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# Is there a gender gap in school travel? An examination of US children and adolescents

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ABSTRACT

Previous research on school travel showed an inconsistent relationship between sex and the prevalence of walking or biking to school. Some studies found that males were more likely to use active transport modes, but other research found no association between sex and school travel. This study used data from the 1977, 1983, 1990, 1995, 2001, and 2009 US National Household Travel Surveys to examine sex differences in school travel and how they have changed over time. The analysis showed that males walked to and from school more than females, though differences were modest – between 1% and 2% points – and were statistically significant only in 1990. In contrast, males biked to school two to three times more than females. These modal differences may result from females' observed lower levels of independent mobility. Policy interventions, such as the Safe Routes to School program, can address gender differences by providing programs such as the Walking School Bus that provide adult supervision on the school trip. Bicycle interventions should ensure that females are participating in the programs.



## 1. Introduction

The proportion of US elementary and middle school students usually walking and biking to school declined from 48% in 1969 to 13% in 2009 (Beschen, 1972; McDonald et al., 2011). Similar trends have been observed in much of the English-speaking world (Buliung et al., 2009; Pooley et al., 2005; Van Der Ploeg et al., 2008). At the same time, youth obesity rates have increased (Ogden et al., 2006). While causal linkages between the two trends have not been established (Faulkner et al., 2009), policymakers have allocated resources to increase active transportation to and from school. For example, the US federal transportation bill, SAFETEA-LU, and its extensions have appropriated over $860 million for a national Safe Routes to Schools program and the White House Task Force on Childhood Obesity set of goal of increasing the proportion of students walking or biking to school by fifty percent (National Center for Safe Routes to School, 2010; White House Task Force on Childhood Obesity, 2010).

One open question – which has not been addressed by current policy initiatives – is whether school travel is gendered. Studies of adult work travel show strong differences in commuting patterns between men and women (Crane, 2007). These differences have persisted despite declining gaps in employment, licensure, and earnings between the sexes. Research on the gender gap in school travel is more mixed. Some studies report significant differences in rates of walking to school between males and females, while others show no gender effect. Theoretical perspectives on gender and the mobility of children and teens are also in flux. Traditionally, researchers have believed that girls had less travel independence than boys because parents were more protective of girls and girls had more household responsibilities (Hart, 1979; Matthews, 1992). However, Valentine (1997) has suggested that these norms may be changing as parents become increasingly concerned about the safety of both sexes in public spaces.

This study looked at gender differences in one particularly important trip – the trip to and from school – using data from the US Department of Transportation's National Household Travel Surveys (NPTS) conducted between 1977 and 2009. The emphasis was on walking and biking to school because it is the focus of current policy interventions. The study analyzed sex differences in school travel and developed a multinomial logit model to more robustly test whether there was a gender gap on the school trip even after controlling for individual and household covariates.

The following section provides background on children and teen's school travel and previous research on gender differences. Next, the paper describes rates of walking and biking to school by sex at national and regional levels and levels of independent mobility. The final section describes a multinomial logit model to more carefully test for gender differences among elementary and middle school students living within two miles of school.

## 2. Previous research

The literature on school travel, particularly walking and biking to school, provides insights into how gender affects school trips.

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Most studies find that males walk and bike to school more than females. However, differences are often not statistically significant.

McMillan et al. (2006) is one of the few studies to focus on gender differences in school travel. The study found that third to fifth grade Californian boys were significantly more likely than girls to walk and bike to school (27% vs. 19%). This study also found that the amount of time the caregiver walks moderated the effect of gender on active transportation to school. When caregivers spent more time walking, there were fewer sex differences in children's behavior. Several other California studies have found significant gender differences. For example, Rosenberg et al. (2006) showed that fourth and fifth grade boys from southern California were more likely to walk, bike, or skateboard to school at least 2–3 days per week than girls. In a study of California teenagers, Babey et al. (2009) found that the odds of walking or biking to school for girls were two-thirds that of boys.

