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Exploratory analysis of recent trends in school travel mode choices in the U.S.

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ABSTRACT

The study explores the recent trends in school travel using the 2017 National Household Travel Survey data. The study also investigates the exogenous factors affecting the school travel mode choice using random parameters multinomial logit (RPMNL) model. The results indicate that urban school trips range between 3 and 5 miles, whereas, average rural trips are longer than 6 miles. School commute times are higher among lower-income households. Further, the share of school bus and auto has declined while that of walking and biking has increased in 2017. This change is significant among high school students. Like other studies, the findings of the RPMNL model confirm that students within shorter distances from school are more likely to walk or bike to school. However, the likelihood of riding a school bus for distances >15 miles is higher than that of auto, indicating a policy implication to support school transportation budgets, especially in rural school districts. Lower-income households have a higher likelihood of riding the school bus. Females are more likely to use a car and less likely to bike to school. Interestingly, households with more than three vehicles are more likely to use the school bus compared to no-vehicle households. Children living in rented houses are less likely to ride the school bus or car. Also, an increase in gas price is indirectly but positively linked with walking, biking, and auto use. The findings from this study will assist policymakers in formulating policies and planning decisions towards improvements in the current school travel trends.

1. Introduction

There is a growing interest in the school travel modes used by elementary and secondary school children. In the 2014–15 academic year, about 50 million elementary and secondary students were reported to attend school daily with 55% of them transported by school buses. With approximately $24 million spent on school transportation, this translates to about $932 per pupil in public expenditure (Snyder et al., 2019). The number of children that walked or biked (active modes) to school has been on a declining trend over the past few decades (Ham et al., 2008; McDonald et al., 2011; Rothman et al., 2018) while children traveling to school in cars has been increasing (Sirard and Slater, 2008). Such shifts in school travel modes have raised many legitimate concerns for the policymakers, including its contribution to childhood obesity (Centers for Disease Control and Prevention, 2018; Larouche et al., 2014) and environmental problems such as pollution (EPA, 2003; Sirard and Slater, 2008). Besides, different school travel modes are likely to affect children's academic achievements differently (Yeung and Nguyen-Hoang, 2019). Further, school travel mode choices can also have longer-term implications for children as they transition into adulthood. Indeed, studies have shown that travel mode choices made by adults are likely influenced by the travel modes used in their childhood (Johansson, 2004; Schlossberg et al., 2006).

National Household Travel Survey (NHTS) is one such data source that provides rich information on school travel modes used by children from households with different socio-demographic backgrounds. The current literature lacks a comprehensive study that explores and analyses the recently published 2017 NHTS data in ways similar to the 2001 and 2009 NHTS data (Ham et al., 2008; McDonald, 2012, 2007; McDonald et al., 2011). Considering the importance of understanding the trends and patterns of school travel in developing policies, this study seeks to explore and document the recent trends in school travel and travel modes (walk, bike, auto, school bus, and others) using the latest 2017 NHTS data (U.S. Department of Transportation; Federal Highway Administration, 2017). The study specifically focuses on differences among rural and urban areas and how they relate to household income levels. Whereas previous studies have used a range of traditional discrete choice modeling techniques to explore school travel mode choice from the NHTS data (Kontou et al., 2020; McDonald et al., 2011; Mehdizadeh et al., 2017; Mitra et al., 2010; Moudon and Lin, 2011; Stone et al., 2014; Sultana, 2019), the current

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study applies a Random Parameters Multinomial Logit (RPMNL) model to better account for unobserved heterogeneity across observations (Bhat, 2000).

2. Literature review

Most school travel related literature primarily focus on understanding underlying factors that influence travel mode choices. Knowledge of such factors is imperative for policymakers and school systems to make school travel a positive experience for children and contribute to their overall health and development. Among the several different exogenous factors that influence school travel mode choice, trip distance and time appear to be important factors (Kontou et al., 2020; Stark et al., 2018; Wen et al., 2007). Shorter commute times to and from school significantly affect the likelihood to walk and bike (Black et al., 2001; Ewing et al., 2004; Sirard and Slater, 2008; Yee-Man Wong et al., 2011), while the longer distances between home and school encourage riding school buses (Ewing et al., 2004), riding in autos (Mackett, 2013; Wen et al., 2007) or transit (Stark et al., 2018). Specifically, McMillan (2007) found that those living within one mile of school are the ones who are most likely to walk, while Schlossberg (Schlossberg et al., 2006) found this distance to be 1.5 miles. However, other studies reveal that it is the perceived distance/time that ascribes convenience to the choice of a mode of school transportation (Emond and Handy, 2012; Faulkner et al., 2010; Lang et al., 2011). Mehdizadeh et al. (2017) further found a threshold of 10 min of perceived walking time to school for use of active travel modes to school.

Travel distance or time or the perception thereof alone does not influence the school travel mode choice. For example, built environment variables such as sidewalks could affect the odds of walking (Ewing et al., 2004; Mitra and Buliung, 2014). Additionally, improved road safety, increased community connectedness, spatial distribution, and denser neighborhood are more likely to encourage active school transportation for children (Braza et al., 2004; Carver et al., 2013; Kontou et al., 2020; McDonald, 2007). However, this can make school bus less attractive compared to other modes (Ewing et al., 2004).

