DEPARTMENT OF TRANSPORTATION

# School start times impact on students walking or biking to school: Safe routes to school

**Michael Levin, Principal Investigator**
Department of Civil, Environmental, and Geo- Engineering
University of Minnesota

**April 2025**

Research Report
Final Report 2025-21

To get this document in an alternative format or language, please call 651-366-4720 (711 or 1-800-627-3529 for MN Relay). You can also email your request to ADArequest.dot@state.mn.us. Please make your request at least two weeks before you need the document.

## Technical Report Documentation Page

| 1. Report No. | 2. | 3. Recipients Accession No. |
|---|---|---|
| MN 2025-21 | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| School start times impact on students walking or biking to school: Safe routes to school | April 2025 |
| | 6. |
| 7. Author(s) | 8. Performing Organization Report No. |
| Michael W. Levin, Jaoting Nie, Jacob Grzesiak | |
| 9. Performing Organization Name and Address | 10. Project/Task/Work Unit No. |
| Department of Civil, Environmental, and Geo- Engineering<br>University of Minnesota<br>500 Pillsbury Dr SE<br>Minneapolis, MN 55455 | 11. Contract (C) or Grant (G) No.<br>(c) 1036342 (wo) 91 |
| 12. Sponsoring Organization Name and Address | 13. Type of Report and Period Covered |
| Minnesota Department of Transportation<br>Office of Research & Innovation<br>395 John Ireland Boulevard, MS 330<br>St. Paul, Minnesota 55155-1899 | Final Report<br>14. Sponsoring Agency Code |

15. Supplementary Notes
http://mdl.mndot.gov/

16. Abstract (Limit: 250 words)

Some school districts schedule elementary schools with early start times for various reasons. Such start times sometimes necessitate travel before sunrise during winter months. Intuitively, this could potentially conflict with a desire for increased use of active transportation, e.g. from the Safe Routes To School program, to reduce motor vehicle travel and associated traffic congestion from driving students to school. Since prior literature has identified that parents are concerned about child safety around traffic, it is possible that travel before sunrise (where visibility is reduced) would also be a concern to parents and further discourage active transportation.
To answer this question, we conducted a stated preference survey of parents about their child's travel choices, asking parents to rank the importance of various factors including travel before sunrise. Due to concerns about whether stated parental preferences would align with actual behavior, we also conducted a revealed preference survey using StreetLight data on travel to elementary schools. Survey distribution and data collection occurred in February in Minnesota, during a period of late sunrise. Overall, the results from all data analyses are aligned. Early school start times were associated with slightly higher use of active transportation in both stated and revealed travel patterns. Parents ranked travel before sunrise only as a moderate concern behind distance, infrastructure, crossing busy roads, and child's age. We did not find data to conclude that travel before sunrise significantly limits use of active transportation.

| 17. Document Analysis/Descriptors | 18. Availability Statement |
|---|---|
| School trips, Dawn, Winter, Walking, Bicycling, Safe Routes to School | No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312 |

| 19. Security Class (this report) | 20. Security Class (this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 49 | |

# School times impact on students walking or biking to school: Safe routes to school

## Final report

*Prepared by:*

Michael W. Levin
Jaoting (Justin) Nie
Jacob Grzesiak
Department of Civil, Environmental, and Geo- Engineering
University of Minnesota

## April 2025

*Published by:*

Minnesota Department of Transportation
Office of Research & Innovation
395 John Ireland Boulevard, MS 330
St. Paul, Minnesota 55155-1899

# Acknowledgements

We gratefully acknowledge the suggestions by the Technical Advisory Panel members Chad Kooistra, Kelly Corbin, Sophie Kalot, Tim Brackett, Benjamin Harri, Dustin Morrow, Ellen Pillsbury, Sarina Praseedom, Jeremy Vann, Dylan Galos, Jackie Jiran, and Micaela Kranz.

# Table of Contents

# List of Figures

# List of Tables

# Executive summary

Due to various reasons, it is often convenient to have elementary schools start earlier. For example, several schools in Minneapolis and St. Paul Public School districts start at 7:30am. One concern about such early start times is a possible conflict with the Safe Routes to School program to encourage students walking or biking to school instead of being driven by parents. With early start times, during winter months, students must travel to school before sunrise (in the dark), and there is concern that early start times might discourage walking or biking to school. Prior to this project, there was no literature and little knowledge about whether (and to what extent) early school start times reduced walking and biking to school.

We conducted both stated preference and revealed preference surveys of parents to answer this question. A stated preference survey might capture parent' preferences to avoid travel before sunrise, but fail to indicate their actual behavior. However, the revealed preference survey cannot indicate the reasons for observed behavior. Moreover, both surveys had limitations: the stated preference survey was limited by the willingness of schools to distribute the survey and the willingness of parents to respond. Due to the difficulties in data collection, the revealed preference survey was based on mobile-sourced data on driving trips to schools from StreetLight, which imperfectly captures parent behavior. However, both the stated and revealed preference surveys gave the same result, and that provides more convincing evidential support for that result.

Overall, we did not find evidence to support the hypothesis that early school start times reduce walking or biking to school. Some analyses suggested that early school start times were associated with higher rates of walking or biking. The number of students using active transportation was quite low compared to alternatives. Based on the evidence, we conclude that school districts should not avoid early school start times due to concerns over walking and biking. Moreover, the stated preference survey indicated two potentially controllable factors that limit active transportation: infrastructure for walking or biking and concerns over crossing busy roads. If higher use of active transportation is desired, modifying the built environment to address those issues might increase use of walking or biking, although establishing a causal relationship would require further work.

# Chapter 1. Introduction

Student travel to school is highly concentrated in space and time. McDonald et al. [9] estimated that 10–14% of road traffic during morning peak hours is related to school trips. Increasing walking and biking could therefore reduce morning peak traffic congestion and the corresponding greenhouse gas emissions. Furthermore, active travel has health benefits for students [7]. Therefore, encouraging walking and biking to school is also supported by policies like the Safe Routes to School programs, which have been associated with increases in walking and biking [10, 16, 4].

The success of such policies requires a solid understanding of the factors affecting students' mode choices to address barriers against walking and biking to school. One potential factor that intuitively seems relevant is an early school start time that results in starting before sunrise for at least several months of the year. Travel before sunrise may discourage walking and biking to school due to safety reasons, particularly for elementary school children who have limited maturity and are smaller in size than older students reducing their visibility. The impact of start times on student performance in school has been studied extensively [19], and insufficient sleep in adolescence is associated with poor performance. Due to staggered start times due to bus schedules or other reasons, later start times for secondary schools creates pressure in some school districts for elementary schools to start earlier. However, the impact of early school start times on walking and biking has not yet been studied in the literature.

## 1.1 Literature review

Stewart et al. [15] synthesized quantitative and qualitative research to identify 8 factors relevant to whether students bike or walk to school under the Safe Routes to School program, with the importance of those factors supported by Aranda-Balboa et al. [3]. Relevant factors include perceived safety (from traffic and crime), weather, distance, and availability of alternative options which may be limited for certain demographics. Yarlagadda and Srinivasan [21] and Ahern et al. [1] found that distance was highly important, but Westman et al. [18] suggested that distance was less important than parent comfort with independent student travel. Distance may have a nonlinear relationship: above some threshold (e.g. 0.5 miles) distance could be much more influential to walking or biking. Wilson et al. [20] conducted a study of mode choices in Minnesota, but school start times were not included. They instead focused on the impacts of school type (magnet vs. neighborhood schools) and parent attitudes towards transportation. Magnet schools were often farther away, resulting in less walking and biking.

Parental concern with safety appeared to be a major concern. Although crime was mentioned, Vonderwalde et al. [17] found that active transportation was higher in high-crime neighborhoods, possibly due to household vehicle availability. Crossing roads was also a concern [14]. In particular, parents often mentioned age 12 (7th grade) as the age when they would feel safe with their children walking or biking alone. Correspondingly, characteristics such as major or minor streets and other infrastructure on routes to school affected mode decisions [8]. Chen et al. [6] found that sidewalk, crosswalk, and bike lane infrastructure increased biking and walking to school. In a study of Finland school travel, Broberg and Sarjala [5] found that poor public transport and single family housing increased biking and walking, while urban environments decreased it. However, Ahlport et al. [2] suggested that multiple factors, including characteristics of parents and children, neighborhood environment, and school characteristics, were barriers to biking and walking. Addressing one of the factors alone might not be sufficient to increase walking and biking. Therefore, Mitra and Buliung [11] suggested that education programs to encourage biking and walking might be more important than infrastructure.

In conclusion, the impacts of school start times on student mode choice does not appear to have been studied in the literature. However, there are numerous studies to suggest that it might be impactful, particularly when students would have to walk or bike to school in the dark. Parents are generally concerned with safety, especially from road traffic. Infrastructure including bike lanes and crosswalks are associated with more biking and walking [6]. It is reasonable to hypothesize that safety might be worse (or at least perceived to be worse) in the dark due to lower visibility of children by drivers.

## 1.2 Contributions

This report directly addresses the question: to what extent does schools starting before sunrise affect walking and biking, which has not been directly studied in the literature. Answering this question is not fully straightforward. We believe that most parents asked about their concerns for having children travel before sunrise would express a preference for later school start times. A stated preference survey is also limited by the response rate. To address these limitations, we believe that a revealed preference survey (observing parents' behavior) is helpful. However, revealed preference surveys have their own limitations in terms of obtaining data and lack of explanation for observed choices. Therefore, we conducted and report on both stated and revealed preference surveys.

We conducted a stated preference survey of parents of elementary school students in the Minneapolis/St. Paul metropolitan area, and we report our findings from that survey on students' travel choices and the relative importance of a variety of factors on whether students walk or bike to school. We also conducted a revealed preference survey using mobile-sourced data on travel to schools from StreetLight, and we report our comparisons of observed trips across several variables related to schools starting before sunrise. By combining our survey findings, we hope to provide the first direct conclusions on the issue of traveling to school before sunrise.

The remainder of this paper is organized as follows. In Section 2, we report on the revealed preference survey using StreetLight data. Our stated preference survey is described in Section 3. We discuss common findings and our conclusions in Section **??**.

# Chapter 2. Revealed preference survey

Survey responses from parents are expected to be incomplete due to low response rates and possibly inaccurate based on stated recollections and preferences instead of direct observations. To avoid directly biasing the results, the survey does not ask parents about early start times directly, and instead asks them to rank it among a variety of factors. However, that could also serve to dilute the importance of early start times. The ideal approach for determining whether early start times are reducing walking or biking is to directly observe students' travel behaviors at different months throughout the year. Because walking and biking could be reduced during winter due to different weather conditions or for travel before sunrise, comparing schools with early and late start times is necessary to isolate the impact of sunrise.

Direct observation requires a significant time commitment: the research team or teachers would need to directly collect data from all individual students, and to obtain a robust dataset it would be necessary to compare many schools and to collect data on multiple days. To avoid the corresponding time cost, we instead made use of the mobile-sourced data provider StreetLight, which provides aggregate data about travel behaviors based on smartphone tracking. However, StreetLight's ability to track and provide data on walking and biking is limited. It does not offer a direct measurement of walking and biking trips per day, unlike its driving data. Furthermore elementary school children may not own smartphones, but older children may walk or bike to school alone. However, StreetLight provides good data on driving trips. Since elementary school children cannot drive, and most adults (parents) living in cities own smartphones that could be providing data to StreetLight, we believe that driving trips are the most accurate data we could obtain from StreetLight. Therefore, we used StreetLight to obtain driving trips to elementary schools, reasoning that increases in driving trips correspond to decreases in the active transportation modes (walking, biking, scooters, etc.) that we want to estimate.

We report on our revealed preference survey of student travel behaviors using StreetLight. We describe our data collection, analysis, and finally our conclusions about the extent to which early school start times are affecting walking and biking trips.

## 2.1 Data collection

### 2.1.1 Elementary school selection

Using StreetLight, we collected data on average daily trips to community elementary schools in the St. Paul Public Schools (SPPS) and Minneapolis Public Schools (MPS) districts. We focused on community schools and excluded magnet schools because community schools primarily serve students in close geographic proximity whereas magnet schools might serve students who live too far to reasonably walk or bike. SPPS and MPS schools were chosen because both districts conveniently have multiple start times for their community elementary schools, including some starting at 7:30 AM(involving travel before sunrise) and at 9:30 AM (well after sunrise). This reduces the impact of district-dependent variables like busing availability that are difficult to capture explicitly/ Furthermore, they have a relatively large number of elementary schools compared to the many smaller school districts around the Minneapolis/St. Paul metropolitan area and greater Minnesota.

In contrast, other school districts often have uniform start times, which means we might need to compare one school district with early start times to another school district with late start times. Differences in travel behavior among those school districts could be due to differences in the populations of enrolled students, different infrastructure in the corresponding cities, or differences in school district services such as busing. We focused on urban and suburban areas because rural counties with lower population densities could have longer distances that would also prevent walking or biking. Furthermore, rural areas might have limited cell phone coverage which could restrict the accuracy of StreetLight. For that reason, we only include SPPS and MPS community schools in this analysis.

It is not known to the research team why the different start times exist, or whether the start times are chosen randomly or based on student input. We hypothesize that different start times might exist to reduce the number of school buses simultaneously in use, which is often the reason why elementary, middle, and high schools have different start times. One possibility that could affect the validity of our analysis is having school start times that were chosen to satisfy the preferences of enrolled students, which could mean that the groups being compared (early and late school start times) are correlated with the start times themselves. However, for schools with hundreds of students and yearly turnover and new enrollment, we believe maintaining start times that match the preferences of a majority of students would be difficult. Furthermore, residence locations are based on multiple factors of which school start times are probably a minor component.

