)	0.9 %	0.2 %	6.4 %	1.9 %
Non-household member(s)	6.4 %	6.2 %	4.7 %	7.1 %
Independent				
Self	22.9 %	20.5 %	25.0 %	30.6 %
Sibling(s)	15.9 %	14.8 %	28.5 %	16.5 %
Total number of trips	3169	2362	172	617
Percentage	100.0 %	74.5 %	5.4 %	19.5 %

^a A small number of trips (N = 18) come from other types of household; these are not included in the Table

(1.94 vs 6.40 %). This may stem from single mothers having “fewer social or personal resources” (McLanahan et al. 1981, p. 602) and lower earning capacity with “grossly inadequate” child support from the non-resident father (McLanahan and Booth 1989, p. 560).

Table 2 gives the distribution of trips by escort status and mode. Row percentages of mode share are given for each type of trip, and column percentages are given for each mode. For example, of the 23 % of all trips travelled alone, walking has the greatest mode share (45.9 %), followed by school bus (32.8 %). The walk mode share across all trips is 21.8 %. When children are escorted by parents, school trips are predominantly undertaken by car, accounting for roughly 90 % of the total. Similar levels of car dependence are observed when children are escorted by other household members or non-household

Table 2 Trips by escort status and mode (row percentage in brackets)

Escort type	Relationship	Travel companion	N	Walk	Cycle	Drive	Passenger	Local/express bus	School bus
Independent	Self	Alone	725 (100)	333 (45.93)	52 (7.17)	74 (10.21)	–	28 (3.86)	238 (32.83)
	Sibling(s)	Sibling(s)	505 (100)	183 (36.24)	14 (2.77)	16 (3.17)	176 (34.85)	2 (0.40)	114 (22.57)
Dependent	With household member	Escorted by parent(s)	51 (100)	4 (7.84)	–	–	47 (92.16)	–	–
		Father and mother	370 (100)	11 (2.97)	2 (0.54)	1 (0.27)	356 (96.22)	–	–
	No household member	Father	1288 (100)	154 (11.96)	3 (0.23)	2 (0.16)	1124 (87.27)	4 (0.31)	1 (0.08)
		Mother	28 (100)	6 (21.43)	–	–	21 (75.00)	–	1 (3.57)
		Other household member(s)	202 (100)	–	–	8 (3.96)	193 (95.54)	–	1 (0.50)
Total			3169 (100)	691 (21.80)	71 (2.24)	101 (3.19)	1917 (60.47)	35 (1.10)	355 (11.20)

Numbers in italic denote dominant transport mode for each escort type

members. An interesting difference is found again between children accompanied by fathers and by mothers. It appears that women have continued their traditional role in childcare (Ferri and Smith 1995); the number of trips accompanied by mothers alone is over three times that of trips accompanied by fathers alone (1288 vs. 370). In addition, when the father escorts school trips, over 96 % of the students are passengers and only 3 % of them walk; whereas when mothers escort the children, more of them walk (11.96 %).

Defining escort-mode (EM) choices

Table 3 shows that there are 7 possible escort types and 6 possible modes, leading to 42 possible combinations. It is not feasible to estimate such a large choice set, given the relatively small number of total observations and the many alternatives for which there are very few observations (e.g., the small number of escorted bicycle trips). We therefore reduce the alternative choice set to seven combinations of escort type and mode as follows:

- EM1 Trips escorted by both mother and father, and trips escorted by father, by private vehicle.
- EM2 Trips escorted by mother by private vehicle, the most frequent escort type, and hence chosen as the reference group.
- EM3 Trips chauffeured by others, also by private vehicle.
- EM4 Trips escorted by parent(s) or others, by non-motorised mode.
- EM5 Independent trips, alone or with siblings, by non-motorised mode.
- EM6 Child driving him or herself, across all escort types.
- EM7 Child travelling by bus, across all escort types.

Table 3 lists the seven escort-mode alternatives to be modelled for all general types of households, although only observations from the dual-earner households will be used for modelling. Chauffeured by mother (EM2) is the dominant escort-mode choice for all households (35 %). It also dominates the escort-mode choice for two-parent households (37 %) and mother-headed households (39 %). The proportion of each escort-mode alternative for students from two-parent families is similar to the proportions observed in mother-headed households (except for the higher proportion of bus trips), suggesting that mothers have primary childcare and escort responsibility (Schwanen 2007; Barker 2011; Waygood 2009). By contrast, students from father-headed households are much more likely to be chauffeured by the father and others. In single-parent households, children are more likely to be chauffeured by others (EM3), commute actively by themselves or with their siblings (EM5), or go to school by bus (EM7). This result is not unexpected; when there is only one parent in the household the involvement of other caregivers, the student's independent travel, or busing increase as a result.

