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GRADUATE SCHOOL

Effect of Education Policy and Urban Form on Elementary-age School Travel

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Abstract

Children's school travel has come under increasing attention from researchers and policymakers for reasons that include health, safety, environmental impacts, traffic congestion, costs, and children's daily exercise levels. Many policymakers view greater walking to school as a partial solution to many of these concerns. Education policies such as school choice, whereby children attend a non-assigned school, may affect the outcome of walk-to-school initiatives. This research advances knowledge of school travel by utilizing local data to examine the influence on elementary-age school travel of variables such as travel distance, child and household characteristics, urban form, and school district policies regarding school choice and transportation.

This research conducts a child school travel survey, quantifies observed school travel, develops multinomial logistic regression models explaining factors that determine school travel mode, and estimates the influence on school travel of alternate education policies. It employs two elementary-age (grades kindergarten-6) data sets in two school districts—St. Paul, MN and Roseville, MN—that vary in school choice, transportation policy, and urban form.

The analyses demonstrate that school choice, transportation policy, school siting, and urban form influences child school travel patterns and school district transportation. Alternate education policies can affect travel by increasing walking opportunities and reducing vehicle emissions and school district transportation costs. The multivariate modeling and policy scenario testing approach herein directly inform policymakers and provide a framework for future evaluations of the transportation effects of education policies.

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1 Introduction

Children's school travel has come under increasing attention from researchers and policymakers for reasons that include health, safety, environmental impacts, traffic congestion, school transportation costs, children's daily exercise levels, and parent's school-related travel time.

Evidence supports many of these concerns. Excluding mandatory in-school physical education, activity levels are declining for children (Trost et al., 2002) and adolescents (Sallis et al., 2000). As few as 20% of students walk or bicycle frequently enough to gain health benefits (Kann et al., 1998). One study found that 23% of children ages 9-13 did not engage in any non-school physical activity and 62% did not participate in a non-school organized physical activity for seven days prior to the survey (Centers for Disease Control and Prevention, 2003).

For students engaging in active travel, parent safety concerns include traffic, as student pedestrians and bicyclists have higher per-mile injury and fatality rates than do students riding on a school bus or in an automobile (Transportation Research Board, 2002), and 'stranger danger' (i.e., potential danger from unknown adults) (McDonald, 2007b). Traffic on busy roads near schools decreases children's safety, especially among those who walk or bicycle (Staunton et al., 2003). Child pedestrians have 14 times greater odds of getting in an accident on streets with traffic volumes higher than 750 vehicles per hour compared to a street with volume less than 250 vehicles per hour (Roberts et al., 1995). Transportation costs in one local school district, St. Paul, Minnesota (U.S.), are 5% of the total district budget (School Choice Taskforce, 2005). Driving a child to school can represent a time and scheduling burden. Research suggests that over 50% of parents driving their children to-school return home immediately afterwards rather than continuing to another destination (trip chaining) (McMillan, 2005).

Many advocates see more walking to school as a partial solution. Several federal (Centers for Disease Control and Prevention, 2005) and state (Boarnet et al., 2005, Butcher, 2006) initiatives aim to raise children's daily activity levels and improve health by increasing rates of walking to school (Krizek et al., 2004). Safe Routes to School, funded through the U.S. Transportation Bill, is a well-known example and source of funding (Federal Highway Administration, 2006). Safe Routes to School programs typically have at least one of four goals: ensuring *dedicated resources* at the federal and state level, *engineering* safer facilities near schools (e.g., constructing sidewalks or improving lighting), *enforcing* traffic laws near schools, and *educating* parents and children on travel safety (Transportation Alternatives, 2002).

How well programs such as Safe Routes to School satisfy their goals is unclear. Many factors may affect travel mode, including school siting (number, size, and location of schools in a district), school bus policy, student participation in extra-curricular activities, and urban form. For example, while traditional school siting had a greater number of small schools, newer schools typically enroll more students and draw students from a larger geographic area (Beaumont and Pianca, 2002). School travel policies also differ among school districts. A district offering school bus service to all students would likely have higher busing rates than one offering limited service. Busing is often a significant and contested portion of school district budgets, especially with rising fuel prices (Belden, 2006).

Surprisingly, studies have not generated robust evidence that walking to school yields a statistically significant increase in children's total daily activity level (Dietz and Gortmaker, 2001, Krizek et al., 2004, Metcalf et al., 2004) [for a counterexample, see (Sirard et al., 2005b)]. Possible explanations as to why this seemingly obvious association (walking to school increases total activity) has not been robustly supported include (1) statistical issues (e.g., insufficient sample size or sample bias), (2) compensating behaviors, whereby walking to school leads to reductions in other physical activities, and (3) use of cross-sectional rather than time-series survey design. While not explored further in this manuscript, this lack of evidence is a notable gap in the literature.

Another factor affecting the selection of school travel mode is school choice. Children historically attended the school closest to their home ("neighborhood school"), while school choice allows attendance at a non-neighborhood, "magnet" school. School choice can be within or between school district(s). School choice programs are significantly more common today than 20 years ago with support and criticism found throughout the political spectrum (Gorard et al., 2001). Rationales for establishing school choice include increasing educational performance and maintaining school racial/socio-economic diversity (“voluntary desegregation”) (Centers for Disease Control and Prevention, 2005, Gorard et al., 2001, Schellenberg and Porter, 2003, Schneider et al., 1997, Whitty, 1998). A study in St. Paul, Minnesota, U.S. suggests the motivation for school choice has shifted over time, from voluntary desegregation to improved educational performance (Schellenberg and Porter, 2003). School choice advocates note higher satisfaction among parents who choose their child’s school (Goldring and Shapira, 1993, Powers and Cookson, 1999, Witte and Thorn, 1996). The 2002 “No Child Left Behind” Act encourages school choice by (1) allowing students whose school has not maintained adequate progress for two years to attend a school with better test scores and (2) encouraging the funding of magnet schools (U.S. Department of Education, 2002). While parents generally support school choice, studies have not quantified its effect on transportation. A recent study applied national elementary-age travel behaviors to two sample schools in St. Paul, Minnesota and found greater vehicle-emissions and less walking for the magnet school versus the neighborhood school (Wilson et al., 2007).

This thesis advances the current school travel literature by utilizing local data to examine the influence of school location and school choice policy on elementary-age school travel. This research concurrently analyzes the effect of commonly studied variables on school travel, including travel distance, child and household characteristics, and urban form. This manuscript has three primary aims: (1) administer a child travel survey and analyze school travel in locations reflecting two eras of elementary school siting, varying school choice, and dissimilar urban form, (2) develop statistical models of the factors that determine school travel mode, and (3) estimate the potential influence on school travel mode of alternate education policies. This thesis does not take a position on the strengths or weaknesses of school choice, but instead aims to understand its potential transportation impacts.

The research employs two elementary-age (grades kindergarten-6) data sets: a child travel survey administered to parents in two school districts (St. Paul and Roseville Area [herein Roseville], Minnesota, U.S.) and a citywide data set acquired from the Saint

Paul School District. St. Paul and Roseville, although adjacent, contrast in their school choice, busing, and school siting policies and in dominant urban form. These two neighboring cities therefore offer a unique opportunity to study school travel in multiple contexts.

In achieving the research aims, this thesis examines the spatial distribution of students, typical urban form near schools, observed school travel between several subpopulations, and parent preferences toward school and travel mode. It utilizes the survey sample to inform and create two statistical models of travel behavior: (1) a ‘full’ model, which provides the best statistical description of the data and can quantify the influence of four alternate education policies on observed travel for the survey respondents, and (2) a ‘simplified’ model, which provides a reasonable description of the survey respondents using a reduced number of variables and can quantify the influence of the same policies for all district students (the citywide data, which contains limited information per student. The models weight the travel survey sample to account for sample differences in income and ethnicity compared to the district school-age population. The modeling and scenario testing directly informs policymakers in the local school districts and provides a framework for future evaluations of the transportation effects of education policies.

The remainder of this manuscript has six sections. The literature review describes general trends in elementary-age school travel and the factors that determine school travel mode, such as travel distance, school attributes, urban form, household and child characteristics, parental perceptions, and education policy. The methods section details the two data sets, the survey locations, sample and census demographic characteristics, variable coding, multivariate models, and alternate education policy scenarios. Three analysis sections then sequentially (1) describe observed school travel, (2) develop weighted statistical models describing the factors that determine school travel mode, and (3) estimate the potential influence on school travel mode of alternate education policies. The final section summarizes key findings and discusses future research opportunities for researchers and policymakers. References and three appendices follow the concluding remarks.

2 Current State of Child School Travel Literature

Children's school travel has come under increasing attention from researchers and policymakers for reasons that include health, safety, environmental impacts, traffic congestion, school transportation costs, and parent's school-related travel time. This section describes recent changes in child school travel mode, the policies affecting school travel, and the factors that determine travel mode choice.

Child school travel mode has shifted the past 40 years from walking (and to a lesser extent bicycling) to auto and school bus. A longitudinal study using the U.S. National Personal Transportation Survey documented a decrease in walking and bicycling among elementary-age students from 41% in 1968 to 13% in 2001 (McDonald, 2007b). Research has yet to answer definitely why travel has changed. Several shifting trends—including school siting policy, travel distance, residential development, affluence, and the number of vehicles per household—likely play a strong role.

Policymakers promoted larger schools as early as 1958, claiming that economies of scale would improve learning opportunities (Lawrence et al., 2002). Until June 2004, the Council of Educational Facility Planners International, largely in charge of establishing school siting guidelines, recommended ten acres of land for an elementary school plus one acre for every 100 students. This decision may have required larger new schools, built on the fringe of development to find affordable and available land (McDonald, 2007a). Between 1940 and 2001 U.S. population increased 70% while the number of public schools decreased 69%; unsurprisingly the average school district grew from 217 to 2,267 students and average single school enrollment grew from 127 to 653 students (Lawrence et al., 2002). Other related effects include an increase in peak period automobile traffic, greater school-related vehicle emissions, the need for larger athletic facilities, and school bus and auto parking (U.S. Environmental Protection Agency, 2003). Many new schools locate on cheap, available land, often on the edge of housing in locations with low density and poor street connectivity (Beaumont and Pianca, 2002).

Fewer students live near schools built on the fringe of development, meaning greater travel distance and fewer opportunities to walk or bicycle. McDonald attributes

47% of the decline in students walking to the change in travel distance (McDonald, 2007b). Changes in the school-age population, including race and child age, and changing attitudes towards school travel likely explain some of the decline as well. Decreasing residential density also serves to locate fewer children near their school. McDonald estimates a one-mile (1.6 km) radius at a residential density of 1,000 people per square mile (386 people per square kilometer) can maintain a school of 300 students, however only 36% of U.S. households with school-age children live in locations at or above this level of density (McDonald, 2007a).

Factors that Determine Mode Choice

Table 2-1 summarizes the influence on school travel of frequently studied variables. Table 2-2 provides summary information for each article presented in Table 2-1. Travel distance has the greatest impact on mode choice. At one-half mile (0.8 km), walking ceases to be the most common travel mode; at one mile (1.6 km) walking rates are effectively zero (DiGuiseppi et al., 1998, McDonald, 2007b). Living within 1.6 km of school has the largest effect on walking or bicycling. A child has nearly three times greater odds of walking or bicycling within 1.6 km than outside 1.6 km (McMillan et al., 2006). Even within 1.6 km, as few as 31% of students walk or bicycle (Dellinger and Staunton, 2002).

Concerning urban form, a recent study found that compared to factors including travel distance and child and household characteristics, urban form plays a lesser but significant role in determining school travel mode (McMillan, 2007). The literature is inconsistent regarding the effect of urban form on child school travel, however, owing perhaps to a lack of common independent variables, infrequent studies of school travel, lack of conceptual framework, and lack of quality urban form data (e.g., sidewalk locations) (McMillan, 2005). U.S. initiatives such as Safe Route to School (passed in 2005) aim to improve pedestrian infrastructure, though few evaluations of programs have occurred. A pre-test post-test examination found new infrastructure constructed through Safe Routes to School increased walking in one study (Boarnet et al., 2005), which is encouraging. Further evaluations are necessary to substantiate conclusions.

Table 2-1: Literature Review – Factors that Influence School Travel Mode

Factor	Effect	Mode[a]	Association[b]
Trip			
Type	from-school (vs. to-)	w	(+) McMillan 2003; Schlossberg et al. 2005; (0) DiGuiseppi et al. 1998; Sirard 2005a
		b	(+) McMillan 2003; Sirard 2005a; Schlossberg et al. 2005;
Travel distance	increase	w // b/a	(-) // (+) McMillan 2007; Schlossberg et al. 2006; Schlossberg et al. 2005; Wen et al. 2007
School attribute			
Choice	magnet (vs. neighborhood)	w // b/a	(-) // (+) Wilson et al. 2007
Enrollment	increase	w	(-) Kouri 1999; Braza et al. 2004; (0) Ewing et al. 2004
Child characteristic			
Grade	elementary (vs. secondary)	w	(0) Dellinger and Staunton 2002
Sex	female (vs. male)	w	(-) Evenson et al. 2003; McMillan et. al 2007 (0) McDonald 2007b
Household characteristic			
Vehicle	increase	w // a	(-) // (+) Ewing et al. 2004; Wen et al. 2007
Sibling	presence	w	(+) McDonald 2007a
Income	increase	w // a	(-) // (+) California Department of Health Services 2004; Ewing et al. 2004
Urban form			
Population density	increase	w	(+) McDonald 2007a; Braza et al. 2004; (0) Ewing et al. 2004
Walkability Index	increase	w	(+) Kerr et al. 2006
Sidewalk connectivity	increase	w	(+) Ewing et al. 2004
Street connectivity	increase	w	(+) Schlossberg 2006

[a] w=walk, b=bus, a=auto

[b] (+) increase in travel for mode, (-) decrease in travel for mode, (0) no effect on travel for mode

Table 2-2: Literature Review – Article Summary of Table 2-1

Authors	Location	Data source	Sample size	Sample population	Mode examined	Primary method
DiGuiseppi et al. 1998	London, UK	Child travel survey	2 086 children	Grades 2-5	Walk and auto	Logistic regression
Kouri 1999	SC, USA	NA	209 schools	K-12	NA	Descriptive
Dellinger and Staunton 2002	USA, nation-wide	HealthStyles Survey	611 children	Grades K-12	Walk, bicycle	Significance testing
Evenson et al. 2003	NC, USA	Youth Risk Behavior Survey	4 448 children	Grades 6-12	Walk, bicycle	Logistic regression
McMillan 2003	CA, USA	UCI Safe Routes to School Study	2 128 children	Grades 3-5	Walk, bicycle, car	Logistic regression
Braza et al. 2004	CA, USA	Survey, observation	2 993	Grade 5	Walk, bicycle	Logistic regression
CA Department of Health Services 2004	CA, USA	CA Children's Healthy Eating and Exercise Practices Survey	814 children	Ages 9-11	Walk, bicycle, bus, auto	Descriptive
Ewing et al. 2004	Gainesville, FL, USA	Household travel survey	709 school trips	Grades K-12	Walk, bus, auto	Nested multinomial logit regression
Schlossberg et al. 2005	Bend, OR, USA	Household travel survey	104 children	Grades 6-8	Walk, bicycle, bus, auto	Descriptive
Sirard 2005a	Columbia, SC, USA	Observation at 8 elementary schools	3 598 children	Grades K-6	Walk, bicycle, bus, auto	Significance testing
Kerr et al. 2006	Seattle, WA, USA	Neighborhood Quality of Life Study	259 children	Grades K-12	Walk	Logistic regression
Schlossberg 2006	Bend & Springfield, OR, USA	Household travel survey	287 children	Grades 6-8	Walk, bicycle, bus, auto	Logistic regression
McDonald 2007a	USA, nation-wide	National Household Travel Survey	6 508 children	Grades K-8	Walk, bus, auto	Multinomial logistic regression
McDonald 2007b	USA, nation-wide	National Personal Transportation Survey	Six year, minimum 'n' of 1 670 children	Grades K-12	Walk, bicycle	Logistic regression
McMillan et. al 2007	CA, USA	Household travel survey	1 128	Grades 3-5	Walk, bicycle	Logistic regression
Wen et al. 2007	Sydney, Australia	Household travel survey	2 047	Grades 4-5	Auto	Logistic regression
Wilson et al. 2007	St. Paul, MN, USA	School enrollment data	1 156	Grades K-6	Walk, bicycle, bus, auto	Descriptive

Studies commonly discuss the importance of parental concerns and preferences about travel but infrequently quantify their effect on travel mode. This gap in the literature is noteworthy as they may be at least as influential as urban form, especially perceptions about safety, social interaction, and convenience (McMillan, 2007). Common concerns include traffic, bullies, and strangers (DiGuiseppi et al., 1998, Hillman et al., 1990, Kerr et al., 2006, Martin and Carlson, 2005). Traffic may prevent up to 40% of children from walking or bicycling (Dellinger and Staunton, 2002). Parents stated a walking escort may increase their willingness have their child walk (Schlossberg et al., 2005), perhaps helping to explain a British study that estimated 84% of parents accompanied their children when they walked to school (DiGuiseppi et al., 1998). A parent might also prefer to drop their child off at school separately or as part of another trip regardless of bus availability or school proximity (Schlossberg et al., 2006).