### 2.1.2 StreetLight data collection

StreetLight provides the average number of daily trips to a specific street within a specific time-of-day period and day-of-year. Since we need trips destined to elementary schools, we selected streets corresponding to entrances or obvious drop-off points for each elementary school as illustrated in Figure 2.1. This introduces a potential source of error into the collected data. Parents might drop their students off farther away out of convenience due to traffic or as part of a separate trip (e.g. to work), and such trips might not be detected. Also, travelers might visit the street for other reasons such as a nearby park. However, the limitations of StreetLight prevent more accurate data collection.

We used StreetLight to obtain the number of trips to each elementary school between 6:00am–12:00pm on weekdays for the months of September 2022, February 2023, and April 2023. The time-of-day was chosen to focus on home-to-school trips and exclude trips to pick up students from school, or other afternoon activities. We assume that the primary source of driving trips to schools during the morning would be either faculty and staff traveling to work, or students being driven to school. Both of these should be correlated with school enrollment as schools with higher enrollment require more faculty and staff. Occasional alternative trips such as parent-teacher conferences, special deliveries, etc. should be averaged out when considering the average daily trips over a month. Overall, we collected data for 31 elementary schools in MPS and 18 elementary schools in SPPS.

We wanted to compare the impacts of early and late start times across 2 dimensions. First, we are comparing schools with early and late start times in months with late sunrise. Second, we are comparing the same school to itself across 2 months with different sunrise times. We focused on February and April for our comparison months. We wanted to select 2 months with cold weather to study the impact of early sunrise times separate from cold weather that could discourage walking and biking. January is unusual due to winter break interrupting travel, and March includes the change to Daylight Savings Time. The winter in 2023 was fairly long with snow remaining on the ground through April. Average temperatures at the Minneapolis/St. Paul international airport were 21.1 Farenheit in February [13] and 45.8 in April [12], which is warmer but still fairly cold, especially during the early morning. We also collected data from September,

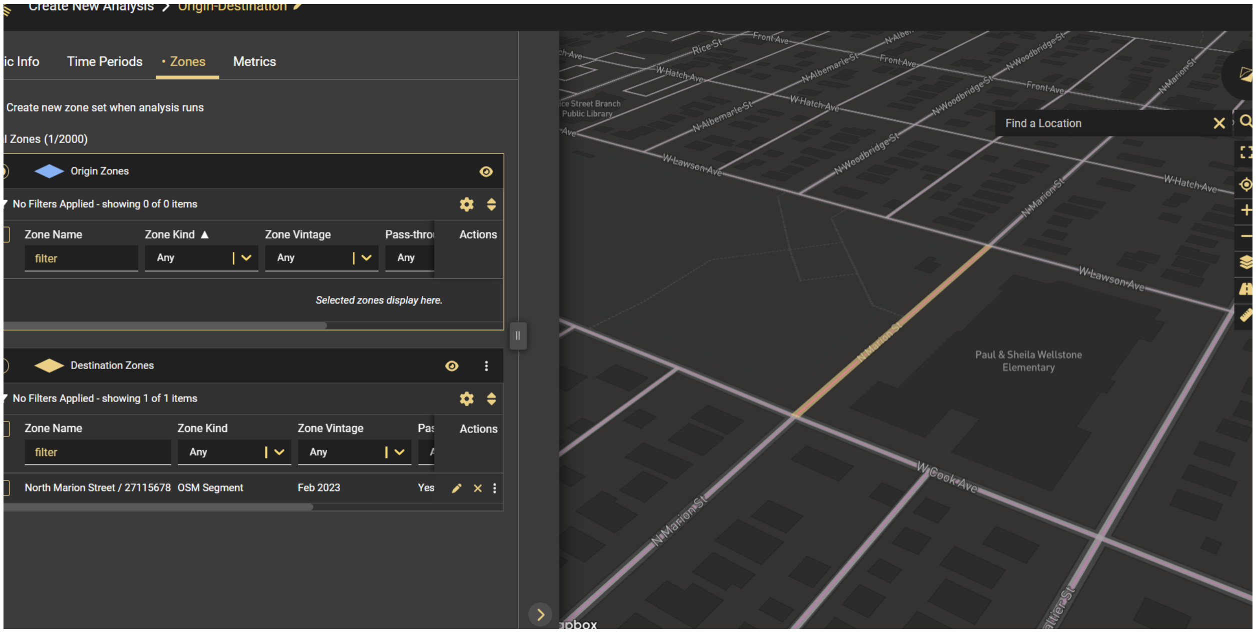



**Figure 2.1: Illustration of collecting trips to elementary schools in StreetLight**

which has relatively early sunrises and warm weather, as a baseline for comparison.

### 2.1.3 Elementary school data

A list of schools considered and their start times is given in Table 2.1. Besides school start times, we also collected public characteristics including enrollment, demographics, income levels, and percent of special education students. These are public data that we collected from the Minnesota Department of Education. The total number of trips, and correspondingly the number of driving trips, would obviously be related to enrollment. However, other factors could affect travel choices too. Higher-income families might be more likely to own a car and drive their children, or they might be more likely to live in areas with better infrastructure for walking or biking. Parents of certain racial groups or ethnicities might have different cultural preferences among driving their children to school. Special education children may need to be driven to school. Therefore we collected these data to study their relationships with observed driving trips.

**Table 2.1: Elementary schools considered with their start times**

| | 7:30 | 8:00 | 8:25 | 9:00 | 9:15 | 9:30 |
|---|---|---|---|---|---|---|
| Minneapolis | Bryn | Pillsbury | Lyndale | Bancroft | Whittier | Marcy Arts |
| Public | Jenny Lind | Pratt Community | Folwell | | Field | Dowling |
| Schools | | Armatage | | | Hale | Barton |
| | | Bethune | | | Lake Harriet Upper | Hiawatha Community |
| | | Burroughs | | | Lake Harriet Lower | Kenny |
| | | Cityview | | | Keewaydin | Kenwood |
| | | Lucy Lane | | | Wenonah | Seward |
| | | Nellie Stone | | | Northrop | Windom |
| | | Webster | | | Waite | |
| St.Paul | Battle Creek | | | | | Hamline |
| Public | Bruce F Vento | | | | | Frost Lake |
| Schools | Chelsea Heights | | | | | Groveland Park |
| | Cherokee | | | | | Nokomis Montessori South |
| | Como Park | | | | | Nokomis Montessori North |
| | Eastern Heights | | | | | |
| | Expo | | | | | |
| | Highland Park | | | | | |
| | Horace Mann | | | | | |
| | Maxfield | | | | | |
| | Randolph Heights | | | | | |
| | St.Anthony Park | | | | | |
| | Wellstone | | | | | |

Walking and biking is affected by certain variables that remain hidden in this revealed preference analysis. Parents may drop off students at schools on their way to work, or may be uncomfortable sending students to walk or bike where infrastructure like sidewalks is lacking or where they would need to cross major roads. We lack data on these factors and do not see a way to obtain them from the limitations of StreetLight. The importance of those factors can only be described by parents in stated preference surveys.

## 2.2 Numerical analyses

Our numerical analyses are comprehensive to achieve a complete and convincing answer to the question of whether school start times affects walking and biking to school. We start by analyzing the data in several ways to understand patterns. Then, we create linear regression models to understand the aggregate effect of start times and month of year on travel patterns. We conduct multiple analyses with different subsets of the data to look for patterns that may only be present for a subset of the population.

For the linear regression we considered multiple variables for each school to try to identify all variables that are statistically significant. These variables which are shown in Table 2.2 are month, attendance, demographics, start time, income, and percent special education students. We then created revised models by removing variables that were not statistically significant to better understand the effect of each significant variable. The main goal we wanted to see in this experiment was whether start times for elementary schools in the Minneapolis, St. Paul area affected how many parents drove their children to school (and implicitly the number of students being driven instead of walking/biking).

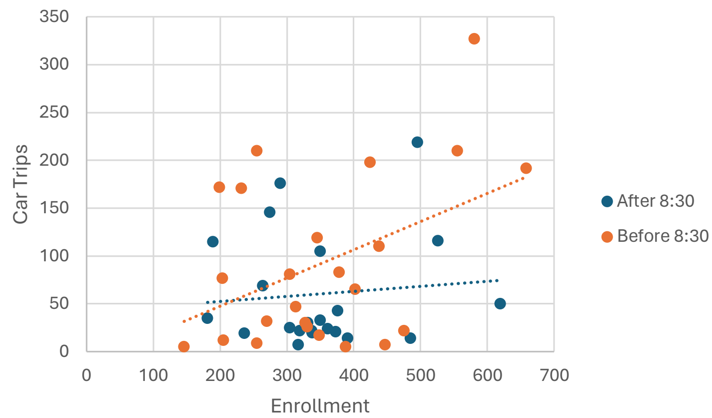
### 2.2.1 Outliers

StreetLight's interface does not directly admit recording all the trips to an elementary school. For many schools, parents drive by the school on an adjacent street to drop off and pick up their children, which would not be recorded as trips to the elementary school's parking lot. This is one of the disadvantages of using such revealed preference data, and is one of the reasons why a complementary stated preference survey was also conducted. Due to this limitation, we looked for trips ending at streets surrounding elementary schools. Some of these schools are located in areas with high attractions (e.g. near Como Park) and many of the observed car trips may not be destined for the elementary school. This resulted in sometimes observing large numbers of trips — larger than than the school's attendance. We treated these as outliers with incorrect data collection and removed them from the data. The schools removed were Lyndale, Como Park, and Nokomis Montessori North.

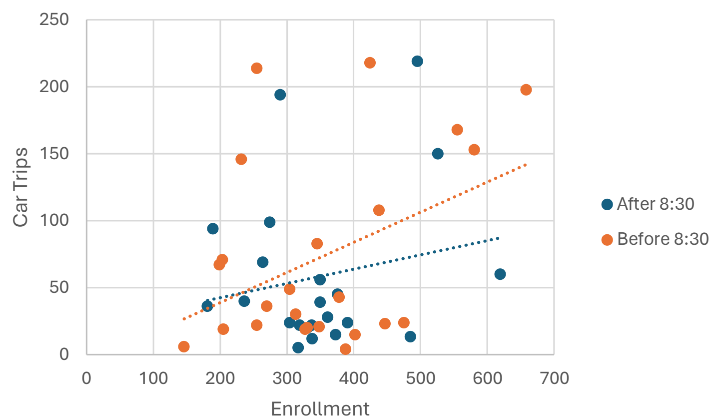
### 2.2.2 Effect of months on car travel

Figure 2.2 graphs the relationship between car trips and enrollment for each month. As expected, as enrollment increases, so does the number of car trips. Note that we are reporting car trips, so increases in car trips correspond to fewer students walking or biking. All months consistently show that the number of car trips increases faster with enrollment for schools that start earlier. This is not conclusive evidence that sunrise time is a significant factor in travel. For sunrise to be a variable, we would like to see different patterns for February than for September or April. Figure 2.2 could be explained as parents dropping their students off at school on the way to work consistently across each month, which would not support sunrise time being an issue. We also note that despite the trendlines, there are many outliers, and it is possible that other variables are more important than the school start time.

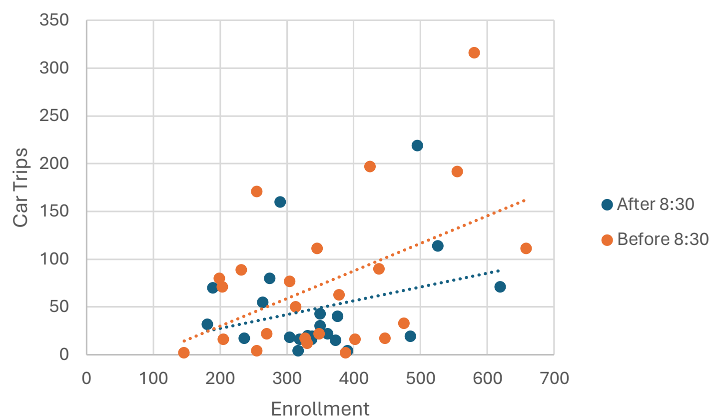
To determine whether sunrise time is a significant factor, we need to examine the numerical relationship between car trips and start times for different months. Therefore, we created several linear regression




(a) September car trips




(b) February car trips




(c) April car trips

**Figure 2.2: Car trips vs. enrollment, separated by month and school start times**

**Table 2.2: Combined linear regression model for Minneapolis and St. Paul Public Schools**

**(a) Linear regression model including all collected variables**

| Variable | Coefficient | Standard error | $t$-stat | $P$-value |
|---|---|---|---|---|
| Intercept | -239.94 | 281.61 | -0.85 | 0.40 |
| Month=Feb | 0 | – | – | – |
| Month=Apr | -9.42 | 22.98 | -0.41 | – |
| Month=Sep | 12.64 | 22.98 | 0.55 | 0.58 |
| Income (percent free lunch) | 0.94 | 2.28 | 0.41 | 0.68 |
| Before 8:30 | -11.17 | 23.95 | -0.47 | 0.64 |
| Special Ed percent | 9.30 | 3.25 | 2.86 | 0.00 |
| Enrollment | 0.33 | 0.10 | 3.31 | 0.00 |
| African American percent | -0.49 | 3.15 | -0.16 | 0.88 |
| Hispanic percent | 0.17 | 3.96 | 0.04 | 0.97 |
| White percent | 0.76 | 2.81 | 0.27 | 0.79 |
| Asian percent | 3.18 | 3.20 | 1.00 | 0.88 |

**(b) Linear regression model removing insignificant demographic variables**

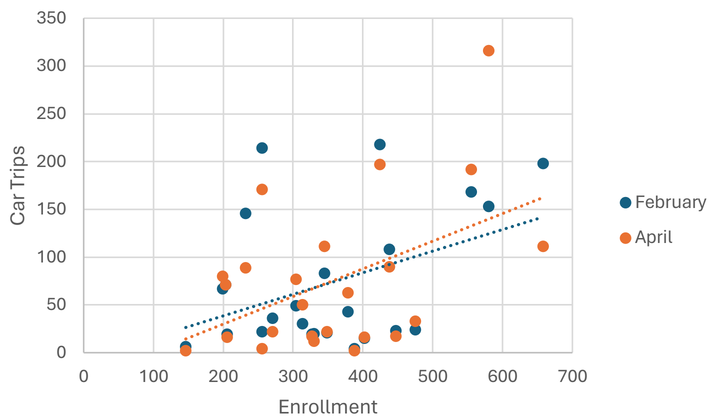
| Variable | Coefficient | Standard error | $t$-stat | $P$-value |
|---|---|---|---|---|
| Intercept | -220.43 | 52.62 | -4.19 | 4.9e-05 |
| Month=Feb | 0 | – | – | – |
| Month=Apr | -9.42 | 24.71 | -0.38 | – |
| Month=Sep | 12.64 | 24.71 | 0.51 | 0.61 |
| Income (percent free lunch) | 0.79 | 0.53 | 1.51 | 0.13 |
| Before 8:30 | -34.93 | 23.81 | -1.47 | 0.14 |
| Special Ed percent | 10.37 | 3.25 | 3.19 | 0.00 |
| Enrollment | 0.45 | 0.09 | 4.81 | 3.8e-06 |

models to examine these effects.

