



An examination of children's school travel: A focus on active travel and parental effects

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ABSTRACT

Concerns regarding children's health and physical activity levels have prompted a growing interest in understanding the school mode choice decision. Walking and biking to school can help school-age children achieve recommended daily physical activity levels. The growing literature in this area has provided valuable insights but has often failed to adequately consider the influence of parents on children's decision making. This study aims to provide additional insights by examining the school mode choice with a focus on active travel and the role of parental effects. A multinomial logit model was estimated for children's school mode choice using the 2009 National Household Travel Survey with the add-on sample for Texas. A comprehensive set of variables, including individual and household characteristics, built and travel environment measures, and parental characteristics and attitudes, were found to be influential on the decision of active travel to school. Although the focus of this study is on children's school mode, a model examining parent's active travel was also estimated to provide a picture of parents and their own active travel decisions through a Poisson count regression model for the parents' non-motorized travel frequency (weekly). Findings strongly suggested that mothers' concerns regarding traffic conditions in the neighborhood can discourage children's active mode use. In contrast, fathers' work flexibility seemed to facilitate more non-motorized school travel. Similarly, many factors were important in determining non-motorized trip frequency. A flexible work environment, particularly for the mothers, was observed to increase the overall trip frequency of parents. The results from this study corroborate the findings from several earlier studies while also indicating new factors not previously identified. The work done in this study can be extended in several directions. One particularly interesting avenue of future research is to model the two decisions in a joint model to identify the causal direction while accounting for unobserved factors.

1. Introduction

Between 2003 and 2004, fewer than half of U.S. children aged 6–11, and just 8 percent between the ages of 12 and 15, met recommended physical activity guidelines (Troiano et al., 2008). These figures are especially worrisome given that nearly one-third of children living in the United States are either overweight or obese (Ogden et al., 2014).

Concerns regarding children's health and physical activity levels have prompted a growing interest in understanding the school mode choice decision. Most research has found that children who walk or bike to school tend to be more physically active overall

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(Alexander et al., 2005; Cooper et al., 2005; Faulkner et al., 2009), even when discounting the school commute itself (Roth et al., 2012). While it is unclear whether or not the relationship between active travel to school and physical activity is causal, encouraging walking or bicycling to school may help children reach recommended levels of daily physical activity. Shifting vehicle trips to active modes could additionally ease congestion and create a safer, more walkable environment. During the morning weekday peak period, trips to school by private vehicles account for over 10 percent of all vehicle trips made in the United States (National Center for Safe Routes to School, 1969).

Active travel to school was once a common occurrence but has become rarer over time. In 1969, nearly half of K–8 students primarily walked or biked to school in the United States, but by 2009, this share had fallen to 13 percent (National Center for Safe Routes to School, 1969). This decline in active travel to school can only partially be explained by rising commute distances, suggesting that other factors are at play. Understanding what these factors are and how they influence the school travel decision will ultimately allow for the implementation of more informed policy measures encouraging active travel modes and reducing vehicle trips to school.

While a number of studies have examined children's active travel, it is important to identify the determinants of active modes specifically for the school commute because they may differ from those influencing active travel for other purposes (Steinbach et al., 2012). The growing literature in this area has provided valuable insights into the school mode choice decision but has often failed to adequately consider the influence of parents, whose travel decisions are typically intertwined with those of their children. The same effect might also exist for parents' travel regarding the influence of children (Vovsha and Petersen, 1921). In addition, attitudes and lifestyle-related factors are typically not captured by analysts in household surveys but may nevertheless be critical to both the school and work commute mode choice decisions. Motivated by this discussion, the researchers of this study focused on examining children's school mode choice decision, with an emphasis on active travel, using 2009 National Household Travel Survey (NHTS) add-on sample data for Texas.

2. Literature review

2.1. Determinants of active travel to school

2.1.1. Distance to school

Most school mode choice research has found that a short commute distance is the strongest predictor of active school travel (Babey et al., 2009; Dessing et al., 2004; Ewing et al., 1895; Larsen et al., 2009; Mcmillan et al., 2006; Mitra et al., 2010; Schlossberg et al., 2006; Easton and Ferrari, 2015; Rodríguez-López et al., 2017). In 2011, Stewart (Stewart, 2011) conducted a comprehensive review [of 42 studies] to identify the variables associated with active school travel. Among the reviewed studies, distance to school was found to have the clearest correlation with active travel to school. In their 2015 study, Easton and Ferrari (Easton and Ferrari, 2015) used data on children aged 11–16 years who attended schools in the UK, and found distance between home and school as the most significant individual-level factor by far. The findings of Mitra et al. (Mitra et al., 2010) also supported this notion by their findings for children aged 11–13 years in the city of Toronto, Canada. The distance between residence and school locations was found to be the most significant factor and “a 1-km (0.62-mi) decrease in travel distance increased the odds of walking by 0.71–0.72 times”. More recently, Rodríguez-López et al. (2017) studied the threshold distance associated with walking to school for students aged 7–18 years from Spain. The study found the threshold distance for walking to school as 875 m (0.54 miles) for children and 1350 m (0.84 miles) for adolescents.

