Transportation (2014) 41:543–565
DOI 10.1007/s11116-013-9500-7

Impacts of parental gender and attitudes on children's school travel mode and parental chauffeuring behavior: results for California based on the 2009 National Household Travel Survey

Hsin-Ping Hsu · Jean-Daniel Saphores

Published online: 15 October 2013

Abstract Research has shown that parental attitudes are a significant predictor of children's active commuting (walking or biking) to school. However, the impact of parental gender on parental attitudes, and the link between parental attitudes and the gender gap in parental chauffeuring behavior have not received much attention. This paper examines these questions by applying discrete choice models to California data from the 2009 National Household Travel Survey while controlling for a wide range of variables characterizing parents, their children, households, schools, and the local built environment. Our results, conveyed via odds ratios, show that mothers are more likely to have higher concerns about traffic volume, which in turn reduces the likelihood that their children will walk or bike to school. Moreover, even though parental attitudes significantly influence parental chauffeuring behavior, their ability to explain the gender chauffeuring gap is limited. When holding equal concerns, mothers are still more likely than fathers to chauffeur their children to school. Finally, while distance to school and several land use measures (e.g., population density, urbanization level, and percentage of renters) are statistically significant, the impact of an objective measure of walkability is quite small. These results suggest that interventions targeting an increase in children's walking and biking to school should focus on the concerns of mothers, especially as they relate to traffic characteristics.

Electronic supplementary material The online version of this article (doi:10.1007/s11116-013-9500-7) contains supplementary material, which is available to authorized users.

H.-P. Hsu · J.-D. Saphores
Department of Planning, Policy, and Design, University of California, Irvine, CA 92697, USA
e-mail: hphsu@uci.edu

J.-D. Saphores (✉)
Department of Civil and Environmental Engineering, University of California, Irvine, CA 92697, USA
e-mail: saphores@uci.edu

J.-D. Saphores
Department of Economics, University of California, Irvine, CA 92697, USA

Keywords Gender · Attitudes · Children's school travel mode · Parental chauffeuring behavior · 2009 NHTS · Odds ratio

Introduction

Ever since active commuting (walking or biking) to school was proposed as a policy intervention to reduce childhood obesity in the U.S., it has attracted much research attention. Studies have reported that parental attitudes as well as characteristics of children, households, schools, and the local built environment can be significant predictors of children's school travel mode (e.g., Larsen et al. 2009; Leslie et al. 2010; Napier et al. 2011). However, relatively little is known about how parental attitudes are formed, and to our knowledge no research has explicitly discussed the effects of parental gender on parental attitudes toward children's active commuting to school. Since a number of studies indicate that women usually exhibit greater concerns about traffic and street safety for themselves (e.g., Loukaitou-Sideris 2005; Yavuz and Welch 2010), we hypothesize that mothers often have greater concerns about letting their children walk or bike to school, which in turn affects their children's school travel mode.

In addition, children's school travel mode and parental escort behavior are usually jointly decided. Some studies show that mothers usually take more household responsibilities to chauffeur or escort their children even after controlling for work status and commuting patterns (Vovsha and Petersen, 2005; Liu et al. 2012), which has been attributed by some researchers to women's traditional gender roles in the division of household labor (e.g., Schwanen 2007; Giuliano and Schweitzer 2010). However, to our knowledge, gender differences regarding concerns about children's active commuting to school have not yet been analyzed quantitatively to explain the within-household chauffeuring or escorting gap.

Unlike previous research that focuses on the gender of children to explain how children travel to and from school (e.g., McMillan et al. 2006; Leslie et al. 2010; Clifton et al. 2011; McDonald 2012), we investigate specifically how the gender of parents affects parental attitudes (related to distance to school, traffic characteristics, and crime), children's school travel mode, and parental chauffeuring behavior after controlling for land use as well as household, children, and school characteristics; Fig. 1 depicts the relationships we examined and how our study contributes to the literature.

Understanding how gender interacts with attitudes is essential to craft more effective policies to promote walking and biking to school by children. We focus on California because it is the largest state by population, it is an add-on state for the 2009 National Household Travel Survey (NHTS), and its built environment, ethnic composition, and social make-up are quite diverse, which also allows us to examine the impacts of these characteristics on parental attitudes, children's school travel mode, and parental chauffeuring behavior.

Literature review

Given the extensive literature reviews by Davison et al. (2008) and Sirard and Slater (2008), we focus mainly on studies published after 2007 (see Table 1 for a summary).

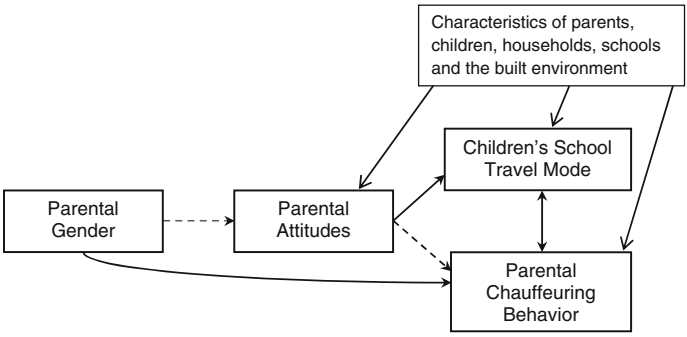

Fig. 1 Conceptual relationships explored in this paper, a *solid link* indicates that it has been explored in the literature; a *dashed link* indicates that it has not yet been explored in the literature and that it is investigated in this paper.

Trends and predictors of children's school travel mode

A number of studies show a decrease in children's active commuting to school over time (McDonald 2007a; Buliung et al. 2009; Grize et al. 2010), with the sharpest decline occurring in the U.S. (McDonald et al. 2011). There is also consistent evidence that girls walk or bike to school less than boys (Yeung et al. 2008; Larsen et al. 2009), but the difference in biking is more prominent (Leslie et al. 2010; McDonald 2012). Moreover, more children travel by active modes from school to home than from home to school (Leslie et al. 2010; McDonald 2012).

Parental attitudes play an important role in children's active commuting to school. Most studies indicate that when parents perceive fewer barriers or more potential benefits, their children are more likely to walk or bike to school (e.g., Hume et al. 2009; McDonald et al. 2011). Kerr et al. (2006) report that parental concerns are the strongest predictor of children's active commuting to school, but school distance was not included in their model.

In addition, parental socio-demographic characteristics such as education level, work status, and commuting patterns have been found to be associated with their children's travel mode to school (McDonald 2008a; Zhu and Lee 2009; Panter et al. 2010).

The effects of parental participation in active or transit transportation have been examined only in a few studies, and the evidence is mixed. From McMillan et al. (2006), the time parents spend on walking can reduce the gender gap in children's active commuting to school, but Babey et al. (2009) disagree. According to Zhu and Lee (2009), regular walking by parents positively correlates with children's walking to school, but their study relies on indirect measures of walking. Moreover, Martin et al. (2007) found that children are more likely to actively commute to school when their parents are physically active.

Several household characteristics also affect children's school travel mode. In general, African-American and Hispanic students, students from low-income families, and students whose households have no access to a car are more likely to walk or bike to school, while White and Asian students, students from high-income families, and students whose households own more cars are more likely to be driven to school (McDonald 2008b; Yarlagadda and Srinivasan 2008; Babey et al. 2009; Rodríguez and Vogt 2009; Zhu and Lee 2009; Clifton et al. 2011).