Among the final sample, which has a total number of 799 school trips from double income households, 39 % of the children are escorted in a car by their mother (EM2), 15 % of them are escorted in a car by their father or both parents (EM1), 13 % of them are passenger-accompanied by others (EM3). Roughly 19 % of them commute actively to school, among whom 16 % commute by themselves or with siblings (EM5) and 3 % are with parents or others (EM4). Approximately 5 % of children are driven to school (EM6) and 10 % of them take a school bus or a local bus (EM7).

Table 3 Escort-mode choice alternatives, by household type

Mode	Escort type	Escort-mode choice	Alternative	All households		Two-parent households		Mother-headed households		Father-headed households	
				Obs.	Col. Pct	Obs.	Col. Pct	Obs.	Col. Pct	Obs.	Col. Pct
Passenger	Father and mother, or father only	Chauffeured by both parents or by father only	EM1	403	12.7 %	344	14.6 %	0	0.0 %	59	34.3 %
			EM2	1124	35.5 %	885	37.5 %	239	38.7 %	0	0.0 %
			EM3	390	12.3 %	246	10.4 %	87	14.1 %	48	27.9 %
Walk or cycle	Siblings, other household or non-household members	Chauffeured by others	EM4	180	5.7 %	145	6.1 %	31	5.0 %	4	2.3 %
			EM5	582	18.4 %	414	17.5 %	131	21.2 %	35	20.4 %
			EM6	101	3.2 %	72	3.1 %	20	3.2 %	6	3.5 %
Drive	Any type	Active commuting with a companion	EM7	389	12.3 %	256	10.8 %	109	17.7 %	20	11.6 %
			EM7	389	12.3 %	256	10.8 %	109	17.7 %	20	11.6 %
School bus or local bus	Any type	Drive									
Total				3169	100 %	2362	100 %	617	100 %	172	100 %

A small number of trips (18) come from other types of household; due to the small number, they are not included

Modelling and results

Multinomial logit model

The escort and mode choice decisions can be assumed to be simultaneous and, thus, they can be considered as a joint choice decision (Yarlagadda and Srinivasan, 2008). The escort-mode choice model is estimated using the multinomial logit (MNL) model (McFadden 1974). We use the Hausman-McFadden (HM) test (Hausman and McFadden 1984) to examine whether the IIA assumption holds. The HM test compares estimates from the full model with those from an alternative model where at least one alternative is excluded. None of the tests rejects the null hypothesis that IIA holds. In the HM test, some test statistics turn out to be negative, which is very common and should be interpreted as evidence that the IIA has not been violated (Hausman and McFadden 1984; Long and Freese 2006). We also test different alternatives as the reference group and then conduct the HM test. All the HM statistics uphold the IIA assumption.

It should also be noted that the escort-mode choice is a short-term choice conditional upon previous long-term choices such as home, work and school location. These prior decisions and the resulting relatively fixed locations of home, work and school are the reason why the spatial coordination of parents and children should be included in the escort-mode choice decision.

Selection of variables

The main objective of this research is to consider both parents' time and space constraints in relation to children's school trips. These temporal and spatial intra-household constraints are measured by the parents' employment status and work arrangements, distance to work and to the child's school. Other factors that influence the escort and mode choice decision are also included in the model. The explanatory variables are grouped into five categories: the student's individual attributes (S); household characteristics (H); neighbourhood built environment (R); parents' employment status (E); and distance variables (D). Definitions of these variables are listed in Table 4, followed by the explanation of our choice of control variables.

Spatial and temporal constraints

Parents' employment in terms of space and time would impact children's escort and mode choice during their journeys to school. If a parent is employed, the total number of working hours is expected to reduce the probability of escorted trips by the parent, while the option of flexible hours may counteract the negative impact of long working hours. Employment status is excluded from the full model because there are no unemployed parents and inadequate observations of part-time fathers in this subset of the sample. However, the inclusion of the total number of working hours can, to some extent, account for the parents' employment status since full-time workers normally work longer hours than part-time workers.

The distance between work place and school is an impediment to joint trips. Although the distance between home and school has been shown to be influential in mode choice decisions, distance from home to work or school to work is rarely considered. We expect that work arrangements and location will have different effects for fathers and mothers. To