School travel models are not common; reasons may include difficulty in obtaining child travel data and lack of policy and/or research interest. Existing models have employed various forms of logistic regression to understand school travel mode choice. Examples include binary (McMillan et al., 2006, Wen et al., 2007), nested (Ewing et al., 2004) and multinomial (McDonald, 2007a).

3 Methods

This thesis analyzes two data sets: a child travel survey administered to parents in two school districts (St. Paul and Roseville, Minnesota, US) and a full citywide sample acquired for St. Paul. Principal investigators for the child travel survey were Professors Elizabeth Wilson and Julian Marshall, University of Minnesota, and Professor Kevin Krizek, University of Colorado. This section details the two data sets and survey locations, compares survey, citywide, and census demographics, describes variable coding, multinomial logistic regression and sample weighting, and outlines the alternate school choice policies considered here.

3.1 School Travel Survey

Parents with children in grades K-8 in two adjacent school districts, St. Paul and Roseville, were sent a 22-question survey regarding their children's school commute. Parents were asked to report the frequency of travel to- and from-school, their perceptions and attitudes concerning school choice and travel mode choice, and child and household characteristics. The travel survey (without district-specific cover letter) is available in Appendix A. A general assumption is that parents or caregivers select the travel mode for elementary-age children, not the children themselves. Literature adds support, suggesting dramatic travel behavior changes in high school when students have auto access (Rhoulac, 2005).

The survey was developed in collaboration with the two school districts. Three previous surveys informed survey design: the Marin County Safe Routes to School Parent Survey[1], the New York City Walk to School Parent/Guardian Survey[2], and the Michigan Fitness Walk to School Day Parent Survey[3]. Professional review from the University of Minnesota Center for Survey Research, and a pilot mailing—yielding 18 responses of 50

[1] Obtained from http://www.marinbike.org/Campaigns/SafeRoutes/PlanningSRTS.shtml; accessed February 15, 2007
[2] Obtained from http://www.nyc.gov/html/dot/downloads/pdf/wts_psurvey.pdf; accessed February 15, 2007
[3] Obtained from www.michiganfitness.org/WalkToSchool/documents/parentsurvey.doc; accessed February 15, 2007

mailed surveys in Roseville—led to minor modifications. Based on school district concerns regarding length, the instrument was limited to an estimated completion time of less than 15 minutes.

Surveys were mailed in late May 2007 to 6,000 parents in St. Paul and 2,744 in Roseville. Reminder postcards (Dillman, 2007) followed one week later. The number of returned surveys totaled 2,185, yielding a 27% response rate accounting for 216 undeliverable (Table 3-1). Surveys returned after June 30th were not included owing to concerns that such responses would not accurately reflect a spring school term ending in mid-June. Non-English households received 24% of mailed surveys, yet comprise only 5% of respondents despite translation of the survey instrument into Hmong, Spanish, and Somali for school district-identified households.

Table 3-1: Summary of Mailed and Returned Surveys by District and Language

	School District			
Status	**St. Paul**	**Roseville**	**Did not disclose**	**Total**
Mailed surveys	6 000	2 744	-	8 744
English	4 165	2 497	-	6 662
Spanish	665	108	-	773
Somali	107	21	-	128
Hmong	1 063	118	-	1 181
Completed surveys	1 264	861	60	2 185
English	1 166	849	41	2 056
Non-English	98	12	19	129
Undeliverable mail	188	28	-	216

Of the 2,185 respondents, 34% were excluded. Three hundred fifty one (16.1%) did not have complete information necessary for geospatial analyses (home address and school attended), 229 (10.5%) were in grades 7-8 or in an undisclosed grade (school choice is not prevalent among 7th and 8th graders), 162 (7.4%) lacked five to- and five from-school trips, and 10 (0.5%) did not specify a dominant travel mode. The remaining sample is 1,433 students. Fifty-eight percent of the final sample attends school in St. Paul (of which 66% attend a magnet school) and 42% in Roseville (of which 80% attend a neighborhood school).

3.2 Description of Survey Locations

The primary reasons for selecting St. Paul and Roseville include the presence and nature of school choice policy, variation in dominant urban form, and school district willingness to facilitate survey administration. Table 3-2 compares school choice policy, urban form, and several other characteristics of St. Paul and Roseville. As described below, school assignment procedures also differ. Figure 3-1 maps neighborhood and magnet elementary school locations in each district. The districts reflect two eras of school siting. St. Paul siting occurred when smaller, neighborhood schools were common. Almost all (91%) of the St. Paul survey sample lives within 1.6 km of *an* elementary school. Larger schools are more common in Roseville; about half (53%) of the Roseville sample lives within 1.6 km of *an* elementary school.

Table 3-2: Comparison of Survey Locations

Characteristic	St. Paul	Roseville
Area (square kilometers)	145	53
Number of municipalities served	1	7
Year(s) incorporated	1854	1948 - 1974
Year-2000 population	287 151	52 143
Dominant urban form	Urban	Suburban
Number of children in public schools	40 543	6 396
Number of children in public elementary schools	21 766	3 222
Number of “neighborhood” public elementary schools	21	6
Number of ”magnet” public elementary schools	34	1
Median enrollment per school (neighborhood / magnet)	392 / 324	412 / 703
% of students living within 0.8 km of an elementary school[a]	52	19
% of students living within 1.6 km of an elementary school[a]	91	53
Number of respondents (% of respondents)	1264 (58)	861 (40)
Number of respondents included in the analyes (% of sample)	917 (58)	516 (42)
Attend neighborhood school (% of sample)	34	80
Attend magnet school (% of sample)	66	20

[a] Network distance

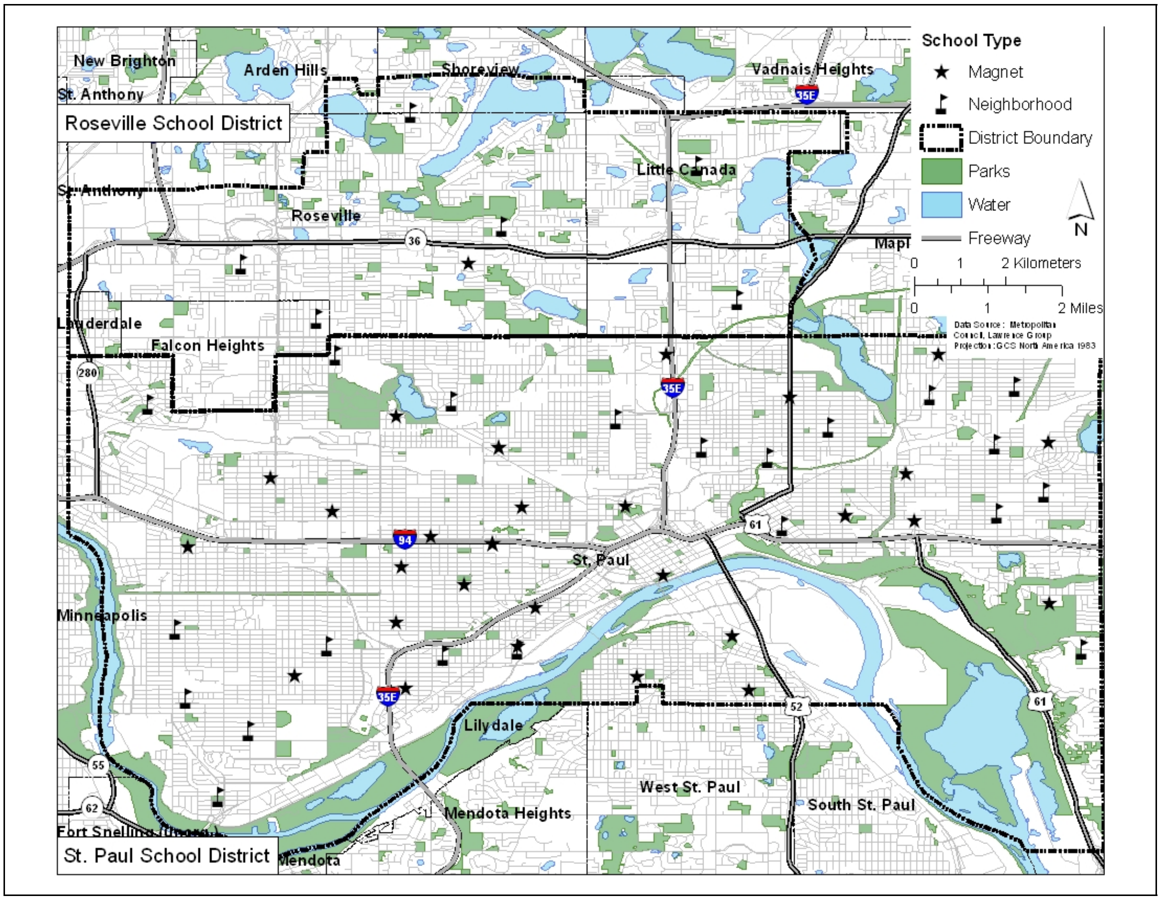

Figure 3-1: Location of St. Paul and Roseville Elementary Schools

Urban form differences reflect expectations. Roseville's largely post-World War II development is typical of many U.S. suburban locations, characterized by longer blocks, lower population density (decreasing farther from the City of St. Paul border), larger lots, and fewer sidewalks (Figure 3-2, left). Urban St. Paul, characterized by shorter blocks, higher density, smaller lots, and sidewalk connectivity, developed largely pre-World War II (Figure 3-2, right).

Figure 3-2: Urban Form Near a Typical Roseville (left) and St. Paul (right) Elementary School[4]

The districts vary in school assignment procedures. Roseville neighborhood enrollment boundaries cumulatively cover the entire district. In St. Paul neighborhood enrollment boundaries cover only 62% of the district's geographic area, though only 52% of the survey sample resides within a neighborhood enrollment boundary. Among that 52%, 27% attend their assigned school, 14% attend a different neighborhood school, and 59% attend a magnet school. Magnet enrollment boundaries cover the remaining 38% of the district's geographic area, though only 6% of sample students residing in a magnet enrollment boundary attend their assigned magnet school. Students living inside a magnet enrollment boundary can attend that magnet school, apply to another magnet school, or attend a neighborhood school via reassignment. A typical neighborhood school thus has two or three enrollment areas, one for the school itself and the other(s) magnet school reassignment. With the exception of two magnet schools (each serving one-half the district), each student can apply to any magnet school. However, because of the number of schools in the district, a student attending a non-assigned school is not necessarily

[4] Images obtained from Google Earth; accessed November 15, 2007

traveling farther there than an assigned school. Considering all sample students, 6% of St. Paul students and 16% of Roseville students reside outside their respective school district.

In an effort to increase neighborhood racial diversity, the boundary for several St. Paul neighborhood schools is not contiguous. The district also uses socio-economic status (specifically, whether a student qualifies for free or reduced lunch programs) to admit students to some high-demand magnet schools (Schellenberg and Porter, 2003). The number of students attending neighborhood schools in St. Paul dropped from nearly all students in 1974 to roughly 34% today (School Choice Taskforce, 2005). In light of these often offsetting school assignment procedures (in terms of travel distance), the research does not differentiate beyond school type: neighborhood or magnet.

3.3 St. Paul Citywide Sample

The St. Paul citywide data set contains all elementary-age students in the St. Paul School District. It was obtained in March 2008 through an agreement between the research team and St. Paul Public Schools. The travel survey sample remains instrumental in understanding travel mode choice as the citywide data contains only child home location, school attended, grade, race, and gender. The sample size is 19,655 of 19,661 total students in grades K-6 attending public elementary schools. Of note, though not in the citywide sample, 5,741 K-6 St. Paul students attend private elementary schools.

3.4 *Sample Socioeconomic and Demographic Characteristics*

Table 3-3 compares travel survey and citywide sample demographics with those of the general population acquired from the 2000 U.S. Census. The travel survey sample and the census exhibit similar racial profiles, though the actual school population is more diverse than the city population. In Roseville, 30% of the actual school population is non-white[5] (Kennedy, 2007) compared to 15.5% in the survey sample. In St. Paul, 75% of the school population is non-white (St. Paul Public Schools, 2005), reflective in the citywide sample data set, though the survey sample is only 32% non-white.

[5] ‘White’ comprises white only and not Hispanic, any other single race, or any mixed race.

The sample is wealthier than the school district population and evenly balanced between male and female children and across grade levels in both districts. The Roseville magnet school parents have higher median household income ($90,000) than Roseville neighborhood parents ($75,000), Saint Paul neighborhood parents ($70,000), and Saint Paul magnet parents ($60,000). Sample affluence may reflect response bias (i.e., higher-income parents were more likely to respond) and/or the sampled populations (i.e., parents could be more affluent than the general public, who include college students and retirees, not likely represented well in the survey sample).