Table 1 Summary of relevant papers published between June 2007 and March 2012

Reference	Research focus/dependent variable	Study area/data source	Method	Sample size	Key findings or predictors
Liu et al. (2012)	Parental pick-up behavior	Chicago, IL	BLM	183 parents of children under 18	Parental gender and work status; household income; car availability; distance
McDonald (2012)	Children's school travel mode	1977–2009 NHTS	MNL	211–3,967 children aged 5–14	Decrease in active commuting; children's gender
Seraj et al. (2012)	Parental attitudes	2009 NHTS for Southern California	MOR	1,000 parents of children aged 5–15	School distance; parental work patterns and socio-demographics
Clifton et al. (2011)	Children's school travel mode	Baltimore, MD	MNL	257 children aged 14–18	Children's age and gender; knowledge of the city; land use
He (2011)	Children's school travel mode	2001 SCAG RHTS for Los Angeles region	MNL	2,967 school trips of children 5–18	Children's age; school distance and location
McDonald et al. (2011)	Children's active commuting to school	2009 NHTS, compared with 1969–2001	BLM	4,508 children aged 5–14	Decrease in active commuting; children's age and gender; parental attitudes; school distance
Napier et al. (2011)	Children's walking to school	Utah	GEE	177 parents 193 children (5th grade)	Parents' and children's attitudes; school distance; community walkability
Yoon et al. (2011)	Parental escort behavior	2001 SCAG RHTS	BLM	3,483 children under 16	Accessibility; population density
Grize et al. (2010)	Children's active commuting to school	1994–2005 SMTB, Switzerland	WLM	4,244 children aged 6–14	Decrease in active commuting; school distance; urbanization level
Leslie et al. (2010)	Children's active commuting to school	Australia	BLM	2,782 children aged 10–14	Children' gender and attitudes; community disorder
Mitra et al. (2010)	Children's walking to school	2001 TTS for Toronto, Canada	BLM	2,729 children aged 11–13	School distance; local built environment
Panter et al. (2010)	Children's school travel mode	SPEEDY Study for Norfolk, UK	MSM	2,012 children aged 9–10	Parental attitudes and work patterns; social support; school distance; community walkability

Table 1 continued

Reference	Research focus/dependent variable	Study area/data source	Method	Sample size	Key findings or predictors
Babey et al. (2009)	Children's active commuting to school	2005 CHIS, CA	BLM	3,451 children aged 12–17	Children's gender and ethnicity; household income; school distance and type; urbanization level
Buliung et al. (2009)	Children's school travel mode	1986–2006 TTS for Toronto, Canada	Statistical tests	11,736–35,300 school trips of children aged 11–15	Decrease in active commuting; children's age; urbanization level
Hume et al. (2009)	Children's active commuting to school	Melbourne, Australia	BLM	309 children aged 9–15	Children's age; parental attitudes; local built environment
Larsen et al. (2009)	Children's active commuting to school	London, Canada	BLM	614 children aged 11–13	Children's gender; school distance; local built environment
McDonald and Aalborg (2009)	Parental escort behavior	San Francisco, CA	Open-ended Interviews	403 parents of children aged 10–14	Parental convenience and safety concerns
Rodríguez and Vogt (2009)	Children's walking to school	Michigan SRTS Student Survey	BLM	1,897 children aged 7–13	Children's age and attitudes; car availability; school distance; school bus availability
Zhu and Lee (2009)	Children's walking to school	Austin, TX	BLM	2,695 parents of elementary school students	Parents' and children's attitudes; parental education level; car and school bus availability
McDonald (2008a)	Children's active commuting to school	2001 NHTS	BLM	4,059 children aged 5–18	Parental work patterns; children's age
McDonald (2008b)	Children's active commuting to school	2001 NHTS	BLM	14,553 children aged 5–18	Parental ethnicity; household income
McDonald (2008c)	Children's school travel mode	2001 NHTS	MNL	6,508 children aged 5–13	School distance and location
Nelson et al. (2008)	Children's active commuting to school	Take PART Study, Ireland	BLM	4,013 children aged 15–17	Children's gender; school distance; population density
Yarlagadda and Srinivasan (2008)	Children's school travel mode and parental escort behavior	2000 San Francisco BATS	MNL	4,352 children under 18	Parental work patterns; children's age, gender, ethnicity; school distance

Table 1 continued

Reference	Research focus/dependent variable	Study area/data source	Method	Sample size	Key findings or predictors
Yeung et al. (2008)	Children's active commuting to school	Queensland, Australia	BLM	324 parents of children aged 4–12	Children's age and gender; school distance
McDonald (2007b)	Children's walking to school	2000 BATS for Alameda County, CA	BLM	612 children aged 5–18	School distance; neighborhood cohesion
Schwanen (2007)	Parental escort behavior	Utrecht, Netherlands	Multivariate regression	475 dual-earner households with children under 9	Parental gender and work patterns; children's age; residential location

BLM binary logit model, *MNL* multinomial logit model, *MOR* multivariate ordered response model, *GEE* generalized estimating equation, *WLM* weighted logit model, *MSM* multilevel statistical model

In addition to gender, children's age is closely related to their school travel mode. While most studies report that older children are more likely to walk or bike to school (e.g., Yeung et al. 2008; Rodríguez and Vogt 2009; He 2011; McDonald et al. 2011), McMillan et al. (2006) found an inverse connection. A few studies also investigated the relationship between children's attitudes and their active commuting to school (Martin et al. 2007; Rodríguez and Vogt 2009; Leslie et al. 2010; Napier et al. 2011). Similar to parental attitudes, children are more likely to walk or bike to school when they believe the built environment is safer and more attractive.

Of various school characteristics, distance between home and school has consistently been found to be the most significant factor of children's active commuting to school (Yeung et al. 2008; Mitra et al. 2010). Moreover, children who attend public school are more likely to walk or bike to school (Babey et al. 2009), but the provision of school bus service has the opposite effect (Zhu and Lee 2009). However, while Braza et al. (2004) find that students are more likely to actively commute to school in smaller schools, Ewing et al. (2004) do not. Also, school quality seems to have no influence on children's active transportation to school (He 2011).

A wide range of land use characteristics has been examined to explain children's school travel mode. Some researchers compare areas with different levels of urbanization (Babey et al. 2009; Grize et al. 2010), communities with different levels of walkability (Panter et al. 2010; Napier et al. 2011), local land use attributes such as density and diversity (McMillan 2007; Larsen et al. 2009; Mitra et al. 2010; Clifton et al. 2011), or the presence of various neighborhood facilities and amenities (Leslie et al. 2010). Overall, the built environment has been found to have significant but small to moderate effects on children's active commuting to school. Although school distance could be seen as a built environment attribute, we categorize it as a school characteristic because households in the same neighborhood may send their children to different schools (e.g., private schools or some magnet schools).

Factors influencing parental attitudes and escort behavior

Although parental attitudes are a significant predictor of children's school travel mode, only a few papers discuss how parental attitudes are shaped. Lam (2001, 2005) find that fathers, parents of older children, and parents who work full-time, who have experienced injuries, or who speak Chinese or Arabic (used as a proxy for culture) tend to perceive roads as less dangerous for their children. School location matters: the closer the school is, the less likely the parents are to be concerned about children's active commuting to school (Seraj et al. 2012). The built environment also influences parental attitudes: living in neighborhoods with less traffic and a higher walkability can reduce parental concerns (Lam 2001; Kerr et al. 2006; Napier et al. 2011). Parents also express concerns about gangs and fights when their children travel to and from school in neighborhoods with high crime and violence rates (Meyer and Avi Astor 2002). Moreover, mothers who have a higher fear of crime and a lower sense of community are more likely to be concerned about the outdoor safety for their children (Prezza et al. 2005), which suggests that parents extend their own concerns to their children.

Studies of parental escort behavior consistently report that mothers are more likely than fathers to perform chauffeuring or escort duties (e.g., Schwanen 2007; Liu et al. 2012), and women's traditional gender roles in the division of household labor is the most common explanation. Work status and commuting patterns also significantly affect parental escort behavior: parents who do not work or who work part-time, and parents who enjoy more

flexibility at work and whose workplace is closer to home are more likely to chauffeur or escort their children (e.g., Yarlagadda and Srinivasan 2008; Liu et al. 2012). Moreover, land use characteristics such as accessibility, population density, and residential location are related to parental chauffeuring or escorting (e.g., Schwanen 2007; Yoon et al. 2011).