Table 4 Definition of variables

Intra-household coordination	Category	Variable	Definition/value
N/A	Student traveller's personal attributes (S)	Age	Age of the student
		Female	1 if the student is female, 0 otherwise
	Household attributes (H)	Number of siblings	Number of siblings of the student
		Total vehicles	Total number of vehicles in the household
		Household income	Low income (less than \$35,000); middle income (\$35,000–\$75,000); high income (over \$75,000)
		Ethnicity	White/Not Hispanic; Hispanic; African-American; Asian/Pacific Islander; other
	Residential neighbourhood built environment (R)	Population density	Population density per square mile of the census tract
		Land use	Single-family residential; multi-family residential; other land use
Temporal	Parent employment status and work arrangements (E)	Father's employment status	Full-time; part-time; unemployed
		Father's working hours	Total number of hours worked per week at main job (answered if employed)
		Father with flexitime	Working hours not fixed (answered if employed)
		Mother's employment status	Full-time; part-time; unemployed
		Mother's working hours	Total number of hours worked per week at main job (answered if employed)
		Mother with flexitime	Working hours not fixed (answered if employed)
Spatial	Distance derived from the location information of home, school, and the parents' workplace (D)	Home–School	Distance from home to school
		Home–Father's job	Distance from home to father's workplace
		Home–Mother's job	Distance from home to mother's workplace
		School–Father's job	Distance from school to father's workplace
		School–Mother's job	Distance from school to mother's workplace
		Father's deviation	Deviation of the school location from father's commute
		Mother's deviation	Deviation of the school location from mother's commute

measure the distance deviation of the school in the parent's commuting trip, we define a deviation variable as the ratio of the sum of the distance from home to school D_{HS} and the distance from school to work D_{SW} over the distance from home to work D_{HW} :

$$\frac{D_{HS} + D_{SW}}{D_{HW}}$$

Two deviation variables are created for the father and the mother, respectively. We expect that the greater the deviation, the less likely that the parent will chauffeur the child. Given that mothers continue to be the main caregiver in two parent households, the mother's spatial and temporal constraints are likely to have more effect on escort-mode decisions.

To further elucidate the interrelationship of the father's and the mother's employment and their effect on their children's travel, we calculate a number of dummy variables to measure the relative flexibilities in terms of working hours, the option of flexible work hours, and the distance. These dummy variables are coded as 1 if the mother has a relatively higher flexibility, measured by shorter working hours than the father, working with a flexible schedule while the father cannot, and working at a place closer to the school than the father. The estimates of these variables, however, are mostly statistically insignificant. Hence, the relative measures are not included in the final model.

Individual and household characteristics

Children's independent travel is associated with their age and gender, as well as the family's socio-economic status. Age is a critical factor; younger children are more likely to be escorted to school (Vovsha and Petersen 2005; Yarlagaadda and Srinivasan 2008), probably due to safety concerns. Older students have a stronger desire for, and a higher chance of being granted, the freedom to travel independently (Clifton 2003). The age effect can be prevalent across all transportation modes such as walking, cycling, driving and taking the bus (Yarlagaadda and Srinivasan 2008). Gender may also affect travel independence (Vovsha and Petersen 2005; Yarlagaadda and Srinivasan 2008). Parents are likely to be more concerned about the personal safety of their daughters. Thus, female students are less often allowed to travel independently (Zwerts et al. 2010).

Household characteristics also affect children's travel. Children with siblings are less likely to travel and conduct activities alone, including going to school. It is also likely that having more siblings will increase the children's active commuting because older siblings are trusted as a caregiver for younger ones, although this role is arguably less important for the middle class (McDonald 2008a). The number of private vehicles is likely to reduce the propensity of using alternative transportation modes (McMillan 2005), and vehicle ownership is associated with income. Both the income (Vovsha and Petersen 2005) and ethnicity (Yarlagaadda and Srinivasan 2008) categories are shown to affect escort-mode choices. In terms of mode choice decisions, higher income households have more travel resources, and are more likely to live further from work, increasing location constraints that would promote more private car escort trips. High-income groups (i.e., over \$75,000) are expected to chauffeur or drive alone more often, whereas low-income groups (i.e., below \$35,000) are more likely to walk or cycle or take the bus (He 2011).

Finally, ethnicity may play a role. A higher rate of active commuting among Hispanic students has been observed nationwide (McDonald 2008a). A recent Southern California study showed that Hispanics are more likely to take the bus, or to commute on foot, or to cycle to school (He 2011). We, therefore, expect school travel to differ across ethnic groups, with relatively less private vehicle use among non-white households.

Built environment

The most commonly used measure of urban form is population density. A number of empirical studies have shown the positive effects of residential density on children's active commuting (McDonald 2008a; He 2011). A higher population density is likely to be associated with more opportunities for activity and street mutual monitoring, thus creating more livable and safer neighbourhoods, which may facilitate children's independent travel. The relationship between density and children's active commuting, nonetheless, is still unclear. However, population density is just one dimension of the built environment. Active travel may be affected by factors such as street width, presence or absence of sidewalks, and opportunities for economic or social interaction. Our interest is not in testing the effects of the built environment, but in selecting variables that sufficiently control for these effects. We use land use designation as our proxy. Single-family land use indicates wealthier and safer neighbourhoods, which may facilitate walking and cycling, but which may have less transit access. Descriptive statistics for the explanatory variables are shown in Table 5.