The effect is apparent for both walking and bicycling trips, but more prevalent for walking given its greater sensitivity to travel distance. Surveys of high school students in Ireland indicated that walking rates to school declined sharply for distances beyond 1.5 miles, while most bicycling trips were within 2.5 miles of school (Nelson et al., 2008). Similarly, Schlossberg et al. (Schlossberg et al., 2006) reported an approximate 1.5-mile active school mode travelshed for middle school students in Oregon, within which the large majority of walking and bicycling trips occurred. With school commute distances rising (Center, 1969) and education trending more toward private schools and large consolidated public schools (Fyhri et al., 2011), trip distances will continue to contribute to declining active travel rates.

2.1.2. Sociodemographic traits

Boys have been found to actively travel to or from school at a higher frequency than girls across all levels, including elementary school (Mcmillan et al., 2006), middle school (Larsen et al., 2009), and high school (Robertson-Wilson et al., 2008), although the disparity may become less pronounced as children age. Analysis of 2001 NHTS data revealed similar rates of active school travel for high school students (McDonald, 2008), while Martin et al. (Martin et al., 2007) found no difference in active travel rates to school between genders among a nationally representative sample of 9- to 15-year-old students. Boys are especially more likely to bicycle to school, with studies in Australia, England, Ireland, and the United States all reporting bicycling rates approximately three times greater for boys than for girls (Nelson et al., 2008; Leslie et al., 2010; Merom et al., 2006; Sidharthan et al., 2011; Van Sluijs et al., 2009). The active school travel gender gap mirrors the overall higher prevalence of physical activity among boys (Van Sluijs et al., 2009; Loucaides and Jago, 2008; Santos et al., 2009), and could partially be explained by differing levels of independent mobility. Due to cultural factors, some parents are likely to be more protective of girls and place greater restrictions on their independent travel.

Findings on the effects of age on school mode choice are more varied. Several studies have reported that after controlling for other factors, younger students are more likely to actively travel than older students across a range of ages (Babey et al., 2009; Mcmillan

et al., 2006; Buliung et al., 2009; Wong et al., 2011), yet other studies have discovered the opposite relationship (Martin et al., 2007; Sidharthan et al., 2011; Deka, 2013; Timperio et al., 2006). As would be expected with the addition of a new travel choice, walking and biking rates decline when children reach driving age (McDonald, 2008), but overall, age effects do not appear to be consistent. Older students tend to walk further to school than younger students (Steinbach et al., 2012) and have longer average travel distances. Because elementary school students often attend nearby neighborhood schools, commute distances typically rise as they transition to more distant middle schools and secondary schools. Wong et al. (Wong et al., 2011), for example, found that middle school students had higher rates of active school travel than high school students, but shorter average travel distances.

Socioeconomic status has also been linked to the school mode choice decision. Most research has linked children from higher-income households to a lower likelihood of active school travel and to higher rates of being driven to school (Babey et al., 2009; Larsen et al., 2009; Mitra et al., 2010; Sidharthan et al., 2011), although 2009 NHTS data indicate that higher-income students had a higher prevalence of walking (Deka, 2013).

2.1.3. Built environment

Researchers have examined several aspects of the built environment in relation to active school travel, with differing results. Students in urban areas appear to be more likely to actively travel to school (Babey et al., 2009; Merom et al., 2006), as do those in more walkable neighborhoods (Giles-Corti et al., 2011). Low residential density and land-use mix have also been associated with active school travel for middle school children in London, Ontario (Larsen et al., 2009), but were not significant for studies in Toronto (Mitra et al., 2010) or Gainesville, Florida (Ewing et al., 1895). The same study conducted in Gainesville found that sidewalk density was positively related to the likelihood of walking to school, but no significant effects were found for the proportion of sidewalks along the school route on children's independent mobility in Norway (Fyhri and Hjorthol, 2009). Intersection density and lower dead-end density were positive predictors of walking to or from school for middle school students in Bend and Springfield, Oregon, but not bicycling (Schlossberg et al., 2006). In contrast, Mitra et al. (2010) reported a negative correlation between intersection density and walking to school for middle school students in the more urban setting of Toronto. It is also possible that intersection density is moderated by traffic volume; Giles-Corti et al. (2011) found that students were less likely to walk in areas with high connectivity if traffic volume was high but more likely to walk when traffic was low. Other built environment factors associated with an increased likelihood of actively commuting to school include perceptions of neighborhood safety and the presence of neighborhood recreational facilities (Leslie et al., 2010). On the other hand, the lack of traffic signals or crossings and the need to traverse a freeway, highway, or arterial to get to school can present significant barriers to the active school commute (Timperio et al., 2006).