However, while children's school travel mode and parental escort behavior are believed to be jointly decided, we found only one paper (Yarlagadda and Srinivasan 2008) that examines them jointly, and no statistical study that explores if parental attitudes explain gender differences in escorting children to school (McDonald and Aalborg (2009) relied on open-ended interviews to explore why parents drive their children to school). These limitations motivate our work.

Data

NHTS data

The 2009 NHTS provides a unique opportunity to analyze the relationship between parental gender, parental attitudes, children's school travel mode, and parental escort behavior. In the California add-on sample, which we analyze in this paper, one parent per household was asked to answer a series of questions regarding safe routes to school for one of their randomly selected children aged 5–15 years. In addition to children's usual travel mode to and from school, these questions probe parental attitudes about distance to school, traffic characteristics (volume and speed), crime, and the weather, as these attitudes may motivate parents to allow their children to walk or bike to and from school. We do not analyze parental concerns about the weather since it is usually not a restrictor in California.

Of the 2,857 respondents who answered these questions, 1,642 live within 2 miles from school. We focus on these households since active commuting to school does not seem a reasonable option for children living more than 2 miles away from school (according to Nelson et al. (2008), 2.5 miles is a barrier beyond which children are unlikely to walk or bike to school). 729 respondents who live within 2 miles from school also completed a travel diary for their children, thus providing information about children's school travel mode and whether or not the parents surveyed accompanied their children to school on their survey day. A child's earliest trip from home to school as a student on his/her survey day was counted as a trip to school when data were extracted from the travel diary. Detailed socio-demographics and some land use characteristics are also available in the 2009 NHTS dataset.

From travel diary data, 464 of 729 children were driven to school on their survey day, 229 walked or biked, and 36 used transit. Moreover, 57 % of children who went to school by car on their survey day were chauffeured by their parent who was surveyed; only 4 % of children who walked or biked to school were escorted by their parent who was surveyed, and no child who used transit to school was accompanied by their parent who was surveyed. These numbers show a very low parental escort rate for non-automobile trips. Although children who were not escorted by their parent surveyed might have been accompanied to school by other household members, friends, or neighbors, we focus on school chauffeuring out of concern for the robustness of our results.

For brevity, Table 2 only lists the definition of explanatory variables considered in our models; descriptive statistics for all dependent and explanatory variables are available in the electronic supplementary material. Of the four issues related to children's walking and biking to school, parents are more worried about traffic characteristics (volume and speed),

Table 2 Explanatory variables considered in models

Variable	Meaning
Parental socio-demographic characteristics	
pa_female	Gender of surveyed parent is female
pa_1829	Age of surveyed parent: 18–29
pa_3044	Age of surveyed parent: 30–44
pa_4559	Age of surveyed parent: 45–59
pa_60pl	Age of surveyed parent: ≥60
pa_ethwh	Surveyed parent is White
pa_ethaf	Surveyed parent is African-American
pa_ethas	Surveyed parent is Asian
pa_ethhi	Surveyed parent is Hispanic
pa_ethot	Surveyed parent's ethnicity: other
pa_usborn	Parent was born in the U.S.
pa_englang	Survey was conducted in English
pa_edulh	Parental education: <high school
pa_eduhi	Parental education: high school
pa_edusc	Parental education: some college
pa_eduba	Parental education: bachelor degree
pa_edugr	Parental education: graduate degree
pa_ftworker	Parental work status: full-time
pa_ptworker	Parental work status: part-time
pa_unemply	Parental work status: unemployed
pa_fixedtime	Parental work start time is fixed
pa_distowk[a]	One-way distance to work (mi)
Parental attitudes	
schdist1	Distance: low concern
schdist2	Distance: medium concern
schdist3	Distance: high concern
schtraf1	Traffic volume: low concern
schtraf2	Traffic volume: medium concern
schtraf3	Traffic volume: high concern
schspd1	Traffic speed: low concern
schspd2	Traffic speed: medium concern
schspd3	Traffic speed: high concern
schcrim1	Crime: low concern
schcrim2	Crime: medium concern
schcrim3	Crime: high concern
Child characteristics	
girl	Gender of child is girl
age0510	Age of child: 5–10 years
age1115	Age of child: 11–15 years
bfschcare	Child attends before school care
afschcare	Child attends after school care
School characteristics	
pubsch	Child attends public school

Table 2 continued

Variable	Meaning
disttosc1	Distance to school: <1/4 mi
disttosc2	Distance to school: 1/4–1/2 mi
disttosc3	Distance to school: 1/2–1 mi
disttosc4	Distance to school: 1–2 mi
Household characteristics	
nchild[a]	Number of children in the household
chiratio	Children > adults in the household
vehratio	Vehicles ≥ drivers in the household
sigadlt	Single-adult household
twoadlt	Two-adult household
thradlt	Three-or-more-adult household
hhinclt10	Household annual income <10 k
hhinc1030	Household annual income 10–30 k
hhinc3050	Household annual income 30–50 k
hhinc5070	Household annual income 50–70 k
hhinc70100	Household annual income 70–100 k
hhincmt100	Household annual income >100 k
Parental level of active/transit transportation	
pa_wlktr0	Walk trips last week: 0
pa_wlktr1	Walk trips last week: 1–7
pa_wlktr2	Walk trips last week: >7
pa_biktr0	Bike trips last week: 0
pa_biktr1	Bike trips last week: 1–2
pa_biktr2	Bike trips last week: >2
pa_wkbktr0	Walk or bike trips last week: 0
pa_wkbktr1	Walk or bike trips last week: 1–8
pa_wkbktr2	Walk or bike trips last week: >8
pa_pubtr0	Transit trips last month: 0
pa_pubtr1	Transit trips last month: 1–4
pa_pubtr2	Transit trips last month: >4
Land use characteristics	
ubsize1	Urban size: 50–200 k
ubsize2	Urban size: 200–500 k
ubsize3	Urban size: 500 k to 1 m
ubsize4	Urban size: >1 m w/o subway/rail
ubsize5	Urban size: >1 m with subway/rail
nonurban	Not in an urbanized area
popdn1[b]	Pop. density/mi^2: 0–500
popdn2[b]	Pop. density/mi^2: 500–2,000
popdn3[b]	Pop. density/mi^2: 2,000–10,000
popdn4[b]	Pop. density/mi^2: >10,000
resdn1[b]	Housing density/mi^2: 0–500

Table 2 continued

Variable	Meaning
resdn2[b]	Housing density/mi^2: 500–10,000
resdn3[b]	Housing density/mi^2: >10,000
renter1[b]	Renter-occupied housing: 0–15 %
renter2[b]	Renter-occupied housing: 15–35 %
renter3[b]	Renter-occupied housing: 35–55 %
renter4[b]	Renter-occupied housing: 55–75 %
renter5[b]	Renter-occupied housing: 75–100 %
walkscore[a]	Home location walkscore (0–100)

See Table S1 in the Electronic Supplementary Material for summary statistics

mi mile, *mi*^{2} square mile, *k* 1,000, *m* million

[a] Continuous or count variable; all others are binary variables

[b] Measured at the census block group level

while distance to school and crime are less of a concern. Most children travel to school by car, 32 % by active mode, and 5 % by public transit (including school bus). The situation is similar for returning home from school, although fewer children are driven home. On their survey day, 58 % of children who went to school by car were chauffeured by their parent who was surveyed.

In our dataset, most households include two adults, live in urban areas, have a higher income, and own two or more cars. Moreover, 62 % of the respondents who completed the safe routes to school questions for their children are female, which may suggest that mothers are the main caregivers for their children.