Table 3-3: Comparison of Census 2000, Travel Survey Sample, and Citywide Sample Demographics

	Roseville[a]		St. Paul[a]		
Characteristic	**Census 2000** (%)	**Survey** (%)[b]	**Census 2000** (%)	**Survey** (%)[b]	**Citywide** (%)[b]
Child sex[c]		99.2		98.5	100
Female	49.8	52.9	47.9	47.1	48.7
Male	50.2	46.3	52.1	51.4	51.3
Respondent sex		98.4		99.1	NA
Female	52.8	78.5	51.6	80.7	NA
Male	47.2	20.0	48.4	19.3	NA
Race		99.6		99.6	100
White	86.4	84.5	64.0	68.3	26.9
African American	3.2	2.5	11.4	8.6	29.5
Asian	7.1	7.0	12.3	10.6	27.0
American Indian	0.4	1.2	1.0	1.4	1.8
Hispanic or Latino	2.3	3.1	7.9	7.6	14.8
Other	0.6	1.4	3.3	3.1	NA
Income ($)		96.1		96.2	NA
0 - 19 999	15.2	3.3	23.3	9.6	NA
20 000 - 39 999	23.5	9.3	28.0	15.5	NA
40 000 - 59 999	20.3	13.4	20.1	16.9	NA
60 000 - 79 999	14.4	19.0	12.0	17.0	NA
80 000 - 99 999	11.1	18.2	7.3	13.8	NA
100 000 - 119 000	5.2	14.1	3.4	10.3	NA
120 000 +	10.2	18.8	5.9	13.1	NA
	Median	Median	Median	Median	Median
Respondent age	38.2	41	31.8	40	NA
Household income ($)	50 573	80 000	38 774	65 000	NA
Family size	2.9	4.0	3.3	4.0	NA

[a] n = 917 in St. Paul, 516 in Roseville

[b] Percentages may not add up to 100% due to missing values

[c] Census imputed for children in public elementary school grades K thru 6

3.5 Variable Coding

Parents circled the number of school days last week their youngest child traveled *to*- and *from*-school via passenger vehicle (herein “auto”), school bus (“bus”), walking, bicycling, or another mode. Herein “walk” combines walking and bicycling because bicycling is the dominant travel mode for only six students. Thirteen students made 16 total trips on an unknown mode. Mimicking the previous child travel models identified in the literature review (section two), this research assigns separate to- and from-school dominant travel mode. Results suggest this simplification is useful: children use one mode of travel for 77% of to-school trips, 79% of from-school trips and 60% of all weekly trips. A minority, 16%, switch dominant mode to- and from-school. These results are similar to an Australian study of children ages 9-11. Among children whose dominant mode was automobile, 89% traveled in an auto ten times per week and only 22% used multiple modes to- or from-school (Wen et al., 2007).

Travel distance is the shortest route between home and school, calculated using a year-2007 road file provided by the Metropolitan Council (metropolitan planning organization). Coding travel distance as a nominal variable that maximizes the number of categories and maintains adequate subpopulations in each category is appropriate for multinomial logistic regression because the relationship between the log odds of travel mode and travel distance is nonlinear (as explained in Appendix B).

Additional non-survey variables might also affect mode choice. For example, the Minnesota Department of Education quantifies school enrollment[6] and standardized test scores[7]. A larger school requires greater enrollment area and, in the absence of higher density, total walking would likely decrease. A school with higher test scores might receive greater interest from parents than one with low scores. A single test score variable is sufficient because within grade math and reading scores and between grade math, reading, and composite scores share significant bivariate correlation of at least 0.83.

[6] Obtained from http://education.state.mn.us; accessed October 18, 2007
[7] Obtained from http://education.state.mn.us; accessed October 18, 2007; math, reading, and combined scores are available for each school.

In the context of child travel, urban form could affect opportunities for walking. A central implementation challenge, similar to studying adult travel, is whether to measure characteristics at the origin and destination or along a route. Route appears most applicable for school travel as students have known origins (home) and destinations (school). Shortest path between home and school, mapped in ArcGIS v9.2, serves as an estimate of actual route traveled. The survey did not ask about travel route.

A second challenge is how to measure characteristics of urban form. Variables might be counted (e.g., number of busy intersections crossed) or summed in a buffer (e.g., percent of land in residential use). Without robust supporting literature for child travel, a distance of 200 meters (one long city block) was selected. This value is likely a good approximation for the influence of urban from on children commuting; a parent will likely know the shortest path, especially at short distances, and won't allow a young child to deviate far from that path.

Variables that may impede walking include traffic (sum of vehicle kilometers traveled[8]), average vehicle speed[9] along the route, busy intersections (measured as number of non-local streets a child crosses) and agricultural, golf course, industrial, utility, undeveloped and water land uses[10]. Variables that could facilitate walking include street or intersection density, a greater mix of residential and commercial uses that could keep "eyes on the street" and increase perceived and objective safety (Jacobs, 1961), and gross population density. Urban form differences exist along survey sample student routes (Table 3-4) and generally reflect expectations associated with St. Paul (higher density, street connectivity, and traffic) and Roseville (lower density, street connectivity, and traffic). Route urban form among St. Paul students might generally support greater walking compared to Roseville student routes.

[8] Obtained from http://www.dot.state.mn.us/traffic/data/html/volumes.html; accessed October 17, 2007
[9] Obtained from http://www.datafinder.org/catalog/index.asp; accessed October 17, 2007
[10] Obtained from http://www.datafinder.org/catalog/index.asp; accessed October 17, 2007

Table 3-4: Student Route Urban Form Descriptive Statistics for the Survey Sample

Variable	District[a]	Mean	Median	Min	Max	Std. Dev.
Number of busy intersection crossings	St.P.	4.5	3.0	0.0	23.0	3.9
	R	3.9	3.0	0.0	14.0	2.6
Number of intersections per square kilometer	St.P.	168.4	168.7	22.2	324.0	35.1
	R	97.5	98.5	16.4	199.9	31.6
Local road kilometers per square kilometer	St.P.	11.1	11.3	4.1	18.1	2.1
	R	6.2	6.0	1.5	12.9	1.9
County and local road kilometers per square kilometer	St.P.	12.5	12.7	5.1	18.1	1.8
	R	8.6	8.6	4.4	14.6	1.6
Non-local road vehicle kilometers travaled per square kilometer (x 1 000)	St.P.	312	202	0	3,581	340
	R	221	107	3	1,565	248
Population density per square kilometer	St.P.	2 480	2 494	655	4 873	716
	R	1 089	1 060	356	2 674	274
Percent of area that is in residential use	St.P.	62.0	63.7	14.6	96.1	17.3
	R	59.8	60.7	8.2	90.2	16.4
Percent of area that is in commercial, office, or residential use	St.P.	69.5	70.8	23.0	97.5	14.8
	R	66.9	66.8	33.1	92.4	12.8
Percent of area that is a less walkable land use[b]	St.P.	13.6	12.2	0.0	54.5	11.9
	R	11.7	8.3	0.0	58.8	11.6
Ratio of less walkable/walkable[c] land use area	St.P.	0.2	0.1	0.0	1.2	0.2
	R	0.2	0.1	0.0	1.4	0.2

[a] Sample size: St. Paul 917, Roseville 516

[b] Less walkable includes: agriculture, golf course, airport, water, industrial, utility, and undeveloped

[c] Walkable includes: office, commercial, institutional, and parks and recreation

3.6 Multinomial Logistic Regression

This research employs multinomial logistic regression, a specific type of discrete choice model, to determine factors that influence travel mode. Discrete choice models are a set of statistical techniques that aim to understand group differences in a categorical dependent variable and predict the likelihood an individual will be in a particular group using continuous and categorical independent variables. The summary below draws from three sources (Ben-Akiva and Lerman, 1985, Garson, n.d., Train, 2003).

Applied to this research, multinomial logistic regression aims to describe the likelihood that a child will travel via auto, bus, or walk as a function of continuous and categorical independent variables that include school-specific attributes, child and household characteristics, and student route urban form. Maximum likelihood estimation maximizes the log likelihood (probability) that observed independent variables can estimate the log of the dependent variable. This is distinct from ordinary least squares regression which estimates the dependent itself.

Many researchers prefer logistic regression over other discrete choice models because logistic regression embodies many of the benefits of OLS regression, including straightforward statistical tests, ability to include nonlinear effects, use of logit coefficients in a model equation, coefficients that correspond to beta weights, and use of a pseudo r-square[11] to summarize the strength of relationships. Unlike OLS regression, logistic regression does not require multivariate normality, linear relationships among dependents and independents, homoelasticity, or equal variance-covariance matrices.

One problem occurs when choices share unobservable yet important qualities, known as a violation of independent irrelevant alternatives (IIA). In other words, the odds of choosing travel mode 'X' relative to 'Y' should not change if alternative 'Z' becomes available [see the classic red bus/blue bus example (Ben-Akiva and Lerman, 1985)]. If the research goal were to understand the impact of a new mode or change service for an existing mode (e.g., bus service available only at distances greater than 3.2 kilometers), a violation of IIA might occur. However, the travel survey sample has known travel choices and school district officials confirmed that nearly all children travel via auto, bus or walk (Schellenberg, 2007). Detailed investigation of a nested logit model, which relaxes somewhat non-independence among choices, would have been useful had a violation of IIA been a larger concern. A nested logit model might also have been appropriate had known travel modes shared greater similarities (e.g., if elementary-age students used city buses).

Model refinement occurs though an orderly testing of independent variables as the difference in log-likelihood ratios, $\chi^2 = [(-2LL)_{h1} - (-2LL)_{h0}];\ df = [(df)_{h1} - (df)_{h0}]$ where h1 is the model that includes the new variable and h0 is the model without the variable. Including an additional variable is preferred if the difference in model log-likelihood ratios is significant, the variable is significant within the model, and its effect

[11] Logistic regressions does not have a widely accepted measure of r-squared because the distribution of categorical dependent responses typically do not follow a normal distribution. This analysis reports Nagelkerke's r-squared which achieves an approximation of percent of variance explained between 0 and 1, allowing easy interpretation.

on other independents is logical. Model refinement preceded based on assessments of expected parameter effect. To address correlations among several measures of route urban form, the research concurrently examined, at most, population density, one measure of land use, one measure of street connectivity, busy intersection crossings, and vehicle kilometers traveled or vehicle speed.

3.7 Logistic Regression Sample Size and Weighting

In testing the effect of alternate education policy, it is appropriate to remove respondents traveling from outside the district. The primary reason is school district policies will not directly influence these students. They will continue to attend their current school and have access to busing as circumstances permit. In St. Paul, 6.1% of survey sample students travel from outside the district compared to 15.7% in Roseville. The final sample size used in sections 5 and 6 of this manuscript is 1,216 (Table 3-5). Applying the same criteria to the citywide sample reduces the sample size from 19,655 to 18,609. In other words, 5.3% of the St. Paul citywide school population travels from outside the district boundary.

Table 3-5: Determination of Travel Survey Sample Size for Analysis

Criteria	St. Paul	Roseville
Sample size for Section 4	917	516
Live outside school district boundary	56	81
Missing variable information	58	22
Sample size for Sections 5 and 6	803	413

A second necessity is survey sample weighting. As described above, the observed survey population is wealthier and has a higher percentage of white respondents than the census and the actual school population in both St. Paul and Roseville. While the St. Paul citywide sample presents an opportunity to weight the survey sample by child age and race, the lack of income data and a comparable data set in Roseville limits the usefulness of this option. Thus, this research weights the observed travel survey sample against the Census 2000 population residing in the school district[12]. The logistic regression models

[12] Obtained from http://www.datafinder.org/catalog/index.asp; accessed October 17, 2007

use a weighting scheme to account for differences in race and income between the observed survey sample and the school district population. Detailed discussion is available in Appendix B.

3.8 Alternate Education Policy Scenarios

The travel models are a necessary first step to quantify the transportation affects of alternate education policies. This section briefly details several policy scenarios aimed at bounding current travel and determining the potential influence of a new district-wide school choice policy. Model beta coefficients can estimate a new student travel mode as policies change. Specifically, under new alternate policies, a student may attend a new school and have new travel distance, school type, and urban form variables for use in the model. This research estimates observed travel for four alternate policies:

(1) Maximum travel distance: all children attend the school farthest from their home, simulating greatest possible district travel. While this scenario is infeasible (schools would exceed capacity), it serves as a useful analytical upper bound.

(2) No school choice: the school district reinstates traditional neighborhood boundaries. All children must attend the school closest to their home, simulating travel without school choice. This scenario represents the ‘minimum required commute’ necessary to connect students and schools (Levinson, 1998).

(3) Random assignment: school districts do not attempt to influence school choice or travel mode and parents do not coordinate school and travel mode choices. As a result, all children attend a randomly assigned school.

(4) Regional school choice (St. Paul only): the school district restricts attendance to one of three school choice regions, simulating a policy that maintains school choice but on a lesser geographic scale. As a politically palatable solution, this scenario maintains five magnet schools[13]. Each student attends a new school in their school choice region unless their current school (1) falls within their choice district or (2) is one of five magnet schools. These assumptions were confirmed as a good approximation of likely outcomes (Schellenberg, 2008).

[13] Adams Spanish Immersion, Benjamin E. Mays, Capitol Hill, French Immersion, and Museum Magnet

4 Analysis: Observed Elementary-age School Travel

This section provides a descriptive comparison of observed elementary-age school travel in St. Paul and Roseville, analyzing the sample of 1,433 students. Section 5 then provides multinomial logistic regression models, which determine the relative effect of each variable on school travel mode, utilizing only students living within the district (n = 1,216; revisit section 3.7 for further explanation). The first examination is the spatial distribution of students by school type (neighborhood vs. magnet) and school location (St. Paul vs. Roseville) as each influences travel distance. An illustration of travel mode and urban form near a typical St. Paul and Roseville elementary school adds further context, highlighting a possible relationship. The principal analysis compares travel mode between several subpopulations: school type, school location, child age and sex, and household income, race and vehicle ownership. Parent preferences towards school and travel mode selection could also inform the models and policy scenario testing. The final subsection summarizes travel mode and travel distance in each school district.

4.1 Spatial Examination of Students by School Type and Location

School siting and school choice policies influence travel distance. As noted previously, St. Paul neighborhood schools average lower enrollment than those in Roseville. Coupled with greater residential density, St. Paul neighborhood schools can draw from smaller enrollment areas than those in Roseville. Figures 4-1 and 4-2 contrast the distribution of students in a sample St. Paul and Roseville neighborhood school, respectively, showing more students live near the St. Paul school.

The distribution of magnet school students is markedly different. Magnet schools draw greater district-wide enrollment in St. Paul and Roseville than do neighborhood schools, and in some cases, from far outside the district[14]. This distribution highlights the potential effect of a school choice policy: to attend non-neighborhood schools increases travel distance.