Parents' attitudes and psychosocial factors were also found to play stronger roles in influencing the travel behavior to the school (Stone et al., 2014; Wen et al., 2007). Similarly, children's comfort with bicycling was found to be strongly associated with bicycling to school (Emond and Handy, 2012). Beyond this, parents' concerns about their children's health and fitness, competence, maturity and cognitive ability regarding road safety, perceived risks, traffic and congestion issues, and social norms were also found to significantly influence children's school trip modes in other studies (Deka, 2013; Faulkner et al., 2010; Lang et al., 2011; Mackett, 2013; Sener et al., 2019). Other household factors were studied and found to affect children's mode of choice to school. These include household income (Deka, 2013; Ewing et al., 2004), availability of adults at the time of school travel (Mitra and Buliung, 2014), the number of cars in the household, which could be a proxy for the economic status of the family (Ewing et al., 2004; Wen et al., 2007), parents' mode of travel to work (Deka, 2013; McDonald, 2008; Wen et al., 2007), parents' decision of school choice (Mackett, 2013), fathers' work flexibility (Sener et al., 2019), school district and family characteristics (Fast, 2020), participation in school activities (Ralph, 2018), and students' driving license status (Ewing et al., 2004).

Other than investigating the exogenous factors of school travel modes, there are other studies that examined the effect of school transport mode on a children's academic achievement (Yeung and Nguyen-Hoang, 2019), barriers for walking to school (Omura et al., 2019), or the effects of school attributes on school choice and hence mode choice (He and Giuliano, 2018). Some other studies assessed the changes in school travel patterns over a period of time in the United States. For example, using the 1969 National Personal Transportation Survey and the 2001 National Household Travel Survey (NHTS) data it was shown that the percentage of students who walked or bicycled to school was significantly lower in 2001 than in 1969 (Ham et al., 2008). The study also found that a smaller percentage of students lived within one mile of school in 2001 than in 1969 and the percentage of students who used automobiles was higher in 2001. Further, McDonald et al. (2011) documented the national estimates of different modes of school travel in 2009 using the 2009 NHTS data. The study found a similar reversal in proportions of students who walked/biked and those who used cars to school between 1969 and 2009. Further, recent studies analyzed the recent 2017 NHTS data and found a decline in active travel to school rates (Kontou et al., 2020; Sultana, 2019). Previous studies based on 2017 NHTS data largely focused only on the active school travel aspect of the school commute. The current study, however, examines school travel patterns across all modes reported in the 2017 NHTS data. Such a study is necessary as the travel attitudes and transportation choices are found to be shifting from the historical trends (FHWA, 2019). Thus, this study examines and documents the current trends in school travel using the recently published 2017 NHTS data (U. S. Department of Transportation; Federal Highway Administration, 2017) specifically focusing on the differences in school travel modes between urban and rural areas and different household income levels. The study further develops a RPML model to investigate the exogenous factors that affect the choice of trip modes to school in recent times. The RPMNL model overcomes the shortcomings of binary logit, binomial logistics regression, and multinomial modeling techniques (Bhat, 2000). The findings of this study will inform policymakers and researchers about the changes in school travel patterns and travel mode choices from historical trends that can aid them in policymaking and planning decisions on related matters.

3. Methods

Federal Highway Administration (FHWA) periodically conducts NHTS since 1969 to collect travel data from a sample of U.S. households for use in policy formulation and for planning purposes. Integrated data pertaining to households, household members, vehicles, and their trips yield a rich demographic profile that can also be linked to trip-making patterns which help in deciphering travel characteristics. The most recent redesigned 2017 NHTS improved the overall survey coverage by including cell phone only households (without a landline), which were excluded in the previous surveys (Mcguckin et al., 2018). Also, changes were made in the questionnaire regarding trip definition and travel logs.

3.1. Measures of school travel

Similar to the past surveys, the 2017 NHTS reported two measures of school trip mode choice. First is the usual mode used to get to/from school captured by the variables SCHTRN1 and SCHTRN2. The second is the survey day school travel mode. This is obtained from the question related to trip purpose “What was […] main activity at [...]?” reported as ‘WHYFROM’ in the data. For this study, trips were considered as school trips if (i) the response to ‘WHYFROM’ was ‘Attend school as a student’, (ii) age was between 5 and 18 (both inclusive) years, (iii) travel months ranged from August to May, and (iv) travel day was a weekday.

3.2. Statistical analysis

Two separate analyses of the school travel using the 2017 NHTS data were performed: summary statistics and correlates of school travel trip modes. Four different trip modes have been considered in this study – i) walking, ii) biking, iii) auto, and iv) school bus. A mode was considered as auto if the response to trip mode (variable ‘TRPTRANS’ in the data) was either of car, SUV, van, or pickup truck. Further, children from age 5 to 11 years were considered as elementary school children, 12–14 years for middle school, and 15–18 for high school students.