Walk score data

In addition to NHTS data, we collected walk scores from walkscore.com for each respondent's home location after obtaining home location information from Caltrans. The walk score of a residence, which ranges from 0 to 100 (where higher values denote higher walkability), is based on distance to amenities (such as stores, restaurants, schools, and parks) and the design of surrounding streets (such as length of street blocks and density of street intersections). For more details, see www2.walkscore.com/pdf/WalkScoreMethodology.pdf. The walk scores of home locations in our sample, shown in the electronic supplementary material, suggest that we cover communities with a wide range of walkability levels.

Methodology

In the following, $\mathbf{X}_i$ is a 1 × k vector of explanatory variables for child "*i*". Before finalizing our results, we performed the relevant specification tests recommended in Long and Freese (2006), including checks that multicollinearity is not a problem here.

Binary logit model

To explore the factors associated with parental chauffeuring behavior, we relied on a binary logit model. Our dependent variable, which is denoted by *y*, equals 1 if child *i* was chauffeured to school by his/her parent who was surveyed, and 0 otherwise. The probability that child "*i*" was chauffeured to school by the parent surveyed is then given by (Greene 2008):

$$\Pr(y_i = 1|\mathbf{X}_i) = \frac{\exp(\beta_0 + \mathbf{X_i}\boldsymbol{\beta})}{1 + \exp(\beta_0 + \mathbf{X_i}\boldsymbol{\beta})}, \tag{1}$$

where $\boldsymbol{\beta}$ is a k × 1 vector of unknown parameters. The odds of observing $y_i = 1$ versus $y_i = 0$ are

$$\Omega(\mathbf{X_i}) = \frac{\Pr(y_i = 1|\mathbf{X_i})}{\Pr(y_i = 0|\mathbf{X_i})} = \exp(\beta_0 + \mathbf{X_i}\boldsymbol{\beta}). \tag{2}$$

If we denote by $\Omega(\mathbf{X_i}, \mathrm{x}_j + \delta)$ the odds obtained by adding $\delta > 0$ to explanatory variable x_j (j ∈ {1,…,k}) in (2), the odds ratio for variable $\mathrm{x_j}$ is given by

$$\frac{\Omega(\mathbf{X_i}, x_j + \delta)}{\Omega(\mathbf{X_i})} = \exp(\delta\beta_j). \tag{3}$$

Hence, increasing x_j raises the likelihood that a student will be chauffeured by a parent if and only if $\exp(\delta\beta_j) > 1$, which holds provided $\beta_j > 0$; we thus report odds ratios (OR) $\exp(\beta_j)$, $1 \le \mathrm{j} \le \mathrm{k}$.

Multinomial logit model

To analyze factors associated with children's school travel mode, we estimated a multinomial logit model for our dependent variable y, which can take three values: active mode (walking or biking; A), car (C), or transit (including school bus; T). With this model, the probability of mode $m \in$ {A, C, T} compared to mode $n \in$ {A, C, T}\{m} for child "i" is (Long and Freese 2006):

$$\Pr(y_i = m|\mathbf{X_i}) = \frac{\exp\left(\beta_{m|n,0} + \mathbf{X_i}\boldsymbol{\beta}_{\mathbf{m|n}}\right)}{1 + \sum_{q\in\{A,C,T\}\setminus\{n\}} \exp(\beta_{q|n,0} + \mathbf{X_i}\boldsymbol{\beta}_{\mathbf{q|n}})}, \tag{4}$$

where the $\boldsymbol{\beta}_{\mathbf{q|n}}$s are k × 1 vectors of unknown parameters and the $\beta_{q|n,0}$s are unknown parameters. Thus, the odds of mode $m \in$ {A, C, T} versus mode $n \in$ {A, C, T}\{m} for child "i" are

$$\Omega_{m|n}(\mathbf{X_i}) = \frac{\Pr(y_i = m|\mathbf{X_i})}{\Pr(y_i = n|\mathbf{X_i})} = \exp\left(\beta_{m|n,0} + \mathbf{X_i}\boldsymbol{\beta}_{\mathbf{m|n}}\right). \tag{5}$$

As a result, if $\Omega_{m|n}(\mathbf{X_i}, x_j + \delta)$ denotes the odds obtained by adding $\delta > 0$ to explanatory variable x_j (j ∈ {1,…,k}) in (5), the odds ratio of mode m relative to mode n for variable $\mathrm{x_i}$ is

$$\frac{\Omega_{m|n}(\mathbf{X_i}, x_j + \delta)}{\Omega_{m|n}(\mathbf{X_i})} = \exp(\delta\beta_{m|n,j}). \tag{6}$$

Hence, an increase in x_j increases the likelihood that a respondent will use mode m relative to mode n if $\exp(\delta\beta_{m|n,j}) > 1$, which holds if and only if $\beta_{m|n,j} > 0$, and it decreases this likelihood otherwise. We thus report odds ratios ($\mathrm{OR_{m|n}}$) $\exp(\beta_{m|n,j})$, $1 \le \mathrm{j} \le \mathrm{k}$.

One implication of Eq. (5), which is important for model specification, is that the odds of a paired comparison do not depend on other alternatives (independence of irrelevant alternatives, or IIA), which we assessed using Hausman and Small-Hsiao tests (Greene 2008).

Generalized ordered model

We estimated generalized ordered models to analyze factors associated with parental attitudes toward children's walking and biking to school. Parental attitudes originally collected via a 5-point Likert scale were recoded into three ordinal outcomes captured by a dependent variable y to obtain better balanced categories and to simplify our analysis: "not an issue" and "a little bit of an issue" were merged into "1 = low concern"; "somewhat of an issue" was relabeled "2 = medium concern"; and "very much an issue" was merged with "a serious issue" into "3 = high concern".

The generalized ordered model for choice $q \in \{1, 2, 3\}$, can be written (Williams 2006):

$$\Pr(y_i = q) = \begin{cases} 1 - F(\tau_1 + \mathbf{X_i}\boldsymbol{\beta}_1), & \text{if } q = 1, \\ F(\tau_1 + \mathbf{X_i}\boldsymbol{\beta}_1) - F(\tau_2 + \mathbf{X_i}\boldsymbol{\beta}_2), & \text{if } q = 2, \\ F(\tau_2 + \mathbf{X_i}\boldsymbol{\beta}_2), & \text{if } q = 3, \end{cases} \tag{7}$$

where $\boldsymbol{\beta_1}$ and $\boldsymbol{\beta_2}$ are k × 1 vectors of unknown parameters to be estimated jointly with unknown "cutpoint" coefficients τ_1 and τ_2; and the link function F is a cumulative distribution function; assuming that $F \sim$ logistic(0, $\pi^2/3$) gives the generalized ordered logit model. Since allowing parameter values to differ for all categories is cumbersome, Stata (a statistics package) performs Wald tests (Greene 2008) to keep equal coefficients of variables that do not differ statistically across equations.

Following Williams (2006), we explored different link functions for our generalized ordered logit models. Based on the AIC and BIC information criteria (Greene 2008), but also to simplify the discussion of our results when AIC and BIC differences between models were under 3, we selected logit link functions. In that case, the odds that y > q versus y ≤ q for q ∈ {1, 2} is given by

$$\Omega_{>q|\leq q}(\mathbf{X_i}) = \frac{\Pr(y_i > q|\mathbf{X_i})}{\Pr(y_i \leq q|\mathbf{X_i})} = \exp\left(\tau_q + \mathbf{X_i}\boldsymbol{\beta_q}\right). \tag{8}$$

Hence, if $\Omega_{>q|\leq q}(\mathbf{X_i}, x_j + \delta)$ denotes the odds that y > q versus y ≤ q obtained by adding $\delta > 0$ to x_j (j ∈ {1,…,k}) in (8), the odds ratio of choices > q ∈ {1,2} versus choices ≤ q for variable x_j is

$$\frac{\Omega_{>q|\leq q}(\mathbf{X_i}, x_j + \delta)}{\Omega_{>q|\leq q}(\mathbf{X_i})} = \exp(\delta\beta_{q,j}). \tag{9}$$

Equation (9) implies that increasing x_j augments the likelihood that a respondent will find an issue more of concern than she does now if $\exp(\delta\beta_{q,j}) > 1$ (which holds provided $\beta_{q,j} > 1$), and decreases this likelihood otherwise; we thus report odds ratios ($OR_{>q|\leq q}$) $\exp(\beta_{q,j})$, 1 ≤ j ≤ k.