International studies have also found significant differences. Timperio et al. (2006), in their study of 235 5–6 year olds and 677 10–12 year olds in Melbourne, Australia, found boys aged 10–12 biked at significantly higher rates than girls (9.2% vs. 3.7%), but there were no differences in walk rates. The study found no gender differences in walk and bike rates among younger children. A larger Australian study ($n = 2961$) of 10 and 14 year olds found significant differences in school travel by sex. They found girls were more likely to walk to school (44.3% vs. 37.4%), but were less likely to bike (8.3% vs. 22.4%) leading to lower overall rates of active travel among females (Leslie et al., 2010). In a London, Ontario study of similarly aged children (11–13 years old), Larsen et al. (2009) found that boys were 1.5 times more likely to walk or bike for school travel. Nelson et al. (2008) found that high school boys in Ireland were significantly more likely to walk to school than girls. Yelavich et al. (2008) found similarly results among elementary school children in New Zealand. In the UK, Panter et al. (2010) report that boys are more likely to use non-motorized modes than girls, but among non-motorized mode users, girls were significantly more likely than boys to walk (boys were more likely to use bicycles).

There are several examples of studies that found no association between gender and school travel. Martin et al. (2007) reported no significant difference in rates of active transportation to school among a nationally representative sample of 2649 US children aged 9–15 living within 1 mile of their school. A study of 315 Georgia children aged 5–15 living within 1 mile of school found that boys walked to school more frequently than girls (19.3–17.9) but the difference was not statistically significant (Bricker et al., 2002). Kerr et al. (2006) reported no gender differences in walking and biking to school for children aged 5–18 living in Seattle. Booth et al. (2007) examined mode choice to school among sixth graders in New South Wales, Australia, and found no significant difference in the likelihood of walking (vs. riding in a car or using public transport) by gender. Similarly, Page et al. (2010) and Black et al. (2001) found no differences in mode choice to school by gender for children in the UK and Grize et al. (2010) found no differences in school mode choice for Swiss boys and girls.

### 2.1. Age

This review suggests that gender effects may be most important for third through eighth grade (ages 8–13) students. In fact some of the variation in results may come from the different age groups studied. Existing research on children's mobility shows that age is a critical determinant of children's travel and play (Matthews, 1992). In a study of a New England town, Hart (1979) found that children, particularly boys, gained much more travel independence around age 10. A study in the UK found the same increase in independence occurred around 8 or 9 (Matthews, 1992). This suggests that studies which do not disaggregate by age may not detect sex differences. In other words, children under 8 may not exhibit sex differences because most are not allowed to travel independently. Data from the UK also suggest that sex differences disappear for high school age children (Hillman et al., 1990).

The documented differences in boys' and girls' travel freedom may relate to gendered parenting practices. In-depth qualitative studies of children's mobility have found that parental concern for the safety of females combined with higher levels of household responsibility may cause girls to have smaller home ranges and make fewer trips without adults (Hart, 1979; O'Brien et al., 2000; Valentine, 1997). However Valentine (1997) found that middle class parents were reluctant to assign older children responsibility for younger siblings and have strong safety concerns for boys as well as girls.

### 2.2. Location in region

O'Brien et al. (2000) found that children's freedom of movement was higher for both boys and girls in a lower-density New Town as compared to London. They concluded that the "sheer vastness and social heterogeneity of global cities, such as London, may make them unknowable to children and adults alike". Earlier research had shown the opposite with sex differences being minimized in an urban setting and maximized in suburban and rural environments (Hart, 1979; van Vliet, 1983) Given the vastly different settings these studies used (and differing definitions of low density), this research may suggest that the effect of density is non-linear and that children have the greatest freedom in places that are small enough for parents to know their neighbors but large enough for children to have walkable destinations.

### 2.3. Sample size

The inconsistent relationship between school travel mode and gender is also a product of varying research designs. The ability to detect statistically significant differences, i.e. power, depends on the size of the differences and sample size. With a small sample, differences must be very large to be judged statistically significant. With a very large sample, even quite small differences can often be statistically significant. Of the studies that report a significant gender effect, the difference in walk rates between males and females ranges from 4% to 8% points. Detecting a difference of this size requires a sample of at least 1000–3000 to have adequate power, e.g. $\sim$0.8. Many of the studies discussed above had smaller sample sizes.