2.1.4. School characteristics

School-level indicators can also be used to predict school mode choice decisions. Public school students, for example, are more likely to actively travel to school than private school students (Babey et al., 2009; Deka, 2013) or those attending magnet schools (Wilson et al., 2010), and larger schools demonstrate lower levels of active travel than smaller schools. These results are not necessarily surprising since larger schools, like private schools, tend to draw from a more diverse geographic pool of students, but effects are still evident even after controlling for differences in travel time (Ewing et al., 1895).

2.1.5. Trips to and from school

Active school travel tends to be more prevalent for the afternoon trip, suggesting that there is greater potential for increased active mode share for the journey to school in the morning. Studies measuring both segments of the school trip have typically reported that active travel rates rise by approximately 3–10 percentage points for the journey home, roughly matching an equivalent decline in vehicle trips (Larsen et al., 2009; Schlossberg et al., 2006; Merom et al., 2006; Buliung et al., 2009; Wong et al., 2011; Ridgewell et al., 2009). Because work and school start times are typically more closely aligned than finish times, it is generally easier for parents to drop their children off at school in the morning than it is to pick them up afterwards. The determinants of active school travel may also differ depending on the direction of the journey. Larsen et al. (Larsen et al., 2009), for example, noted that a lower income was associated with greater active travel for the trip home, but not the trip to school, possibly because lower-income parents had less flexibility in their work schedules.

2.2. Influence of parents

In addition to the aforementioned student, school, and trip-related factors, it is necessary to consider the influence of parents on school mode choice. Studies looking at the interdependence of parents' commute mode and children's school mode choice (Panter et al., 2010; Wen et al., 2008), have indicated that the travel decisions of parents are often directly tied to children's travel mode choices. Younger students requiring accompaniment or who are unable to travel independently will be especially reliant on parental decision-making.

2.2.1. Parental factors

Parental support for active travel has been linked by some to a greater likelihood of children walking or biking to school. Chaufan et al. (2012) found that students in California were three times more likely to walk or bike to school if parents considered the act fun or healthy. Children in England were similarly more likely to actively travel to school if they reported that their parents encouraged the act (Panter et al., 2010), though this effect may weaken for older students. Robertson-Wilson et al. (2008) found that perceived parental support for active commuting had no influence on active travel rates for high school students. Researchers have also

attempted to relate parents' physical activity levels to active school travel under the assumption that children with active parents are more likely to be active themselves. Studies conducted in California and in the United States at the national level indicate that there is a relationship between parents' physical activity and children's active school travel (Mcmillan et al., 2006; Martin et al., 2007), though another study in Southern California did not find a relationship (Sidharthan et al., 2011). In regards to general physical activity levels, Jago et al. (Jago et al., 2010) attempted to relate overall physical activity between children and parents using accelerometer data, but no significant associations were found.

Along with parental attitudes toward active travel, perceptions of convenience and safety may also factor into the school mode choice decision. For parents of children driven to school, convenience plays a strong role, especially because school trips can often be combined with the work commute (Schlossberg et al., 2006; Fyhri and Hjorthol, 2009; McDonald and Aalborg, 2009). As far as barriers to active school travel, for many parents, concerns over traffic safety and crime cause them to favor vehicle trips over active travel modes (Fyhri and Hjorthol, 2009; Ridgewell et al., 2009; Panter et al., 2010; Cole et al., 2007). Contradicting these findings, other studies have reported that parental perceptions of safety do not significantly impact the school mode choice decision (Babey et al., 2009; Mcmillan et al., 2006). Interestingly, distance may not be a strong deterrent of active travel for some. Ridgewell et al. (Ridgewell et al., 2009) reported that just 3 percent of middle school parents in Brisbane, Australia, who drove their children to school did so because of the length of the trip.

2.2.2. The escort decision

In the United States, nearly 90 percent of school trips are escorted, primarily by parents or school bus drivers (McDonald, 2008), while Queensland, Australia, has a parental school escort rate of 65 percent for children below Grade 8 (Cole et al., 2007). Understanding these decisions can be especially important when considering overall travel impact since unchained escort trips often represent an additional trip home, thus doubling travel costs (Cooper et al., 2005). According to 2009 NHTS data, 40 percent of parents who drove their children to school returned home immediately afterwards (National Center for Safe Routes to School, 1969).

A few studies have specifically analyzed the factors influencing the decision to escort children to school. He (2013) modeled the probability of a joint school trip between the child and parent. While active travel modes were not considered, results indicated that the closer a mother's workplace is to the child's school, the more likely it is that she will escort the child. In general, studies have found that mothers are approximately three to four times more likely to escort children to school than fathers (Mcmillan et al., 2006; McDonald, 2008; He, 2013). Longer working hours tend to decrease the likelihood of a parent making an escorted school trip, but this could be offset by having a flexible work schedule (He, 2013). Vovsha and Peterson (Vovsha and Petersen, 1921) determined that parents working part-time were more likely to escort their child to school. They also measured the impact of route deviation on the escort decision. Schools that were further out of the way from the workplace only resulted in a lower likelihood of escorting for the trip to school, not for the trip home.