3.2.1. Amount of school travel and trip modes

The summary statistics of school travel during the survey period provides a broad overview of demographic and trip characteristics related to school travel in the U.S. The analysis was performed using Westat's ‘summarizeNHTS’, an R language based open-source toolkit (Fucci and Cates, 2017). The toolkit is tailored specifically for handling NHTS data

files that is capable of processing weighted data, computing common statistics and standard errors, and producing interactive web visualizations (FHWA, 2018). The statistics were estimated using the NHTS supplied weighting factors to project the samples to nationally representative estimates.

3.2.2. Correlates of school travel trip modes

The second statistical analysis of the sampled data was performed using a RPMNL model developed using NLOGIT 6 (Greene, 2016) to examine the exogenous factors that affect the choice of school trip modes. Various modeling techniques have been adopted in the past for analyzing the household travel survey data. For example, bivariate analyses and multiple logistic regression (Wen et al., 2007), binomial logit model (Mitra et al., 2010; Sultana, 2019), binary logistic regression model (Emond and Handy, 2012; Kontou et al., 2020), multinomial (conditional) logit model (Mitra and Buliung, 2014). However, unobserved heterogeneity is an important concern in mode choice research. Failure to account for the effect of unobserved variables can lead to biased estimates and incorrect inferences if inappropriate methods are used (Bhat, 2000). For this study, discrete outcomes of the classification of school travel modes make the use of discrete-choice modeling techniques appropriate to identify the factors that affect the mode choice probabilities. To achieve this objective, a RPMNL model is adopted that estimates a function to determine the discrete choice probabilities (Washington et al., 2010). The RPMNL formulation is summarized in Table 1.

Variables that were used in the model are school levels which is also an indicator of age groups (elementary (5–11 years) and middle (12–14 years)), trip distances (<1 mile, 2–5 miles, 5–15 miles, and >15 miles), gender, race/ethnicity, household income, homeownership status and the region of residences. Because the sample was exogenously stratified, the RPMNL model was estimated without the survey weights (Ben-Akiva and Lerman, 1985; McDonald et al., 2011). The final sample size for the model was 15,840 trips after accounting for missing or irrelevant responses.

4. Results

In 2017, a total of 301 million Americans traveled by making about 371 billion trips, and accounted for 3970 billion vehicle miles traveled, as shown in Table 2. Of this, about 19.5% (58.6 million) were children (5–18 years) and were involved in about 16% (59.6 billion) of the trips. Further, school trips for the children (5–18 years) were 10.4 billion and accounted for 2.8% of the total trips.

Table 3 shows the school travel statistics by school grade and household income levels. In general, the average distance traveled to school in 2017 was 4.44 miles, with elementary school children traveling 3.48 miles, and high school children 6.20 average miles to school daily. On the average, elementary school students spent about 21.08 min commuting to school, while middle and high school students spent about 24.02 and 26.76 min respectively.

Table 3 also indicates that rural children had to travel almost twice the distances than urban children traveled to school. While the urban school trips ranged between 3 and 5 miles, average rural trips were longer than 6 miles. Further, school commute times were longer for rural children as compared to urban children. Despite such differences between urban and rural trip distances and durations, the analysis shows that commute time to school increases as the income levels drop, with trip duration for income less than $10,000 being highest and lowest for income $150,000 and above.

Table 2
Summary of weighted persons, trips, and trip-miles, 2017 NHTS.

	Total		Age Group 5-18 years		School Trips	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Person Counts	301.6	0.0	58.6	0.1	26.7	0.4
Trip Counts	371152.0	2,214.8	59623.4	649.2	10406.0	157.3
Trip Miles	3970287.0	76034.6	513664.6	24353.9	46192.9	2,006.3

Note: All figures are in millions.

4.1. School trips

Table 4 shows the weighted summary statistics of demographic, household, and trip-related factors for school travel in 2017. The estimates were generated using the weights file in the NHTS data and hence represent the national estimates. The table also shows the trip percentages out of the total 371 billion trips made in the U.S. in 2017 and the percentage distribution within school trips. For example, out of the total 10.4 billion school trips, 5.3 billion were made by elementary school students, 2.2 billion and 2.9 billion were made by middle and high school students, respectively. These formed 1.42, 0.60, and 0.78% respectively of the total trips in the U.S. and 50.69, 21.34 and 27.97% respectively of the total school trips. The statistics also indicate that more boys than girls attended school in 2017. In terms of race and ethnicity, white children made the majority of school trips followed by African Americans and then Hispanics. The distribution of trip modes shows no change in the school travel trends with car travel dominating the share at about 50%. Riding the school bus, with about 33%, is the next highest used mode for school travel. Walking is 13% and biking is the least at about 1%. About 32% of school-going children lived within 2 to 5 miles radius of the school, while <5% lived >15 miles away from the school. Of the total school trips in 2017, <10% trips were made by children from households with income lower than $10,000. Children from households with income between $50,000 and $99,999 made 2.9 billion trips. >80% of school trips were made in urban areas compared to 16.7% in rural areas. Similarly, about 18% school trips were made by children from households with one parent and about 63% trips were made by children from households that owned their houses.