## 3. Data

The NPTS is a population-based survey conducted by the US Department of Transportation (DOT) in 1969, 1977, 1983, 1990, 1995, 2001, and 2009. The survey collects information on all trips undertaken by members of selected households on a randomly-assigned survey day. Household members are asked to provide information on all trips including purpose, mode, and travel time. Data are collected on the demographic characteristics, e.g. age and sex, of all household members. Race and ethnicity are collected for the adult respondent, generally a parent or guardian. Individual data are available for the 1977–2009 surveys.

The unit of analysis is the unlinked trip to and from school. Trips to school had a trip purpose of Civic/Educational/Religious (1977), School/Church (1983, 1990), School (1995), Go to school as student (2001, 2009); occurred on weekdays between 5am and 11am from September to May; the respondent was between the ages of 5 and 18; and the respondent began the travel day at home. Trips from school had a similar definition with the exception that the trip had to begin between 1 pm and 6 pm. In the limited number of cases where a respondent had more than one trip qualifying as a to or from school trip, the earlier trip was counted as the school trip. To be included in the analysis, respondents had to report travel mode and sex. Based on this definition, 3297 surveyed individuals made trips to school in 1977, 1295 in 1983, 4048 in 1990, 8398 in 1995, 12,426 in 2001, and 19,363 in 2009. Sample sizes for trips home from school were slightly lower in each year with 3120 observed trips home in 1977, 1199 in 1983, 4105 in 1990, 7812 in 1995, 11,681 in 2001 and 18,100 in 2009. These varying sample sizes mean that for similar effect sizes power is lowest in 1983.

Although the NPTS is the only source of trend data on school travel in the United States, there are several important limitations. All of the information for youth under fourteen and much of the data for fifteen and 16 year olds is proxy-reported by adults in the household (US Department of Transportation, 2004a). However, it is likely that parents are accurate reporters for school trips. Next, there have been important changes in the administration and design of the NPTS. First, the 1977 and 1983 surveys utilized in-person interviews conducted by field staff of the Census Bureau; subsequent surveys relied on telephone interviews conducted by private research firms (Research Triangle Institute and Federal Highway Administration, 1997; US Department of Transportation, 2004a). Second, prompts were added in the 2001 survey to encourage reporting of non-motorized trips (US Department of Transportation, 2004a). Third, the 1977 and 1983 surveys were based on a clustered sample design; more recent surveys used a non-clustered list-assisted Random Digit Dial sample stratified by geographic area (US Department of Transportation, 2004a). Finally, response rates were significantly lower for the 1995, 2001, and 2009 surveys due to the introduction of a travel diary system which required a two-stage data collection process (US Department of Transportation, 2004a). While it is difficult to quantify the effects of these changes, analyses by DOT have shown that reporting of school and work trips has been relatively unchanged (US Department of Transportation, 2004b). Because of that, methodological changes should not alter the findings of this analysis which focuses on comparing mode split for a primary trip purpose across years.

Another important consideration with the NHTS is the role of place. The literature documents variation in school travel behavior in urban and suburban areas and even suggests the potential for varying sex effects in different contexts. Analyses looking only at national averages might miss this important local variation. The large sample size in the 2009 data allows analysis of regional and even neighborhood patterns in certain jurisdictions where additional samples were collected, thereby allowing study of whether the national patterns are repeated at the local level.

## 4. Results

The following sections present the findings from the NHTS series. The first section presents national and regional estimates of school trip mode shares by sex in aggregate and stratified by age. The second section focuses on differences in independent mobility between boys and girls. The third section develops multinomial logit models of the trip to school to test whether behavior varies significantly by sex even when accounting for individual and household factors. These findings are then related to current policy interventions for school travel.