[14] 21 St. Paul students and 9 Roseville students have a travel distance of 16 km (10 miles) or greater

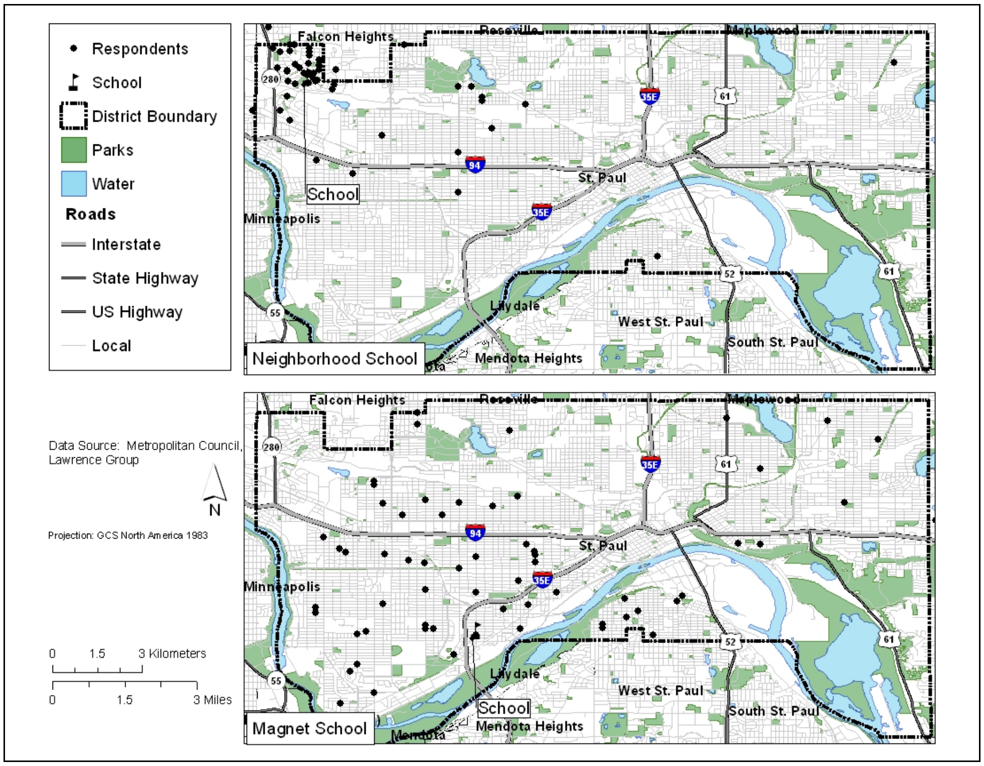

Figure 4-1: Typical Distribution of St. Paul Students by School Type

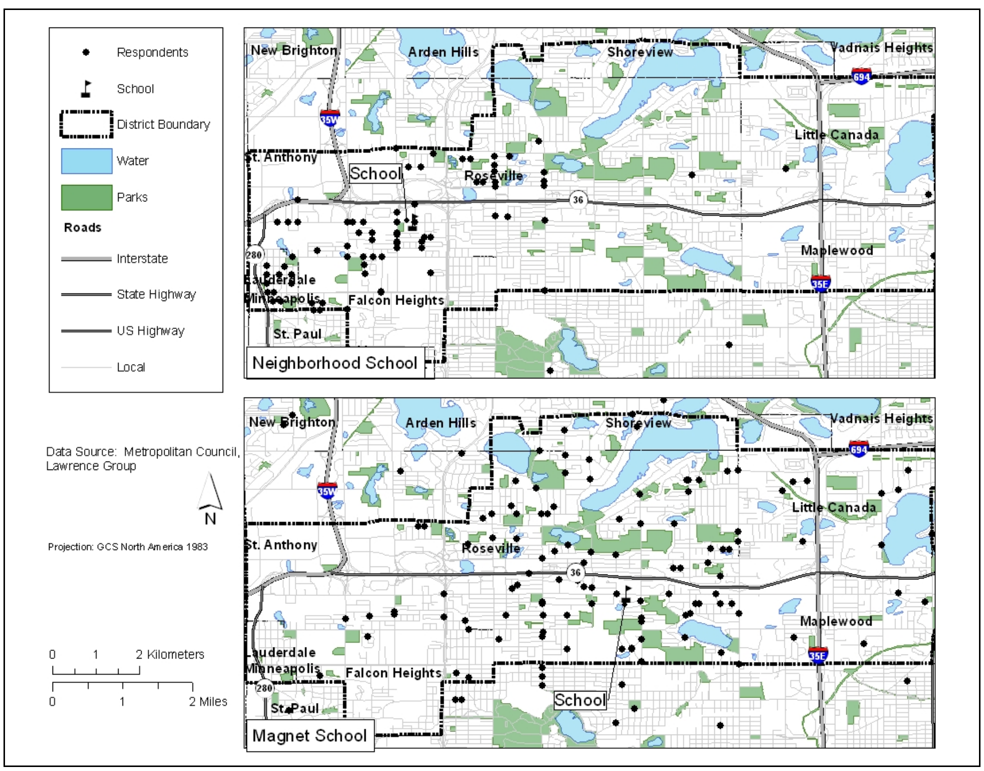

Figure 4-2: Typical Distribution of Roseville Students by School Type

Figure 4-3 compares cumulative distribution plots for travel distance by school type and school location. Neighborhood schools experience greater enrollment near the school than do magnet schools, in both St. Paul and Roseville. The percent of students traveling less than 0.8 km, the maximum distance for which the literature (and the survey sample) found walking to have the largest mode share, is greater for St. Paul neighborhood (26%) than Roseville neighborhood (18%), St. Paul magnet (9%), and Roseville magnet (5%). At a travel distance of 1.6 km, the near-maximum distance for which the literature (and the survey sample) found children walk to school, the percent of students living inside that distance grew for St. Paul neighborhood (49%), Roseville neighborhood (44%), St. Paul magnet (17%) and Roseville magnet (20%).

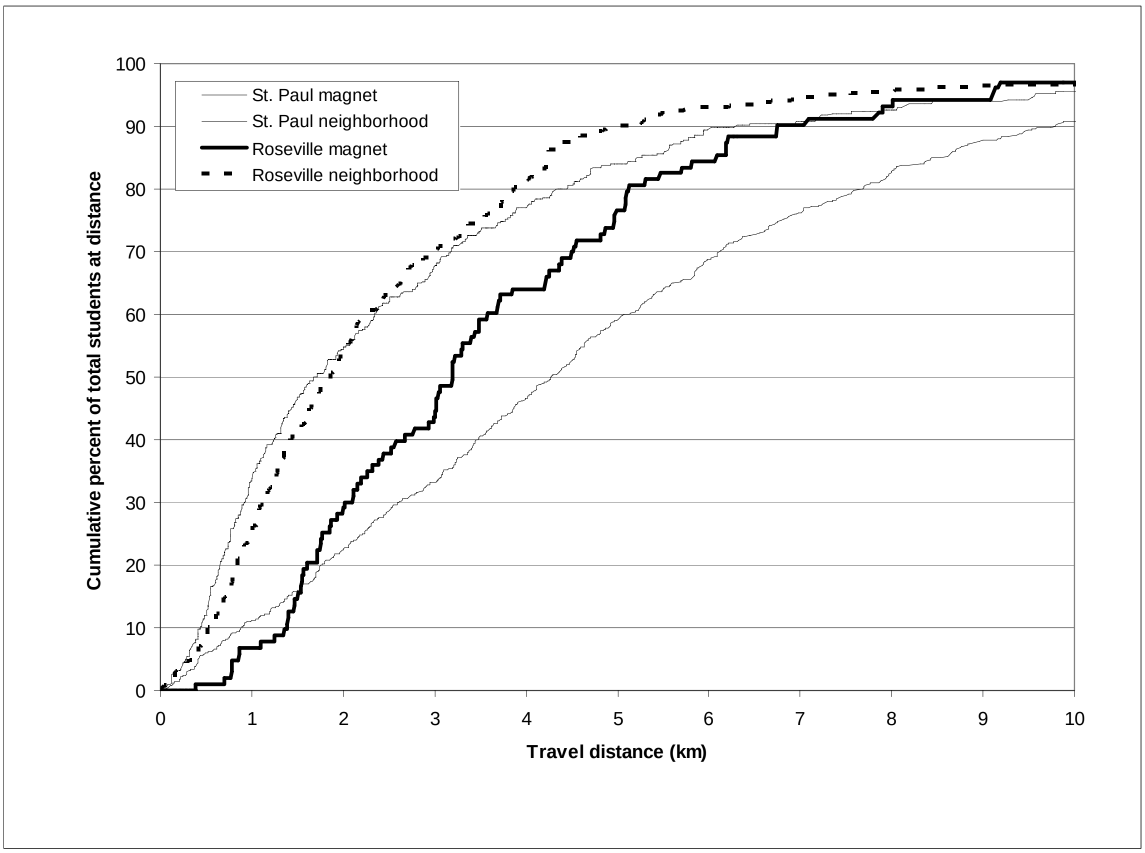

Figure 4-3: Travel Distance by School Location and School Type

The influence of school siting and school choice policies changes at greater travel distances. Referencing again Figure 4-3, St. Paul neighborhood and magnet schools experience greater enrollment than Roseville neighborhood and magnet schools at travel distances less than 1.6 km. A likely explanation is traditional school siting and greater residential density in St. Paul. Roseville magnet enrollment surpasses St. Paul magnet enrollment at distances greater than 1.6 km, however. Roseville neighborhood schools experience greater enrollment than St. Paul neighborhood schools outside 2.1 km. The most likely explanation is district size, 145 square kilometers in St. Paul versus 53 in Roseville (i.e., students in Roseville simply cannot travel as far), though school choice and school siting are also possible explanations. The single Roseville magnet school is centrally located while the many St. Paul magnet schools are spread citywide. St. Paul neighborhood schools also allow limited citywide enrollment unlike neighborhood schools in Roseville.

A separate yet related question is whether school choice and bus service jointly effect the decision to attend an assigned school. Recall, St. Paul provides bus service to elementary-age students living outside 1.6 km from their school. The distance is 0.8 km in Roseville. If a parent desires for a child to travel via bus and bus service is unavailable to the assigned school, a parent might choose instead to send that child to a farther magnet school. Parents might similarly choose a non-assigned school if they perceive travel distance to the assigned school too far for walking and bus service is not yet available.

While the survey instrument cannot definitively answer this question, the following comparison, of whether a student attends their assigned school at varying travel distances, does provide some insight (Table 4-1). At the shortest travel distance, < 0.4 km, the highest percentage of students attend their assigned school in both St. Paul (37%) and Roseville (96%). The St. Paul percent is far lower because of its strong school choice policy. That percentage drops in the second interval, 0.4-0.8 km, where bus service remains unavailable in both districts. In the third interval, the percentage of students attending their assigned school drops further from 30 to 22% in St. Paul, while increasing from 75 to 79% in Roseville, perhaps because of now available bus service in Roseville.

In the last interval, > 1.6 km, the percent attending their assigned school drops to its lowest value in both districts, despite available bus service to the assigned school. These trends suggest a possible relationship between available bus service and the choice to attend an assigned school in Roseville. In St. Paul, however, students are less likely to attend their assigned school as travel distance to that school increases. Bus service availability at 1.6 km appears to not have an effect.

Table 4-1: Assigned School Attendance by Travel Distance to Assigned School

Travel distance	St. Paul			Roseville		
	Attend (%)	Do not attend (%)	Total[a]	Attend (%)	Do not attend (%)	Total[a]
< 0.4 km	37	63	104	96	4	26
0.4-0.8 km	30	70	219	75	25	65
0.8-1.6 km	22	78	292	79	21	126
> 1.6 km	12	88	246	64	36	218
All	23	77	861	72	28	435

[a] Total 'n' is 1,296 and includes all students who live in the school district. Students living outside the district do not have an assigned school.

4.2 Spatial Examination of Travel Mode and Urban Form

A second spatial examination illustrates the possible connection between urban form and school travel mode. The concept, adapted from previous research (Schlossberg et al., 2005), centers on the idea that a map combining travel mode and urban form could assist policymakers in identifying locations in need of investment to improve opportunities for walking. For instance, a school bounded by heavily traveled roads, perhaps prohibiting children from walking even at close distances, could be the focus of speed enforcement, added signage, and crossing guards. Unfortunately, the travel survey sample size is too small for a school-specific analysis and travel mode is unknown for the citywide sample. Those facts preclude a comprehensive analysis. However, examining four schools—one of each school type and school location combination—with large survey sample populations can assist in making generalizations and guiding future research. Details about the four schools are in Table 4-2.

The concept maps illustrate dominant from-school travel mode, network buffers around each school, simplified land use, and major roads. Traversing major roads and less walkable land uses (agricultural, golf course, airports, water, industrial, utility, and undeveloped land) could prohibit walking and increase bus and auto travel, even at short distances. Alternatively, local streets with high connectivity (decreasing travel distance) and residential and walkable (commercial, office, institutional, parks and recreation) land uses may provide opportunities for greater walking.

The St. Paul neighborhood school (Figure 4-4a) is in a location of residential and walkable land uses with shorter blocks, good street connectivity, and few major roads. Much of the residential neighborhood is within 0.8 km of the school. Given this urban form, one expects and finds greater walking to this school. The St. Paul magnet school (Figure 4-4b) is similarly in an area of high street connectivity and surrounded principally by residential neighborhoods, though three major roads cross within 0.8 km of the school—including an interstate to the west and principal arterial to the north and south. Twelve survey sample students live within 0.8 km of this magnet school, though only one enrolls there, a possible reflection of an environment not supportive of walking.

Urban form differs in Roseville. The neighborhood school (Figure 4-4c) is in a location of residential and walkable land use, though street connectivity is lower and blocks are longer than in St. Paul. Several students walk from the residential area to the south, though several more live within 0.8 km of school but must cross at least one major road, perhaps increasing the perceived danger for walking. The Roseville magnet school (Figure 4-4d) is in less residential area, with longer blocks, and poorer street connectivity. Twenty-one students live within 1.6 km of the school, though most must navigate at least one busy street and, perhaps as a result, only one walks.

This brief analysis alone cannot answer conclusively whether urban form has a connection with school travel mode. The analysis found some evidence to support the hypothesis that certain characteristics (i.e., less walkable land uses, longer blocks, and major roads) are not conducive of walking whiles others (i.e., walkable land uses, shorter blocks, and few major roads) are (Table 4-2). The last column finds greater walking among students living within 0.8 km who attend the two St. Paul schools, where characteristics are more supportive of walking. A more comprehensive analysis using a citywide sample with known travel mode could have great utility in identifying locations for infrastructure investments through programs such as Safe Routes to School.