Yarlagadda and Srinivasan (2008) developed an econometric model to simultaneously model school mode choice and the decision to escort. Working mothers were more likely to escort children by car to school but less likely to escort on the way back, likely due to it being more difficult to coordinate work and school finish times. Longer commute times were negatively associated with driving a child to school but had no effect on driving children home, and land-use and built environment variables had little impact on mode choice. Younger children and girls were more likely to be escorted by mothers, while boys and older children were more likely to actively travel or drive independently.

Deka (2013) developed another joint model that allowed for bidirectional influences between children's school mode choice and parents' commute mode choice. Results indicated that parents' commute mode significantly impacted the mode choice to school, but children's school mode choice had no effect on the mode choice to work.

The review conducted by Stewart (2011) identified 480 variables that are associated with active travel with most influential factors being distance, income, traffic and crime fears, and parental attitudes and schedules. The literature review presented in this paper supports this assertion, and clearly indicates a wide variety of factors influencing the school mode choice decisions. While there are differences across studies, several factors were common. For example, distance to school was one of the most influential factor, especially for walking behavior. Gender differences were observed, with males being more likely to actively travel to/from school though this effect was more pronounced for younger children. The built and travel environment and when the trip has been made significantly affected the active travel decision. In addition to the infrastructure that might encourage walking or biking, perceptions of the built or travel environment was also found to be important in decision making process. Finally, parents have always been noted to play a significant role in children's active travel to school. However, the results of the studies were not as consistent or strong as the other variables like distance to school. In an effort to contribute to the growing body of the literature on school travel, this study aims to provide additional insights by examining the school mode choice with a comprehensive set of variables, including individual and household characteristics, built and travel environment measures, and parental characteristics and attitudes, all in a single model.

3. Data and methods

The main data for this project were drawn from the 2009 NHTS and the 2009 NHTS add-on sample for the state of Texas. The single-day travel diaries provided detailed information on over 20,000 Texas households. Among these households, this study focused specifically on those with children between the ages of 5 and 15, resulting in a final sample comprising 2783 children and 4886 parents. Personal, travel-related, and work-related variables were developed at the individual and household levels, as well as variables characterizing parental attitudes toward travel. The details of all NHTS variables can be found in the 2009 NHTS documentation and codebook: <https://nhts.ornl.gov/documentation.shtml>.

In particular to attitudinal questions, individuals were asked to indicate their level of concern for general travel-related issues: “Of the following issues, please tell me which one is the most important to you?” with the following issues listed: “highway congestion, access to or availability of public transit, lack of walkways or sidewalks, the price of travel including things like transit fees, tolls and the cost of gasoline, aggressive or distracted drivers, and safety concerns like worrying about being in a traffic accident”. In addition to asking for these general travel-related issues, parents were asked for issues pertaining specifically to their child’s school commute: “Please tell me how much each of the following affects your decision to allow {child’s name/age/sex} to walk or bike to or from school” with the following issues listed: “the distance between home and school, the amount of traffic along the route, the speed of traffic along route, violence or crime along route, poor weather or climate in their area”. Parents were asked to provide a rating on a scale of 1–5 (ranging from ‘not an issue’ to ‘a serious issue’) for each of these issues. Interested readers are referred to actual NHTS 2009 questionnaire for additional details on questions: <https://nhts.ornl.gov/2009/pub/QuestionnaireFieldDocuments2009.pdf>.

To go along with the NHTS data, several supplementary data sources were acquired in order to characterize the neighborhood environment around respondents’ residences. U.S. Census American Community Survey data from 2005 to 2009 were used to create neighborhood demographic measures at the block group level, and retail employment (tract level) was used as a proxy for the availability of nearby retail opportunities. Spatial datasets representing Texas roadways and land cover [2006 National Land Cover Database) were also used in the development of measures of accessibility and developed land use. In addition, school locations were geocoded with the aid of the Texas Education Agency’s School Database, which allowed for the development of the same set of spatial and built environment measures around children’s schools.

The analyses started with a descriptive analysis emphasizing some important points of active travel to school decision. Following the descriptive statistics, a multinomial logit (MNL) model was estimated to study determinants of children’s school travel mode decision with children’s school mode as the dependent variable. School mode consisted of five categories: private vehicle to and from school, walk/bike to and from school, school bus to and from school, combination private vehicle and walk/bike, and combination private vehicle and school bus. Private vehicle to and from school was the most frequently observed alternative and was used as the reference category in the MNL model. Although the focus of this study is on children’s school mode, a model examining parent’s active travel was also developed to provide a picture of parents and their own active travel decisions. Parents’ active travel trips were then modeled at the household level using a Poisson count regression model. The count dependent variable used was the number of walk and bike trips (including for exercise) taken by parents in the last week, aggregated at the household level. The final model results indicated a good model fit and a statistically significant chi-square statistic ($p < 0.05$). Significant improvements were obtained with the final models compared to their corresponding intercept-only models. The data compilation was conducted in SPSS statistical package, and the model estimation was completed using GAUSS, a matrix programming language.