### 4.1. School travel

Table 1 shows the modal distribution for trips to and from school by sex from 1977 to 2009. The data highlight some important differences between males and females. Biking rates were two to three times higher for males than females in nearly every year (Table 1). However, biking accounted for a small proportion, approximately one to two percent, of all school travel. The prevalence of walking to or from school did not vary significantly between girls and boys in most years (Table 1). Differences were generally one to two percentage points with boys often having the higher prevalence of walking. One exception was 1990 where significant differences of approximately four percentage points were observed in the prevalence of walking between males and females. Given the anomalous nature of this finding, it is difficult to interpret. The data confirmed the findings from other studies that automobility has increased and walking is more common on the trip from school vs. the trip to school (Buliung et al., 2009; Hayghe, 1996; McDonald et al., 2011; Schlossberg et al., 2006). But patterns of difference between males and females were similar in the morning and the afternoon even though walking and biking were more common in the afternoon.

#### 4.1.1. Robustness check: regional analyses

The national results could mask important gender differences at the local level by "averaging out" gender effects. For example, consider two identical cities. In City A, all girls are driven to school and all boys walk to school; in City B, the reverse is true. An overall analysis would find no gender differences even though substantial differences exist at the city level. Oversampling of some regions in the 2009 NHTS allowed detailed analyses of sub-regional differences in walk mode share by sex. In five metropolitan areas with large samples of students, there were no statistically significant differences in the proportion of students walking to school by gender in 2009 (Table 2). This was true overall and when disaggregated by residential density. For example, in the New York PMSA (which includes New York City and Westchester, Rockland, and Putnam counties) 12.9% of boys and 11.1% of girls walked to school ($p = 0.490$). A county by county analysis of the PMSA also shows no significant gender differences. For example in the Bronx, 33.3% of females walked to school and 34.6% of males walked ($p = 0.925$). In Staten Island, 12.5% of females walked and 10.0% of males walked ($p = 0.687$). In the highest density areas of the NY PMSA (defined as block groups with densities above 10,000 people per square mile), 21.9% of boys and 18.4% of girls walked ($p = 0.468$). These results suggest it is unlikely that there is substantial averaging out of gender differences.

### 4.2. Independent mobility

Theory suggests females have less travel freedom than males. Studies have shown boys traveling further from home and being more likely to travel without an adult (Matthews, 1992). These differences might appear not only in how the student traveled to school, but also in whom they traveled with. The 1990 through 2001 travel surveys showed that males were somewhat more likely to be traveling by themselves or with friends and siblings as they walked to schools; females were more likely to walk with a household adult (Table 3).[1] Many of the differences are not statistically significant but the pattern is consistent particularly for elementary school students.

The 2009 survey asked parents whose children lived within 2 miles of their school when they would allow their child to walk or bike to school *without* an adult. Approximately 6% of parents planned to give their first-graders permission to walk independently (Fig. 1). By 12th grade, nearly 90% of parents planned to give

[1] The 2009 data was omitted from this analysis because the results from the travel diary escort data were inconsistent with the special section on school travel.