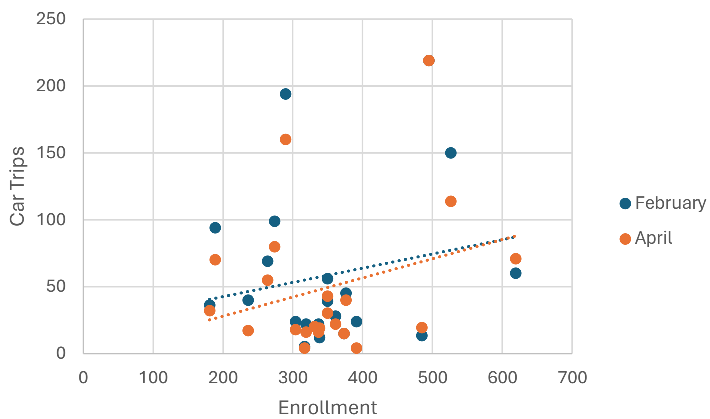
We first conducted a linear regression including all variables collected, shown in Table 2.2a. We observed that the demographic variables were not statistically significant. Therefore, we created a second linear regression model removing those variables in Table 2.2b. Although the month does not have a statistically significant effect, we retained it for the purpose of analysis. As expected, enrollment and the percent of special education students were both significant variables. The percent of students qualifying for a free lunch became more significant once demographics were removed.

February is the base month for comparison. Table 2.2b shows that there are more driving trips in September than in February. This is consistent with the car trip numbers shown in Figure 2.2. If sunrise time was a major factor, we would expect to observe the opposite effect: more car trips in February than in September. Although we see more car trips in February than in April, this pattern is also consistent with students increasing their walking and biking as the school year progresses and does not clearly indicate an issue with early sunrise times.

Table 2.2 also shows the impact of early start times on the number of trips. Surprisingly, the coefficient is consistently negative in both Tables 2.2a and 2.2b, and is not statistically significant. We will revisit this in more detailed analyses, but for now it is not consistent with sunrise time being a major factor.




**(a) Schools with start times before 8:30**




**(b) Schools with start times after 8:30**

**Figure 2.3: Separated comparison of February and April trips for schools with early and late start times**

### 2.2.3 Separate analysis for schools with common start times

To confirm the above results, we conducted further analyses on schools with early and late start times separately. Figure 2.3 shows the number of trips in February and April. If early sunrise times were a major issue, we would expect to see a major decrease in car trips in April for schools that start earlier. However, the overall change appears fairly small in Figure 2.3a.

We created linear regression models to study the effects in more detail in Table 2.3. Table 2.3b is the linear regression after insignificant demographic variables were removed. April has a slightly higher number of trips than February, but the difference is fairly small. However, this is inconsistent with sunrise times being a significant factor because sunrise in April is typically before 7:00 AM. A much larger difference is observed between February and September, with September having more car trips. Table 2.4 creates a similar linear regression for schools starting after 8:30 AM. A larger reduction in car trips is observed in Table 2.4b for April compared to February.

**Table 2.3: Linear regression model for schools starting before 8:30 AM**

**(a) Linear regression model including all collected variables**

| Variable | Coefficient | Standard error | $t$-stat | $P$-value |
|---|---|---|---|---|
| Intercept | -587.64 | 219.11 | -2.68 | 0.01 |
| Month=Feb | 0 | – | – | – |
| Month=Sep | 19.58 | 15.86 | -1.24 | 0.22 |
| Month=Apr | 0.98 | 15.86 | -1.17 | 0.25 |
| Income (percent free lunch) | 2.17 | 1.60 | 1.35 | 0.18 |
| Special Ed percent | 9.32 | 1.94 | 4.81 | 1e-05 |
| Attendance | 0.44 | 0.07 | 6.38 | 2.6e-08 |
| African American percent | 1.80 | 2.40 | 0.75 | 0.45 |
| Hispanic percent | 2.82 | 3.01 | 0.94 | 0.35 |
| White percent | 3.95 | 2.42 | 1.63 | 0.11 |
| Asian percent | 2.35 | 2.42 | 0.97 | – |

**(b) Linear regression model removing insignificant demographic variables**

| Variable | Coefficient | Standard error | $t$-stat | $P$-value |
|---|---|---|---|---|
| Intercept | -264.12 | 40.17 | -6.57 | 9.19e-09 |
| Month=Feb | 0 | – | – | – |
| Month=Sep | 19.58 | 15.83 | 1.24 | 0.22 |
| Month=Apr | 0.98 | 15.83 | 0.06 | – |
| Income (percent free lunch) | 0.61 | 0.32 | 1.91 | 0.06 |
| Special Ed percent | 8.47 | 1.79 | 4.72 | 1.28e-05 |
| Attendance | 0.48 | 0.06 | 8.15 | 1.43e-11 |

### Table 2.4: Linear regression model for schools starting after 8:30 AM

#### (a) Linear regression model with all collected variables

| Variable | Coefficient | Standard error | $t$-stat | $P$-value |
|---|---|---|---|---|
| Intercept | 687.25 | 357.28 | 1.92 | 0.06 |
| Month=Feb | 0 | – | – | – |
| Month=Sep | 2.80 | 26.27 | -0.11 | 0.92 |
| Month=Apr | -9.66 | 26.27 | -0.47 | 0.64 |
| Income (percent free lunch) | 1.55 | 3.13 | 0.50 | 0.62 |
| Special Ed percent | -3.95 | 5.56 | -0.74 | – |
| Attendance | 0.09 | 0.15 | 0.59 | 0.56 |
| African American percent | -9.00 | 4.21 | -2.14 | 0.04 |
| Hispanic percent | -7.50 | 5.70 | -1.32 | 0.19 |
| White percent | -6.65 | 3.33 | -2.00 | 0.05 |
| Asian percent | -2.98 | 4.05 | -0.74 | 0.46 |

#### (b) Linear regression model removing insignificant demographic variables

| Variable | Coefficient | Standard error | $t$-stat | $P$-value |
|---|---|---|---|---|
| Intercept | -10.70 | 34.92 | -0.31 | 0.76 |
| Month=Feb | 0 | 0 | 65535 | – |
| Month=Sep | 1.75 | 16.26 | 0.11 | 0.91 |
| Month=Apr | -9.18 | 16.26 | -0.56 | – |
| Income (percent free lunch) | 0.65 | 0.37 | 1.78 | 0.08 |
| Special Ed percent | 2.28 | 2.76 | 0.83 | 0.41 |
| Attendance | 0.06 | 0.07 | 0.95 | 0.34 |

**Table 2.5: Linear regression models separated by school district in February**

**(a) Minneapolis Public Schools**

| Variable | Coefficient | Standard error | $t$-stat | $P$-value |
|---|---|---|---|---|
| Intercept | 578.68 | 365.13 | 1.58 | 0.13 |
| Income (percent free lunch) | -2.11 | 2.91 | -0.73 | 0.48 |
| before 8:30 | -12.87 | 27.18 | -0.47 | 0.64 |
| Special Ed percent | 2.47 | 3.64 | 0.68 | 0.50 |
| Attendance | -0.02 | 0.13 | -0.14 | 0.89 |
| African American percent | -3.60 | 4.07 | -0.89 | 0.39 |
| Hispanic percent | -5.18 | 5.81 | -0.89 | 0.38 |
| White percent | -6.03 | 3.53 | -1.71 | 0.10 |
| Asian percent | -0.25 | 4.68 | -0.05 | 0.96 |

**(b) St. Paul Public Schools**

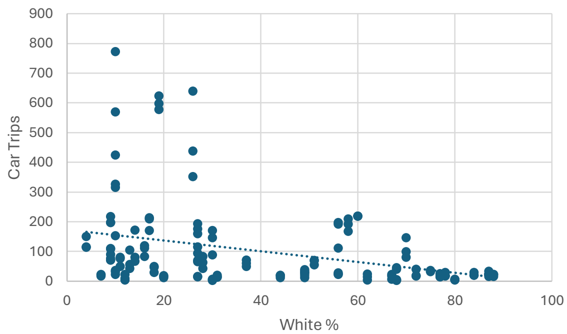
| Variable | Coefficient | Standard error | $t$-stat | $P$-value |
|---|---|---|---|---|
| Intercept | -39.27 | 947.14 | -.04 | 0.97 |
| Income (percent free lunch) | 9.05 | 5.78 | 1.56 | 0.16 |
| before 8:30 | -83.76 | 37.81 | -2.22 | 0.06 |
| Special Ed percent | 9.88 | 6.32 | 1.56 | 0.16 |
| Attendance | 0.54 | 0.19 | 2.78 | 0.03 |
| African American percent | -11.64 | 14.69 | -0.79 | 0.45 |
| Hispanic percent | -12.14 | 15.57 | -0.78 | 0.46 |
| White percent | -1.57 | 11.28 | -0.14 | 0.89 |
| Asian percent | -8.92 | 14.56 | -0.61 | 0.56 |

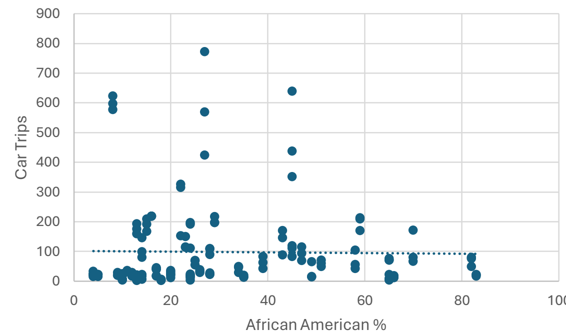
### 2.2.4 Comparison of different school districts

While reviewing the data, we noticed different patterns for Minneapolis Public Schools and St. Paul Public Schools, although their start time options were identical. These differences could be caused by different infrastructure in the two cities, different busing availability between the two school districts, or other district-specific variables. To examine whether early school start times had a different effect, we created separate linear regression models for each school district for the month of February in Table 2.5. The magnitude of the effect of early start times is much greater for St. Paul Public Schools. However, for both school districts, the best fit line had a negative coefficient for starting before 8:30, suggesting that other variables were responsible for the observed increase in car trips.

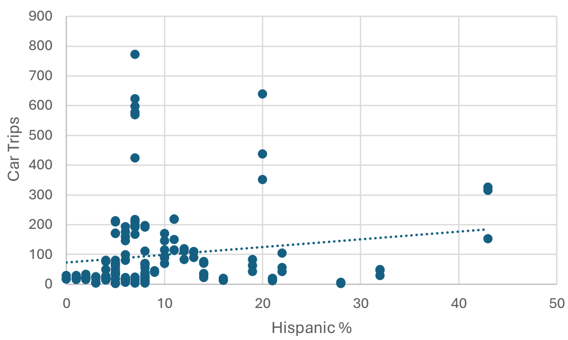
### 2.2.5 Effects of demographics

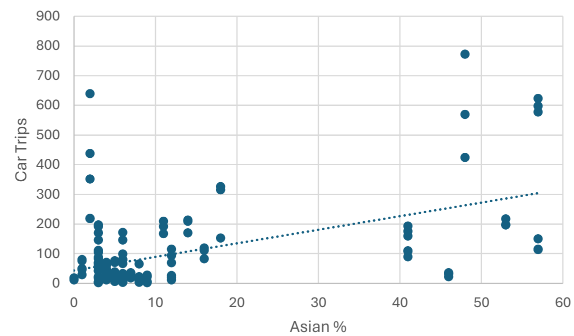
In our previous linear regression models, ethnicity and race were not observed to be significant variables. To confirm this, we studied the number of car trips with respect to the percent of the school that identifies as specific races or ethnicities, which is shown in Figure 2.4. The overall line fit was fairly weak, but we observed trends for Asian, Hispanic, and white demographic groups. Higher percentages of Asians and Hispanics were associated with increased numbers of car trips, whereas higher percentages of white students were associated with decreased car travel. It is not clear from this data why these trends were observed. It




**(a) Impact of white students** **(b) Impact of African American students**




**(c) Impact of Hispanic students** **(d) Impact of Asian students**

**Figure 2.4: Effects of races and ethnicities on the numbers of car trips**

could be due to cultural factors or the available infrastructure in neighborhoods trending towards specific demographics.