4. Results

4.1. Descriptive statistics

Overall, levels of active school travel in Texas were lower than national rates. Over half of the children traveled both to and from school using a private vehicle, while approximately one-third traveled by school bus for at least one leg of the journey. Moreover, 7.4 percent of children traveled to and from school using an active mode. The active mode share rose to 11 percent when those who walked or biked in only one direction were included. There were some differences in the trip to school in the morning and the trip home in the afternoon (Fig. 1).

Additionally, more active modes were observed for the trip home after school when it is often more difficult for parents to accommodate their work schedules in order to drive their children. While this finding was consistent with previous research, the magnitude of the disparity was smaller than what other research had reported. Vehicle mode share declined by 7.6 percentage points after school, but the consequent increase in walking rate (+ 2.4 percentage points) was somewhat lower than has been reported by

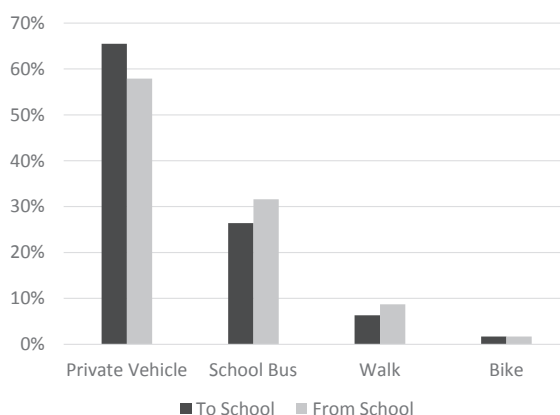


Fig. 1. Children’s mode share to and from school.

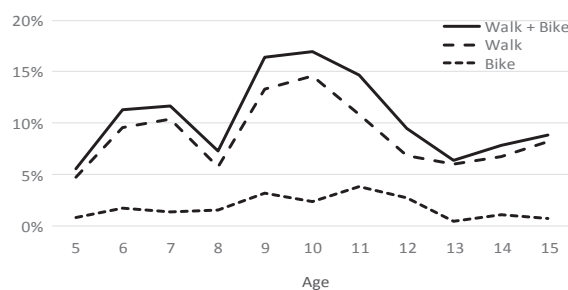


Fig. 2. Proportion of children who used an active mode as part of their school commute by age.

previous studies. Instead, a greater proportion of morning vehicle trips shifted to school bus travel. This may be indicative of the auto-oriented cities typically found within the Texas setting. Bicycle mode share was low—at just 1.7 percent—and remained unchanged between the journeys to and from school, as expected.

Children's active travel mode share also differed depending upon age and distance. The youngest students had the lowest levels of walking and biking, which is presumably indicative of lower levels of independent mobility. Active mode share peaked between the ages of 9 and 10, after which walking and biking rates trended downwards (Fig. 2). This can be partially accounted for by a corresponding increase in average trip distances to school. As children progress to middle school and beyond, trip distances tend to increase as the typically larger schools draw from a wider geographic region. Unsurprisingly, students living closer to school were more likely to actively travel. In fact, 57 percent living within 0.25 mile of their school walked or biked, but that proportion declined steeply with increasing distance. About one-third of children living between 0.25 and 0.5 mile from school walked or biked, and only 16.2 percent of those living within 0.5 mile to 1 mile walked or biked.

Much like children, parents walked much more frequently than they biked. A higher proportion of women had walked for transportation in the previous week (67 percent to 63 percent), but bicycling was much more prevalent among men (13.5 percent to 7.7 percent). At the household level, parents averaged 6.9 combined walk and bike trips in the previous week (median 5.0), with single-parent households averaging 4.4 (median 2.0) and multi-parent households averaging 7.6 (median 5.0). Moreover, 81.2 percent of households totaled five or fewer walk trips in a week, and just 5.2 percent of households had more than one bike trip in the previous week.

Looking at the issues related active travel to school, the two most important issues identified by parents were the amount and speed of traffic along the school route. Almost half of the parents indicated these as serious issues preventing them to allow their kids use active travel to school. Indeed, only around 10–15 percent of parents did not consider traffic congestion or speed as an issue for walking and biking to/from school. The next important factor was the distance between home and school. More than 40 percent of parents thought distance as a serious issue affecting their decision to allow their children to walk or bike to/from school.

4.2. What are the factors influencing active travel to school? School mode choice model

Table 1 presents the findings from the school mode choice model, which revealed that several factors increased the likelihood of walking, biking, or taking a school bus to or from school compared to being driven.