Results

Results, estimated using Stata, are presented in Tables 3, 4, 5 and discussed below. For brevity, we report and discuss only OR [see the text below Eqs. (3), (6), and (9)] of statistically significant explanatory variables (at 10 % of significance or less). Variables with OR farther from 1.0 have more sway in changing the probability of an outcome than variables with OR closer to 1.0.

Parental attitudes: effects of parental gender and other factors

We hypothesized that mothers have greater concerns for their children's active commuting to school; results in Table 3 partially confirm this hypothesis. Of the four issues pertaining to children's walking and biking to school, mothers are statistically more likely than fathers to have higher concerns about traffic volume (OR = 1.32), but they do not seem to have different attitudes toward distance to school, traffic speed, and crime when living within 2 miles from school.

Seraj et al. (2012) used the same dataset to analyze these parental attitudes focusing on a smaller area of Southern California. Although our attitudinal models might look similar, they do not discuss how parental gender affects parental attitudes. In addition, we went further to explore how parental gender and attitudes interact to affect children's school travel mode and parental chauffeuring behavior (see "Children's school travel mode: effects of parental attitudes and other factors" and "Parental chauffeuring behavior: interaction of parental gender and attitudes" sections).

A number of other parental characteristics also matter for explaining parental attitudes toward children's walking and biking to school. Compared with parents aged 30–44, both younger and older parents are less concerned about traffic characteristics (OR 0.46–0.79) or crime (OR = 0.41). Asian and Hispanic parents, parents who were born in the U.S., and parents who were interviewed in English all show higher concerns for at least one of the four questions considered (OR 1.42–2.20). Moreover, parents with a high school degree, some college, or a bachelor's degree worry less about distance to school and traffic volume than parents with less education or than highly educated ones (OR 0.61–0.69), while parents who work full-time worry more about crime (OR = 1.44) and less about traffic volume (OR = 0.78) than those who don't.

Parental use of active transportation or transit is statistically associated with parental attitudes. Parents who walk or bike more often are less concerned about school distance for their children (OR 0.47–0.77), but parents who use transit more often worry more about traffic volume (OR = 1.35).

A few household characteristics also influence parental attitudes: households with more children are less concerned about traffic and crime (OR 0.81–0.89); households with an annual income under $10 K worry less about traffic volume (OR = 0.52); and households with a low to medium annual income ($10–$50 K) show higher concerns about crime (OR 1.43–1.73).

Somewhat surprisingly, parents show no attitudinal differences when they consider letting a daughter or a son walk or bike to school, but parents have greater concerns about traffic characteristics (OR 1.31–1.33) for younger children (5–10 years old). However, our results suggest, as expected, that the most important factor here is the distance between home and school: when it is shorter, parents are less concerned about school distance and traffic characteristics (OR 0.31–0.73). This implies that attending a nearby school could reduce parental concerns and encourage children to walk or bike to school. We also note that parents of children who attend public schools are more concerned about distance to school (OR = 1.58).

Of the land use variables we considered, parents worry less about crime when the population density and the percentage of renter-occupied housing is lower (OR 0.19–0.56). A lower percentage of renter-occupied housing also helps reduce parental concerns about traffic volume (OR 0.60–0.66), but residing in cities over 1 million with subway or heavy rail increases this concern (OR = 1.52),

Table 3 OR in generalized ordered logit models for parental attitudes

Odds ratios	Distance		Traffic volume		Traffic speed		Crime	
	$OR_{>1\|\leq 1}$	$OR_{>2\|\leq 2}$	$OR_{>1\|\leq 1}$	$OR_{>2\|\leq 2}$	$OR_{>1\|\leq 1}$	$OR_{>2\|\leq 2}$	$OR_{>1\|\leq 1}$	$OR_{>2\|\leq 2}$
Parental socio-demographic characteristics								
pa_female	–	–	–	1.32**	–	–	–	–
pa_1829	–	–	0.54**	0.54**	0.63*	0.63*	–	–
pa_4559	–	–	–	–	0.79*	0.79*	–	–
pa_60pl	–	–	–	–	0.46**	0.46**	0.41*	0.41*
pa_ethas	1.59*	1.59*	–	–	1.69*	1.69*	2.13***	2.13***
pa_ethhi	–	–	–	–	–	–	1.82**	–
pa_usborn	–	–	1.42**	–	1.61***	–	–	–
pa_englang	–	–	–	2.20***	–	–	2.03**	2.03**
pa_eduhi	–	–	0.61**	0.61**	–	–	–	–
pa_edusc	–	0.63**	0.69**	0.69**	–	–	–	–
pa_eduba	–	–	0.66***	0.66***	–	–	–	–
pa_ftworker	–	–	0.78*	0.78*	–	–	–	1.44**
Parental level of active or transit transportation								
pa_wlktr1	0.77**	0.77**	–	–	–	–	–	–
pa_biktr1	0.68*	0.68*	–	–	–	–	–	–
pa_biktr2	0.47**	0.47**	–	–	–	–	–	–
pa_pubtr1	–	–	1.35*	1.35*	–	–	–	–
Household characteristics								
nchild	–	–	0.89*	0.89*	0.86**	0.86**	0.81***	0.81***
hhinclt10	–	–	0.52*	0.52*	–	–	–	–
hhinc1030	–	–	–	–	–	–	1.73**	1.73**
hhinc3050	–	–	–	–	–	–	1.43*	1.43*
Child characteristics								
age0510	–	–	1.31**	1.31**	1.33**	1.33**	–	–
School characteristics								
disttosc1	0.31***	0.44***	0.38***	0.56***	0.59***	0.59***	–	–
disttosc2	0.50***	0.50***	0.61***	0.61***	0.68**	0.68**	–	–
disttosc3	0.54***	0.54***	0.73**	0.73**	–	0.67***	–	–
pubsch	1.58**	1.58**	–	–	–	–	–	–
Land use characteristics								
ubsize5	–	–	1.52*	1.52*	–	–	–	–
popdn1	–	–	–	–	–	–	0.19***	–
popdn2	–	–	–	1.83*	–	–	0.54*	0.54*
renter1	–	–	0.60**	0.60**	–	–	0.27***	0.48***
renter2	–	–	0.65*	0.65*	–	–	0.34***	0.56**
renter3	–	–	0.65*	0.65*	–	–	0.42***	–
renter4	–	–	0.66*	0.66*	–	–	0.36***	–

Table 3 continued

Odds ratios	Distance		Traffic volume		Traffic speed		Crime	
	$\mathbf{OR_{>1\|\leq 1}}$	$\mathbf{OR_{>2\|\leq 2}}$	$\mathbf{OR_{>1\|\leq 1}}$	$\mathbf{OR_{>2\|\leq 2}}$	$\mathbf{OR_{>1\|\leq 1}}$	$\mathbf{OR_{>2\|\leq 2}}$	$\mathbf{OR_{>1\|\leq 1}}$	$\mathbf{OR_{>2\|\leq 2}}$
walkscore	–	–	0.99**	0.99**	–	–	–	–

Only statistically significant coefficients are reported for brevity. For a full list of model variables, please consult Table S1 in the Electronic Supplementary Material

$\mathbf{OR_{>1|\leq 1}}$ for an explanatory variable is the odds ratio for a unit increase in that explanatory variable that a parent shows medium or high concerns versus low concerns for distance to school, traffic volume, traffic speed, or crime; $\mathbf{OR_{>2|\leq 2}}$ is similar except for high concerns versus medium or low concerns; see Eq. (9) and the text below

Models in this table were estimated using 1,391 observations; pseudo R^2 values are respectively 0.0547, 0.0514, 0.0391, and 0.0662 for the distance, traffic volume, traffic speed, and crime models

*, **, *** denote statistical significance respectively at the 10, 5, and 1 % levels

We supplemented the indirect land use measures above with walkability data from walkscore.com. Consistent with previous research (e.g., Kerr et al. 2006; Napier et al. 2011), parents in more walkable communities worry less, but the corresponding practical impact is very small and significant only for traffic volume (OR = 0.99). One possible explanation is that the walkscore component that account for local amenities does not matter here since the destination of a school trip is fixed.