**Table 1**
Travel to and from school by sex and mode, 1977–2009.

| | 1977 | | 1983 | | 1990 | | 1995 | | 2001 | | 2009 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male |
| *To school* | | | | | | | | | | | | |
| Auto | | | | | | | | | | | | |
| Passenger | 18.5 | 15.9 | 31.6 | 29.8 | **34.5** | **28.9** | 45.5 | 42.4 | **47.9** | **43.1** | 47.7 | 45.5 |
| Driver | 5.1 | 6.5 | **4.1** | **6.7** | 6.6 | 8.1 | 6.9 | 8.2 | **6.7** | **8.3** | 7.4 | 8.2 |
| School bus | 46.2 | 45.1 | 40.8 | 42.2 | 37.1 | 37.2 | 33.9 | 34.3 | 30.9 | 32.4 | 32.3 | 33.5 |
| Walk | 21.1 | 23.1 | 14.0 | 14.5 | **15.6** | **19.7** | 10.1 | 11.3 | 12.2 | 12.5 | 9.2 | 8.8 |
| Bike | **0.6** | **2.2** | 0.7 | 0.7 | **0.5** | **1.4** | **0.7** | **1.4** | **0.4** | **1.1** | 0.6 | 1.0 |
| Transit | 7.9 | 6.9 | 7.0 | 4.7 | 5.5 | 4.5 | 2.8 | 2.3 | 1.7 | 2.4 | 2.0 | 2.1 |
| Other | 0.5 | 0.3 | 1.8 | 1.4 | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.6 | 0.9 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| *From school* | | | | | | | | | | | | |
| Auto | | | | | | | | | | | | |
| Passenger | **18.2** | **13.3** | 26.0 | 21.6 | **32.0** | **25.5** | 38.5 | 35.0 | 39.3 | 37.7 | **43.4** | **36.7** |
| Driver | 5.1 | 6.1 | 4.2 | 5.8 | 6.6 | 7.7 | 6.1 | 6.7 | 5.7 | 7.2 | 6.3 | 7.4 |
| School bus | 44.6 | 45.5 | 42.3 | 47.1 | 38.8 | 39.2 | 38.5 | 39.4 | 35.6 | 36.2 | 34.1 | 37.0 |
| Walk | 22.6 | 25.5 | 16.1 | 16.2 | **16.4** | **21.3** | 12.5 | 14.8 | 16.5 | 14.7 | 12.3 | 14.5 |
| Bike | **0.6** | **2.0** | 0.6 | 0.7 | **0.5** | **1.4** | 0.8 | 1.5 | **0.4** | **1.3** | 0.6 | 1.0 |
| Transit | 7.9 | 7.1 | 7.5 | 6.0 | 5.6 | 4.4 | **3.6** | **2.3** | 2.3 | 2.4 | 2.4 | 2.6 |
| Other | 0.9 | 0.6 | 3.3 | 2.6 | 0.1 | 0.3 | 0.1 | 0.3 | 0.2 | 0.5 | 0.9 | 0.7 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Bold denotes the difference between males and females is significant at $p < 0.05$.

**Table 2**
Walk mode share by region, census block group density, and sex.

| | Dallas PMSA | | Houston PMSA | | New York PMSA | | Phoenix MSA | | San Diego MSA | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male |
| *To school* | | | | | | | | | | |
| All densities | 7.6 | 7.2 | 4.7 | 3.4 | 11.1 | 12.9 | 11.3 | 12.0 | 15.1 | 13.8 |
| >4000 people per mile$^2$ | 9.9 | 8.1 | NA | NA | 17.6 | 20.2 | 13.5 | 14.6 | 19.6 | 16.8 |
| >10,000 people per mile$^2$ | NA | NA | NA | NA | 18.4 | 21.9 | NA | NA | 16.4 | 22.4 |
| *From school* | | | | | | | | | | |
| All densities | 11.4 | 12.2 | 7.6 | 4.8 | 15.5 | 16.9 | 14.8 | 15.1 | 19.2 | 21.3 |
| >4000 people per mile$^2$ | 12.9 | 16.9 | NA | NA | 24.7 | 26.6 | 18.1 | 19.5 | 24.0 | 24.6 |
| >10,000 people per mile$^2$ | NA | NA | NA | NA | 28.2 | 29.8 | NA | NA | 29.1 | 32.8 |

NA = Fewer than 15 walkers observed, sample too small to meet requirements of difference in proportions test.

**Table 3**
Escort for walk trips to school by sex, 1990–2001.

| | Elementary (5–11) | | Middle (12–14) | | High (15–18) | |
|---|---|---|---|---|---|---|
| | Female | Male | Female | Male | Female | Male |
| *1990* | | | | | | |
| Alone | 35.0 | 44.0 | 58.6 | 65.4 | 73.7 | 76.1 |
| With HH Adult | **14.9** | 7.7 | 3.2 | 2.7 | 1.8 | 3.5 |
| With HH Minor | 40.2 | 41.6 | 26.5 | 16.9 | 9.4 | 7.2 |
| With Non-HH Member | 10.0 | 6.7 | 11.7 | 14.9 | 15.1 | 13.2 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |
| *1995* | | | | | | |
| Alone | 14.9 | 19.8 | 40.2 | 51.6 | **37.0** | **70.2** |
| With HH Adult | 32.2 | 28.5 | **11.5** | **0.3** | 3.0 | 1.9 |
| With HH Minor | 33.8 | 31.6 | 14.2 | 22.8 | 8.6 | 10.3 |
| With Non-HH Member | 19.1 | 20.1 | 34.1 | 25.2 | 51.5 | 17.7 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |
| *2001* | | | | | | |
| Alone | 23.3 | 25.8 | **39.5** | **70.2** | 71.2 | 58.6 |
| With HH Adult | 45.3 | 34.7 | 5.8 | 1.1 | 0.7 | 5.3 |
| With HH Minor | 18.6 | 23.4 | 29.3 | 16.9 | 14.6 | 15.7 |
| With Non-HH Member | 12.8 | 16.2 | 25.4 | 11.8 | 13.5 | 20.3 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