Results

The coefficient estimation and marginal effects are reported in Tables 6 and 7, respectively. As the main variables in this research, the variables that measure the intra-household temporal synchronisation and spatial coordination have a significant impact on the escort-mode decisions. Furthermore, the results indicate the intra-household sharing of childcare responsibilities. For example, when the father has a flexible work schedule or his job location is closer to the child's school, or when the mother's workplace is farther away from the school or when driving to the school requires more deviation during the mother's commuting trip, then the child has a higher probability of being escorted by the father or both parents (EM1) as compared to being escorted by the mother (EM2).

With respect to temporal variables, parents exhibit time-wise synchronisation in their escort-mode choice decisions. Compared to the reference alternative (i.e., EM2: chauffeured by the mother), working hours and the option of flexible time both considerably affect the probability of a student's escort-mode choice: working longer hours reduces the parents' chauffeuring activities whereas working flexible hours makes chauffeuring trips more feasible. For the work duration variable, the mother's longer working hours increase the utility of all other alternatives (i.e., EM1, EM3–7) relative to the reference while the father's working hours increase significantly the utility of only one alternative (i.e., EM3); this reflects the findings from a multi-national study which showed that full-time employed mothers in the United States reduced their childcare time by more than 50 min per day compared to unemployed mothers, whereas the effect of the father's employment on childcare time was much less noticeable (Versantvoort 2010). For the flexitime variable,

when the mother works flexible hours, the student has a lower probability of being escorted by others (EM3) and is less likely to commute actively alone or with siblings (EM5); when the father works with this option, the student is more likely to be chauffeured by the father (EM1) and is less likely to be chauffeured by others (EM3). This finding suggests that the flexible hours programme facilitates parent–child joint trips.

The spatial dimension of the intra-household coordination is reflected through estimates of the distance and deviation variables. The distance from home to school, as previous studies have shown (McDonald 2008b; He 2011), considerably reduces the probability of walking or cycling trips over escort trips. The distance between school and the parent's work place also has statistically significant effects on the escort-mode choice decisions. The further away the parent works from the school, the less likely it is that they will drive their children to school. Moreover, when the distance between the mother's work place and the school increases, children are more likely to walk to school independently (EM5). These findings along the spatial axis suggest that the parent–child joint trip would be more likely if the child attends a school closer to the parent's workplace. Such a school location choice, which is made possible by the choice policy in California's education system that takes into account the parent's work location in a child's school transfer application, may facilitate the escort trip and childcare outside school hours but, at the same time, it may cause a longer travel distance for the child should he or she forgo the neighbourhood school. For the distance deviation variable, the coefficient estimate of the deviation from the mother's commuting trip is statistically significant across all alternatives, whereas the deviation from the father's seems not to be an important factor in escort-choice decisions. This implies that, if the mother escorts the child in a car, the chosen school is likely to be on her way to work whereas the father, though not sharing as much escorting responsibility as the mother, may be more willing to make a detour for the school trip.

Among the explanatory variables, demographic variables have strong effects. Age, in general, increases the utility of several alternatives relative to that of the base alternative. The marginal effect of this variable shows that older students have a higher probability of walking or cycling independently (EM5) and driving (EM6) compared to being chauffeured by the mother (EM2). This result reflects that, as the children get older, they gain more independence from their parents and can experience greater variety of modes to travel to school. As only individuals aged 16 or above can obtain a driving licence and legally drive in the United States, the age effect on students' driving is great. When it comes to gender, although previous findings have suggested that female students tend to be less likely to undertake journeys on foot or by bicycle than males (Black et al. 2001; He 2011; Sirard and Slater 2008; Timperio et al. 2004), this variable is statistically insignificant.

Regarding the household structure variables, the number of siblings increases non-motorised joint trips with parents and reduces independent trips; students with more siblings are less likely to be in escorted trips involving both parents or the father (EM1) and are more likely to walk or cycle to school with parents (EM4). Our result echoes findings from a previous study (McDonald 2008a), which shows that having siblings is associated with a higher likelihood of non-motorised travel for high school students.

Car availability is often considered to influence the mode choice (McMillan 2005; He 2011). The outcomes here show that the number of vehicles reduces active commuting regardless of whether the trips are undertaken with parents (EM4) or independently (EM5). Vehicle availability also contributes to a student's driving (EM6) because easy access to a car can considerably reduce the relative attractiveness of alternative modes.