4.2. School trip modes

A normalized analysis of survey day and usual travel mode to school is presented in Table 5. Overall, on the survey day, the auto mode was the dominant travel mode to school, followed by school bus. While this trend is observed for elementary and high school students, middle school students were an exception. School bus was the primary mode used by

Table 1
Equations used in random parameters multinomial logit model formulation.

Equation	Description
$S_{in} = \beta_i X_{in} + \varepsilon_{in}$	S_{in} = severity function for category i in crash n β_i = estimable severity parameters f category i, X_{in} = explanatory variables of severity category i in crash n, ε_{in} = error term – generalized extreme value distributed (McFadden, 1981)
$P_n(i) = \frac{\exp(\beta_i X_{in})}{\Sigma\ exp(\beta_i X_{in})}$	$P_n(i)$ = probability of ith outcome occurring in the nth observation (Washington et al., 2010)
$P_n(i\|\varphi) = \int \frac{exp(\beta_i X_{in})}{\Sigma\ exp(\beta_i X_{in})} f(\beta_i\|\varphi)\beta_i$	$P_n(i\|\varphi)$ = probability of injury severity i conditional on $f(\beta_i\|\varphi)$ φ = vector of parameters with known density function (McFadden and Train, 2000; Train, 2003)

Table 3
Weighted trip-distance and weighted trip-duration, 2017 NHTS

(i) By School Grade

	Average Trip Distance (miles)			Average Trip Duration (minutes)		
School Grade	***Urban***	***Rural***	***Total***	***Urban***	***Rural***	***Total***
Elementary	3.02	6.02	3.48	20.28	25.40	21.08
Middle	3.78	7.11	4.42	23.27	27.16	24.02
High	5.59	9.24	6.20	26.99	25.62	26.76
Total	3.89	7.20	4.44	22.77	25.89	23.29

(ii) By Household Income

	Average Trip Distance (miles)			Average Trip Duration (minutes)		
***Household income* (in thousands)**	***Urban***	***Rural***	***Total***	***Urban***	***Rural***	***Total***
<10	3.15	6.79	3.39	36.93	39.02	37.06
10-25	3.25	9.79	4.09	25.18	36.20	26.59
25-50	3.55	6.92	4.15	23.89	25.10	24.11
50-100	4.06	7.47	4.64	20.20	25.52	21.11
100-150	4.08	6.70	4.65	19.40	22.28	20.03
>150	4.73	6.63	5.03	20.66	23.75	21.15
Total	3.89	7.20	4.44	22.77	25.89	23.29

about 42% of middle school students and auto was used by 41%. High school students were the highest (57%) auto users for school travel among the three school levels. Elementary school students were the least to ride the school bus and also to walk or bike to school.

In 2017, car travel (52%) dominated the choice of usual travel mode to school, about 36% of trips were by school bus, while walking was 8.77%, and biking was least with 1.12% trips. High school students were the highest (61.5%) auto-dependent category for their school travel needs. Middle school students were the least to travel by car and they were also the most (44%) to ride the school bus to school. Only 24.76% of high school students rode the school bus to school on the usual travel day. The proportions of elementary students who took auto and school bus were between those of the high and middle school students.

However, elementary students were highest in walking to school. While middle and high school students were about the same at 8.24%, >9% of elementary school students walked to school. In general, high school students were the least to walk, bike, or ride the school bus among the three school level categories as their mode choice to school as they were more auto dependent. Similarly, among the three categories, biking and school bus were most used by the middle school students.

Comparison between the survey day school travel mode choice and the usual mode choice highlights the variations in travel between the usual mode used and how students traveled on the survey day. Such variations in the survey day and usual travel mode have been studied in the past (McDonald et al., 2011). Estimates of walking to school based on survey day data are higher and estimates of biking are lower than the usual day travel modes. Similarly, fewer students took the school bus and more used auto on the survey-day compared to the usual days.

4.3. Random parameters multinomial logit analysis

Table 6 shows the frequencies and percentages of the variables in the sampled data used in model estimation. For example, of the 15,840 observations, 8894 school trips were made with autos and represented 56.15% of the total school trips. Similarly, 4794 (30.27%) trips were made by the school bus, and 1645 (10.39%) and 206 (1.30%) were made by walking and biking respectively. All model variables were binary with the exception of "Gas Price" which was the only continuous variable in the data and is described in Table 6 by its mean and standard deviation. While different studies have used different buckets for analyzing trip distances (Braza et al., 2004; Ham et al., 2008; Schlossberg et al., 2006), this study adopts five categories of trip distances: <1 mile, 1–2 miles, 2–5 miles, 5–15 miles, and > 15 miles. This effectively capture the effects of trip distances on the choice of every different modes of school travel considered in this study. For example, the first two categories capture the choice of active school travel modes, whereas >15 miles capture the use of mode for very long distances which is usually the case in most rural school districts.

Preliminary analysis of the data showed that 43% of school trips were by elementary school children and 23% and 28% were by middle and high school children respectively. The trip distance of 2 to 5 miles was the most with 33% whereas trips longer than 15 miles were least at only 4.34%. Boys made about 51% of the total school trips, about 3% more than girls. In terms of race, whites were the highest in school travel at 78%. Most trips (29.26%) were made by children with a household income level from $50,000 to $99,999 while the least number of trips were made by those with the lowest income of less than $10,000. Rural trips contributed to about 80% of the total school trips. In terms of vehicle counts, households with two vehicles show the highest (45%) number of school trips, and those with no vehicles were the least (1.76%). Also, the gas price affects the travel of about 20% of families from the filtered data.