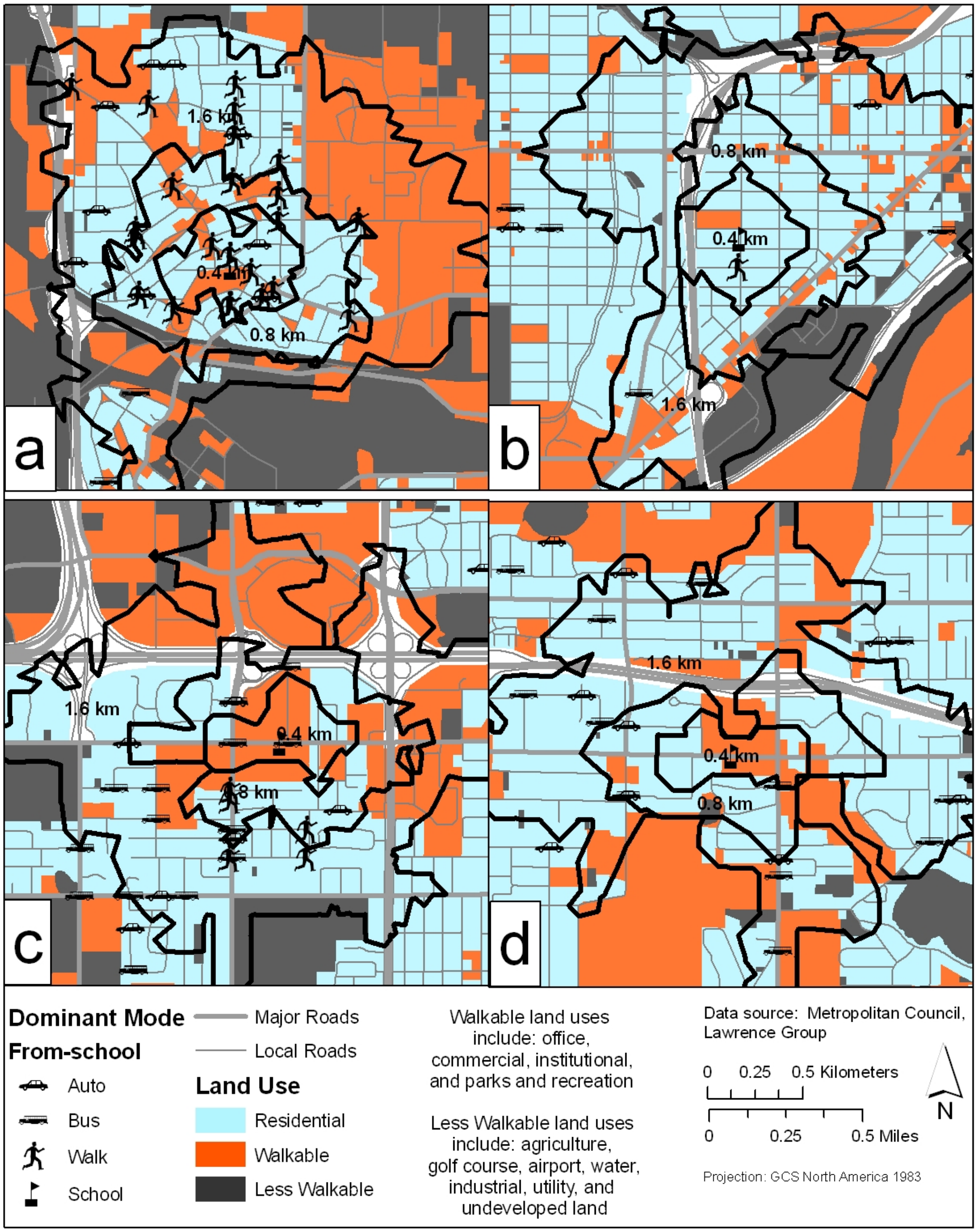

Figure 4-4: Urban Form and Dominant From-school Travel Mode for Sample School (a) St. Paul Neighborhood, (b) St. Paul Magnet, (c) Roseville Neighborhood, and (d) Roseville Magnet

Table 4-2: Travel Mode Summary for the Four Example Schools

School	n	Travel distance (%) < 0.5 km	0.5-1 km	>1 km	From-school travel mode (%) auto	bus	walk	Urban Form[a]	% within 0.8 km who walk
St. Paul neighborhood	59	42	25	32	39	7	54	R.L.U., short blocks, few major roads	88
St. Paul magnet	65	2	5	94	32	65	3	R.L.U., short blocks, 3 major roads	100
Roseville neighborhood	121	10	11	79	27	69	4	W.L.U. longer blocks, 4 major roads	2
Roseville magnet	103	5	16	80	36	63	1	W.L.U. longer blocks, 3 major roads	0

[a] R.L.U.: residential land use; W.L.U.: walkable land use

4.3 Dominant Travel Mode by Distance

This section moves beyond spatial analysis and compares dominant travel mode between several subpopulations, including trip type (to- vs. from-school), school location (St. Paul vs. Roseville), school type (neighborhood vs. magnet), child sex (female vs. male), race (non-white vs. white), number of household vehicles (0 or 1 vs. 2 or more), and household income (below or above district median). Travel mode differs between most of these subpopulations.

Total walking (14% vs. 12%) and busing (56% vs. 55%) is more common from-school than to-school (Figure 4-5b, c). Explanations of greater from-school walking may include more daylight, warmer temperatures, more eyes on the street, challenges getting children off to school on time, or parents better able to coordinate work and school start times in the morning. Walking decreases considerably outside 0.8 km and to nearly zero (2% or less) outside 1.6 km. Auto use is greater to-school than from-school at distances less than 1.6 km and lower than bus for travel distances greater than 1.2 km (Figure 4-5a, b). The average trip distance is four km and 32% of students travel between 0 and 1.6 km, 23% between 1.6 and 3.2 km, 18% between 3.2 and 4.8 km, and 27% travels greater than 4.8 km (Figure 4-5d).

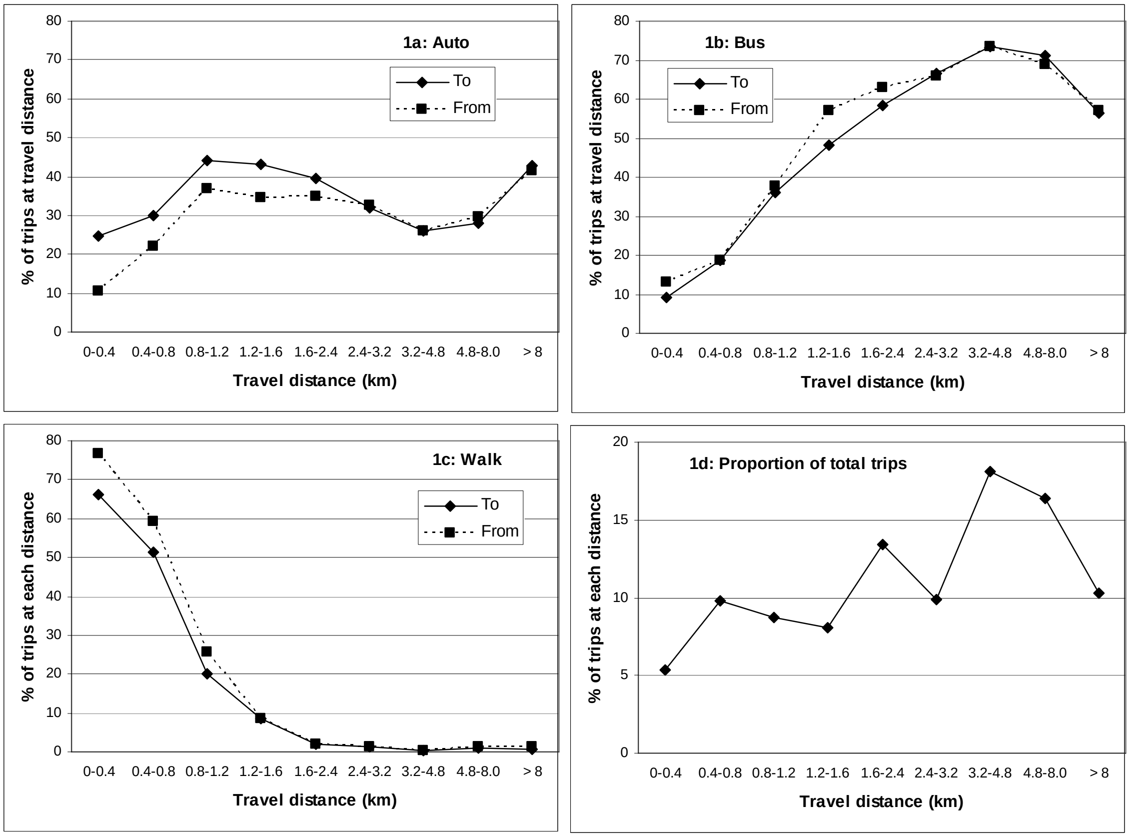

Figure 4-5: Comparison of To- and From-school (a) Auto, (b) Bus and (c) Walk. (d) Total Trips at Each Travel Distance Bin

Analyzing travel mode by school location illustrates differences between St. Paul and Roseville. For commutes less than 1.6 km, more children in St. Paul walk than in Roseville both to-school and from-school (Figure 4-6). Fewer children bus in St. Paul than in Roseville, largely because St. Paul policy provides bus service only for commutes greater than 1.6 km while Roseville provides bus service for commutes greater than 0.8 km. To-school and from-school busing is typically much greater than auto at distances greater than 1.6 km in both districts.

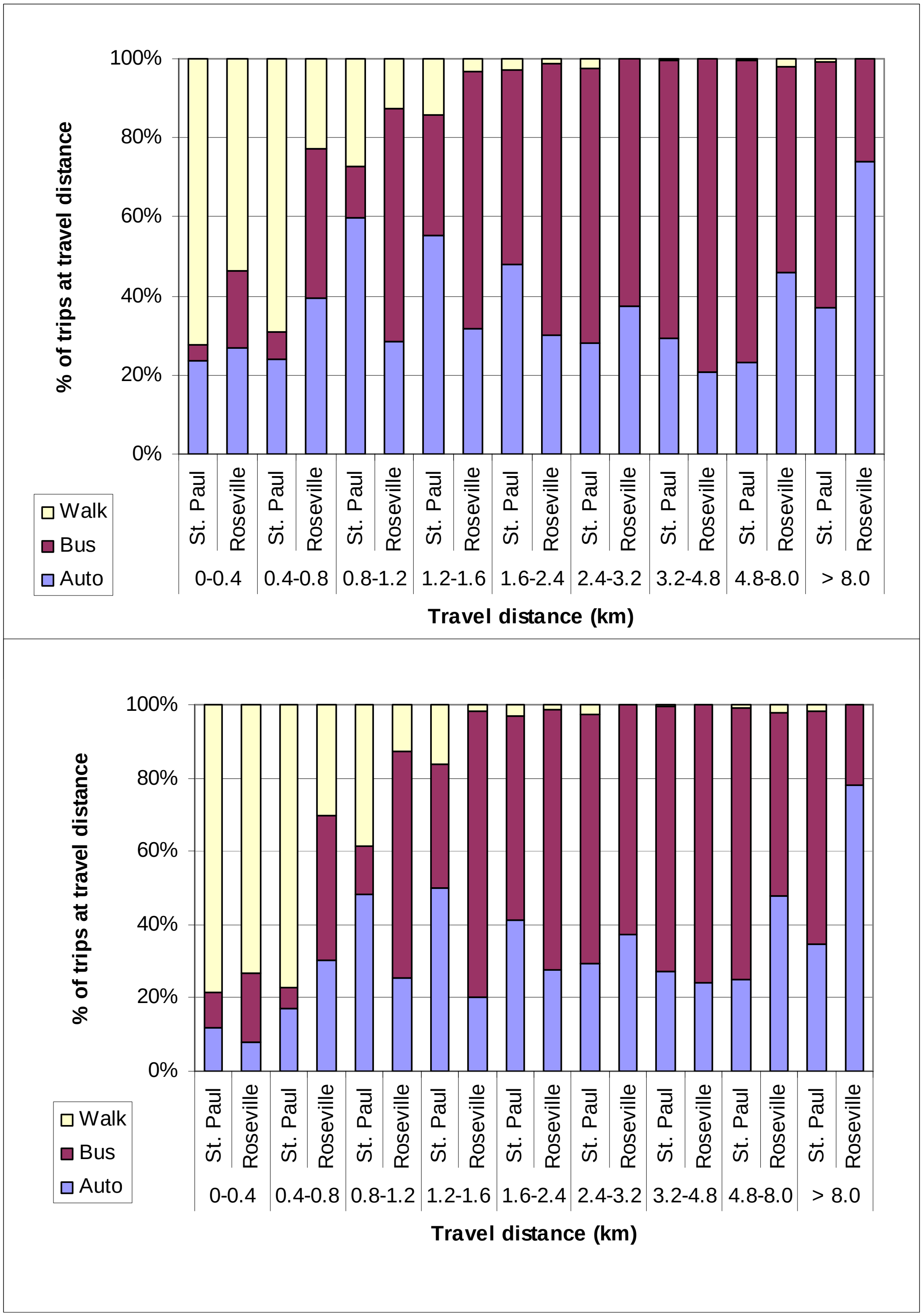

Figure 4-6: Dominant Travel Mode To-school (top) and From-school (bottom); Comparison between St. Paul and Roseville Elementary Schools

Analyzing travel mode by school type illustrates differences between neighborhood and magnet schools. Total busing is greater among magnet school students than neighborhood school students, though for both school types, busing accounts for roughly 65% of from-school trips outside 1.6 km (Figure 4-7). Variation occurs principally in the '0.8-1.2 km' and '4.8-8.0 km' categories, likely reflecting district size and varying bus policies in St. Paul versus Roseville. Walking differences between neighborhood and magnet schools are small, confirming the expectation that the type of school alone does not influence the decision to walk. Compared with from-school trips, to-school trips exhibit less walking and greater auto use in both school types.

From-school travel mode differences by child sex are minor (Figure 4-8). To-school trips exhibit the same small differences; both sexes shift towards less walking and greater auto use.

At travel distances greater than 1.6 km, busing is greater among non-white students than white students with the difference ranging from 15 to 24% (Figure 4-9). As section 5 will show, this difference exists after accounting for differences in household income ($78,900 among whites vs. $48,400 among non-whites) and per household vehicle ownership (1.9 among whites vs. 1.6 vehicles among non-whites). Variation in white and non-white walking is minor.

Travel mode also differs by the number of household vehicles and household income. Busing is higher among households with zero or one vehicles than households with two or more vehicles for both to-school and from-school trips (Figure 4-10). Households with two or more vehicles exhibit slightly greater walking than do households with zero or one vehicles. Households below the school district median household income[15] exhibit far greater busing and less walking than households above the median household income both to-school and from-school (Figure 4-11).

[15] Year 2006 median household income for St. Paul estimated as $43,654 using the year 2006 American Community Survey. Roseville calculated as $56,293 in 2006 using the year 2000 ($51,056, calculated average for the school district) Census adjusted for inflation using a ratio of St. Paul median household income in 2000 ($38,774) and 2006 ($43,654). Obtained from http://factfinder.census.gov; accessed May 3, 2008.