Bold denotes the difference between males and females is significant at $p < 0.05$.

their child permission to travel independently. Statistically significant gender differences emerged in this metric at 5th grade and continued into high school. Parents were less likely to give females permission to travel alone compared with boys of the same age.

The in-depth qualitative studies undertaken by geographers offer a basis for explaining these observations. Research done in the 1970s in the US and UK found that parents were quite concerned about sexual molestation of girls and therefore limited their time in the public realm (Matthews, 1992). At the same time, boys were given substantial independence around age 10 in accordance with the idea that "boys will be boys" and are less vulnerable to stranger danger than girls (Hart, 1979). While less discussed in the literature, this could also explain why a significant proportion of parents expect to restrict travel freedom for high school girls. There is no evidence that parents' intention to limit the travel freedom of high school girls comes to fruition as there are few gender differences in the travel pattern of high school male and females.

### 4.3. Multivariate analysis

The simple proportions revealed strong sex differences in biking to school and modest to non-existent differences in other modes. However, the descriptive analyses highlighted the strong influence of demographic factors such as age on mode choice. Multinomial logit models were developed to better control for this and other demographic factors. The models focused on trips of less than 2 miles – a common cut point where many school districts provide school bus service – for students aged 5–14 (McDonald and Howlett, 2007). The travel decisions of older students are complicated by the transition to driving and therefore best explored separately. Rural areas were also excluded from the analysis because of the different conditions in those areas. By simultaneously controlling for multiple individual and household factors, the logit models provided the most efficient test of whether there are gender differences in school travel.

For 1977–1995, multinomial logit models analyzed three modal options: being driven to school, walking, or taking transit/school buses. Biking was excluded from these models because the samples were too small to allow a robust set of covariates. For 2001 and 2009, biking was included as a fourth travel option. The models controlled for distance to school, age, race, vehicle ownership, single parent status, and location in region. From 1977 to 1990, trip distance was available as a two categories variable (<1 mile, 1–1.99 miles); from 1995 to 2009, distance information was continuous though users tended to report in common increments (e.g. 1/2 mile, 1 mile). Data from these later years was recoded as a categorical variable (<0.5 miles, 0.5 miles, 0.51–0.99 miles, 1 mile, 1.01–1.99 miles). Density of a household's block group was available for 1990–2009. For 1977 and 1983, only information on whether the residence was in the census-designated center city area was available.