Children's school travel mode: effects of parental attitudes and other factors

Table 4 presents results from two models that explain children's usual travel mode to and from school. As in previous studies (e.g., Hume et al. 2009; Panter et al. 2010; Napier et al. 2011), parental attitudes significantly influence children's school travel mode. When parents are more concerned with school distance, traffic volume, and crime, their children are less likely to walk or bike to and from school (OR 0.38–0.73). Interestingly, children whose parents worry more about traffic speed are more likely to use transit than cars (OR = 2.25), possibly because these parents' perceived risk reduces their willingness to drive their children from school.

As expected, parental gender is not statistically significantly associated with children's school travel mode. This makes sense since only one parent per household was surveyed, so the gender of the participating parent should not be correlated with the child's travel mode to school, assuming parents reached a joint agreement on that choice. However, since parental attitudes significantly affect children's school travel mode and since parental gender affects parental attitudes, parental gender may still play an indirect role in deciding children's school travel mode, but understanding this link will require surveying both parents in the household.

Several other parental characteristics matter. Younger parents (18–29 years old) are more likely to let their children travel to school actively (OR = 2.03), while Asian parents are less likely to do so (OR = 0.57). Moreover, parents who have at most some college education are less likely to let their children actively commute to and from school (OR 0.14–0.69) compared to parents with more education.

Parental participation in active or transit transportation impacts children's school travel mode. When parents take more walk or bike trips, their children are more likely to actively

Table 4 OR in multinomial logit models for children's school travel mode

Odds ratios	To school travel mode			From school travel mode		
	$OR_{A\|C}$	$OR_{T\|C}$	$OR_{A\|T}$	$OR_{A\|C}$	$OR_{T\|C}$	$OR_{A\|T}$
Parental attitudes						
schdist3	–	2.00*	0.44**	–	–	0.54*
schtraf2	0.68*	0.48*	–	–	–	–
schtraf3	0.61*	0.44*	–	0.60**	–	–
schspd3	–	–	–	–	2.25**	–
schcrim2	–	2.68**	0.38**	–	1.90*	–
schcrim3	–	–	–	0.73*	–	–
Parental socio-demographic characteristics						
pa_1829	2.03*	–	–	–	–	–
pa_ethas	–	–	–	0.57*	–	–
pa_edulh	–	3.95*	0.17**	–	4.35*	0.14**
pa_eduhi	–	–	0.36*	0.61*	–	0.29**
pa_edusc	0.68*	–	0.31**	0.69*	2.75*	0.25**
Parental level of active and transit transportation						
pa_wkbktr1	1.63***	–	2.16**	1.44**	–	1.94**
pa_wkbktr2	2.99***	–	4.72***	3.05***	–	6.03***
pa_pubtr1	–	2.13*	–	–	–	–
Household characteristics						
nchild	–	–	–	–	–	1.51*
chiratio	–	–	0.47*	–	1.93*	0.42**
vehratio	–	0.42**	–	–	0.42**	–
hhinc1030	–	–	–	1.91**	3.53**	–
hhinc5070	–	3.59**	0.31**	–	–	–
hhinc70100	–	3.21**	0.28**	–	2.51**	–
Child characteristics						
girl	0.79*	0.57**	–	0.69***	0.56**	–
age0510	0.46***	–	0.32***	0.26***	–	0.23***
bfschcare	0.29**	0.13**	–	(not included in "from school" model)		
afschcare	(not included in "to school" model)			0.33***	0.45*	–
School characteristics						
disttosc1	13.75***	0.23**	58.72***	10.97***	0.25**	44.03***
disttosc2	5.66***	0.41**	13.90***	4.81***	0.30***	16.04***
disttosc3	2.44***	0.38**	6.36***	2.83***	0.38***	7.40***
pubsch	2.22***	–	–	2.53***	6.88*	–
Land use characteristics						
ubsize3	0.44**	–	–	–	–	–
ubsize4	–	–	–	–	0.42*	–
nonurban	–	–	–	0.56*	–	–
popdn1	–	–	0.12*	–	–	–
popdn2	–	8.27***	0.08***	–	5.09**	0.13**
renter1	–	0.25**	4.24**	–	0.14***	5.40***
renter2	–	0.29**	3.29*	–	0.24***	2.85*

Table 4 continued

Odds ratios	To school travel mode			From school travel mode		
	$\mathbf{OR_{A\|C}}$	$\mathbf{OR_{T\|C}}$	$\mathbf{OR_{A\|T}}$	$\mathbf{OR_{A\|C}}$	$\mathbf{OR_{T\|C}}$	$\mathbf{OR_{A\|T}}$
renter3	–	–	–	–	0.43*	–
renter4	–	–	–	–	0.35*	–
walkscore	–	0.98**	1.02**	–	0.97***	1.03***

Only statistically significant results are reported for brevity. For a full list of model variables, please consult Table S1 in the Electronic Supplementary Material

$\mathbf{OR_{m|n}}$ for an explanatory variable is the odds ratio for a unit increase in that explanatory variable of mode $m \in \{A, C, T\}$ versus mode $n \in \{A, C, T\}\backslash\{m\}$, where A active mode (walking/biking), C car, and T transit (including school buses); see Eq. (6) and the text below

These models were estimated using 1,362 observations; pseudo R^2 values are respectively 0.2338 and 0.2481 for the "To school travel mode" and "From school travel mode" models

*, **, *** denote statistical significance respectively at the 10, 5, and 1 % levels

Table 5 OR in binary logit models for parental chauffeuring behavior

Odds ratios	Restricted model OR	Unrestricted model OR
Parental attitudes		
schtraf3	(not included in model)	2.15**
Gender of parent surveyed		
pa_female	2.79***	2.99***
Other parental socio-demographic characteristics		
pa_1829	0.22**	0.23**
pa_ethaf	–	0.29*
pa_ftworker	0.35**	0.39**
Household characteristics		
sigadlt	11.69***	12.51***
twoadlt	2.21*	2.61*
hhinc3050	3.52**	3.59**

Only statistically significant results are reported for brevity. For a full list of model variables, please consult Table S1 in the Electronic Supplementary Material

OR for an explanatory variable is the odds ratio that a child is chauffeured to school by his/her parent who was surveyed for a unit increase in that explanatory; see Eq. (3) and the text below

Parental attitudinal variables were not included in the restricted model

These models were estimated using 334 observations; pseudo R^2 values are respectively 0.2134 and 0.2274 for the restricted and unrestricted models

*, **, *** denote statistical significance respectively at the 10, 5, and 1 % levels

commute to and from school (OR 1.44–6.03). Likewise, children of parents who use transit are more likely to take transit to school (OR = 2.13).