# Chapter 3. Stated preference survey

Understanding the reasons why elementary school students choose their travel mode requires more than observing students' travel behaviors. We cannot identify why observed patterns occur. Students might choose to be driven in winter due to late sunrise times (which is the purpose of this study) or simply to avoid cold weather. We will attempt to tease out these variables by observing the travel choices at schools with different start times, e.g. comparing travel choices to community elementary schools in St. Paul Public Schools that start at 7:30am and 9:30am. However, that is still at best a guess at student preferences, and the only way to collect information about their reasoning is to ask.

Because this project focuses on elementary school students, we anticipate that their travel decisions are made in cooperation with, and maybe even primarily by their parents/guardians. During elementary school, most students are starting to become comfortable enough to travel to school by themselves. Parents/guardians may not be comfortable with their children crossing roads alone, for instance, whereas middle school students would be more comfortable with it. Furthermore, elementary school students may not be able to accurately articulate the reasons for their travel choices on a survey due to lack of awareness of all parental concerns. We also expect that parents/guardians of elementary school children are sufficiently involved in how they travel to school, unlike some parents/guardians of older (e.g. high school) children. Therefore, we believe it more accurate to survey parents/guardians of elementary school children to learn their preferences.

## 3.1 Reasons for mode choice

To compare travel preferences with actual travel, we asked parents/guardians how often their child travel to and from school each week using various options including walking, biking, scooter, being driven to school, school bus. Qualtrics enforced that the answers add up to 5. The survey asked about travel to school and from school separately, recognizing that these answers might differ. Besides asking which school children attend, we also asked when students arrive at and leave school each day to capture early arrivals or late departures due to parent/guardian schedules, daycare, etc. that might affect students' travel choices.

We anticipated that if we ask parents/guardians "does sending elementary school children to walk/bike to school before sunrise affect your travel choices" then the answer would be "yes". Walking or biking in the dark increases the risk of collisions with cars, crime, and other issues, and few parents/guardians would like their children to be more exposed due to early school start times. Therefore, we needed to compare the relative importance of traveling in the dark to other factors that could affect students' travel choices such as weather, distance, crossing busy roads, neighborhood infrastructure, etc. We divided these factors into several categories which are listed below.

### 3.1.1 Safety

These are factors that could affect whether it is safe for young children to be walking/biking to school, especially walking or biking alone, not accompanied by an adult.

- Neighborhood crime, which could make walking/biking feel unsafe.
- Crossing a high-traffic or busy road to get to school, which could increase the risk of a collision with motor vehicles.
- Traveling before sunrise or after sunset, which could increase the risk of the above factors.
- Child's age, which affects maturity and parental/guardian trust in their independence.

### 3.1.2 Comfort

These factors make walking or biking uncomfortable separate from safety issues.

- Weather conditions including temperature and rain/snow/ice, especially if infrastructure is not cleared of snow/ice or students want to avoid being outside in the cold.
- Comfortable and safe options for walking or biking (e.g. sidewalks, crosswalks, bike trails).
- Distance to school, since longer distance travel is more tiring. Note that the actual distance to school will be asked as a separate question.
- Child's interest in physical activity, since some children are more comfortable with walking/biking than others.

### 3.1.3 Convenience

These factors affect how convenient it is to drive.

- Parent/guardian travel plans (e.g. driving to work), since parents may find it easy to drop their child off as part of another trip.
- Driving times, vehicle speeds, and traffic congestion, which would make driving more onerous.
- Carpooling with other students.

## 3.2 Demographic information

We also anticipate that demographic information might affect the preferences of students and parents/guardians. For example, the availability of cars (owned, leased, borrowed, etc.) affects whether students have the option to be driven to school and how convenient it is for the parents/guardians. For example, a household with only 1 car that is used by a parent to drive to work may force the student to walk or bike to school.

Household income may affect parent/guardian preferences on how they and their children travel, and it is also correlated with the neighborhood that the child lives in. Higher income neighborhoods may have more infrastructure for walking/biking or less crime. Asking parents about issues like the quality of infrastructure or worry about crime is difficult because everyone has a different perceptions and scale to rate it. However, income is an objective number that is easy to ask.

Gender could also affect travel preferences. It is established in the literature that men and women walk at different speeds [**?** ], and gender also affects mode choices in general [**?** ] and for school travel [**?** ] Parents/guardians may be more protective of certain genders, and the gender of the parent primarily responsible for sending the child to school could also affect their travel preferences. For whatever reason, gender could be important.

Cultural factors could also affect parent/guardian preferences on how children travel to school. Although asking parents/guardians about the influence on culture may not yield clear answers, we asked about race and ethnicity. These demographic characteristics might also be correlated with neighborhood choice and the infrastructure available in that neighborhood for walking/biking.

We asked about the following demographic information in our survey.

- Number of cars at household
- Household income
- Child's race, ethnicity, and gender
- Gender of parent primarily responsible for taking child to school

## 3.3 Final survey

The final survey is given below. This reflects revisions made after meeting with the TAP. The actual survey was a Qualtrics interactive form that could be viewed on a phone or computer.

1. Which school does your child attend?
2. On average, how many times per week does your child travel to school using the following alternatives:
   - Walking
   - Bicycle
   - Scooter
   - Driven to school
   - School bus
   - Other
3. On average, how many times per week does your child travel from school using the following alternatives:
   - Walking
   - Bicycle
   - Scooter
   - Driven to school
   - School bus
   - Other
4. How far do you live from school?
   - ○ 0–0.25mi
   - ○ 0.25–0.5mi
   - ○ 0.5–0.75mi

- 0.75–1mi
- 1–1.25mi
- 1.25–1.5mi
- $>$ 1.5mi

5. How important are each of the following factors to whether you child walks or bikes to school? Rank each one (most important is rank 1). Drag and drop.

   (a) Your child's age
   (b) Traveling before sunrise or after sunset
   (c) Your child's interest in physical activity
   (d) Distance to school
   (e) Parent/guardian travel plans (e.g. driving to work)
   (f) Comfortable and safe options for walking or biking (e.g. sidewalks, crosswalks, bike trails)
   (g) Neighborhood crime
   (h) Carpooling with other students
   (i) Weather conditions including temperature and rain/snow/ice
   (j) Driving times, vehicle speeds, and traffic congestion
   (k) Crossing a high-traffic or busy road to get to school

6. How important are each of the following factors to whether you child walks or bikes from school? Rank each one (most important is rank 1). Drag and drop.

   (a) Your child's age
   (b) Traveling before sunrise or after sunset
   (c) Your child's interest in physical activity
   (d) Distance to school
   (e) Parent/guardian travel plans (e.g. driving to work)
   (f) Comfortable and safe options for walking or biking (e.g. sidewalks, crosswalks, bike trails)
   (g) Neighborhood crime
   (h) Carpooling with other students
   (i) Weather conditions including temperature and rain/snow/ice
   (j) Driving times, vehicle speeds, and traffic congestion
   (k) Crossing a high-traffic or busy road to get to school

7. When does your child usually arrive at school in the morning?

8. When does your child usually leave school in the afternoon/evening?

9. What grade is your child in?

   - Kindergarten
   - 1st grade
   - 2nd grade

- 3rd grade
- 4th grade
- 5th grade

10. What was the total income of your household in the past year?
    - Less than $20,000
    - Between $20000 and $34999
    - Between $35000 and $49,999
    - Between $50000 and $74999
    - Between $75000 and $99999
    - Between $100000 and $124999
    - Between $125000 and $149999
    - $150,000 or greater
11. How many cars are at your household (including cars owned, leased, borrowed, etc.)?
    - 0
    - 1
    - 2
    - 3
    - 4 or more
12. What is your child's race?
    - ☐ White
    - ☐ Black or African American
    - ☐ American Indian or Alaska Native
    - ☐ Asian
    - ☐ Native Hawaiian or other Pacific Islander
    - ☐ Other
13. What is your child's ethnicity?
    - ☐ Hispanic or Latino
    - ☐ Not Hispanic or Latino
14. What is your child's gender?
    - Male
    - Female
    - Transgender
    - Non-binary
    - Prefer not to answer

15. What is the gender of the parent primarily responsible for sending the child to school?
    - Male
    - Female
    - Transgender
    - Non-binary
    - Prefer not to answer

## 3.4 Preparation for data collection

In September 2023, the project team began preparations for data collection. The Minneapolis and St. Paul Public Schools districts were our primary targets because they include multiple community elementary schools with varying start times, including some starting at 7:30 AM before sunrise and some at 9:30 AM.

### 3.4.1 Departments of Research, Evaluation, and Assessment

Both Minneapolis Public Schools (MPS) and St. Paul Public Schools (SPPS) have a formal process for applying for permission to conduct research at their schools through their Departments of Research, Evaluation, and Assessment. In September, we submitted formal applications to MPS and SPPS to survey parents of students. The application to SPPS is attached as Appendix A. Ultimately, SPPS approved our application, but MPS declined saying that they did not have time to support another survey. Therefore, we were not able to survey any students at schools in MPS.

### 3.4.2 Institutional Review Board

Our research involves human participants (surveying parents), and therefore we submitted an application to the UMN Institutional Review Board. Ultimately, they determined that our survey was exempt from a full review because of the nature and content of the study.

### 3.4.3 Survey distribution by principals

Simultaneously reaching out informally to principals of community elementary schools that we wanted to survey. Distributing the survey to parents of enrolled students ultimately required support from school staff, as the project team did not have nor wish to obtain contact information for all relevant parents. PI Levin attempted to contact principals of all community elementary schools in SPPS via email in September 2023 to obtain their support for survey distribution in January or February. When a response was not received, PI Levin attempted to contact principals multiple times.

We received positive responses from the principals of these schools in SPPS:

- Bruce Vento Elementary School
- Burroughs Elementary School
- Chelsea Heights Elementary School
- Groveland Park Elementary School
- Hamline Elementary School
- Highwood Hills Elementary School

- Horace Mann Elementary School
- Maxfield Elementary
- Northrop Elementary School
- St. Anthony Park Elementary School

Some other school principals responded but were unwilling to support survey distribution.

With the help of Kelly Corbin and other TAP members, we also made connections with staff at other school districts. We received positive support from staff at Richfield Public Schools, Rochester Public Schools, and Minnetonka Public Schools. The staff we contacted worked at the district level and planned to help distribute the survey to elementary schools across the district.

The survey was published in December, and the Qualtrics link was distributed to principals and staff between January 24 and February 1 as a link and a QR code. Methods of distribution varied: some principals included it in a newsletter sent to parents, and others may have attempted to hand out paper flyers or cards with the link.

### 3.4.4 Language barriers and survey translation

Several principals expressed that parents were not native English speakers and would not be able or willing to participate in a survey distributed in English. Therefore, we paid the Minnesota Translator and Interpreter Cooperative to translate the survey into Spanish, Somali, and Hmong, which were the languages requested by principals and suggested by the TAP. The translations were added as an alternative language option within Qualtrics: the same survey link gave respondents 4 language options.

Parents were asked to rank the importance of the following 11 factors that could affect their child's travel choices.

Four factors were based on safety:

1. **Neighborhood crime**: This could make walking or biking feel unsafe.
2. **Crossing a high-traffic or busy road to get to school**: This could increase the risk of a collision with motor vehicles.
3. **Traveling before sunrise or after sunset**: This could increase the risk associated with the above factors.
4. **Child's age**: This affects maturity and parental/guardian trust in their independence.

Four more factors were based on comfort:

1. **Weather conditions**: Including temperature and rain/snow/ice, especially if infrastructure is not cleared of snow/ice or students want to avoid being outside in the cold.
2. **Comfortable and safe options for walking or biking**: For example, sidewalks, crosswalks, and bike trails.
3. **Distance to school**: Since longer distance travel is more tiring. Note that the actual distance to school will be asked as a separate question.
4. **Child's interest in physical activity**: Some children are more comfortable with walking or biking than others.

The remaining three factors were based on convenience:

1. **Parent/guardian travel plans**: For example, driving to work, since parents may find it easy to drop their child off as part of another trip.

2. **Driving times, vehicle speeds, and traffic congestion**: These factors could make driving more onerous.

3. **Carpooling with other students**: This could affect travel choices.

## 3.5 Stated importance of travel factors

As of May 1, 2024, our survey had received 436 responses from parents across multiple schools.

As part of the survey, parents were asked to rank the importance of each of several factors on their decisions to have or not have their children walk or bike to school. Lower rankings indicate higher importance. Figure 3.1 shows the average ranking of each factor by parents. The factors are

1. Child's age
2. Distance to school
3. Traveling before sunrise or after sunset
4. Your child's interest in physical activity
5. Parent/guardian travel plans (such as driving to work)
6. Comfortable and safe options for walking or biking (such as sidewalks, crosswalks, bike trails)
7. Neighborhood crime
8. Carpooling with other students
9. Weather conditions including temperature and rain/snow/ice
10. Driving times, vehicle speeds, and traffic congestion
11. Crossing a high-traffic or busy road to get to school

Item 3, traveling before sunrise, is neither the most or least important; on average it is roughly in the middle in terms of importance.

We also obtained graphs of the distribution of responses for each factor in Figures 3.2 and 3.3. These graphs are effective at illustrating the relative importance to parents. Overall, traveling before sunrise is ranked in the middle, meaning it is not irrelevant but also not the most important factor to parents.