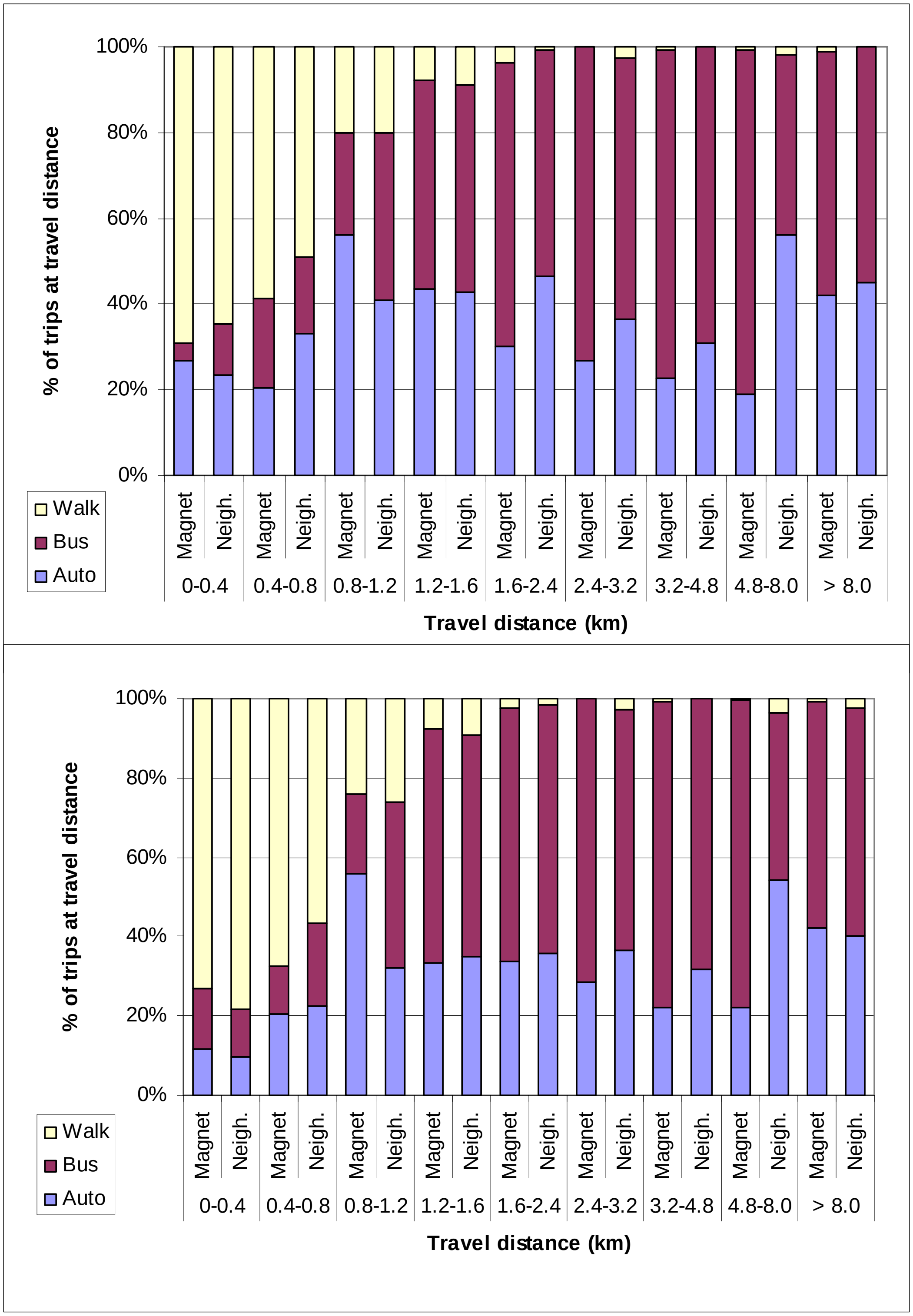

Figure 4-7: Dominant Travel Mode To-school (top) and From-school (bottom); Comparison between Magnet and Neighborhood Elementary Schools

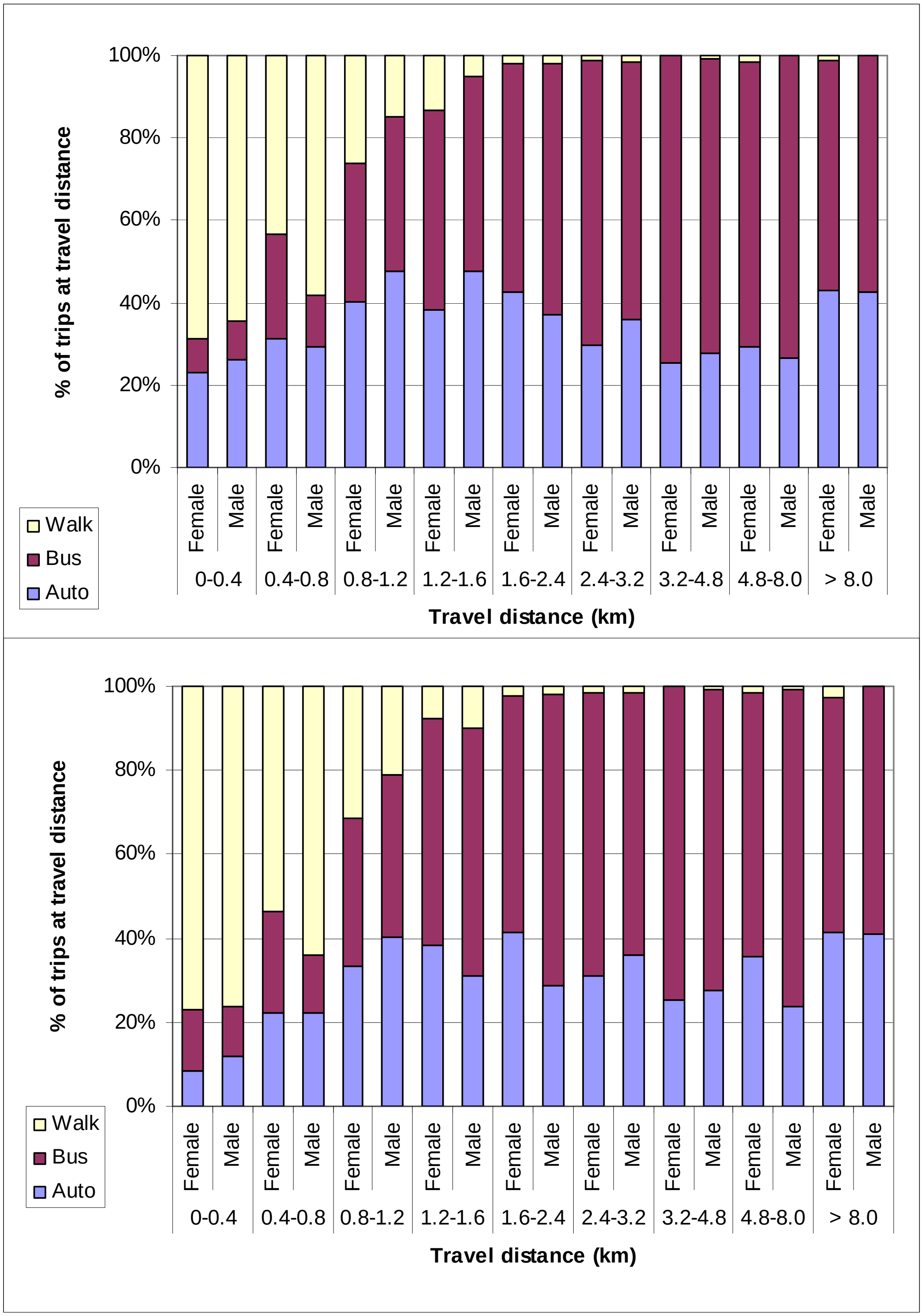

Figure 4-8: Dominant Travel Mode To-school (top) and From-school (bottom); Comparison between Female and Male Children

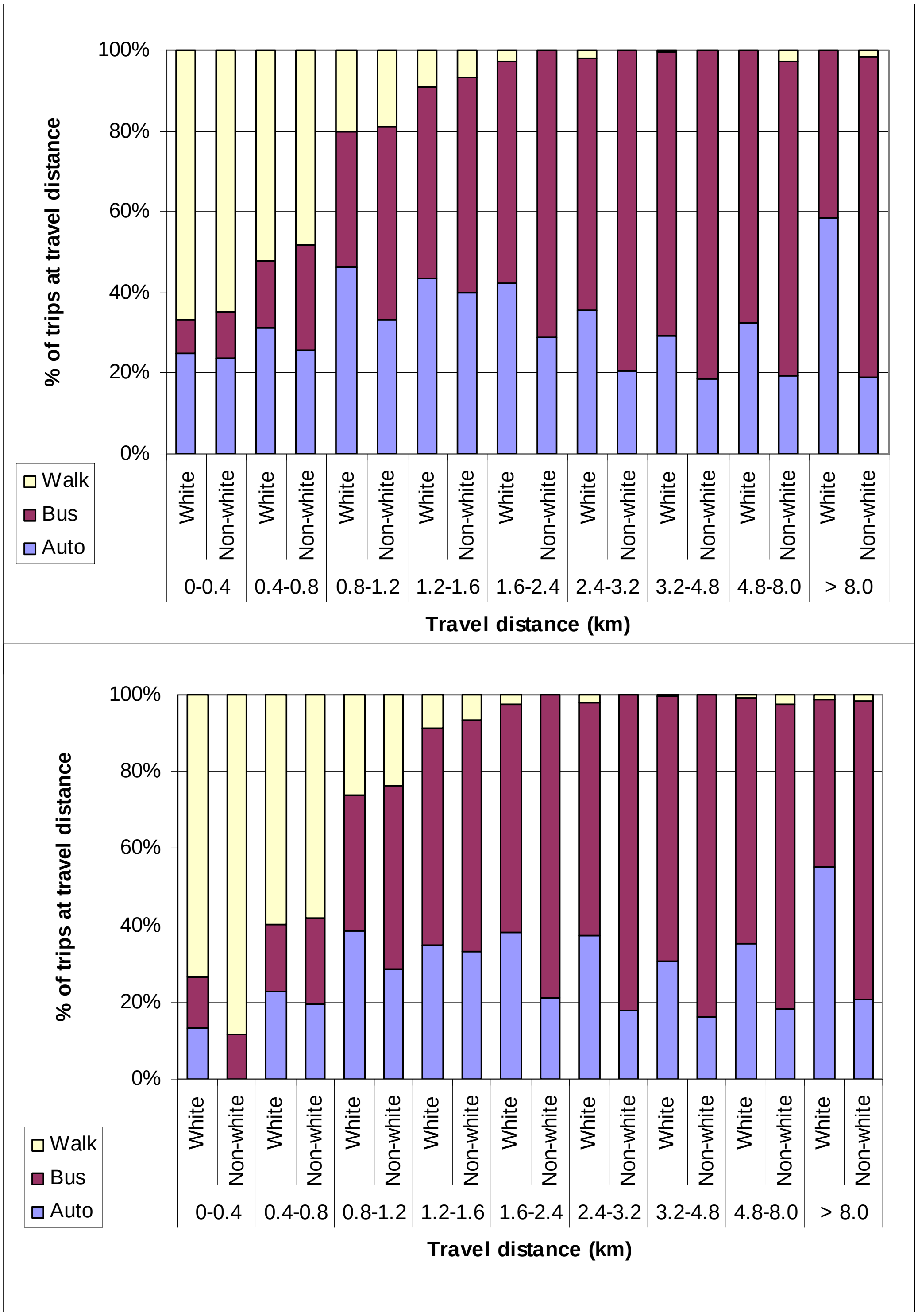

Figure 4-9: Dominant Travel Mode To-school (top) and From-school (bottom); Comparison between White and Non-white Parents

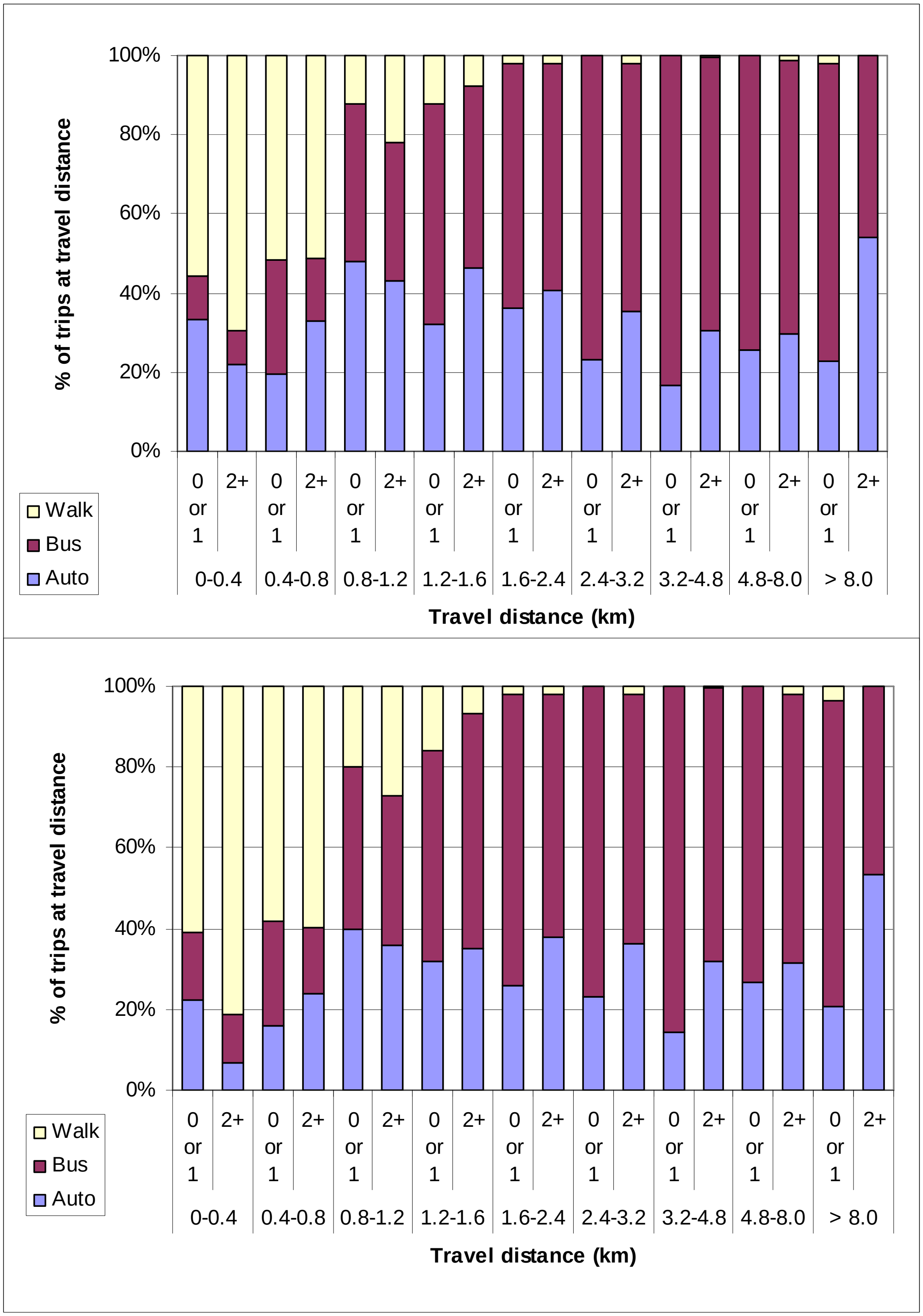

Figure 4-10: Dominant Travel Mode To-school (top) and From-school (bottom); Comparison between Households with '0 or 1 vehicles' and '2 or more vehicles'