Results for household characteristics suggest that children are more likely to walk or bike from school when they have more siblings (OR = 1.51) or when their households have a lower income ($10–$30 K, OR = 1.91). Moreover, children are less likely to take

transit to and from school when there are more cars than drivers in the household (OR = 0.42), but they are more likely to do so in households with medium to higher income ($50–$100 K, OR 2.51–3.59).

As expected, child characteristics correlate with their school travel mode. Girls, younger children (5–10 years old), and children who attend before and/or after school care are less likely to walk, bike, or use transit to and from school (OR 0.13–0.79).

Again, the actual distance from home to school seems to have by far the greatest impact on children's school travel mode. The shorter that distance is, the more likely children are to walk or bike to and from school (OR $\geq$ 2.44). We also note that children who attend public school are more likely to actively commute or use transit for their school travel (OR 2.22–6.88).

Finally, our models show that living in non-urban areas reduces the likelihood of active commuting from school by children (OR = 0.56). In addition, living in neighborhoods with a lower population density increases children's transit use to and from school (OR = 5.09–8.27), while living in neighborhoods with a lower percentage of renter-occupied housing reduces such use (OR 0.14–0.43).

Parental chauffeuring behavior: interaction of parental gender and attitudes

We also explored the role that attitudinal differences may play in the gender gap for chauffeuring children to school; results are presented in Table 5. We estimated a restricted model (which does not include parental attitudes) and an unrestricted model (which includes parental attitudes) in order to gauge the impacts of parental attitudes on the results.

Note that the sample of both models contains only respondents whose children went to school by car on their survey day because, as explained in the "NHTS data" section, we found an extremely low parental escort rate for children who walked, biked, or took transit to school. To obtain more robust results, we focused on parental chauffeuring behavior instead. In other words, all children in both models were driven to school on their survey day by either parents surveyed or by other household or non-household members. Our goal here is to compare whether parental gender or attitudes are more important in deciding parental chauffeuring behavior.

Our results suggest that gender and attitudes are intertwined in influencing parental chauffeuring behavior. Parental attitudes significantly affect parental chauffeuring behavior: parents are more likely to chauffeur their children to school when they have high concerns about traffic volume (OR = 2.15, in the unrestricted model). However, the extent to which attitudinal differences can explain the gender chauffeuring gap is limited: the odds ratio of mothers chauffeuring their children to school compared with fathers is even slightly higher in the unrestricted model (OR = 2.99) than in the restricted model (OR = 2.79) after adjusting for parental attitudes. This suggests that, when holding equal concerns, mothers are still more likely than fathers to chauffeur their children to school, which confirms that the division of household chauffeuring duties is gendered.

As expected, parents' characteristics affect their chauffeuring behavior. Younger parents (18–29 years old, OR = 0.22–0.23) as well as African-American parents (OR = 0.29, only in the unrestricted model) are less likely to chauffeur their children to school, and so do parents who work full-time (OR 0.35–0.39) compared to those who do not.

Few household characteristics were found to be significant. In single parent (OR 11.69–12.51) and two-adult households (OR 2.21–2.61), the parent surveyed is much more likely to be chauffeuring his/her child to school, but this was expected since these families

are more constrained than families with more adults in sharing chauffeuring duties (recall that all children in the sample used to estimate this model were driven to school on the survey day). Moreover, income matters: parents in households with an annual income between $30 and $50 K are more likely to chauffeur their children to school (OR 3.52–3.59).

Whereas actual distance to school was paramount in explaining parental attitudes and children's school travel mode, it has no impact on parental chauffeuring behavior. One explanation is that children's school travel mode is jointly decided with parental chauffeuring behavior, making the decision to select a parent or an adult household member for the chauffeuring task irrelevant to school distance. Likewise, child and land use characteristics do not seem to affect parental chauffeuring behavior.

Conclusions

In this paper, we examined whether parental gender affects parental attitudes toward letting their children actively commute to school, and how parental gender and attitudes interact to influence children's school travel mode and parental chauffeuring behavior. Our results show that mothers usually have higher concerns about traffic volume, which in turn reduces the likelihood that their children will walk or bike to school. Moreover, although parents are more likely to chauffeur their children to school when they have higher concerns about traffic volume, mothers are still more likely than fathers to do so even when mothers and fathers have equal concerns. Based on these results, we conclude that maternal attitudes might matter more for children's active commuting to school.

These findings are relevant for two current programs that aim at increasing the number of children who actively commute to school: the Safe Routes to School program, and the Walking School Bus program. For the former, a national project that focuses on infrastructure improvements such as traffic signals and sidewalks, our results suggest measures that can effectively reduce mothers' perceptions of risk related to traffic volume. For the Walking School Bus program, which seeks adults to volunteer walking a group of neighborhood children to and from school, our results suggest targeting mothers when recruiting volunteers and trying to address their concerns.

Fostering active commuting to school by children is equally important to mothers. According to a recent OECD report (2012), household chores, childcare, and looking after aging parents are the main barriers to gender equality in employment. Our results provide support for this viewpoint by showing that mothers bear most of the chauffeuring burden not because they worry more but because chauffeuring children still appears to be more a woman's responsibility. The high level of space and time rigidity of such activities partly explains why women are more likely to work part-time and work closer to home, which in turn reduces their economic opportunities and does not allow them to take full advantage of their education (OECD 2012).

Lastly, our results have some implications for future research. In this paper, we estimated three sets of models to explain the relationships between parental gender, parental attitudes, children's school travel mode, and parental chauffeuring behavior. These links have been ignored in the literature mainly because all current research (including ours) relies on surveys that collect information only from one parent in each household (see the "Children's school travel mode: effects of parental attitudes and other factors" section for more details). As a result, the parental decision-making process regarding how children commute to school and who is responsible for chauffeuring them cannot be elicited. To

advance our understanding of relevant issues, it is important to explore if these decisions correlate with within-household gender differences in wages, attitudes, preferences, or social norms. Future research could overcome current limitations by surveying both parents.

Acknowledgments The authors are grateful to the editor (David Hartgen) and three anonymous referees for very helpful suggestions. All remaining errors are our responsibility.

References

Babey, S., Hastert, T., Huang, W., Brown, E.R.: Sociodemographic, family, and environmental factors associated with active commuting to school among US adolescents. J. Public Health Policy **30**, S203–S220 (2009)

Braza, M., Shoemaker, W., Seeley, A.: Neighborhood design and rates of walking and biking to elementary school in 34 California communities. Am. J. Health Promot. **19**(2), 128–136 (2004)

Buliung, R., Mitra, R., Faulkner, G.: Active school transportation in Greater Toronto Area, Canada: an exploration of trends in space and time (1986–2006). Prev. Med. **48**, 507–512 (2009)

Clifton, K., Akar, G., Livi-Smith, A., Voorhees, C.: Gender differences in adolescent travel to school: exploring the links with physical activity and health. In: Women's Issues in Transportation: Summary of the 4th International Conference, Technical Papers, TRB Conference Proceeding 46, vol. 2, pp. 203–212. National Research Council, Washington DC (2011)

Davison, K., Werder, J., Lawson, C.: Children's active commuting to school: Current knowledge and future directions. Prev. Chronic Dis. **5**(3), 1–11 (2008)

Ewing, R., Schroeer, W., Greene, W.: School location and student travel: analysis of factors affecting mode choice. Transp. Res. Rec. **1895**, 55–63 (2004)

Giuliano, G., Schweitzer, L.: Her money or her time: A gendered view of contemporary transport policy. In: Women's Issues in Transportation: Summary of the 4th International Conference, Conference Overview and Plenary Papers, TRB Conference Proceeding 46, vol. 1, pp. 78–93. National Research Council, Washington DC (2010)

Greene, W.: Econometric Analysis, 6th edn. Prentice Hall, Englewood Cliffs (2008)