## 3.6 Analyses of stated travel patterns

We separately studied the modes that parents stated their children used to attend school. Parents were asked to describe how often (out of 5) children traveled to school using each mode per week. These results complement the StreetLight revealed preference analyses. StreetLight suffers from some missed observations and also cannot distinguish between students walking, biking, and taking the bus. On the other hand, parent memories of child travel patterns can be faulty, and the survey responses are limited creating opportunities for response bias. Overall, it is beneficial to analyze all data that could be relevant to our research question.

Most of the students either take the school bus to the school or get driven by parents. This type of practice would be more common in the suburbs as distance to school might preclude walking or biking. Safety is another major reason parents preferred to drive or have their kids take the school bus, especially

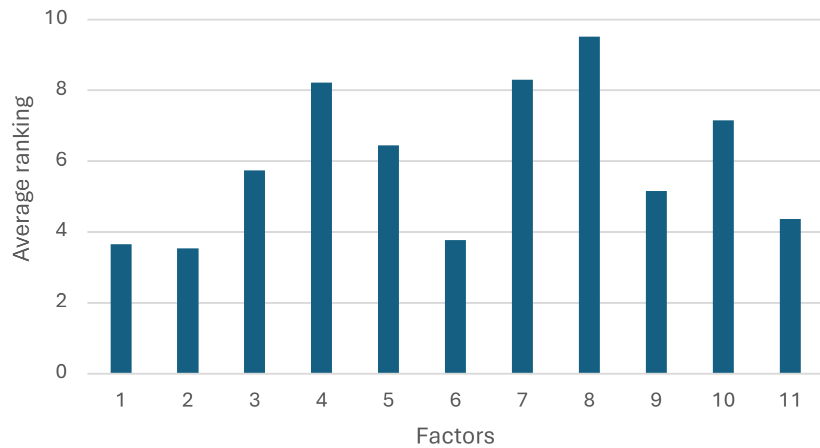



**Figure 3.1: Average ranking of each factor**

**Table 3.1: Percent of students living at different distances from school**

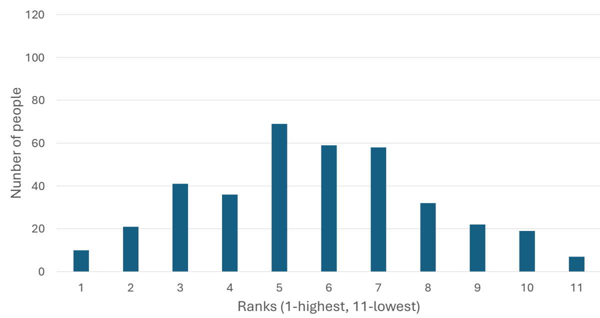
| Distance | % of respondents |
|---|---|
| 0–0.25 | 13.21% |
| 0.25–0.50 | 11.32% |
| 0.50–0.75 | 7.82% |
| 0.75–1.00 | 9.97% |
| 1.00–1.25 | 13.48% |
| 1.25–1.5 | 8.63% |
| 1.5 or greater | 35.58% |

safety concerns around crossing busy roads. This analysis shows the dominance of motorized travel and explains that infrastructure such as sidewalks and options to avoid collisions with traffic could increase the number of children using active transportation.

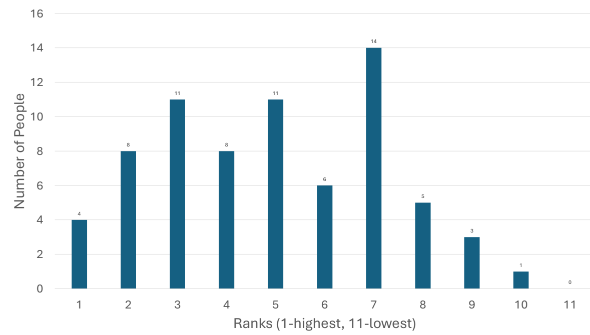
Table 3.1 shows the % of respondents living at different distances from school. For public transit, travelers are usually willing to walk between 0.25 to 0.5miles to reach a transit stop. Similar distances might be considered as reasonable for walking to school, although biking longer distances is more feasible. Nevertheless, Table 3.1 suggests that many students may choose not to use active transportation due to their distance from school.

### 3.6.1 Effects of school start times on travel choices

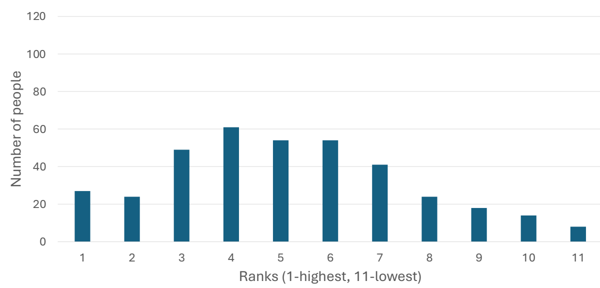
Figure 3.4 shows stated travel mode choices for schools with early or late start times relative to sunrise. Active transportation modes were actually reported to be more common among students with early school start times. This appears to be consistent with StreetLight data analyses and suggests that early start times did not reduce active transportation. It is possible that early start times were more convenient for parent work schedules despite issues with sunrise during winter. The survey was given to parents during February



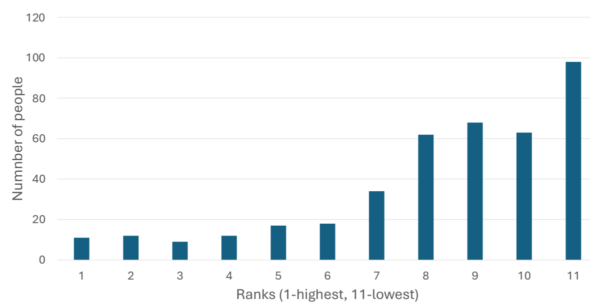

**(a) Importance of traveling before sunrise**



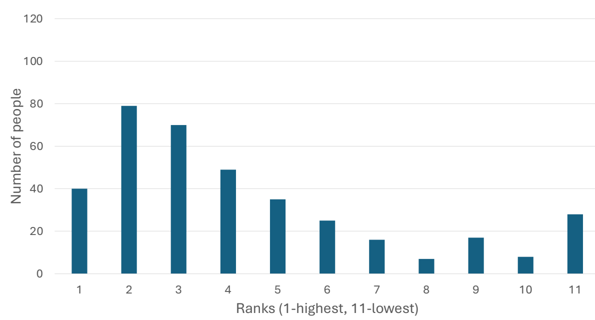

**(b) Importance of traveling before sunrise by respondents with schools that start before 8:00am**



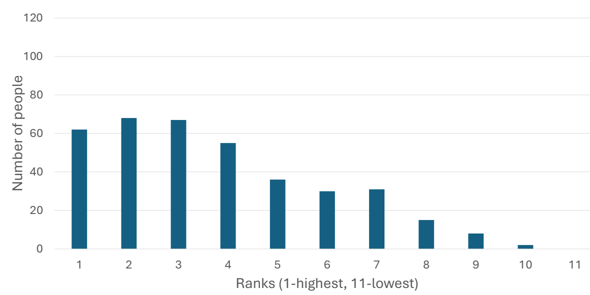

**(c) Importance of weather conditions including cold weather and snow on the ground**




**(d) Importance of neighborhood crime**

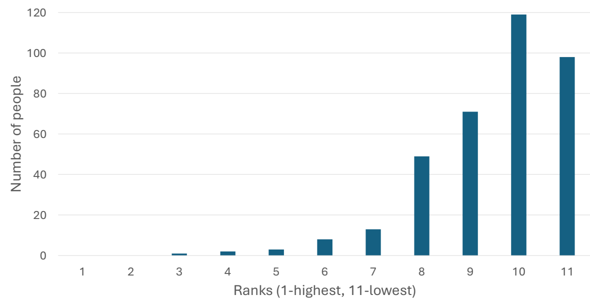



**(e) Importance of needing to cross busy roads while walking or biking to school**

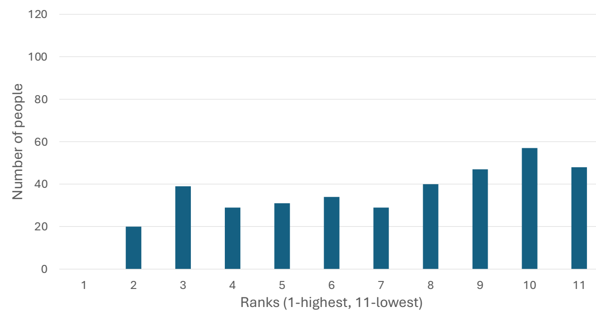



**(f) Importance of infrastructure availability such as sidewalks**

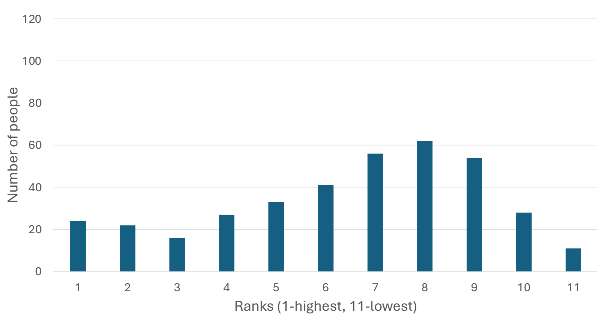
**Figure 3.2: Importance of factors relating to safety while walking or biking**



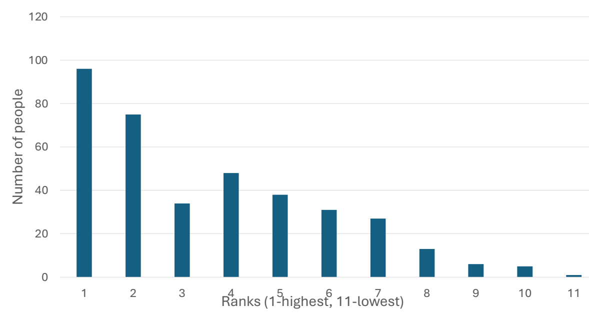

**(a) Importance of carpooling availability**



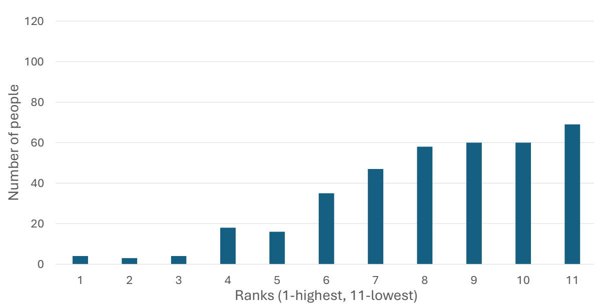

**(b) Importance of driving times, driving speeds, and traffic congestion**



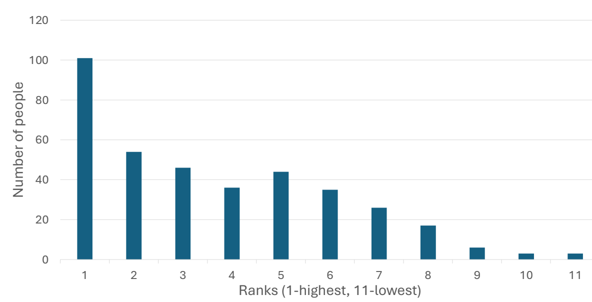

**(c) Importance of parent travel plans**




**(d) Importance of distance to school**

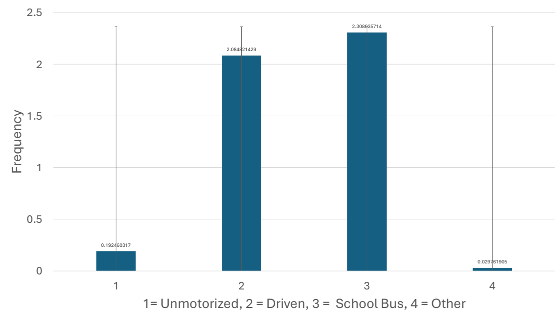



**(e) Importance of child's interest in physical activity**

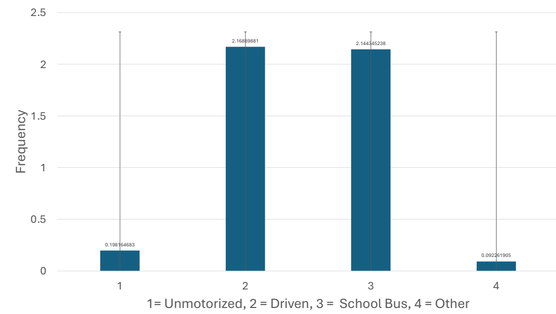



**(f) Importance of child's age**

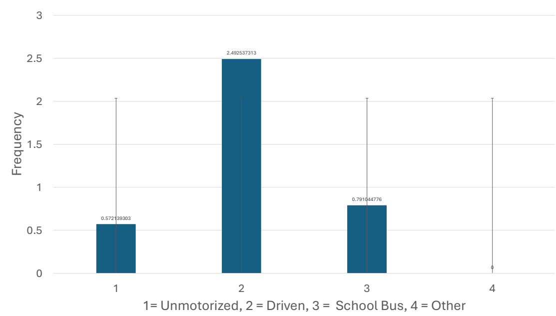
**Figure 3.3: Importance of factors relating to travel convenience or interest**



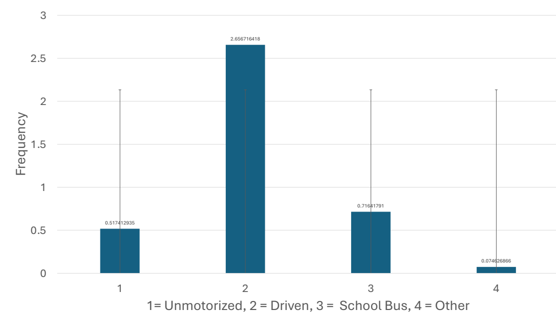

**(a) Average mode of transportation — After sunrise — to school**




**(b) Average mode of transportation — After sunrise — from school**




**(c) Average mode of transportation — Before sunrise — to school**




**(d) Average mode of transportation — Before sunrise — from school**

**Figure 3.4: Travel mode choices by school start times**

when late sunrise times would be relevant or recently relevant to student travel. Figure **??** replicates Figure 3.2b but only includes responses for parents of students at schools with early start times. The similar patterns indicate that late sunrise was not a significantly more important issue among such parents.