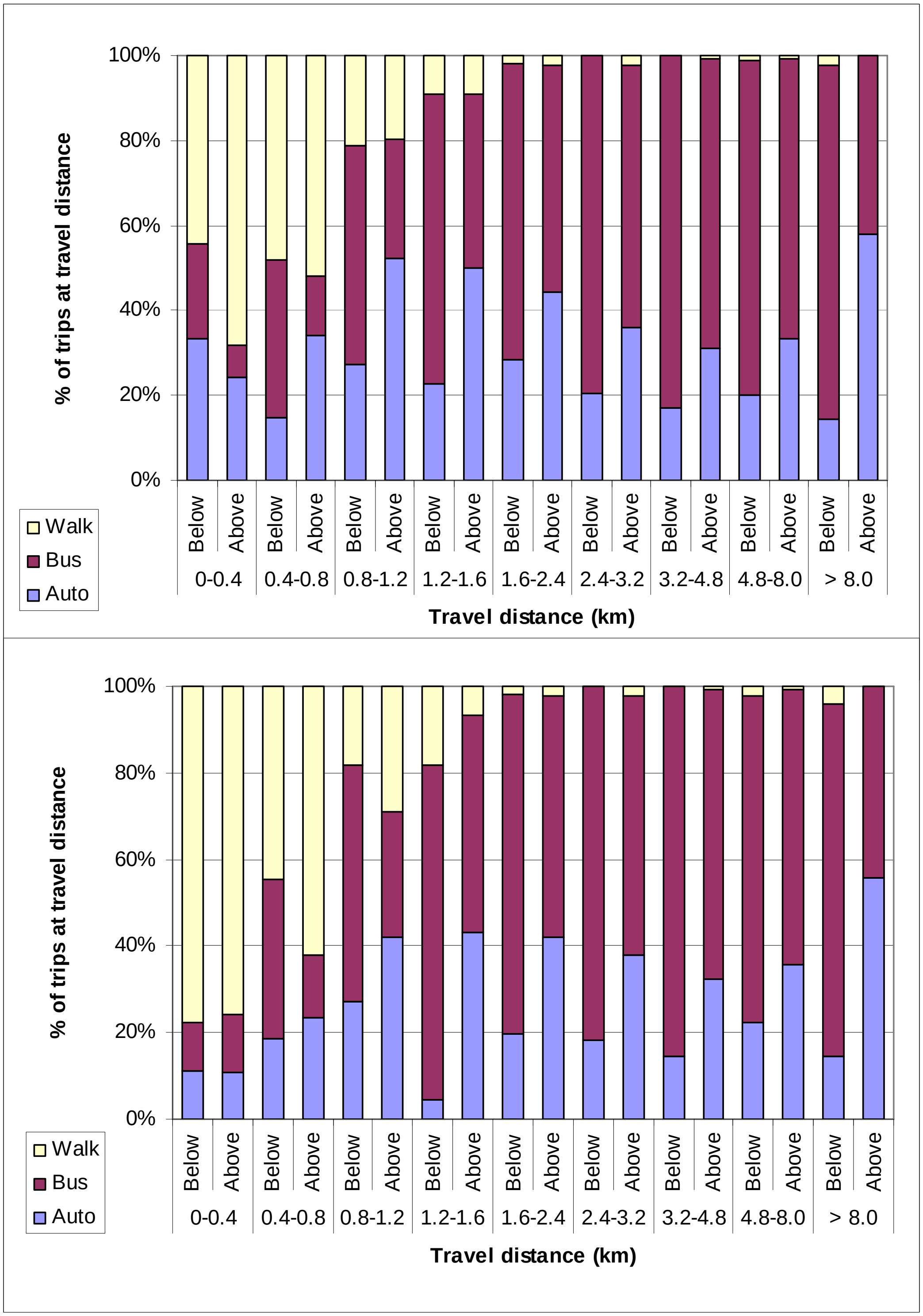

Figure 4-11: Dominant Travel Mode To-school (top) and From-school (bottom); Comparison between Households Below and Above School District Median Household Income

4.4 Parent Preferences towards School and Travel Mode Selection

Parent preferences towards school and travel mode selection may play a strong role in the school travel models. This subsection examines reasons parents chose school and travel mode, differentiating by race and school type.

Table 4-3 compares St. Paul neighborhood and magnet parent attitudes towards school selection. When parents stated the primary reasons behind what school their child attended, three criteria (of nine offered in the survey) were very or somewhat important for more than 90% of parents: quality of teachers, size of class, and curriculum. Among magnet school parents, 85% ranked curriculum as very important compared to 76% of neighborhood-school parents (statistically significant at $p<0.01$). This result is unsurprising as most magnet schools offer specific curriculum (e.g., language, math and science, arts). Other differences include the importance of being close to home, higher among neighborhood parents, and the importance of bus service, higher among magnet school parents. A greater percentage of magnet parents also identified diversity as an important attribute ($p<0.01$). When analyzed by race, a notable difference between St. Paul white and non-white parents emerged (Table 4-4). Seventy-two percent of non-white parents ranked the availability of school bus service as very important as opposed to 37% of white parents ($p<0.01$), owing perhaps to greater bus travel among non-white respondents ($p<0.01$). Non-white parents also placed greater importance on diversity and the school being close to home.

Differences also exist between St. Paul white and non-white parents' responses to important factors in determining whether their child rides the bus. Eighty one percent of non-white parents placed bus stop safety—child safety waiting for the bus—as 'very important' compared with only 66% of white parents ($p<0.05$). Non-white parents were more concerned about cold temperatures at the bus stop ('very important' 63%) than white parents were ('very important' 25%) ($p<0.01$). Overall, among the eight offered reasons why children did *not* recently walk or bicycle to school, distance was primary reason (61% of the sample) and difficult crossings, at 44%, the second.

Table 4-3: Comparison of St. Paul Neighborhood and Magnet School Parent Stated Importance of School Attribute in Selecting School

	Neighborhood students (%)[a] (n=322)					Magnet students (%)[a] (n=605)					Difference
School Attribute	Very	Somewhat	Not very	Not at all	NA	Very	Somewhat	Not very	Not at all	NA	statistic[b,c]
School bus service available	33	24	14	23	6	56	25	8	9	2	-6.23**
Close to home	49	40	8	1	1	31	46	16	5	1	-6.01**
Quality of teachers	95	3	1	0	0	96	3	1	0	0	-0.16
Size of class	71	26	2	0	0	65	30	4	1	0	-2.16*
Diversity	34	47	13	3	1	46	41	10	2	0	-3.17**
Curriculum	76	20	2	0	1	85	13	1	0	0	-3.28**
Close to work	5	17	34	33	9	7	21	34	30	6	-0.69
School start time	20	38	29	11	1	20	37	28	13	0	-0.49
Distance from other child's school	10	19	19	10	40	36	12	20	19	12	-0.77

[a] Percentages may not add up to 100% due to missing values
[b] Reporting Z-statistic from Mann Whitney u-test (2-tailed significance)
[c] * $p < 0.05$ ** $p < 0.01$

Table 4-4: Comparison of St. Paul White and Non-white Parent Stated Importance of School Attribute in Selecting School

	White (%)[a] (n=633)					Non-white (%)[a] (n=294)					Difference
School Attribute	Very	Somewhat	Not very	Not at all	NA	Very	Somewhat	Not very	Not at all	NA	statistic[b,c]
School bus service available	37	29	12	17	3	72	15	4	5	3	-9.30**
Close to home	33	48	15	3	1	47	36	10	3	1	-3.76**
Quality of teachers	97	3	0	0	0	91	5	2	0	0	-3.61**
Size of class	67	30	2	0	0	66	26	6	1	0	-0.92
Diversity	35	50	12	2	0	55	27	8	4	1	-4.02**
Curriculum	82	17	1	0	0	82	13	1	0	1	-0.07
Close to work	3	16	36	38	6	13	27	30	16	10	-6.91**
School start time	10	40	34	15	0	42	32	16	7	1	-10.00**
Distance from other child's school	6	20	18	12	42	22	19	19	9	28	-1.45

[a] Percentages may not add up to 100% due to missing values
[b] Reporting Z-statistic from Mann Whitney u-test (2-tailed significance)
[c] * $p < 0.05$ ** $p < 0.01$

For Roseville survey respondents, the same three reasons behind what school their child attended—quality of teachers, size of class, and curriculum—were somewhat or very important for most parents (Table 4-5). Unlike in St. Paul, however, the differences between neighborhood and magnet schools were not statistically different. Neighborhood parents value school closeness to home and to work more than magnet parents do. Examining differences by race (Table 4-6), 60% of non-white parents ranked school bus availability as very important compared to 43% of white parents ($p<0.05$). Other differences include the importance of class size and school start time, greater among white parents (both at $p<0.05$), and diversity and school closeness to work, higher among non-white parents (both at $p<0.05$). Distance to school and difficult crossings were again the primary reasons for not walking to school recently.

Differences in respondent attitudes towards school travel mode are similar to those in St. Paul. Among children who were driven to school, approximately 47-56% (neighborhood-magnet) did so as part of a parent's trip to work and 42-44% (neighborhood-magnet) did so in a separate trip. A much lower percentage carpooled, only 1.9% in neighborhood schools and 2.2% in magnet schools.

Table 4-5: Comparison of Roseville Neighborhood and Magnet School Parent Stated Importance of School Attribute in Selecting School

	Neighborhood students (%)[a] (n=414)					Magnet students (%)[a] (n=103)					Difference
School Attribute	Very	Somewhat	Not very	Not at all	NA	Very	Somewhat	Not very	Not at all	NA	statistic[b,c]
School bus service available	46	26	12	11	5	44	33	5	16	1	-1.18
Close to home	52	40	5	2	1	29	55	12	3	1	-4.15**
Quality of teachers	96	4	0	0	0	98	0	0	0	1	-1.81
Size of class	73	24	2	0	0	79	20	0	0	1	-1.48
Diversity	32	44	17	5	0	23	55	14	7	1	-0.67
Curriculum	78	20	1	0	0	82	17	1	0	1	-1.24
Close to work	4	18	34	33	9	2	10	36	45	8	-2.13**
School start time	13	38	31	14	2	8	47	31	13	2	0.957
Distance from other child's school	6	18	22	14	39	7	16	18	15	46	0.182

a: Percentages may not add up to 100% due to missing values
b: Reporting Z-statistic from Mann Whitney u-test (2-tailed significance)
c: * $p < 0.05$ ** $p < 0.01$

Table 4-6: Comparison of Roseville White and Non-white Parent Stated Importance of School Attribute in Selecting School

	White (%)[a] (n=437)					Non-white (%)[a] (n=80)					Difference
School Attribute	Very	Somewhat	Not very	Not at all	NA	Very	Somewhat	Not very	Not at all	NA	statistic[b,c]
School bus service available	43	28	11	13	4	60	24	8	6	3	-2.53*
Close to home	46	44	7	2	1	53	40	6	1	0	-0.82
Quality of teachers	97	3	0	0	0	96	5	0	0	0	0.25
Size of class	76	22	1	0	0	64	30	5	0	1	-2.13*
Diversity	27	49	18	6	0	50	36	10	1	1	-4.24**
Curriculum	78	20	1	0	0	81	18	1	0	0	-0.58
Close to work	3	14	35	38	9	10	28	31	20	10	-3.88**
School start time	10	40	33	14	2	24	39	21	10	3	2.41*
Distance from other child's school	5	17	21	16	40	13	18	20	2	41	1.32

a: Percentages may not add up to 100% due to missing values
b: Reporting Z-statistic from Mann Whitney u-test (2-tailed significance)
c: * $p < 0.05$ ** $p < 0.01$

Cumulatively these findings suggest two main conclusions. First, parent attitudes towards school travel mode are markedly different between white and non-white parents. Non-white parents place greater importance on school bus availability and safety while waiting for the bus than white parents do. Second, school siting policy and magnet school popularity is likely strongly affecting children's ability to walk or bicycle to school, evidenced through distance being the primary walking-to-school barrier.

Appendix C provides additional tabular information detailing parent's stated importance of mode attribute in selecting travel mode (Tables 11-1 thru 11-4). This section does not present these tables as each parent did not answer these questions.

4.5 Survey Sample Summary of Observed Travel

Below is a summary of average travel distance, travel mode, and total travel distance in St. Paul and Roseville. This summary strengthens the descriptive results and identifies differences by school type and school location (Table 4-7). Median average travel distance is slightly less in St. Paul neighborhood schools (1.7 km) than Roseville neighborhood schools (1.9 km); the opposite is true of magnet schools (3.2 km in Roseville, 4.3 km in St. Paul) as Roseville is smaller in geographic size and has one central magnet school.

Walk and bus is greater from-school than to-school. Total busing is higher among magnet students than neighborhood students in both districts, though the difference is greater in St. Paul, likely because of fewer students living in the no busing zone. Total to- and from-school walking rates are at least 3 times larger in St. Paul neighborhood than magnet schools and 9 times larger in Roseville neighborhood than magnet schools. Total walk travel, however, is higher for St. Paul magnet and neighborhood students as for Roseville magnet and neighborhood students, reiterating the earlier observation that both school location and school type influence walking rates. Total auto travel distance is higher for magnet schools than neighborhood schools to-school and from-school despite greater auto use in neighborhood schools (except for from-school travel in Roseville, where auto is higher among magnet school students). Student kilometers by bus[16] indicate bus usage is greater for St. Paul magnet schools than St. Paul neighborhood, Roseville magnet, and Roseville neighborhood schools.

A necessary final comparison is to ensure the 1,216 respondent sample (used in sections 5 and 6) is not dissimilar from the sample described in section 4 (n = 1,433). Racial, demographic, and economic differences are slim and not statistically significant.

[16] Student kilometers by bus are an estimate of bus travel, calculated as the sum of student travel by bus. In other words, the sum of shortest path travel distances among students who bus.

For example, in St. Paul and Roseville, the sample that lives within the district boundary (n = 1,216) is slightly more white and has slightly greater median income than the larger sample (n = 1,433). The shift in travel mode and travel distance is also expected; the 1,216 sample population has slightly higher bus and walk rates and a lower auto rate than the 1,433 population, likely because of auto having the greatest mode share among students traveling from outside the district.