As discussed in the literature review, distance to school is frequently cited as one of the most significant factors influencing the active mode choice decision (Babey et al., 2009; Dessing et al., 2004; Ewing et al., 1895; Larsen et al., 2009; Mcmillan et al., 2006; Mitra et al., 2010; Schlossberg et al., 2006; Easton and Ferrari, 2015; Rodríguez-López et al., 2017; Stewart, 2011). Broadly consistent with the school travel literature, in the current study, active travel rates were also found to be most prevalent in travel distances under 2 miles. Because of the relatively slow speeds for walking and bicycling, these modes are particularly sensitive to travel distance. In the rural United States, where destinations are widely spaced and the underlying infrastructure is vehicle-supportive, driving maintains a high utility for the vast majority of trips (Fan et al., 2015). In more urbanized areas, as trip distances shorten and roads become more congested, active modes become much more competitive. Children from lower income households and children attending a public school were also had a higher likelihood of using active travel to school. Another consistent finding with the literature was observed with the gender impact. As noted in many studies [e.g. 13–14, 20, 22, 25–28], boys were also more likely to actively travel than girls, potentially indicating their higher levels of independent mobility. The average grade that children were allowed to walk or bike to school unaccompanied was no different between boys and girls, but a significantly higher proportion of girls had parents who would never allow their child to walk or bike to school alone. Upon controlling for other factors, age did not significantly impact the school mode choice decision; previous studies have shown inconsistent findings with respect to age.

Parental characteristics and attitudes also strongly influenced children's school mode. As discussed earlier, studies found that for many parents traffic safety was an important barrier to active travel to school (e.g. Ridgewell et al., 2009; Panter et al., 2010), which was supported with the current study's findings. Greater parental concern for traffic congestion on the school route reduced the likelihood of active travel, but concern for weather on the school route had the opposite effect. The positive association between concern for weather and active travel likely reflects the negligible impact weather has on vehicle trips. On the other hand, the increased degree of exposure for walkers and bicyclists make them far more sensitive to, and cognizant of, weather-related threats (which in Texas primarily consist of thunderstorms and intense heat). Apparently, even though the parents cited weather as an issue

Table 1
Children's school mode MNL model results.

Model variables		Children's school mode											
Category	Variable	Private vehicle		Walk/Bike		Private vehicle + Walk/Bike		School bus		Private vehicle + School bus			
		Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat		
Constants	Alternative specific constant	-	-	-5.260	-6.58	-3.339	-9.46	-0.619	-1.99	-1.250	-6.73		
	Male	-	-	0.480	2.74	0.569	2.57	-0.264	-2.42	-0.295	-2.07		
	Aged between 5 and 9 years old	-	-	-	-	-0.854	-3.75	-	-	-	-		
	African American	-	-	-	-	-	-	0.270	1.36	-	-		
Household characteristics	Attends after school care	-	-	-	-	0.464	1.40	-0.836	-3.56	0.712	3.62		
	Attends private school	-	-	-0.617	-1.51	-1.727	-2.32	-4.614	-6.46	-2.635	-6.25		
	Income: Less than \$35,000	-	-	0.636	2.56	-	-	0.742	4.66	-	-		
	Income: \$35,000-\$65,000	-	-	-	-	-	-	0.440	3.25	-	-		
Residential (neighborhood) characteristics	Number of household vehicles	0.160	3.22	-	-	-	-	-	-	-	-		
	Rural area	-	-	-	-	-	-	0.392	3.15	0.645	4.65		
	Home owner	-	-	-0.553	-2.15	-	-	-0.446	-2.84	-	-		
	Resides in an apartment/condominium	-	-	-	-	-	-	0.722	3.43	-	-		
Parental characteristics	Distance to school: < ¼ mile	-	-	4.980	10.13	3.122	9.24	-1.247	-4.45	-1.234	-2.61		
	Distance to school: ¼-½ mile	-	-	3.721	7.48	2.403	7.23	-1.387	-5.91	-0.852	-2.84		
	Distance to school: ½-1 mile	-	-	2.848	5.65	1.646	4.84	-1.146	-6.30	-	-		
	Distance to school: 1-2 miles	-	-	1.667	3.17	-	-	-0.633	-4.77	-0.297	-1.76		
	Population density (block group level)	-	-	0.0002	2.85	-	-	-	-	-	-		
	Percent population under 18 years old (block group level)	-	-	-	-	-	-	1.876	2.70	-	-		
	Percent Asian population (block group level)	-	-	1.418	1.18	3.578	2.88	2.278	2.86	-	-		
	Percent Hispanic population (block group level)	-	-	-1.260	-3.20	-	-	-	-	-	-		
	Percent family households (block group level)	-	-	1.537	2.08	-	-	-	-	-	-		
	Percent medium and highly developed land (census tract level)	-	-	-	-	-	-	0.766	2.50	-	-		
Parental characteristics	Total retail employment (census tract level)	-	-	0.0004	2.51	-	-	0.0002	1.80	-	-		
	Length of roadways (census tract level)	-	-	-0.001	-1.39	-	-	-0.001	-2.24	-	-		
	Single parent	-	-	-0.407	-1.85	-	-	-	-	-	-		
	Walk/Bike issue for school: Distance between home & school	-	-	-0.290	-1.34	-0.470	-1.70	-	-	-	-		
Parental characteristics	Walk/Bike issue for school: Amount of traffic along route	-	-	-0.404	-1.89	-0.387	-1.45	0.354	3.33	0.205	1.52		
	Walk/Bike issue for school: Poor weather or climate in area	-	-	0.705	2.18	-	-	-	-	-	-		
	Education: Less than high school	-	-	-	-	-	-	0.304	1.36	-	-		
	Flexible work start time	-	-	-	-	-	-	0.270	2.01	0.472	3.07		
Parental characteristics: Female parent	Most important transportation issues: Price of travel	-	-	-	-	-	-	-0.414	-3.42	-	-		
	Most important transportation issues: Aggressive driving	0.240	1.91	-	-	-	-	-	-	-	-		
	Most important transportation issues: Safety concerns	-	-	-	-	-	-	-0.357	-2.62	-	-		
	Occupation: Clerical or administrative support	-	-	-	-	0.695	2.40	-	-	0.249	1.31		
Parental characteristics: Female parent	Occupation: Manufacturing, construction, maintenance, or farming	-	-	-	-	-	-	0.732	2.27	-	-		