Table 4
Summary of weighted statistics for school travel, 2017 NHTS.

Category	# Trips (billion)		Within Category (%)		% of Total U.S. Trips	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Total School Trips (ages 5 – 18)	10.4	0.2	17.45	0.24	2.80	0.04
School Grade						
Elementary (5- 11 years age)	5.3	0.2	50.69	1.15	1.42	0.04
Middle (12 – 14 years age)	2.2	0.1	21.34	0.51	0.60	0.01
High (15 – 18 years age)	2.9	0.1	27.97	1.07	0.78	0.03
Gender						
Male	5.3	0.1	51.07	0.69	1.43	0.03
Female	5.1	0.1	48.93	0.69	1.37	0.03
Ethnicity						
Hispanic	1.5	0.1	13.95	1.11	0.39	0.03
Race						
White	5.9	0.1	56.93	1.07	1.60	0.03
African American	1.5	0.1	14.54	0.58	0.41	0.02
Asian	0.6	0.1	6.04	0.46	0.17	0.01
American Indian or Alaska Native	0.0	0.0	0.43	0.15	0.01	0.00
Native Hawaiian or other Pacific Islander	0.0	0.0	0.16	0.06	0.00	0.00
Other	0.8	0.1	7.94	0.61	0.22	0.02
Trip Mode						
Walk	1.4	0.1	13.00	0.97	0.36	0.03
Bike	0.1	0.0	1.08	0.16	0.03	0.00
Auto	5.2	0.2	50.32	1.24	1.41	0.05
School Bus	3.4	0.1	32.79	0.80	0.92	0.02
Other	0.3	0.0	2.81	0.22	0.08	0.01
Trip Distance						
< 1 mile	2.2	0.1	21.58	0.98	0.60	0.03
1 - 2 miles	2.1	0.1	20.22	1.30	0.57	0.04
2 - 5 miles	3.4	0.2	32.26	1.52	0.90	0.05
5 - 15 miles	2.3	0.1	21.78	1.06	0.61	0.03
> 15 miles	0.4	0.1	4.17	0.52	0.12	0.01
Household Income						
Less than $10,000	0.8	0.1	7.75	0.74	0.22	0.02
$10,000 to $24,999	1.2	0.1	11.89	1.04	0.33	0.03
$25,000 to $49,999	1.8	0.1	17.48	0.63	0.49	0.02
$50,000 to $99,999	2.9	0.1	28.08	0.90	0.79	0.02
$100,000 to $149,999	2.0	0.1	19.85	0.79	0.56	0.03
$150,000 or more	1.5	0.1	14.95	0.75	0.42	0.02
Region						
Urban	8.7	0.2	83.30	0.62	2.34	0.04
Rural	1.7	0.1	16.70	0.62	0.47	0.02
Family Type						
Single adult/parent	1.9	0.1	18.30	1.01	0.51	0.03
Two adults/parents	8.5	0.2	81.70	1.01	2.29	0.04
Home Ownership						
Own	6.9	0.1	63.10	0.70	1.85	0.03
Rent	3.5	0.1	36.21	0.76	0.94	0.03
Some other arrangement	0.1	0.0	0.68	0.12	0.02	0.00

Table 5
Survey day vs usual day mode of school travel, 2017 NHTS.

Mode	Elementary (Grades K-5)		Middle (Grades 6-8)		High (Grades 9-12)		Grades K-12	
	%	Std. Error	%	Std. Error	%	Std. Error	%	Std. Error
Survey Day Travel Mode								
Walk	11.53	1.10	13.09	1.53	15.60	1.70	13.00	0.97
Bike	0.83	0.22	1.86	0.42	0.94	0.25	1.08	0.16
Auto	50.45	1.69	40.91	2.12	57.28	1.88	50.32	1.24
School Bus	35.73	1.44	41.62	1.54	20.74	0.91	32.79	0.80
Other	1.47	0.35	2.52	0.32	5.45	0.60	2.81	0.22
Total	*100.00*		*100.00*		*100.00*		*100.00*	
Usual Travel Mode								
Walk	9.20	1.19	8.24	1.48	8.23	1.58	8.77	0.93
Bike	1.08	0.30	1.85	0.25	0.46	0.11	1.12	0.22
Auto	51.56	1.37	43.36	2.03	61.51	2.48	51.84	1.32
School Bus	36.66	1.02	44.08	1.57	24.76	1.43	35.77	1.00
Other	1.50	0.27	2.47	0.41	5.04	0.65	2.50	0.21
Total	*100.00*		*100.00*		*100.00*		*100.00*	

Table 7 presents the detailed RPMNL model estimation results for the survey-day mode to school. Five dependent variables (walk, bike, auto, school bus, and other) were considered for building the model, where "other" is considered as the base case among the five school travel modes. Thus, the estimated coefficients of the selected variables in Table 7 represent the effects of the respective variables on the travel mode choice compared to using the other mode. The Hausman-McFadden test statistics for the independence of irrelevant alternatives (IIA) for school travel modes indicate the non-violation of IIA assumption based on chi-square distribution table. Note that only the variables found significant at a 90% level of significance for at least one school travel mode were included in the utility functions of the model. In all, 20 of the variables were found significant in at least one school travel mode. The elasticities of these variables were determined to examine the effects of the individual factor on the probabilities of choice of travel modes to school.