Table 5 Descriptive statistics, by household structure

Continuous variable Discrete variable	All Households (N = 3151)		Two-parent households				Non dual-earner households (N = 1042)				Mother-headed households (N = 617)		Father-headed households (N = 172)	
	Mean Percent	Std	Dual-earner households (N = 1320)		Mean Percent	Std	Mean Percent	Std	Mean Percent	Std	Mean Percent	Std		
			Mean Percent	Std										
Demographics														
Age	10.7	3.6	10.9	3.6	10.3	3.6	10.8	3.6	11.2	3.5				
Female	46.7 %		45.6 %		47.2 %		48.2 %		45.9 %					
Household structure														
Number of siblings	1.4	1.1	1.3	1.0	1.7	1.2	1.4	1.3	1.1	1.1				
Car availability														
Total vehicles	2.0	1.0	2.3	.9	1.9	1.0	1.4	1.0	1.8	1.0				
Income category														
Low income (<35 k)	36.8 %		18.2 %		46.9 %		60.8 %		34.4 %					
Middle income (35 k–75 k)	35.6 %		42.0 %		30.5 %		27.9 %		44.0 %					
High income (> = 75 k)	27.6 %		39.8 %		22.7 %		11.3 %		21.7 %					
Ethnicity														
White/not Hispanic	45.4 %		55.5 %		40.0 %		32.0 %		42.4 %					
Hispanic	39.3 %		29.9 %		49.4 %		43.5 %		36.4 %					
African–American	6.9 %		4.8 %		3.5 %		17.5 %		12.1 %					
Asian/Pacific Islander	3.4 %		4.6 %		2.3 %		2.5 %		2.3 %					
Other	5.0 %		5.3 %		4.8 %		4.5 %		6.8 %					
Neighbourhood BE														
Population density	8159.3	8387.8	7214.0	7453.9	8364.9	9083.4	9995.2	9116.0	7582.2	6793.9				
Single-family residential	59.2 %		65.7 %		57.2 %		49.6 %		55.8 %					
Multi-family residential	11.8 %		9.6 %		11.5 %		15.9 %		15.7 %					

Table 5 continued

Continuous variable Discrete variable	All Households (N = 3151)		Two-parent households				Mother-headed households (N = 617)		Father-headed households (N = 172)	
	Mean Percent	Std	Dual-earner households (N = 1320)		Non dual-earner households (N = 1042)		Mean Percent	Std	Mean Percent	Std
			Mean Percent	Std	Mean Percent	Std				
Other land use	29.0 %		24.7 %		31.3 %		34.5 %		28.5 %	
Parents employment										
Father worked FT	89.8 %		96.2 %		83.1 %		–		81.1 %	
Father worked PT	3.7 %		3.8 %		3.3 %		–		5.5 %	
Father unemployed	6.5 %		0 %		13.6 %		–		13.5 %	
Father's working hours ^a	44.9	11.0	45.2	11.1	44.8	11.0	–		43.3	11.5
Father with flexitime ^b	40.5 %		41.9 %		47.0 %		–		35.1 %	
Mother worked FT	47.0 %		73.8 %		7.8 %		55.7 %		–	
Mother worked PT	14.7 %		26.2 %		2.2 %		10.5 %		–	
Mother unemployed	38.3 %		0 %		90.0 %		34.2 %		–	
Mother's working hours ^a	35.8	13.3	35.2	13.8	36.4	11.5	38.0	11.9	–	
Mother with flexitime ^b	36.2 %		36.4 %	63.6 %	33.0 %		36.3 %		–	
Distance (miles)										
Home–School	2.7	7.5	2.9	6.9	2.6	9.9	2.2	3.7	2.7	4.2
Home–Father's job	13.1	19.9	13.3	17.8	13.1	23.4	–	–	10.8	16.0
Home–Mother's job	7.8	10.5	7.7	9.8	9.5	14.4	8.0	11.4	–	–
School–Father's job	13.6	20.4	13.7	18.2	13.9	24.0	–	–	11.1	15.3
School–Mother's job	8.0	10.7	7.8	10.0	9.9	14.4	8.4	11.7	–	–
Father's deviation ^c	2.6	10.2	2.4	7.3	2.6	10.4	–	–	4.7	22.9

Table 5 continued

Continuous variable Discrete variable	All Households (N = 3151)		Two-parent households (N = 1320)				Non dual-earner households (N = 1042)		Mother-headed households (N = 617)		Father-headed households (N = 172)	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
	Percent		Percent		Percent		Percent		Percent		Percent	
Mother's deviation ^c	3.3	14.1	3.3	14.1	3.1	7.0	3.3	15.5	–	–	–	–

^a Working hours are available for employed father or mother only

^b Percentage of father or mother with flexitime is available for employed father or mother only

^c Observations with D_{HW} less than 0.02 miles are not included in this table because the mean would be otherwise upward biased due to a very small denominator

Table 6 Coefficient estimation for escort-mode choice of dual-earner households (Reference group: chauffeured by mother [EM2])