## 3.6.2 Effect of demographic patterns on travel choices

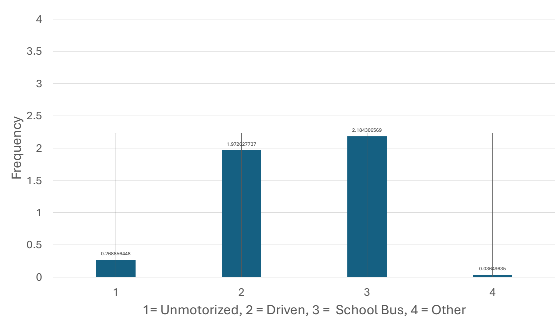
From Figures 3.6 and 3.7, it can be seen that race and ethnicity demographics has some impact on travel patterns. Some other demographics are also important. To systematically identify important factors, we conducted a hypothesis test for each of the demographics and mode of transportation. A common hypothesis test, the t-test involves finding the p-value and a t-statistic. Using excel, we obtained the following results in the graph above. Comparing p-values to the number of significance, the alpha value of 0.05, all p-values with less than 0.05 were taken out and put into this graph. Then, whether or not they were above or below the global average is then known by using the t-stat data. A positive t-stat value represents that the frequency is above the global average. On the other hand, a negative t-stat would mean that the frequency is less than that of the global average. Table 3.2 reports the factors that were observed to be statistically significant. Graphs of travel frequency obtained from survey data are also presented as further evidence for these results.

Figure 3.5 shows that we did not find major differences between whether younger and older children would walk and bike. However, younger children were less likely to take the bus.

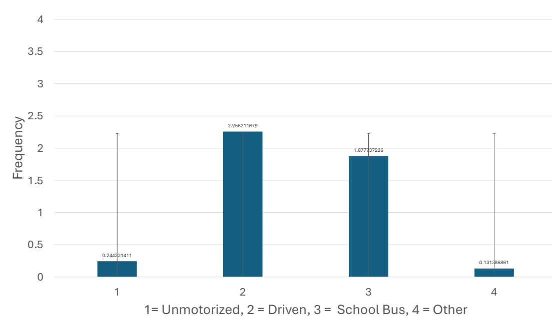
Figure 3.7 gives us a clear picture of how most students got to school. As can be seen, the dominant

| Demographics | Mode of Transport | To/From | P-Value | T-Stat |
|---|---|---|---|---|
| Asian+ | unmotorized | from | 0.014814179 | -2.450126389 |
| Hispanic/Latino | unmotorized | from | 0.030167467 | -2.183282062 |
| $100,000 < x <$150,000 | other | to | 6.33158E-11 | 7.58668705 |
| 3+ cars | unmotorized | to | 0.037051875 | -2.104592826 |
| 3+ cars | unmotorized | from | 0.028860922 | -2.207053178 |
| early sunrise | unmotorized | to | 0.003771449 | 2.926783683 |
| early sunrise | car | to | 7.7267E-11 | 7.740150857 |
| early sunrise | school bus | to | 0.018011216 | 2.424987793 |
| early sunrise | other | to | 7.88639E-18 | -8.736815443 |
| early sunrise | unmotorized | from | 0.010757599 | 2.571442364 |
| early sunrise | car | from | 4.135E-12 | 8.450892686 |
| early sunrise | school bus | from | 0.020686757 | 2.368921899 |
| early sunrise | other | from | 0.032922866 | -2.167980097 |

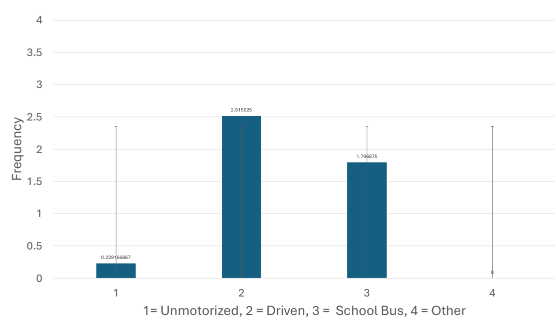
**Table 3.2: Variables where travel mode choices differ from average**



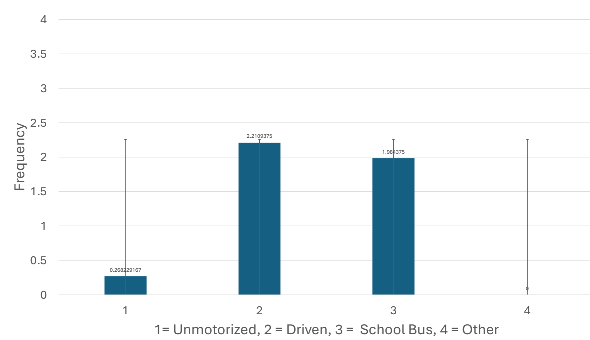

**(a) Average mode of transportation — K–3 — to school**




**(b) Average mode of transportation — K–3 — from school**




**(c) Average mode of transportation — 4–5 — to school**




**(d) Average mode of transportation — 4–5 — from school**

**Figure 3.5: Travel mode choices by age**

method is driving and taking the school bus. For people who are not Hispanic nor Latino, the frequency of using cars and school buses is similar, but for Hispanic and Latino people, the clear dominant method used for transportation to school is driving. However, Figure 3.6 shows that for other races as that the school bus is the dominant choice for kids to get to school.

In Figure 3.8, the average of how often a child goes to school can be seen for different genders. Small differences were observed between genders, such as the use of scooters by male children. There were only seven respondents who were neither male or female, and that data has been excluded from these graphs.

We also studied the impact of income on student travel choices. Household income was reported directly in the survey and indirectly via the number of cars available to the household. Active transport was most common among households with incomes between \$100,000–\$150,000 (Figure 3.9), and appeared to decrease with the number of household cars (Figure 3.10).

## 3.7 Logit model for travel choices

The previous data analyses identified the impact of various factors on student mode choices, but we wanted to quantify their effects based on stated demographic data, distance to school, and school start times. To do so, we used logistic regression to construct utility-based mode choice models. demographics affect the likely-hood of a child using non-motorized transportation. Utility theory states that each of the discrete travel choices $m$ has some travel utility $U_i(m)$ for household $i$, which is comprised of various travel-related components such as distance and school start times, and further depends on student household characteristics such as number of available cars. We focus on predicting the utility of active transportation modes. Formally, the utility for walking or biking is defined as

$$U_i = \beta^0 + \sum_j \beta^j x_i^j + \epsilon \tag{3.1}$$

where $x_i$ is the value of that factor for the household, $\beta^j$ is its importance, $\beta^0$ is the alternative specific constant, and $\epsilon$ is a random error representing estimation errors and/or traveler perception error (cannot be distinguished). The probability of traveler $i$ choosing active transportation is predicted as

$$P(\text{traveler } i \text{ uses active transportation}) = \hat{p}_i = \frac{1}{1 + \exp(-U_i)} \tag{3.2}$$

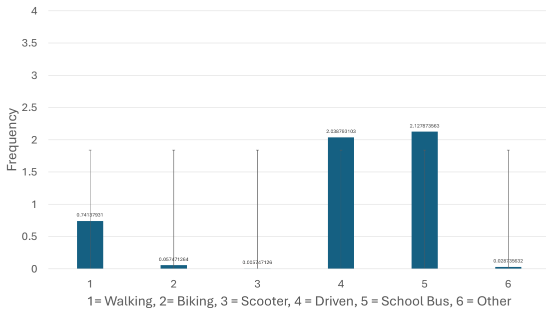
Our goal is to find the $\beta^j$ values so that we can quantify the relative importance of each factor. We achieve that by finding the $\beta^j$ values that best match the stated mode choices in the survey data. We aim to maximize the sum of log likelihoods, representing the difference in predicted vs. stated probabilities of mode choices:

$$\max p_i \cdot \ln(\hat{p}_i) + (1-p) \cdot \ln(1-\hat{p}_i) \tag{3.3}$$

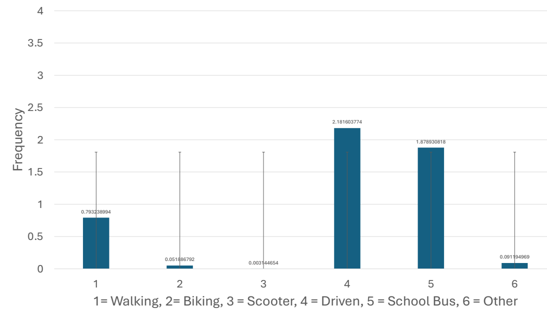
We solved this using logistic regression. The average of the log likelihood was calculated as $-0.260237171$, indicating a good match with the data.

We found the $\beta^j$ coefficients in Table 3.3. Positive coefficients indicate a higher utility for active transportation, and the magnitude of the impact on utility, $\beta^j x_i^j$, can be compared. Distance to school had a large impact on walking and biking. Gender and ethnicity had some impact, but it was fairly small compared to distance. Because income can take on values above \$100,000, it has an impact on the same order of magnitude as early school start times.

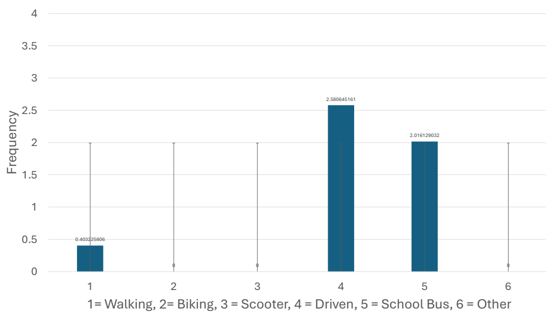
Surprisingly, early school start times was associated with increased use of active transportation, but that is consistent with Figure 3.4. It is difficult to explain these results. However, Figure 3.1 indicates that



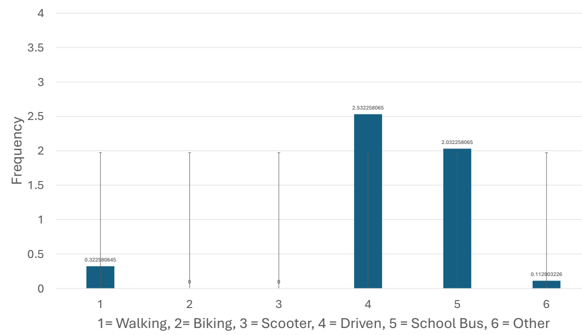

**(a) Average mode of transportation — White — to school**



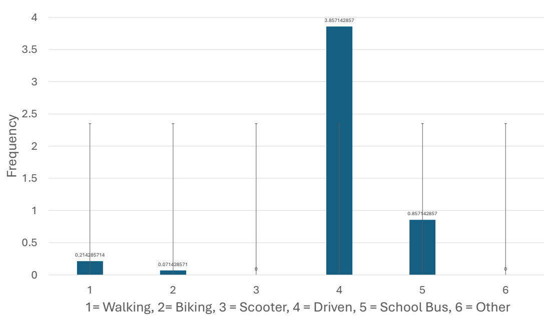

**(b) Average mode of transportation — White — from school**



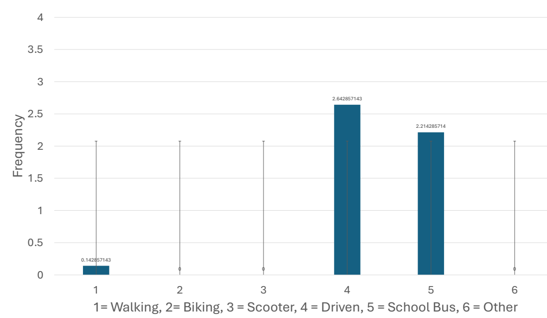

**(c) Average mode of transportation — Asian+ — to school**




**(d) Average mode of transportation — Asian+ — from school**

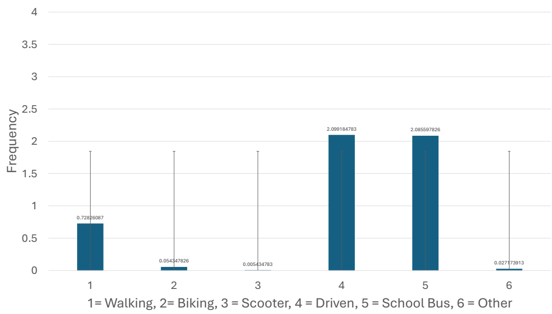



**(e) Average mode of transportation — Other — to school**

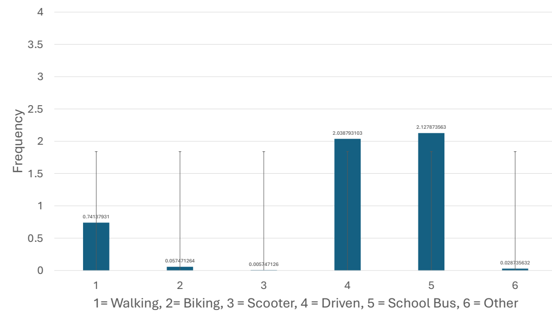



**(f) Average mode of transportation — Other — from school**

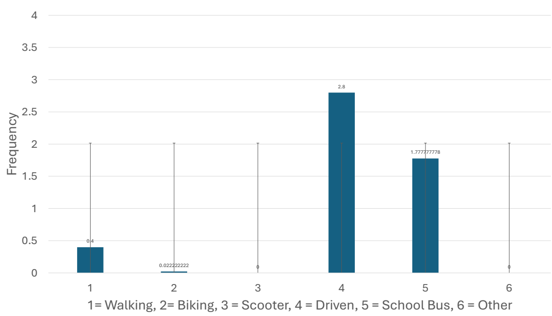
**Figure 3.6: Travel mode choices by race. The number of respondents from other races were small, so they were grouped and presented in the "other" category.**