Grize, L., Bringolf-Isler, B., Martin, E., Braun-Fahrländer, C.: Trend in active transportation to school among Swiss school children and its associated factors: three cross-sectional surveys 1994, 2000 and 2005. Int. J. Behav. Nutr. Phys. Act. **7**, 28 (2010)

He, S.: Effect of school quality and residential environment on mode choice of school trips. Transp. Res. Rec. **2213**, 96–104 (2011)

Hume, C., Timperio, A., Salmon, J., Carver, A., Giles-Corti, B., Crawford, D.: Walking and cycling to school: predictors of increases among children and adolescents. Am. J. Prev. Med. **36**(3), 195–200 (2009)

Kerr, J., Rosenberg, D., Sallis, J., Saelens, B., Frank, L., Conway, T.: Active commuting to school: associations with environment and parental concerns. Med. Sci. Sports Exerc. **38**(4), 787–794 (2006)

Lam, L.: Parental risk perceptions of childhood pedestrian road safety. J. Saf. Res. **32**, 465–478 (2001)

Lam, L.: Parental risk perceptions of childhood pedestrian road safety: a cross cultural comparison. J. Saf. Res. **36**, 181–187 (2005)

Larsen, K., Gilliland, J., Hess, P., Tucker, P., Irwin, J., He, M.: The influence of the physical environment and sociodemographic characteristics on children's mode of travel to and from school. Am. J. Public Health **99**(3), 520–526 (2009)

Leslie, E., Kremer, P., Toumbourou, J., Williams, J.: Gender differences in personal, social, and environmental influences on active travel to and from school for Australian adolescents. J. Sci. Med. Sport **13**, 597–601 (2010)

Liu, S., Murray-Tuite, P., Schweitzer, L.: Analysis of child pick-up during daily routines and for daytime no-notice evacuations. Transp. Res. A **46**, 48–67 (2012)

Long, J.S., Freese, J.: Regression Models for Categorical Dependent Variables Using Stata, 2nd edn. Stata Press, College Station (2006)

Loukaitou-Sideris, A.: Is it safe to walk here? Design and policy responses to women's fear of victimization in public places. In: Research on Women's Issues in Transportation: Report of a Conference, Technical Papers, TRB Conference Proceeding 35, vol. 2, pp. 102–110. National Research Council, Washington DC (2005)

Martin, S., Lee, S., Lowry, R.: National prevalence and correlates of walking and bicycling to school. Am. J. Prev. Med. **33**(2), 98–105 (2007)
McDonald, N.: Active transportation to school: trends among U.S. school children, 1969–2001. Am. J. Prev. Med. **32**(6), 509–516 (2007a)
McDonald, N.: Travel and the social environment: evidence from Alameda County, California. Transp. Res. D **12**, 53–63 (2007b)
McDonald, N.: Household interactions and children's school travel: the effect of parental work patterns on walking and biking to school. J. Transp. Geogr. **16**, 324–331 (2008a)
McDonald, N.: Critical factors for active transportation to school among low-income and minority students: evidence from the 2001 National Household Travel Survey. Am. J. Prev. Med. **34**(4), 341–344 (2008b)
McDonald, N.: Children's mode choice for the school trip: the role of distance and school location in walking to school. Transportation **35**, 23–35 (2008c)
McDonald, N.: Is there a gender gap in school travel? An examination of US children and adolescents. J. Transp. Geogr. **20**, 80–86 (2012)
McDonald, N., Aalborg, A.: Why parents drive children to school: implications for safe routes to school programs. J. Am. Plan. Assoc. **75**(3), 331–342 (2009)
McDonald, N., Brown, A., Marchetti, L., Pedroso, M.: U.S. school travel, 2009: an assessment of trends. Am. J. Prev. Med. **41**(2), 146–151 (2011)
McMillan, T.: The relative influence of urban form on a child's travel mode to school. Transp. Res. A **41**, 69–79 (2007)
McMillan, T., Day, K., Boarnet, M., Alfonzo, M., Anderson, C.: Johnny walks to school—Does Jane? Sex differences in children's active travel to school. Child. Youth Environ. **16**(1), 75–89 (2006)
Meyer, H., Avi Astor, R.: Child and parent perspectives on routes to and from school in high crime neighborhoods. J. Sch. Violence **1**(4), 101–128 (2002)
Mitra, R., Buliung, R., Roorda, M.: Built environment and school travel mode choice in Toronto, Canada. Transp. Res. Rec. **2156**, 150–159 (2010)
Napier, M., Brown, B., Werner, C., Gallimore, J.: Walking to school: community design and child and parent barriers. J. Environ. Psychol. **31**, 45–51 (2011)
Nelson, N., Foley, E., O'Gorman, D., Moyna, N., Woods, C.: Active commuting to school: how far is too far? Int. J. Behav. Nutr. Phys. Act. **5**, 1 (2008)
OECD: Closing the gender gap: act now. OECD Publishing. (2012) http://dx.doi.org/10.1787/9789264179370-en
Panter, J.R., Jones, A.P., van Sluijs, E.M.F., Griffin, S.J.: Attitudes, social support and environmental perceptions as predictors of active commuting behavior in school children. J. Epidemiol. Community Health **64**, 41–48 (2010)
Prezza, M., Romana-Alparone, F., Cristallo, C., Secchiano, L.: Parental perception of social risk and of positive potentiality of outdoor autonomy for children: the development of two instruments. J. Environ. Psychol. **25**, 437–453 (2005)
Rodríguez, A., Vogt, C.: Demographic, environmental, access, and attitude factors that influence walking to school by elementary school-aged children. J. Sch. Health **79**(6), 255–261 (2009)
Schwanen, T.: Gender differences in chauffeuring children among dual-earner families. Prof. Geogr. **59**(4), 447–462 (2007)
Seraj, S., Sidharthan, R., Bhat, C., Pendyala, R., Goulias, K.: Parental attitudes towards children walking and bicycling to school: multivariate ordered response analysis. Transp. Res. Rec. **2323**, 46–55 (2012)
Sirard, J., Slater, M.: Walking and bicycling to school: a review. Am. J. Lifestyle Med. **2**(5), 372–396 (2008)
Vovsha, P., Petersen, E.: Escorting children to school: statistical analysis and applied modeling approach. Transp. Res. Rec. **1921**, 131–140 (2005)
Williams, R.: Generalized ordered logit/partial proportional odds models for ordinal dependent variables. Stata J. **6**(1), 58–82 (2006)
Yarlagadda, A., Srinivasan, S.: Modeling children's school travel mode and parental escort decisions. Transportation **35**(2), 201–218 (2008)
Yavuz, N., Welch, E.W.: Addressing fear of crime in public space: gender differences in reaction to safety measures in train transit. Urban Stud. **47**(12), 2491–2515 (2010)
Yeung, J., Wearing, S., Hills, A.: Child transport practices and perceived barriers in active commuting to school. Transp. Res. A **42**, 895–900 (2008)
Yoon, S.Y., Doudnikoff, M., Goulias, K.: Spatial analysis of propensity to escort children to school in southern California. Transp. Res. Rec. **2230**, 132–142 (2011)
Zhu, X., Lee, C.: Correlates of walking to school and implications for public policies: survey results from parents of elementary school children in Austin, Texas. J. Public Health Policy **30**, S177–S202 (2009)

Author Biographies

Hsin-Ping Hsu is a PhD candidate in the Planning, Policy and Design Department at the University of California, Irvine. She earned a BS in Civil Engineering and an MA in Philosophy from National Taiwan University. Her research interests include transportation planning with a special focus on gender and travel behavior.

Jean-Daniel Saphores is a Professor in Civil and Environmental Engineering with appointments in Planning, Policy and Design as well as Economics at the University of California, Irvine. His research interests include transportation planning, travel behavior, transportation systems engineering, and transportation and the environment.