Mode choice	Passenger		Walk or cycle		Drive		Bus					
	Both or father (EM1)		Others (EM3)		Siblings or alone (EM5)		Any (EM6)		Any (EM7)			
	Coef.	Std err.	Coef.	Std err.	Coef.	Std err.	Coef.	Std err.	Coef.	Std err.		
Escort choice												
Constant	−1.528*	0.861	−5.145***	0.950	1.297	3.389	−4.025***	0.926	−50.134***	9.960	−5.068***	1.049
Demographics												
Age	0.014	0.035	0.137***	0.038	−0.120	0.105	0.169***	0.036	2.555***	0.518	0.169***	0.042
Female	0.075	0.226	0.224	0.243	0.062	0.517	−0.261	0.234	0.947	0.627	−0.137	0.274
Household structure												
Number of siblings	−0.324**	0.131	−0.066	0.132	0.705**	0.313	−0.014	0.126	−0.444	0.373	0.134	0.152
Car availability												
Total vehicles	−0.066	0.144	0.150	0.149	−1.395***	0.464	−0.270*	0.162	1.219***	0.368	−0.122	0.173
Income category												
Low income	0.001	0.408	.958**	0.407	0.026	0.906	0.848**	0.409	1.393	1.757	1.112**	0.468
Middle income	−0.150	0.254	−0.367	0.290	−0.128	0.832	0.484*	0.274	0.579	0.716	0.427	0.335
Ethnicity												
Hispanic	0.216	0.284	0.262	0.306	1.372**	0.658	−0.110	0.287	−0.460	0.879	0.396	0.330
Neighbourhood BE												
Population density	−0.008	0.019	−0.024	0.024	0.009	0.034	0.013	0.016	−0.072	0.079	−0.042*	0.024
Single-family residential	−0.065	0.288	0.208	0.326	−0.971	0.650	0.049	0.313	1.441	0.930	−0.779**	0.320
Multi-family residential	0.016	0.516	0.686	0.564	−0.596	0.975	1.026**	0.455	1.413	1.680	0.111	0.545
Parents employment												
Father's working hours	−0.001	0.010	0.023**	0.010	−0.014	0.024	−0.001	0.011	0.032	0.030	0.005	0.013
Father with flexitime	0.414*	0.236	−0.389	0.266	0.144	0.552	0.073	0.246	−0.576	0.745	−0.153	0.292
Mother's working hours	0.026***	0.009	0.021**	0.010	0.043***	0.014	0.047***	0.009	0.055**	0.026	0.044***	0.009
Mother with flexitime	0.058	0.236	−0.553**	0.276	0.669	0.590	−0.437*	0.254	−0.205	0.681	0.386	0.287

Table 6 continued

Mode choice	Passenger			Walk or cycle			Drive			Bus		
	Both or father (EM1)			Others (EM3)			Parents (EM4)			Siblings or alone (EM5)		
	Coef.	Std err.		Coef.	Std err.		Coef.	Std err.		Coef.	Std err.	
Escort choice												
	Coef.	Std err.		Coef.	Std err.		Coef.	Std err.		Coef.	Std err.	
Distance												
Home–School	−0.096**	0.043		−0.024	0.027		−1.468**	0.676		−0.231***	0.071	
School–Father’s job	−0.021**	0.010		0.008	0.006		0.018**	0.009		−0.020**	0.010	
School–Mother’s job	0.040***	0.013		0.041***	0.013		0.014	0.038		0.053***	0.014	
Father’s deviation	−0.030	0.033		−0.001	0.031		−1.876	2.230		−0.033	0.042	
Mother’s deviation	0.102***	0.033		0.059*	0.035		0.187***	0.059		0.094***	0.034	
Summary statistics												
N = 799												
Log likelihood												
Null model	−1345.7037									Pseudo R ²	0.2083	
Full model	−1065.4577									LR χ^2	560.49	
										p	0.0000	