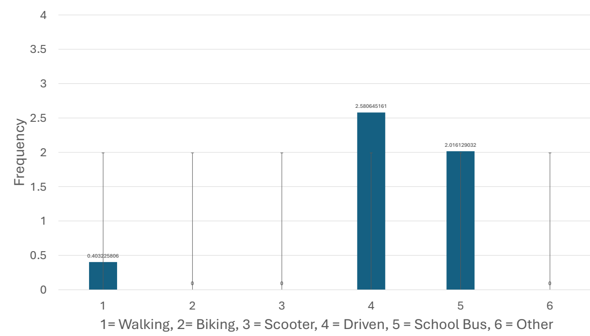

**(a) Average mode of transportation — Non-Hispanic — to school**




**(b) Average mode of transportation — Non-Hispanic — from school**




**(c) Average mode of transportation — Hispanic — to school**



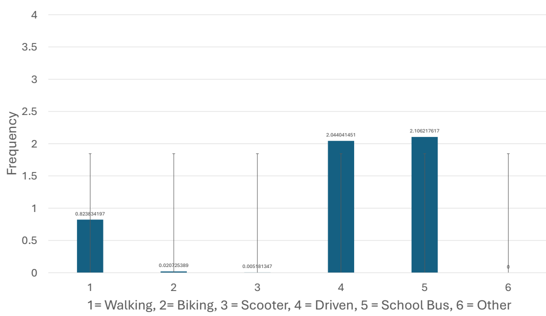

**(d) Average mode of transportation — Hispanic — from school**

**Figure 3.7: Travel mode choices by ethnicity**

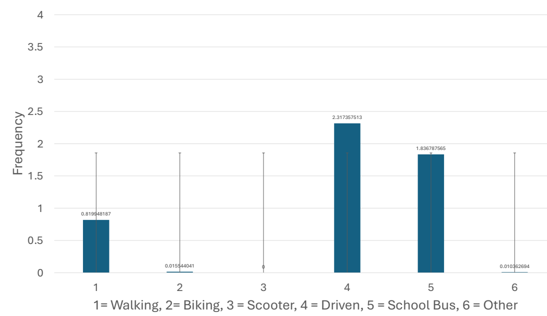
**Table 3.3: Logit model where age is an integer and number of cars is a binary indicator**

| Variable | Coefficient |
|---|---|
| Alternative specific constant | $-0.199710795$ |
| Distance | $-3.877433665$ |
| Age | $-0.003017755$ |
| Income | $0.000002280$ |
| Gender | $0.359325958$ |
| Race | $0.080644637$ |
| Ethnicity | $0.22061093$ |
| Early school start time | $0.544313797$ |
| Household has 3+ cars (binary variable) | $0.554980405$ |
| Household has 2 cars (binary variable) | $0.457776659$ |

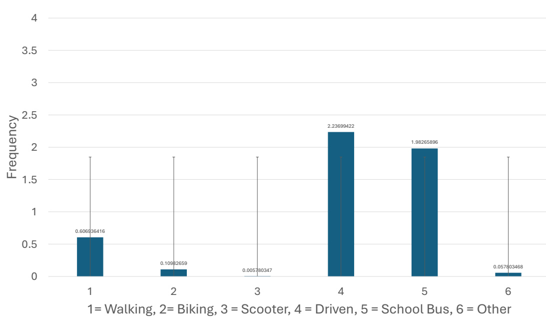
Almost all households had at least 1 car.



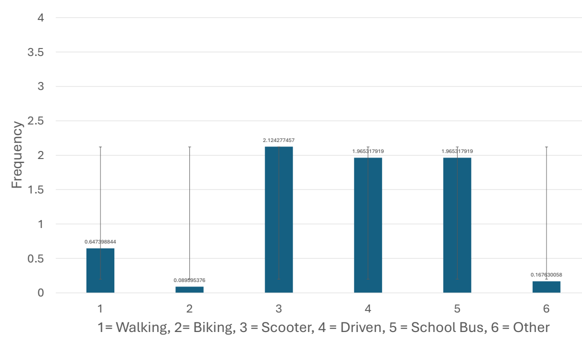

**(a) Average mode of transportation — Female — to school**




**(b) Average mode of transportation — Female — from school**

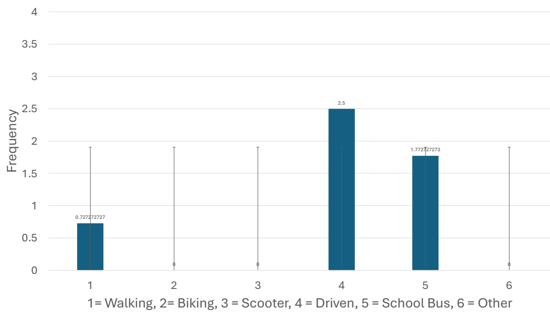



**(c) Average mode of transportation — Male — to school**

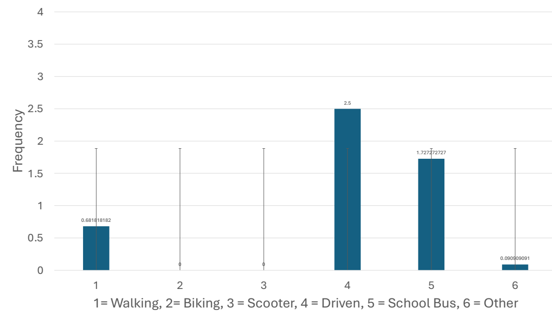



**(d) Average mode of transportation — Male — from school**

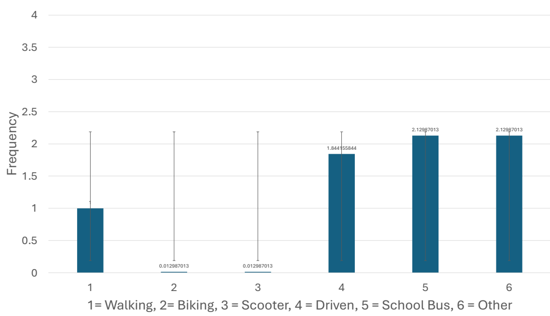
**Figure 3.8: Travel mode choices by student gender**



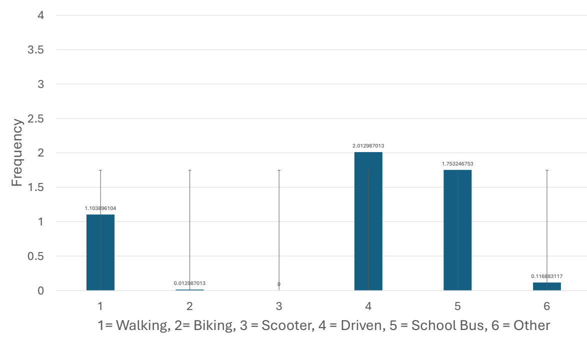

**(a) Average mode of transportation — less than 100,000 — to school**



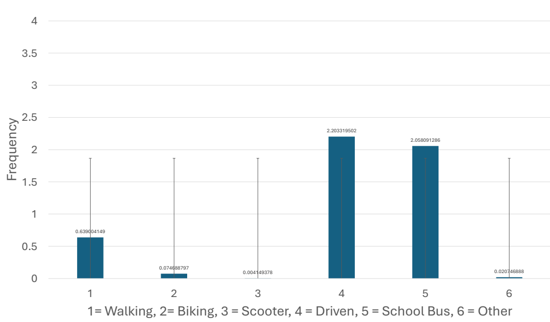

**(b) Average mode of transportation — less than 100,000 — from school**



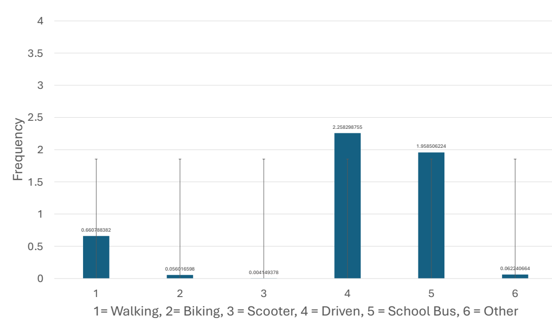

**(c) Average mode of transportation — between 100,000 and 150,000 — to school**




**(d) Average mode of transportation — between 100,000 and 150,000 — from school**

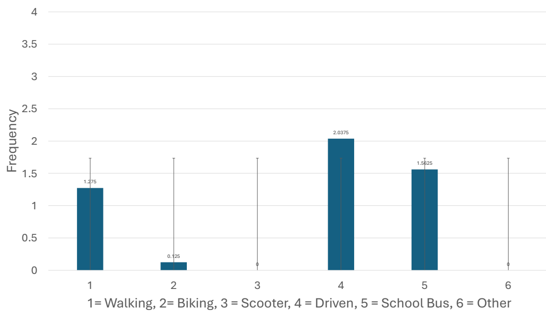



**(e) Average mode of transportation — greater than 150,000 — to school**

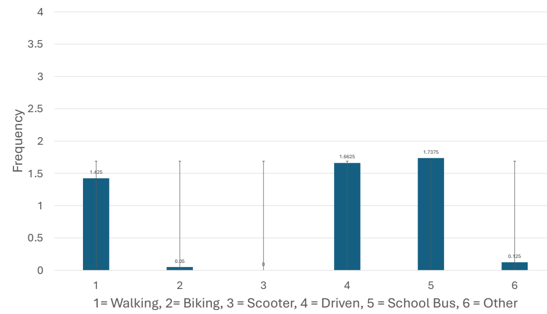



**(f) Average mode of transportation — greater than 150,000 — from school**

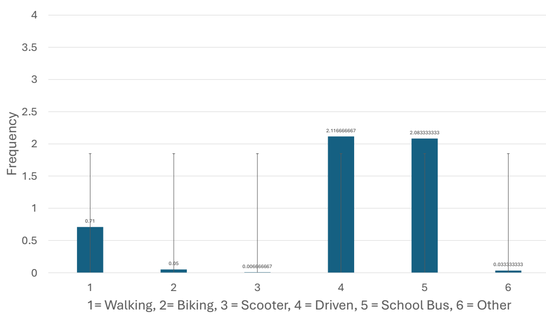
**Figure 3.9: Travel mode choices by income**



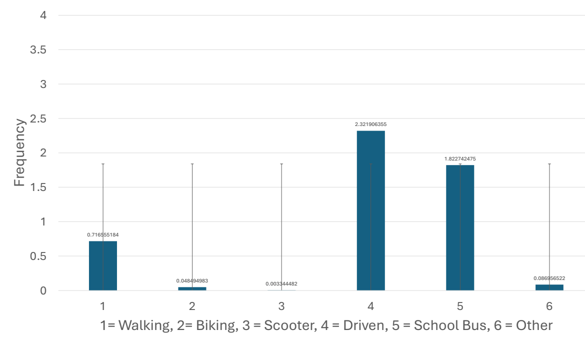

**(a) Average mode of transportation — one car — to school**



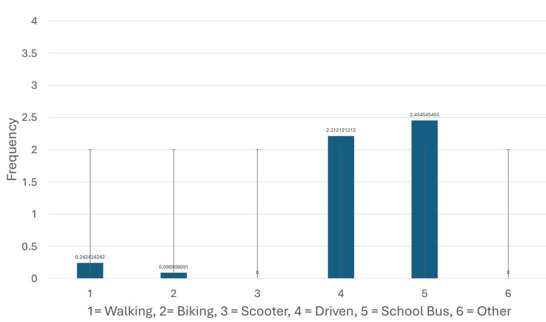

**(b) Average mode of transportation — one car — from school**



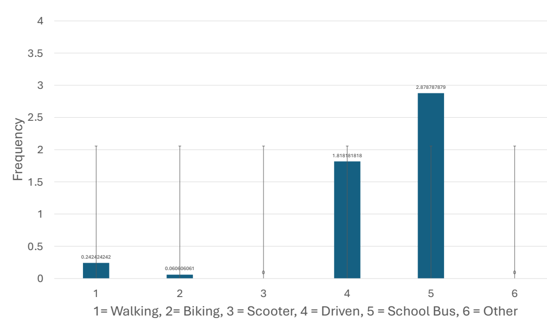

**(c) Average mode of transportation — two cars — to school**




**(d) Average mode of transportation — two cars — from school**




**(e) Average mode of transportation — three/more cars — to school**




**(f) Average mode of transportation — three/more cars — from school**

**Figure 3.10: Travel mode choices by number of household cars**

**Table 3.4: Logit model where age is binary and number of cars is an integer**

| Variable | Coefficient |
|---|---|
| Alternative specific constant | $-0.166446049$ |
| Distance | $-3.927383647$ |
| Age (grades 3–5) | $-0.000030099$ |
| Income | $0.022860509$ |
| Gender | $0.359148889$ |
| Race | $0.088076826$ |
| Ethnicity | $0.177464469$ |
| Early school start time | $0.51396322$ |
| Number of cars | $0.277341797$ |

travel before sunrise was only of moderate importance relative to other factors. It is possible that early start times are more convenient for parent work schedules while being only moderately undesirable for travel before sunrise.