(continued on next page)

Table 1 (continued)

Model variables		Children's school mode									
Category	Variable	Private vehicle		Walk/Bike		Private vehicle + Walk/Bike		School bus		Private vehicle + School bus	
		Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Parental characteristics: Male parent	Education: Less than high school	–	–	–	–	–	–	0.779	3.70	–	–
	Self employed	–	–	0.606	2.11	–	–	–	–	–	–
	Flexible work start time	0.319	2.81	–	–	–	–	0.216	1.52	–	–
	Occupation: Clerical or administrative support	–	–	1.303	2.49	–	–	–	–	–	–
	Occupation: Manufacturing, construction, maintenance, or farming	–	–	–	–	–	–	–	–	0.296	1.80

of concern in their children's active school mode use, it did not discourage them from allowing the children to use an active mode. Other significant parental factors were specific to either mothers or fathers. Children were more likely to be driven if they had a mother who expressed a greater concern for unsafe drivers or a father with a flexible work schedule. On the other hand, children with fathers' self-employed were more likely to walk or bike to/from school. While similar to some previous studies, the gender-specific nature of these findings further suggests that work-related characteristics are more influential for fathers than mothers and that the attitudes of mothers are more dominant in the school mode choice decision.

Several of the determinants of active school travel decision were common to the school bus travel decision, perhaps reflecting the absence of parents' participation in both walking/biking and in school busing, though some factors have opposing effects. Unlike active school travelers, children who lived within 2 miles of their school were less likely to commute by school bus. Likewise, parental concern for traffic congestion on the school route decreased the likelihood of walking or biking but was positively related to school bus travel. Built environment effects also differed between active and bus modes. Whereas walking and biking were more prevalent for children living in neighborhoods with a higher population density and retail employment, school bus travel occurred with greater frequency in rural areas. Children attending after-school programs demonstrated a higher propensity for a combination of school bus and vehicle travel, but were less likely to travel by school bus in both directions. Since school bus pickups tend to occur immediately at the conclusion of the school day, students in after-school programs need to be picked up by parents or find an alternative travel mode home.

4.3. Who are the parents?: Parents' active travel model

While the main focus of this study is on active travel to school, we have also developed a Poisson Count model to provide additional insights on who are the parents of these children and what are the factors influencing their general active travel decision. The decision for parents to walk or bike at the household level was governed by a combination of household, demographic, work-related, attitudinal, travel-related, and built environment characteristics (Table 2). Lower rates of active travel were associated with

Table 2
Parent's active mode count model results.