The elasticity indicates that both elementary and middle school students were associated with an increased likelihood of riding a bike/school bus or using the household vehicle to school compared to other travel modes. Particularly, trip distances of less than one mile is positively associated with students walking or biking to school (see positive coefficient of these school travel modes in Table 7) instead of using the auto or school bus. Our RPMNL model also captures the potential effects on the biased estimations due to the unobserved heterogeneity. The scale parameter of trip distance less than one mile indicates that the likelihood for students to use walking to school is greater among some respondents compared to other respondents. However, if the school travel distance is >2 miles, the likelihood of student walking or biking to school is significantly decreased, and auto and the school bus would be their dominant usual travel modes, especially when the school travel distances is >15 miles.

The other significant correlates of school travel modes also present interesting relationships with each individual school mode. For example, the likelihood of females biking to school is significantly lower than males, and females used the auto mode to school if such mode is available to them. Additionally, the scale parameter of females for biking mode indicates that even though the majority of the female respondents are associated with a decreased likelihood of riding bike to school, there were a few who were associated with an increased likelihood of using a bike for school travel. In terms of race or ethnicity, White and African American children are more likely to ride the school bus. Whites are also associated with a higher chance of walking or using the auto mode to school, whereas, African Americans are lesser likely to bike to school, and Hispanics are more likely to ride in a car to school and less likely to bike. Household income was found to significantly affect the school travel mode used. The likelihood of auto travel decreases for children from households with less than $10,000 income. In contrast, the likelihood of riding school bus increases for households with income levels $10,000–$24,999 and $50,000–$99,999. The indicator variable for children from households with higher income (e.g., $100,000 or more) was not found to significantly correlate with any of the school travel modes. This may perhaps be because students from these families probably have the option to use any of the modes for school travel.

Further, children living in rental houses were associated with a decreased likelihood of using a car or ride the school bus which is counterintuitive, maybe because the school for these respondents living in the rentals is within walking or biking distance (e.g., over 46% of travel distance for children living in rental houses is within 2 miles). Also, for children from urban regions, there was a decreased likelihood for them to walk, use a car, or ride the school bus to school, which indicates that students in those urban areas may have other school travel options such as transit or ride-share. This parameter is randomized in the RPMNL model, indicating that some respondents are even less likely to use a school bus compared to others for school travel. Children from households without a vehicle are associated with a higher likelihood of riding a school bus for school travel, while those from the household with two vehicles tend to use auto for the daily school trips.

Interestingly, children from the households having three or more vehicles indeed may have access to any of the other travel options for school travel such as walk, bike, auto, and school bus, and compared to children from households with no vehicles, they are even more likely to use school

Table 6
Descriptive statistics of variables included in RPMNL model.

Variable	Binary variable	Frequency	Percentage
Trip mode	Walk	1,645	10.39
	Bike	206	1.30
	Auto	8,894	56.15
	School Bus	4,794	30.27
	Other	301	1.90
School grade	Elementary (5–11 years age)	7,765	49.02
	Middle (12–14 years age)	3,672	23.18
	High (15–18 years age)	4,403	27.80
Trip distance	<1 mile	3,205	20.23
	1–2 miles	3,155	19.92
	2–5 miles	5,232	33.03
	5–15 miles	3,561	22.48
	>15 miles	687	4.34
Gender	Female	7,752	48.94
	Male	8,088	51.06
Ethnicity	Hispanic	1,901	12.00
Race	White	12,320	77.78
	African American	1,394	8.80
	Asian	944	5.96
	American Indian or Alaska Native	123	0.78
	Native Hawaiian or other Pacific Islander	32	0.20
	Other	1,027	6.48
Household income	Less than $10,000	554	3.50
	$10,000 to $24,999	1,326	8.37
	$25,000 to $49,999	2,416	15.25
	$50,000 to $99,999	4,635	29.26
	$100,000 to $149,999	3,707	23.40
	$150,000 or more	3,202	20.21
Home ownership	Own	12,188	76.94
	Rent	3,652	23.06
Region	Urban	3,260	20.58
	Rural	12,580	79.42
Household vehicle count	0	278	1.76
	1	2,469	15.59
	2	7,157	45.18
	3 and more	5,936	37.47
Gas price[a]	Value range [2.019, 2.951]	2.383	0.23
Other	Price of gasoline affects travel	3,179	20.07

[a] Since "Gas Price" is a continuous variable, its mean and standard deviation are reported.

Table 7
Random parameters multinomial logit model estimation results and elasticities.