Also unexpected was that increases in the number of cars available to the household was also associated with increased use of active transportation. However, income was also associated with increased walking and biking, and income is likely to be correlated with having more cars in the household. This can likely be explained by households with more income choosing to live near schools or in neighborhoods with better infrastructure to support active transportation.

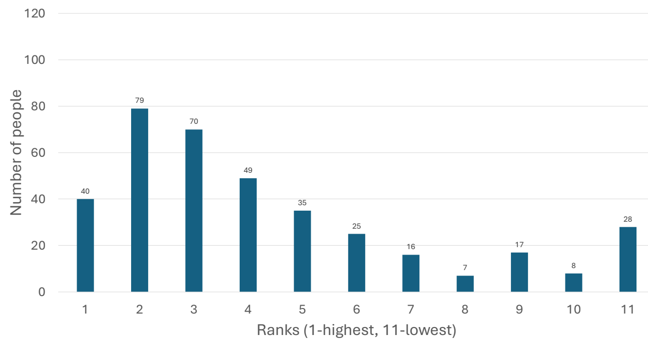
We constructed a second logit model in Table 3.4 where the number of cars was integer and grade was split into K–2 and 3–5 by binary variables. The average log-likelihood was $-0.259504102$. The resulting coefficients are given in Table 3.4. The results are mostly the same. Both Tables 3.3 and 3.4 suggest that age only has minor importance for the use of active transportation.

### 3.7.1 School-specific effects of nearby busy roads

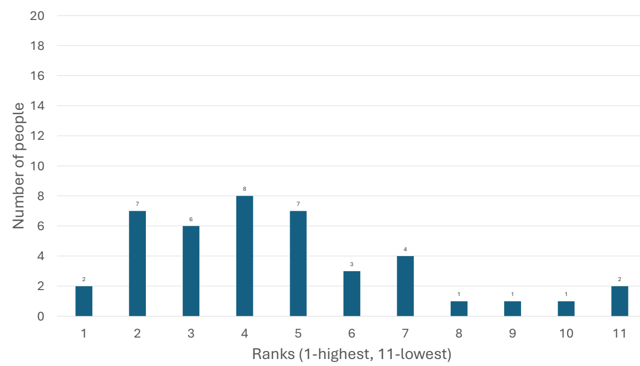
Because parents rated crossing a high-traffic or busy road as an important factor, we wonder whether active transportation to certain schools is more limited due to being located near busy roads. To study this question, we looked for schools that had higher than average use of driving. To investigate further, we focused on Horace Mann School, with 3.378 and Scenic Heights Elementary, with 3.383 driving trips per week per student, compared to 2.169 overall. We compared the average importance of crossing a busy road, as stated by parents, for survey respondents from those schools vs. overall. However, as shown in Figure 3.11, we did not find any significant differences. However, an examination of the roads around Horace Mann School and Scenic Heights Elementary suggests that there may be busy roads nearby that could discourage walking and biking. Horace Mann School is near West Highland Parkway and Scenic Heights Elementary is next to Excelsior Boulevard. The lack of difference in parent rankings may simply indicate that parent preferences are fairly similar overall, and parents of those two schools find themselves in different location circumstances.

## 3.8 Discussion

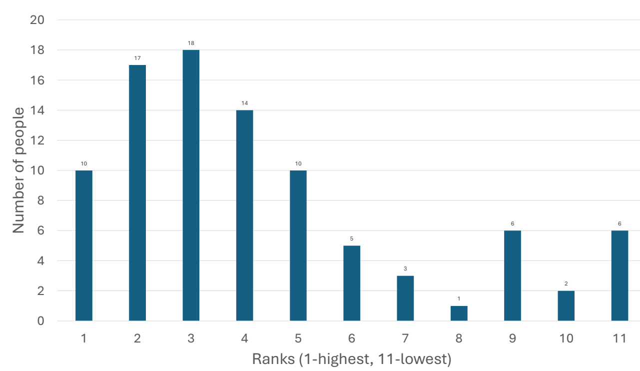
Overall, it was more difficult than anticipated to obtain support from elementary schools to distribute the survey to parents. We expected it to be a simple task, but many schools ignored us outright or declined




**(a) Average importance of crossing a busy road — overall**

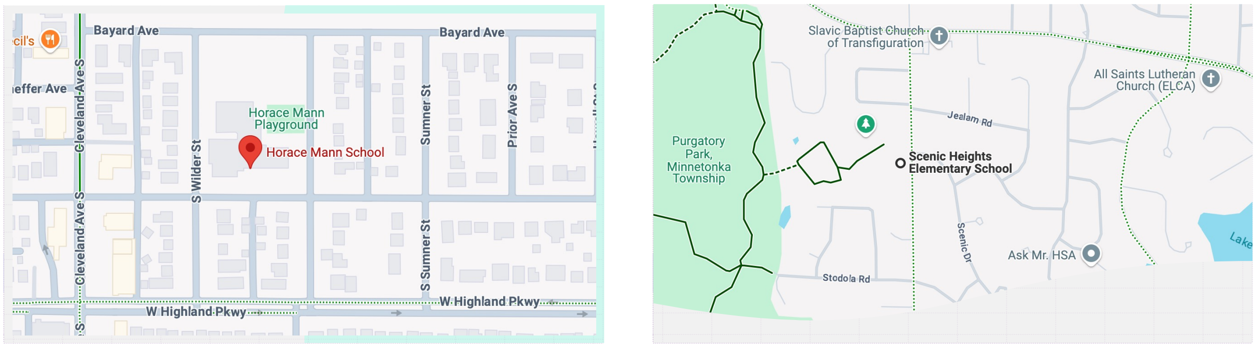



**(b) Average importance of crossing a busy road — Horace Mann**




**(c) Average importance of crossing a busy road — Scenic Heights**

**Figure 3.11: Comparison of overall and school-specific ranking of the importance of crossing a busy road**




**(a) Roads around Scenic Heights Elementary**

**(b) Roads around Horace Mann School**

**Figure 3.12: Maps showing locations of Horace Mann School and Scenic Heights Elementary**

to send the survey due to prioritizing other messages or surveys. Nevertheless, we obtained 436 parent responses, which we believe is a large enough dataset to study parent preferences. Our data in Section 3.5 suggests we have robust aggregate responses to some major questions from the survey.

We were able to identify demographic and travel factors affecting how often students use active transportation. These factors were analyzed both from parents' stated importance and parent reports on their children's travel choices. Unsurprisingly, the most important factor was distance. However, early school start times did not seem to have significant impact. Like results from Section 2, early school start times were actually associated with *increased* use of active transportation. Due to the timing of this survey in February, we expect that parents would have been recently aware of late sunrise times and any corresponding concerns when taking this survey. Combined with parents stating that travel before sunrise was only a moderate concern compared to safety issues such as infrastructure and crossing busy roads, we must conclude that early school start times are not a significant factor for discouraging students from walking or biking to school.

# Chapter 4. Conclusions

The question of whether early school start times necessitating travel before sunrise reduce active transportation is of interest to policymakers hoping to promote active transportation and reduce motor vehicle transport. This question does not have a direct answer in the literature but is of interest to practitioners. As such, we conducted three separate analyses on two datasets to answer this question, including a revealed preference survey on motor vehicle trips to elementary schools during the morning, a stated preference survey on student travel choices, and a stated preference survey ranking the importance of factors (including travel before sunrise) to those travel choices. Data was collected in Minnesota where sunrise varies significantly due to the high latitude. We further noted that although winter weather in Minnesota could affect interest in active transportation, the 2023–2024 school year during which the stated preference survey occurred had an unusually mild winter, and the effects of weather were considered by comparing multiple months of StreetLight data and giving parents the option to rank weather as a primary concern during the stated preference survey. The stated preference survey was furthermore given in February during the period of late sunrise.

Overall, results suggested that more walking and biking occurs for schools with early start times. StreetLight results found less motor vehicle travel for schools with early start times (from which we infered more walking and biking), and among those schools, less motor vehicle travel in February (when late sunrise causes travel before sunrise to be an issue) than in September. These results were consistent with stated travel choices by parents indicating more walking and biking for schools with early start times. When asked to rank the importance of travel before sunrise on student travel choices, parents ranked it as only a moderate issue relative to alternatives, suggesting that other factors had a larger impact on whether students walk or bike to school.

In conclusion, we did not find evidence to support the idea that travel before sunrise from early school start times was significantly detrimental to the total number of students walking or biking to school. In other words, we can conclude that other factors are more important than travel before sunrise, and those other factors appeared to increase walking and biking for schools with early start times. Although we did not obtain positive results in our data analyses, we nevertheless believe that answering this research question is valuable to practitioners and researchers who might have similar questions about how to increase walking and biking among elementary school students.

# Bibliography


[1] S. M. Ahern, B. Arnott, T. Chatterton, A. de Nazelle, I. Kellar, and R. R. McEachan. Understanding parents' school travel choices: A qualitative study using the theoretical domains framework. *Journal of Transport & Health*, 4:278–293, 2017.

[2] K. N. Ahlport, L. Linnan, A. Vaughn, K. R. Evenson, and D. S. Ward. Barriers to and facilitators of walking and bicycling to school: Formative results from the non-motorized travel study. *Health Education & Behavior*, 35(2):221–244, 2008.

[3] M. J. Aranda-Balboa, F. J. Huertas-Delgado, M. Herrador-Colmenero, G. Cardon, and P. Chillón. Parental barriers to active transport to school: A systematic review. *International Hournal of Public Gealth*, 65: 87–98, 2020.

[4] H. Atteberry, D. Dowdy, A. Oluyomi, D. Nichols, M. G. Ory, and D. M. Hoelscher. A contextual look at safe routes to school implementation in Texas. *Environment and Behavior*, 48(1):192–209, 2016.

[5] A. Broberg and S. Sarjala. School travel mode choice and the characteristics of the urban built environment: The case of Helsinki, Finland. *Transport Policy*, 37:1–10, 2015.

[6] P. Chen, J. Jiao, M. Xu, X. Gao, and C. Bischak. Promoting active student travel: A longitudinal study. *Journal of Transport Geography*, 70:265–274, 2018.

[7] S. M. George, S. A. Sliwa, K. A. Cornett, V. Do, A. A. Bremer, and D. Berrigan. Improving active travel to school and its surveillance: An overlooked opportunity in health promotion and chronic disease prevention. *Translational Behavioral Medicine*, 12(7):810–815, 2022.

[8] K. Ito, T. G. Reardon, M. C. Arcaya, S. Shamsuddin, D. M. Gute, and S. Srinivasan. Built environment and walking to school: Findings from a student travel behavior survey in Massachusetts. *Transportation Research Record*, 2666(1):78–84, 2017.

[9] N. C. McDonald, A. L. Brown, L. M. Marchetti, and M. S. Pedroso. US school travel, 2009: An assessment of trends. *American Journal of Preventive Medicine*, 41(2):146–151, 2011.

[10] N. C. McDonald, Y. Yang, S. M. Abbott, and A. N. Bullock. Impact of the safe routes to school program on walking and biking: Eugene, Oregon study. *Transport Policy*, 29:243–248, 2013.

[11] R. Mitra and R. N. Buliung. Exploring differences in school travel mode choice behaviour between children and youth. *Transport Policy*, 42:4–11, 2015.

[12] M. D. of Natural Resources. Climate summary for April 1, 2023 through April 30, 2023. Retrieved from `https://files.dnr.state.mn.us/natural_resources/climate/historical/monthly_summaries/monthly_202304.pdf`, 2024.

[13] M. D. of Natural Resources. Climate summary for February 1, 2023 through February 28, 2023. Retrieved from https://files.dnr.state.mn.us/natural_resources/climate/historical/monthly_summaries/monthly_202302.pdf, 2024.

[14] I. N. Sener, R. J. Lee, and R. Sidharthan. An examination of children's school travel: A focus on active travel and parental effects. *Transportation Research Part A: Policy and Practice*, 123:24–34, 2019.

[15] O. Stewart, A. V. Moudon, and C. Claybrooke. Common ground: Eight factors that influence walking and biking to school. *Transport Policy*, 24:240–248, 2012.

[16] O. Stewart, A. V. Moudon, and C. Claybrooke. Multistate evaluation of safe routes to school programs. *American Journal of Health Promotion*, 28(3_suppl):S89–S96, 2014.

[17] M. Vonderwalde, J. Cox, G. C. Williams, M. M. Borghese, and I. Janssen. Objectively measured crime and active transportation among 10–13 year olds. *Preventive Medicine Reports*, 13:48–51, 2019.

[18] J. Westman, M. Friman, and L. E. Olsson. What drives them to drive?—Parents' reasons for choosing the car to take their children to school. *Frontiers in Psychology*, 8:267963, 2017.

[19] A. G. Wheaton, D. P. Chapman, and J. B. Croft. School start times, sleep, behavioral, health, and academic outcomes: A review of the literature. *Journal of School Health*, 86(5):363–381, 2016.

[20] E. J. Wilson, J. Marshall, R. Wilson, and K. J. Krizek. By foot, bus or car: Children's school travel and school choice policy. *Environment and Planning A*, 42(9):2168–2185, 2010.

[21] A. K. Yarlagadda and S. Srinivasan. Modeling children's school travel mode and parental escort decisions. *Transportation*, 35:201–218, 2008.