Model variables		Parents' active mode	
Category	Variable	Estimate	t – stat
Constants	Constant	1.920	70.58
Household characteristics	Income: Less than \$35,000	–0.118	–4.82
	Income: \$35,000 – \$65,000	–0.080	–4.00
Residential (neighborhood) characteristics	Urban area (Population: 50,000–199,999)	0.254	10.89
	Rural area	0.205	11.98
	Apartment/condominium	0.337	10.38
	Distance to school: < ¼ mile	0.051	1.93
	Distance to school: ¼ – ½ mile	0.115	4.52
	Percentage of Asian population (in block group)	1.210	11.65
	Total retail employment (in census tract)	–0.0001	–9.61
	Length of roadways (in census tract)	0.000004	7.06
Parental characteristics	Single parent household	–0.504	–20.58
	Walk/Bike issue: violence/crime along route	–0.102	–4.71
	Walk/Bike issue: amount of traffic along route	–0.059	–3.90
Parental characteristics: Female parent	Aged between 51 and 65 years old	–0.146	–4.72
	Aged > 65 years old	–1.947	–2.75
	Immigrant	–0.195	–8.03
Parental characteristics: Male parent	Flexible work start time	0.100	5.18
	Most important transportation issue: Lack of access to or availability of public transit	0.215	5.93
	Most important transportation issue: Lack of walkways or sidewalks	0.067	1.75
	Part time employed	0.133	7.02
	Have a regular work place	–0.114	–6.92
	Times used public transit in last month > 10	0.302	11.33
	Times worked from home in last month: > 5	0.119	2.39
	Aged between 36 and 50 years old	0.106	6.23
	Immigrant	–0.313	–11.51
	High school graduate (including GED)	–0.154	–6.89
	Most important transportation issue: Lack of access to or availability of public transit	0.215	5.59
	Most important transportation issue: Highway congestion	0.162	7.35
	Most important transportation issue: Lack of walkways or sidewalks	0.393	6.49
	Most important transportation issue: Price of travel	0.296	14.02
	Most important transportation issue: Aggressive driving	0.163	6.00
	Most important transportation issue: Safety concerns	0.195	7.17
	Part time employed	–0.146	–2.90
	Have a regular work place	–0.164	–10.36
	Times used public transit in last month > 10	0.171	6.56
	Times worked from home in last month: > 5	–0.150	–3.45

households having immigrant parents, older mothers, fathers with low levels of education, and low-income households. Transit use and living in a rural or small urban area were also associated with more walking and biking trips, while availability of nearby retail opportunities decreased walking and biking trips.

Similar to the determinants of active travel to school for children, parents' walk and bike trips were positively associated with concerns for traffic on the school route. General travel-related concerns, particularly for fathers, were significantly related to increased rates of parental walking and bicycling. Much like the effect of weather-related concerns on children's active school travel, this finding indicates that active travelers are more acutely aware of a number of traffic-related concerns. Walkers and bicyclists are forced to deal more directly with travel-related issues such as congestion, a lack of public transit or pedestrian facilities, and traffic safety. Some researchers have made a similar argument (e.g. [Zuniga, 2012](#)) contending that regular active travel appears to diminish parents' perceptions of barriers so that negotiation becomes second nature.

Along with attitudes, parents' work-related characteristics played a prominent role in the active travel decision. Mothers with more accommodating jobs in terms of location and start time were associated with higher household active travel rates, yet the opposite effect was found for fathers. It is not immediately clear why this divergent effect was split along gender lines, but it underscores the need to consider the independent effects of parents when evaluating household travel. Notably, children's variables did not impact parents' active travel, in contrast to the children's school mode choice model, which was strongly influenced by parental factors.

5. Conclusion

This study examined children's school mode choice and parents' active travel trips. Two distinct models were estimated for each decision. Overall, an opportunity appears to be present for increased active school travel among children in Texas. Rates of walking and biking to school were lower in Texas than the national average. Additionally, the lower rate of walking in the morning indicates that there are children able and willing to walk to school who do so only in one direction.

Findings from this research highlight the importance of parental attitudes and characteristics on the school mode choice decision, with notable differences between mothers and fathers. The travel-related concerns of mothers, in particular, acted as a deterrent to children's active school travel. Improvements to neighborhood safety and walkability would not only make it physically easier to reach destinations by active modes but also perhaps alleviate parental barriers to independent mobility. Work-related factors also influenced the way children traveled to school. Although flexible employment is often conceived as a way to ease the travel burden of parents, paradoxically, it can also make it easier for them to drive their children to school. While prior research has independently looked at the travel impacts of employment flexibility on the work commute and the school commute, it would be beneficial for future researchers to simultaneously assess their net effects. This study additionally shed light on the determinants of school bus travel. While it is a less frequently studied area of the literature, school bus travel often provides walking-related benefits, while its substantially higher mode share dictates that it can potentially be more impactful in substituting for private vehicle travel.

Distance to school was found to be one of the primary factors influencing the likelihood of active travel and partially explains the decline in walking and bicycling over the years. The movement away from neighborhood public schools toward more specialized charter and magnet schools and private schools is only serving to increase the average distance students must travel. School policy makers should keep in mind the travel implications of school district boundaries and alternative schooling opportunities. Rates of walking and bicycling to school have declined considerably over the last 50 years, but a better understanding of the many forces driving these decisions can help planners and policy makers combat this worrisome trend.

A limitation of this study is that the data used in this study is limited to Cities in the state of Texas and the results obtained here may not be applicable to cities in other parts of the country. The differences could occur due to differences in both the urban density and the climate. Modeling school mode choice using a comprehensive and rich list of variables provides valuable insights to the literature, and performing a similar study to other urban areas in the United States would add much value to the field. As a next step to the insights obtained from this study, it would be important to examine the interdependency between the two distinct choices, which will help identify the causal directionality of the two choice decisions. Understanding the primary causal direction of one choice on the other as well as the magnitude of the effect (relative to other factors) is essential in order to understand the policy implications of measures encouraging non-auto-dependent mode choices.

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