*** Significance at the 1 % level, ** Significance at the 5 % level, and * Significance at the 10 % level

Table 7 Marginal effects for escort-mode choice of dual-earner households

Mode choice	Passenger			Walk or cycle			Drive			Bus		
	Both or father (EM1)			Others (EM3)			Siblings or alone (EM5)			Any (EM6)		
	ME	Std Err.		ME	Std Err.		ME	Std Err.		ME	Std Err.	
Escort choice												
Age	-0.013***	0.003		-0.033***	0.004		-0.005**	0.002		0.041***	0.005	
Female	0.011	0.025		-0.002	0.032		0.002	0.011		0.016	0.010	
Household structure												
Number of siblings	-0.040***	0.014		0.015	0.018		0.016**	0.006		-0.007	0.006	
Car availability												
Total vehicles	-0.001	0.015		0.020	0.021		-0.028***	0.010		0.021***	0.005	
Income category												
Low income	-0.056	0.044		-0.131**	0.058		-0.009	0.019		0.014	0.029	
Middle income	-0.030	0.028		-0.015	0.037		-0.005	0.017		0.009	0.012	
Ethnicity												
Hispanic	0.015	0.031		-0.041	0.040		0.027**	0.014		-0.010	0.014	
Neighbourhood BE												
Population density	-0.000	0.002		0.003	0.003		0.000	0.001		-0.001	0.001	
Single-family residential	-0.002	0.031		0.018	0.042		-0.019	0.013		0.025*	0.015	
Multi-family residential	-0.038	0.056		-0.090	0.072		-0.020	0.020		0.017	0.028	
Parents employment												
Father's working hours	-0.001	0.001		-0.001	0.002		-0.000	0.000		0.000	0.000	

Table 7 continued

Mode choice	Passenger			Walk or cycle			Drive											
	Both or father (EM1)			Others (EM3)			Parents (EM4)			Siblings or alone (EM5)			Any (EM6)			Any (EM7)		
	ME	Std Err.		ME	Std Err.		ME	Std Err.		ME	Std Err.		ME	Std Err.		ME	Std Err.	
Escort choice																		
	0.058**	0.026	−0.004	0.034	0.025	−0.045*	0.003	0.011	0.010	0.026	−0.009	0.012	−0.013	0.022				
Father with flexitime																		
Mother's working hours	0.001	0.001	−0.007***	0.001	0.001	−0.000	0.000*	0.000	0.003***	0.001	0.001	0.000	0.002***	0.001				
Mother with flexitime	0.020	0.026	0.027	0.035	0.026	−0.055**	0.016	0.012	−0.051*	0.027	−0.001	0.011	0.043**	0.021				
Distance																		
Home-School	−0.001	0.005	0.031***	0.008	0.003	0.008**	−0.030**	0.014	−0.017**	0.009	−0.003	0.003	0.012***	0.003				
School-Father's job	−0.002**	0.001	0.002*	0.001	0.001**	0.001***	0.001***	0.000	−0.002*	0.001	0.000*	0.000	0.000	0.001				
School-Mother's job	0.003*	0.001	−0.008***	0.002	0.001	0.002*	−0.000	0.001	0.004***	0.001	0.000	0.001	−0.001	0.001				
Father's deviation	0.004	0.008	0.020	0.019	0.006	0.007	−0.040	0.047	0.007	0.012	−0.004	0.009	0.005	0.006				
Mother's deviation	0.007***	0.003	−0.018***	0.006	0.003	0.000	0.003**	0.001	0.005*	0.003	0.002***	0.001	0.001	0.002				

ME marginal effects

*** Significance at the 1 % level, ** Significance at the 5 % level, and * Significance at the 10 % level

Income is also an important determinant in several alternative transportation mode choices. Students from low-income households have a greater tendency to take the bus (EM7) compared to being chauffeured by the mother (EM2). Students from middle-income households have fewer vehicle trips escorted by others and they have more independently active commuting trips (EM5). The effect of ethnicity is found to be statistically significant only in one alternative: Hispanic children have a higher probability of commuting actively accompanied by their parents (EM4).

The last explanatory variables are the neighbourhood built environment variables. Population density is shown to have a positive effect on a student's independent active commuting (EM5) and a negative effect on a student's busing (EM7), although the effects are only marginally statistically significant. A higher density is likely to be associated with shorter trip distances and, hence, a higher probability of walking or cycling independently and a lower likelihood of taking the bus. As for the land use variables, children living in neighbourhoods of single-family residential land use are less likely to take the bus (EM7) while those from neighbourhoods of multi-family residential land use are more likely to walk or cycle alone or with their siblings (EM5).

Discussion

Compared to the studies of adults' activity-travel patterns, "the activity-travel field is in its infancy in its understanding of children-adult activity-travel and decision-making interactions" (Paleti et al. 2011, p. 277). That said, more empirical research is needed for a better understanding of the parents–children joint trip. School trips of K-12 students, perhaps, are the most representative joint trips between parents and children since they are mandatory trips, during the majority of which the children are escorted by their parent(s). The research on joint-trip decisions accounting for temporal and spatial coordination is especially needed because women's increasing participation in the work force may cause scheduling constraints for escorted trips and, consequently, lead to changes in children's travel modes.

This paper reveals the strong effect of parental, especially women's, work arrangements and location on children's travel behaviour patterns. The results show that the parents' longer working hours increase the likelihood of alternative modes, such as active commuting and busing, being used. It also implies that the effect of working hours on the escort-mode choice may be offset by the option of flexible working hours, which reduces the probability that a child is escorted by others or independently walks or cycles. In addition, the closer the mother's workplace is to the school, the more likely it is that the mother will chauffeur her children to school. As this distance increases, the child is more likely to be escorted by the father or others, and is more likely to commute on foot or by bicycle independently. Lastly, deviation to the school from the mother's commuting trip can statistically significantly influence several escort-mode choices as well. The greater the deviation is, the lower the probability of the child being chauffeured by the mother.