	WALK			BIKE			AUTO			SB		
Variable	Estimate	t-stats	Elasticity (%)	Estimate	t-stats	Elasticity (%)	Estimate	t-stats	Elasticity (%)	Estimate	t-stats	Elasticity (%)
Constant	-2.15	-4.21		-2.76	-3.32		1.05	2.91		2.19	9.15	
School Grade												
Elementary (5- 11)				0.49	2.13	21.35	1.35	13.29	24.95	2.02	17.04	59.01
Middle (12 - 14)				0.41	1.75	8.31	0.18	1.72	1.85	1.21	10.42	14.99
Trip Distance												
< 1 mile	2.36	18.27	23.41	1.43	7.16	22.72				-0.78	-7.81	-12.81
(standard deviation)	*1.11*	*3.02*										
2 - 5 miles	-2.07	-13.13	-67.45	-2.15	-6.45	-66.17				0.25	4.83	4.33
5 - 15 miles	-3.66	-10.02	-82.03	-3.09	-5.35	-66.44						
> 15 miles							1.25	5.88	1.42	-0.78	3.58	2.25
Gender												
Female				-4.49	-2.80	93.85	0.26	5.52	4.43			
(standard deviation)				*3.20*	*3.77*							
Ethnicity												
Hispanic				-0.43	-1.69	-4.59	0.12	1.94	0.55	-0.37	-2.18	-0.03
Race												
White	0.29	2.18	19.70				0.39	3.46	11.06	0.54	4.40	26.11
African American				-1.84	-3.56	-15.20				0.57	5.43	2.48
Household Income												
Less than $10,000							-0.55	-4.31	-1.09			
$10,000 to $24,999				-0.50	-1.17	-3.80				0.55	5.83	2.31
$50,000 to $99,999										0.14	2.90	2.52
Home Ownership												
Rent							-0.48	-6.00	-4.98	-0.46	-5.41	-6.29
Region												
Urban	-0.64	-2.84	-43.25				-0.96	-4.80	-27.72	-1.57	-7.52	-66.38
(standard deviation)										*0.76*	*2.58*	
Household Vehicle Count												
0										0.52	3.05	0.44
2							0.47	5.99	7.88			
3 and more	0.35	2.17	11.69	0.45	1.96	15.04	1.22	7.45	14.38	0.53	3.64	13.07
Gas Price												
Value range [2.019, 2.951]	1.56	8.52	320.37	1.13	3.43	239.88	0.74	6.54	65.61			
(standard deviation)							*0.29*	*1.99*				
Other												
Price of Gasoline Affects Travel										0.21	4.50	6.27

Model Statistics	
Number of observations	15840
Log-likelihood at constants	-25493.5
Log-likelihood at convergence	-13705.9
McFadden ρ^2	0.462

Hausman-McFadden Test Statistics for IIA

Mode	IIA q-statistics	p-value
Walk	-63.66	0.000
Bike	108.58	0.000
Auto	236.76	0.000
School Bus	-107.46	0.000

Note: Only variables that are significant at 90% level of significance are shown in the table; the empty cells and missing variables indicate that they are not used to build the utility function of each individual school travel mode.

bus as a travel mode. Lastly, the gas price and its effect on school travel modes also show interesting outcomes. For example, the respondents who said the gas price is a financial burden affecting their travel, are more likely to use the school bus for school travel. An increase in gas price is positively, albeit indirectly, associated with children walking or biking to school, but interestingly also to auto use. This observation might be due to the fact that people who use auto for their daily travel are more likely to continue using it for the convenience and comfort regardless of the impact of the gas price. Even though gas price is randomized in the model, it did not show negative relationship with auto as the school travel mode.

5. Discussion

In this section, two significant past studies on school travel modes (Ham et al., 2008) and (McDonald et al., 2011) are used as baseline to contrast findings from this study. Both studies are based on older NHTS data. While (Ham et al., 2008) used the 1969 NPTS and 2001 NHTS data, (McDonald et al., 2011) is based on the 2009 NHTS data. Although (McDonald et al., 2011) also reports the percentages of modal share based on 2001 NHTS data, they vary from the ones reported by (Ham et al., 2008). This study uses the results from (Ham et al., 2008) for the modal shares in year 2001. These studies as baseline would help in comparing the findings of this study with theirs and hence establishing the trend of recent school travel modes in relation to the past.

In 1969, the share of automobile as school travel mode was 16.3%. This went up to 46.2% in 2001 and then to 54.3% in 2009. The results of this study show that the share of this mode in 2017 was 50.3% (Table 5). Thus, a drop in the proportion of students using automobile for their school travel was observed between 2009 and 2017. While the reasons for this trend are beyond the scope of this study, such a drop favors the proponents of active school travel modes. However, this did not apply in the case of school bus. The fraction of students who rode school buses in 1969 was 38.1%, 35.4% in 2001, and 33.4% in 2009. This declining trend continued in 2017 with 32.8% taking school buses for their school trips. Previous studies indicate various reasons such as increasing car ownership (White, 2008), longer commute time (Jimerson, 2007), and poor service and quality (Wilson et al., 2010) for the decline in school bus ridership in the past. In terms of the two active modes of school travel (walking and bicycling), which accounted for 42% of the school trips in 1969, saw a dip in 2001 at 16.2% and further declined to 9.8% in 2009. Interestingly, findings

in this study indicate a jump to 14.8% in 2017. While several researchers raised concerns over declining active school transportation, the rise in the share of active modes to school in 2017 indicates a positive change.