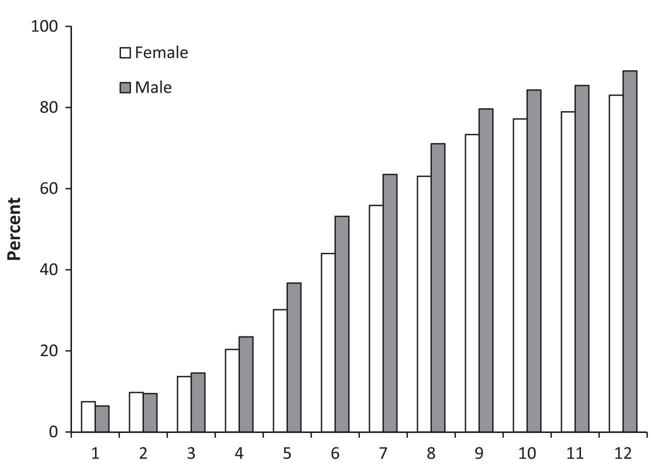


**Fig. 1.** Cumulative proportion of students with permission to walk or bike without an adult by grade.

The modeling had two goals. The first was to test whether males and females responded differently to the factors that affect walking. In other words, were the coefficient vectors equal for males and females? This required a Chow-type test. However because logit models are conditioned on the variance of unobserved factors, a standard Chow test would fail to account for these scale differences (Swait and Louviere, 1993). The Louviere–Swait test is a modified Chow test accounting for potential differences in variance between males and females by adding a scale parameter based on sex. To make the problem identifiable, only the ratio of the male to female scale parameters was estimated, i.e. the scale parameter for males is arbitrarily set to 1. The likelihood ratio was then used to test whether the coefficient vectors are equal (allowing the alternative specific constants to vary), i.e. $\beta_F = \beta_M$. This was done by comparing the log likelihood of the joint model to the sum of the log likelihood of the female only and male only models.

$$\text{Joint Model}: P_{ni} = \frac{\exp\left(V_{ni}\lambda_F I_{sex_n=female}\right)}{\sum_j \exp\left(V_{nj}\lambda_F I_{sex_n=female}\right)},$$
$$V_{ni} = \beta_{0,i} + \beta_{1,i} * I_{sex_n=female} + \beta_{M+F,i}X$$

$$\text{Female Only}: P_{ni} = \frac{\exp(V_{ni})}{\sum_j \exp(V_{nj})}, \quad V_{ni} = \beta_{0,i,F} + \beta_{F,i}X$$

$$\text{Male Only}: P_{ni} = \frac{\exp(V_{ni})}{\sum_j \exp(V_{nj})}, \quad V_{ni} = \beta_{0,i,M} + \beta_{M,i}X$$

$$\text{Louviere} - \text{Swait Likelihood Ratio Test}: -2[LL(\text{Joint Model}) - (LL(\text{Male}) + LL(\text{Female}))]$$
$$\text{dof} = \#\ \text{of Elements in}\ \beta_F + 1$$

The second goal was to test whether females were less likely to walk or bike to school than males even if they had similar responses to explanatory factors such as age and trip distance. So even if there were no significant differences in the coefficients on explanatory variables between males and females, did the alternative specific constant differ between males and females? This is simply a test of whether the coefficient on the female dummy variable is significantly different from zero and is appropriate when the Louviere–Swait test shows no differences in coefficient vectors. Borrowing the previous notation, this was a test that $\beta_1 = 0$ with $\beta_F$ constrained to equal $\beta_M$.

The Louviere–Swait test showed no evidence that the coefficients on explanatory variables differed between males and females, i.e. there was no reason to reject the null hypothesis of equality between $\beta_F$ and $\beta_M$ (Table 4). This means that variables like trip distance and density do not have differential effects on the utility of each travel mode for males vs. females. In addition, there was no evidence that the variance of unobserved factors, i.e. the scale factor $\lambda$, varied between males and females. Therefore final models did not include a scale factor. Full model results are available from the author upon request.

While there was no evidence of differing responses to the variables of interest, models estimated jointly for males and females suggested that females were less likely to walk or bike to school for short trips. Specifically the coefficient on the female dummy variable in the walk and bike utilities was always negative with one exception (walk utility in 2001). For biking, the multivariate models reinforced the descriptive findings. Females are significantly less likely to bike to school than males. The story is more complex for walking. Females are generally less likely to walk to