This study has two main implications. Firstly, women's increasing participation in the labour market has created a new challenge for parents' childcare options and children's travel. Since most escorting trips are carried out by the mother, the distance between the mother's workplace and the school has a greater influence on the escort decision than the father's. To make the parental escorting trip possible and childcare before/after school hours more manageable, a short distance between the parents' workplace and the school,

and a shorter deviation from the parent's commuting trip are important. A short distance from home to school would facilitate non-motorised travel modes. Yet when the parent chooses a school closer to his or her workplace instead of the neighbourhood school, the child's travel distance is likely to increase substantially and the child is more likely to be escorted by car. On the other hand, when the child attends the neighbourhood school, the mother's long working hours and remote workplace away from home would lead to a more independent active commute for the child (EM5). Moreover, the scenario would also be very different if the mother were a (full-time) housewife. If all other school characteristics remain the same, the housewife who stays at home may prefer the child to attend the neighbourhood school because the home is likely to be her preferred geographic anchor for the school (Bell 2007).

Secondly, the results of this research are also useful in understanding the working mother's dual responsibilities. Traditionally, mothers undertake more childcare responsibilities and more chauffeuring trips than men. Nowadays, working mothers devote more time to their career. Their longer working hours and the increased distance to their work place from home and/or school would inevitably change the child's means of travel to school. This dual role in the labour market and in the family may cause considerable amounts of stress for working mothers (Staines and Pleck 1983); this is largely because childcare and the chauffeuring responsibility in a household still primarily rest on the mother's shoulders (Schwanen 2007; Barker 2011; Waygood 2009). From within the household, the father's childcare involvement over the years is increasing (Sayer et al. 2004; Peterson and Gerson 1992), and the help from the spouse for childcare has been a robust predictor of the mother's psychological well-being and distress (Ozer 1995). From society's perspective, certain labour policies and programmes have been created to address this issue. For example, in Nordic countries, family-friendly government policies grant mothers paid maternity and parental leave, child allowances, and part-time work (Scarr 1998). These types of labour policy may have their own disadvantages because they may cause the women's loss of experience and discontinuity in the labour force (Cherlin 1992), but in the long run women's labour market participation may significantly increase (Spiess and Wrohlich 2008). In the Netherlands, even in dual income families, women are typically employed as part-time workers to maintain a balance of labour force participation and care-work in the family (Schwanen 2007). In comparison, there are more working women in the United States. The continuous work experience in most cases is a condition of "career advancement, higher incomes, retirement benefits, and other markers of gender equality" (Scarr 1998, p. 100). More importantly, women's labour force participation can lead to "higher family income, greater personal satisfaction, and more social support" (Scarr 1998, p. 100). Conflict and stress can arise when women need to carry dual responsibility. Due to gender-role constraints, women are often given pre-assigned care-work (e.g., parenting) in the family regardless of their employment status (Schwanen et al. 2007). To address this issue, government and private employers can create more family-friendly policies and programmes to improve the family-work balance and help to reduce the workers' stress induced by fixed working hours and job locations. Since the option of flexible time and the proximity of the mother's workplace to the school increase the likelihood of mother-children joint school trips, programmes (e.g., flexitime, school choice policy) that can relax the mother's temporal and spatial constraints may improve the mother's childcare options.

Conclusion

Using the RHTS data of 2001, we examine the escort-mode choice of K-12 students' school trips in the Los Angeles region. We demonstrate that parental work arrangements and locations can affect the child's escort-mode choices. Parents, especially mothers, who work longer hours and further away from home, or when the school is not on the way to work, are less likely to chauffeur their children. These trips have been substituted by alternative escort choices such as being escorted by others, or alternative mode choices such as active commuting and busing. Moreover, the estimates of the spatial coordination variables suggest that, when the parents would like to escort their child to school, the child may attend a school closer to his or her parent's workplace in order to facilitate the joint-trip realisation.

This research contributes to school transportation literature by illustrating the effects of the parents' employment schedule and workplace location on the children's travel. School trips accompanied by the mother (or the father) do not necessarily lead to a better, active commuting outcome: rather, these trips are likely to be motorised trips. This change stems from the changing societal roles of women, leading to fewer full-time mothers who would devote their time to walking or cycling to school with their children. Therefore, the children's journeys to school are frequently embedded in commuting trips, which are likely to be undertaken by car. In future, longitudinal studies need to be conducted to obtain greater insight into the changes in the relationship between parents' employment, childcare responsibilities and children's journeys to school over the years.

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