The analysis of 2017 NHTS data further shows other interesting results. For example, rural children are found to travel longer distances to school than urban children. Denser habitation and more schools in urban areas (Snyder et al., 2019) can be attributed for such disproportions in the school travel distances between urban and rural areas. However, the disproportions do not significantly impact school travel times. Although marginally longer, trip times in rural areas are close to those in urban areas which could be attributed to urban traffic. Analysis based on household income levels indicates an inverse relationship between school commute times and income levels. Children from households with lower income typically travel longer to school compared to children from higher income households. This could be correlated with the residential locations as higher income families tend to reside away from the downtown areas (Pendall et al., 2014).

To further explore these trends, we examined the results of the RPMNL model results. These results suggest trip distance continues to be a significant determinant in travel mode to school. Distance less than a mile promote walking or biking as trip mode. Similarly, the likelihood of using auto or school bus for longer than 15 miles to school is high, with the likelihood for school bus use being higher than that of auto. This finding has an important policy implication to advocate for increase in school transportation budgets, especially in the rural school districts where the schools travels are longer. Also, other demographic factors were found to significantly affect school travel modes. In general, students from households with higher income were found to be more likely to use cars, while the ones with lower household income were more likely to ride the school bus to school. These findings are similar to other studies (Black et al., 2001; Deka, 2013; Ewing et al., 2004; Mackett, 2013; Sirard and Slater, 2008; Wen et al., 2007; Yee-Man Wong et al., 2011). Further, females are more likely to go to school in a car, and less likely to bike to school.

Although, this study does not provide a strong evidence about the cause of the increase in walking/bicycling to school proportions, there could be factors beyond the scope of this study that influence most recent travel attitudes. For example, considering that the children who were surveyed during the year 2017 belong to generation Z, they are likely to have differing attitudes from earlier generations (Polzin et al., 2014) and their travel choices are bound to be different (Lee et al., 2013; Parkany et al., 2004), in a similar way as residential locations and other lifestyles (Circella et al., 2017). Additionally, recent increase in the number of charter schools in the US (Snyder et al., 2019) could also have an impact on school distance and hence school travel modes. Changing demographic profiles of the schools could also have similar impacts (Fry and Taylor, 2012). Policymakers and school officials need to understand the changes happening within and outside the schools to adopt strategies and policies that could make school travel convenient, healthier and comfortable.

6. Conclusions

School travel is an important issue, especially when the available options of school travel mode is considered to have significant psychological, health, and safety impact the on individuals (e.g., school children) as well as on society. This study used the publicly available 2017 NHTS data and investigated two primary questions related to the school travel. First, what are the recent trends in school travel in terms of different modes used for traveling to schools? Second, which, and to what extent, exogenous factors impact the use of school travel mode? The answers to these questions were explored using two separate analyses. The first question was answered by the summary statistics at different levels for different demographics and trip characteristics. The second question was analyzed by developing a RPMNL model with trip modes as response variables and other demographic-, household-, and trip-related factors as exogenous variables.

Comparisons of the results of this study with findings from other past studies that analyzed earlier NHTS datasets indicate that the trends in 2017 have significantly changed between now and then. It is found that the share of both school bus and auto as travel modes has decreased, while the share of walking and biking has increased in recent years. Although the trends are consistent across the elementary, middle and high school levels, the change is significant among high school students. The findings from the RPMNL model indicate that students living within shorter distance to schools (less than a mile) are likely to walk or bike to schools. Students living longer (>15 miles) from the school are more likely to take a school bus to school. Auto travel is also likely to be used by children living longer than 15 miles, but not as likely as using a school bus. The likelihood of riding a school bus increases for lower-income households ($10,000–$24,999) but households with higher income ($50,000–$99,999) are more likely to ride a school bus. It was also found that females are more likely to use an auto mode, and less likely to bike to school. Households affected by gas price are more likely to ride the school bus.

Increase in the proportion of students that walk and bike to school is a positive sign towards building healthy communities. While this study used the 2017 NHTS data for its analyses, there is still a possibility to combine this data with other datasets to further investigate the factors responsible for the modal shifts in school travel. One such important consideration is the effect of the built environment (e.g., walking facilities) and land use patterns along with other demographic factors on school travel mode options. Nevertheless, this study provides a useful baseline for other studies and also contributes to the existing body of literature on school travel behaviors. Policymakers who work in education and school systems should consider the changing landscape of school demographics, attitudes, and social behavior and can use the findings of this study for informed decision making towards improvements to the current school travel trends.

CRediT authorship contribution statement

Abhay Lidbe: Conceptualization, Methodology, Data curation, Formal analysis, Writing - original draft. **Xiaobing Li:** Conceptualization, Methodology, Formal analysis, Writing - review & editing. **Emmanuel Kofi Adanu:** Conceptualization, Methodology, Formal analysis, Writing - review & editing. **Shashi Nambisan:** Supervision, Writing - review & editing. **Steven Jones:**Conceptualization, Writing - review & editing.

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