**Table 4**
Logit model gender effects for trips to school of less than 2 miles.

| | 1977 | 1983 | 1990 | 1995 | 2001 | 2009 |
|---|---|---|---|---|---|---|
| *Louviere–Swait likelihood ratio test: $\beta_F = \beta_M$* | | | | | | |
| ($p$-Value) | $\chi^2$ = 14.69 (0.547) | $\chi^2$ = 19.68 (0.235) | $\chi^2$ = 23.75 (0.095) | $\chi^2$ = 20.33 (0.206) | $\chi^2$ = 12.32 (0.722) | $\chi^2$ = 17.71 (0.278) |
| *Logit model coefficients on female variable* | | | | | | |
| Walk utility ($p$-value) | −0.229 (0.34) | −0.636 (0.11) | −0.371 (0.02) | −0.507 (0.00) | 0.00301 (0.98) | −0.155 (0.08) |
| Bike Utility ($p$-Value) | | | | | −0.772 (0.01) | −0.517 (0.01) |
| *Discrete effects of being female on* | | | | | | |
| Probability of walking | −0.049 | −0.079 | −0.062 | −0.054 | −0.006 | −0.015 |
| Probability of biking | | | | | −0.016 | −0.014 |
| N | 596 | 211 | 983 | 1945 | 2773 | 3967 |

school for short trips, but the effect was only significant in 1990 and 1995. In 2009, the coefficient was at the edge of statistical significance ($p = 0.08$).

To better understand sex differences, it is helpful to translate the model coefficients into estimates of how sex affects the probability of walking or biking to school. This discrete effect was estimated as the average over the sample of each individual's predicted probability of walking if the respondent were female less the predicted probability if the individual were male (Train, 2003). The results showed that the effects of sex on walking to school have decreased over time, but being female was always associated with a decrease in walking (Table 4). In 1977, being female was associated with a 4.9% point decrease in the probability of walking all else being equal. In 2009, being female was associated with a 1.5 percentage point decrease.

## 5. Implications for planners and researchers

The models and simple averages provide evidence that females are somewhat less likely to walk to school than males, with the differences narrowing in recent decades. However, the lack of strong differences in walking to school does not imply that females have begun walking as much as males, but rather that both groups have become equally unlikely to walk.

In contrast to walking, strong sex differences exist in biking to school in the US. This is a particular concern because studies of adult biking suggest women in the US are less likely to bike than men (Garrard et al., 2008). While no studies have looked at the lifecycle effects of bicycling, it is certainly intriguing that gender differences in cycling emerge at such a young age in the US. This stands in contrast to countries where biking is more common. A study of 9-year olds in Denmark found equal rates of biking (38%) to school among boys and girls (Cooper et al., 2006) and in Jiangsu Province, China approximately two-thirds of 12–14 year old boys and girls cycled to school (Shi et al., 2006).

For advocates and policymakers interested in increasing walking and biking to school, these findings suggest the need for attention to gendered travel behavior. But the findings do not fully explain the mechanisms causing differences between males and females. The data suggest that parental limits on mobility may be stronger for females than males as evidenced by differences in when children were allowed to travel without an adult. This argues for creating interventions that affect parental behavior. However, this approach privileges parental perspectives without recognizing children's agency (Thomsen, 2004). Could gender differences emerge from different travel preferences between boys and girls? Or do gender differences emerge from complex interactions between parents and children? Even if parents place equal restrictions on males and females and both sexes have similar preferences for walking and biking, differences could emerge if males are more likely to negotiate with parents about the rules governing travel. Further research is needed to sort out these mechanisms and provide a more rigorous explanation for observed differences.

Nevertheless, existing programs can address some of the causes of gender differences. If parental concerns limit walking and biking for females, then organized parental escorts might overcome those fears. These efforts could mimic the existing "walking school bus" programs where a designated parental escort walks a group of children to school at a set time and route (Collins and Kearns, 2005). If youth travel preferences are key factors in gender differences, then school or community-based encouragement programs might change behavior. For example, the Boltage program offers individualized encouragement to bike to school. Schools adopting this program could focus on ensuring that substantial numbers of females enroll in the program.

## 6. Conclusion

This study found that males were somewhat more likely to walk to and from school than females but the differences were generally not statistically significant. In contrast, males were two to three times more likely to bike to and from school than females. The observed differences in walking and biking to and from school may result from females' being less likely to have permission to walk or bike without an adult than males of the same age. These differences in permission to travel independently emerge around 5th grade and continue through high school. These results suggest that policymakers and advocates for increasing active transportation to school should pay attention to gendered travel behavior by developing interventions that address parental concerns about students traveling alone and encourage females to take part in active transport programs. Further research is needed to understand how gender differences in school travel emerge.

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