Table 4-7: Travel Survey Sample Summary of Observed Travel (n = 1 433)

	St. Paul			Roseville		
	Magnet	Neighborhood	Total	Magnet	Neighborhood	Total
Students	603	314	917	103	413	516
Travel distance						
Mean (km)	5.1	2.8	4.3	3.8	2.8	3.0
Median (km)	4.3	1.7	3.4	3.2	1.9	2.1
Dominant travel mode to-school						
Auto (%)	28	45	34	28	35	34
Bus (%)	63	30	52	71	56	59
Walk (%)	8	25	14	1	9	7
Dominant travel mode from-school						
Auto (%)	27	37	31	36	29	30
Bus (%)	64	32	53	63	60	61
Walk (%)	9	30	16	1	11	9
Total district travel to-school[a,b]						
Auto (km)	994	751	1 746	871	790	1 661
Walk (km)	66	103	169	9	38	47
Total district travel from-school[a,b]						
Auto (km)	1 011	622	1 634	982	739	1 721
Walk (km)	67	160	226	9	41	50
Total student km by bus[c]						
To-school	1.0	0.4	NA	0.7	0.4	NA
From-school	1.0	0.5	NA	0.6	0.5	NA

[a] St. Paul neighborhood and Roseville magnet/neighborhood travel adjusted to 603

[b] Sum of student travel distance by mode

[c] Bus travel is a measure of student kilometers by bus relative to St. Paul magnet

Table 4-8: Travel Survey Sample Summary of Observed Travel (n = 1 216)

	St. Paul			Roseville		
	Magnet	Neighborhood	Total	Magnet	Neighborhood	Total
Students	522	281	803	82	331	413
Travel distance						
Mean (km)	4.4	2.6	3.7	3.0	1.9	2.2
Median (km)	4.0	1.6	3.1	2.7	1.6	1.8
Dominant travel mode to-school						
Auto (%)	25	45	32	16	31	28
Bus (%)	65	29	53	83	59	63
Walk (%)	9	26	15	1	11	9
Dominant travel mode from-school						
Auto (%)	25	38	29	27	24	25
Bus (%)	66	31	54	72	63	65
Walk (%)	10	31	17	1	13	10
Total district travel to-school[a,b]						
Auto (km)	495	592	1 087	218	321	539
Walk (km)	41	90	131	10	32	42
Total district travel from-school[a,b]						
Auto (km)	524	523	1 047	350	307	657
Walk (km)	42	122	164	10	34	44
Total student km by bus[c]						
To-school	1.0	0.4	NA	0.8	0.4	NA
From-school	1.0	0.4	NA	0.7	0.4	NA

[a] St. Paul neighborhood and Roseville magnet/neighborhood travel adjusted to 603

[b] Sum of student travel distance by mode

[c] Bus travel is a measure of student kilometers by bus relative to St. Paul magnet

In culmination, these results reemphasize the influence of school choice and school siting in lengthening travel distances and likely reducing opportunities to walk and increasing motorized transportation. Coupled with variations between race and child sex, as well as parent attitudes towards school and travel mode selection, they likely play a role in explaining child travel mode.

5 Analysis: Factors that Determine School Travel Mode

This section employs multinomial logistic regression to move beyond descriptive analysis and identify the relative effect of school location, school choice, travel distance, child and household characteristics, parent attitudes, and urban form in determining school travel mode. It utilizes the survey sample to create two models of travel behavior (1) a 'full' model to best explain travel mode choice in St. Paul and Roseville using the full travel survey and detailed geographic information systems data and (2) a 'simplified' model necessary for the St. Paul citywide data set that contains limited student information. The models use the weighted travel survey respondents (n = 803 in St. Paul; n = 413 in Roseville), though section 5.1 also compares un-weighted results. The travel models provide the coefficients necessary to assign a most-likely new travel mode (auto, bus, or walk) resulting from alternate education policies (Section 6).

5.1 Full Model: Travel Survey Sample

The 'full' multinomial logistic regression model estimates the odds of (1) bus and (2) walk relative to the reference mode auto and codes 'trip type' (to- or from-school) as a dummy variable. The weighted model has a pseudo r-squared of 0.528, and correctly predicts travel mode for 75% of the travel survey sample (Table 5-1). Beta coefficient size and statistical significance are highly representative of separate to- and from-school models. Notable insignificant variables include child sex, parent attitudes towards school and travel mode selection, school enrollment, and school-specific test scores.

A sample interpretation follows for a student walking relative to the reference mode auto at a distance of '0.8-1.2 km'. The logit coefficient is -1.677, rejecting the null hypothesis, at a p-value of 0.05, that a student is not less likely to walk relative to auto at a travel distance of '0.8-1.2 km' compared to the reference category of '<0.4 km' when other model variables are held constant. The odds ratio is often an easier interpretation (odds ratio defined as the probability of an event occurring divided by the probability of an event not occurring). The odds of a student walking who travels '0.8-1.2 km' are 19%

of a student who travels ‘<0.4 km’, relative to the reference mode automobile. Thus, the odds of walking are less at longer travel distances.

Travel distance has the largest effect on school travel mode, identified through large beta coefficients as compared to other variables. Busing odds are greater at most distances outside 1.2 km and walking odds decrease markedly outside 0.8 km and are nearly zero outside 1.6 km. The odds of walking are higher from-school than for to-school travel, though trip type is not a statistically significant predictor of bus relative to auto. As mentioned earlier, possible explanations for greater from-school walking include more daylight, warmer temperatures, more eyes on the street, challenges getting children off to school on time, or parents better able to coordinate morning work and school start times.

Magnet students are more likely to bus than neighborhood students are (odds: 2.413). The likely explanation is more students live near the neighborhood school and must travel via auto since bus service is unavailable. School type is not separately predictive of walking odds. However, total walking rates are 2.3 times greater for neighborhood as for magnet (18 % and 8%, respectively), likely a reflection of greater travel distance (46% of neighborhood and 17% of magnet students travel less than 1.6 km).

Examining school location, busing is less likely among St. Paul than Roseville students (odds: 0.155). Again, this reflects in part that no school bus service in St. Paul at travel distances less than 1.6 km while Roseville offers bus service at 0.8 km. Despite expectations, after controlling for other variables the odds of walking relative to auto in St. Paul are not significantly higher than those in Roseville are. However, total walking rates are 1.9 times greater for St. Paul as for Roseville (15% and 8%, respectively). School siting policy alone cannot explain this finding as 28% of St. Paul students and 39% of Roseville students travel less than 1.6 km. A possible influence of urban form or some other unidentified policy exists.

Child and household characteristics also play a role. Busing and walking are more likely among older children (grades 3 thru 6 busing odds: 1.597 to 4.441; grades 5 and 6 walking odds: 2.595 and 8.621 respectively) than the youngest children (grade kindergarten). Parents might place greater trust in older children to travel without them, though the survey does not discern if the child travels alone or in a group [e.g., the walking school bus; varied success demonstrated in New Zealand (Kingham and Ussher, 2007)]. Students from households with income below $80,000 are more likely to bus than ride in an auto (odds ranging from 1.754 to 8.790) while students from households with income between $20,000 and $60,000 are more likely to walk than ride in an auto (odds ranging from 2.581 to 2.701). One possible explanation is that households with greater income have greater vehicle ownership[17], on average, and may feel more inclined to drive their children. Alternatively, lower income households might not have the means or available time to drive their child; instead having he or she walk or bus. The odds increase with each additional household member that a student will bus or walk (busing odds 1.502, walking odds 1.807). Students from larger households may have older siblings to walk or bus to school with. Finally, white students are less likely to ride in a bus than non-white students (odds 0.569), though race is not separately predictive of walking odds.

The model found only one measure of urban form significant among the ten tested (recall section 3.5). A student whose route is in a location with greater kilometers of local (i.e., non-county, highway, or interstate) streets per square kilometer is more likely to walk than ride in an auto. This variable effectively measures street connectivity; greater street connectively means more local streets and possibly lower vehicle speed, making that walk safer. This finding of only one significant urban form variable has one of two implications: either local urban form is not a large factor in determining school travel mode or local urban form does matter and the right measures has yet to be found.

A useful comparison to the weighted travel model in Table 5-1 is the un-weighted model (Table 5-2). Expectedly the beta coefficients of the un-weighted model are similar to those in the weighted model. The key difference (reflecting the need to weight the sample) is the bus and walk income beta coefficients are higher in the weighted model than un-weighted model in all but one category (walk, $0 - 19 999).

[17] Vehicle ownership and household income share a significant bivariate correlation (0.437); thus testing only one variable is necessary. Household income improved the model more so than vehicle ownership.

Table 5-1: Full Multinomial Logistic Regression Model Estimating Elementary-age Travel Mode Using Weighted Survey Sample

	Bus[a]				Walk[a]			
Variable	Coef.	Std. error	P >|z|	Odds	Coef.	Std. error	P >|z|	Odds
Intercept	-2.514	0.546	0.000		-4.118	0.773	0.000	
Trip type								
To-school (0 = from-school)	-0.208	0.111	0.061	0.813	-0.470	0.192	0.014	0.625
School attributes								
Travel distance, 0.4-0.8 km	0.307	0.430	0.475	1.360	-0.370	0.345	0.284	0.691
Travel distance, 0.8-1.2 km	0.277	0.408	0.497	1.319	-1.677	0.352	0.000	0.187
Travel distance, 1.2-1.6 km	1.071	0.411	0.009	2.919	-2.167	0.400	0.000	0.114
Travel distance, 1.6-2.4 km	0.934	0.393	0.017	2.544	-3.833	0.457	0.000	0.022
Travel distance, 2.4-3.2 km	1.682	0.410	0.000	5.378	-4.637	0.811	0.000	0.010
Travel distance, 3.2-4.8 km	1.688	0.398	0.000	5.408	-5.944	1.097	0.000	0.003
Travel distance, > 4.8 km	1.845	0.397	0.000	6.329	-4.668	0.593	0.000	0.009
Travel distance, < 0.4 km	0				0			
Type, magnet (0 = neighborhood)	0.881	0.136	0.000	2.413	-0.091	0.233	0.697	0.913
City, St. Paul (0 = Roseville)	-1.866	0.210	0.000	0.155	0.292	0.338	0.388	1.339
Child characteristics								
Child grade, 1	0.565	0.175	0.001	1.760	0.181	0.348	0.602	1.199
Child grade, 2	0.094	0.188	0.616	1.099	0.091	0.347	0.793	1.095
Child grade, 3	1.023	0.206	0.000	2.782	0.038	0.401	0.924	1.039
Child grade, 4	0.468	0.213	0.028	1.597	0.241	0.370	0.514	1.273
Child grade, 5	0.979	0.212	0.000	2.662	0.954	0.382	0.013	2.595
Child grade, 6	1.491	0.232	0.000	4.441	2.154	0.379	0.000	8.621
Child grade, kindergarten	0				0			
Household characteristics								
Size (1 member)	0.407	0.052	0.000	1.502	0.592	0.083	0.000	1.807
Race, white (0 = non-white)	-0.564	0.156	0.000	0.569	0.147	0.271	0.589	1.158
Income, $0 - 19 999	2.174	0.249	0.000	8.790	0.005	0.585	0.993	1.005
Income, $20 000 - 39 999	1.459	0.225	0.000	4.303	0.994	0.383	0.009	2.701
Income, $40 000 - 59 999	0.980	0.223	0.000	2.665	0.948	0.368	0.010	2.581
Income, $60 000 - 79 999	0.562	0.246	0.023	1.754	0.760	0.394	0.053	2.139
Income, $80 000 - 99 999	0.205	0.243	0.399	1.227	0.663	0.404	0.101	1.940
Income, $100 000 - 119 000	-0.140	0.308	0.650	0.870	0.299	0.497	0.547	1.349
Income, > $120 000	0				0			
Route urban form (per square kilometer)								
Local street length (km)	0.046	0.028	0.100	1.047	0.167	0.047	0.000	1.181

[a] Car is the reference mode

Log-likelihood with constants only	4142.496	Nagelkerke pseudo-r^2	0.528
Log-likelihood at convergence	2766.154	Number of observations	1216
Likelihood ratio chi-squared (50 d.f.)	1376.341		
Prob > chi-squared	0.000		

Table 5-2: Full Multinomial Logistic Regression Model Estimating Elementary-age Travel Mode Using Un-weighted Survey Sample

	Bus[a]				Walk[a]			
Variable	Coef.	Std. error	P >|z|	Odds	Coef.	Std. error	P >|z|	Odds
Intercept	-1.776	0.484	0.000		-3.417	0.682	0.000	
Trip type								
To-school (0 = from-school)	-0.129	0.103	0.213	0.879	-0.420	0.174	0.016	0.657
School attributes								
Travel distance, 0.4-0.8 km	0.058	0.374	0.876	1.060	-0.640	0.288	0.026	0.527
Travel distance, 0.8-1.2 km	0.245	0.363	0.500	1.278	-2.183	0.313	0.000	0.113
Travel distance, 1.2-1.6 km	0.757	0.356	0.034	2.132	-2.859	0.366	0.000	0.057
Travel distance, 1.6-2.4 km	1.019	0.344	0.003	2.770	-4.218	0.449	0.000	0.015
Travel distance, 2.4-3.2 km	1.481	0.359	0.000	4.397	-4.263	0.578	0.000	0.014
Travel distance, 3.2-4.8 km	1.623	0.346	0.000	5.068	-5.572	0.763	0.000	0.004
Travel distance, > 4.8 km	1.659	0.347	0.000	5.256	-5.411	0.645	0.000	0.004
Travel distance, < 0.4 km	0				0			
Type, magnet (0 = neighborhood)	0.880	0.124	0.000	2.411	-0.320	0.218	0.142	0.726
City, St. Paul (0 = Roseville)	-1.643	0.196	0.000	0.193	0.550	0.300	0.067	1.734
Child characteristics								
Child grade, 1	-0.014	0.174	0.934	0.986	-0.149	0.321	0.643	0.862
Child grade, 2	-0.111	0.181	0.538	0.895	0.123	0.310	0.692	1.131
Child grade, 3	0.388	0.190	0.041	1.474	-0.107	0.336	0.751	0.899
Child grade, 4	0.197	0.194	0.309	1.218	0.622	0.319	0.051	1.862
Child grade, 5	0.498	0.194	0.010	1.645	0.867	0.329	0.009	2.379
Child grade, 6	0.969	0.220	0.000	2.636	1.781	0.346	0.000	5.938
Child grade, kindergarten	0				0			
Household characteristics								
Size (1 member)	0.335	0.050	0.000	1.399	0.513	0.079	0.000	1.670
Race, white (0 = non-white)	-0.549	0.149	0.000	0.577	0.151	0.267	0.571	1.163
Income, $0 - 19 999	1.864	0.305	0.000	6.448	0.326	0.771	0.673	1.385
Income, $20 000 - 39 999	1.277	0.211	0.000	3.587	0.842	0.381	0.027	2.320
Income, $40 000 - 59 999	0.888	0.182	0.000	2.431	0.819	0.309	0.008	2.267
Income, $60 000 - 79 999	0.509	0.180	0.005	1.664	0.763	0.292	0.009	2.144
Income, $80 000 - 99 999	0.096	0.162	0.554	1.101	0.530	0.279	0.057	1.700
Income, $100 000 - 119 000	-0.204	0.183	0.264	0.815	0.212	0.304	0.485	1.237
Income, > $120 000	0				0			
Route urban form (per square kilometer)								
Local street length (km)	0.037	0.027	0.176	1.037	0.156	0.042	0.000	1.168

[a] Car is the reference mode

Log-likelihood with constants only	4644.099	Nagelkerke pseudo-r^2	0.541
Log-likelihood at convergence	3140.894	Number of observations	1216
Likelihood ratio chi-squared (50 d.f.)	1503.205		
Prob > chi-squared	0.000		

Table 5-3 compares observed un-weighted travel to estimated weighted and un-weighted travel (calculated using the beta coefficients in Table 5-1 and Table 5-2, respectively). By definition, the un-weighted estimation represents observed travel accurately. The weighted estimation exhibits greater busing than the un-weighted sample, an expected result given the weighted sample is less wealthy and less white. The un-weighted model predicts less auto use among these populations. Travel distance is greater in St. Paul among the weighted sample that among the un-weighted sample because non-white students generally travel farther than white students, owing perhaps to districts busing such students for purposes of maintaining racial and socio-economic diversity.

Table 5-3: Comparison of Observed and Estimated Survey Sample Travel Mode

	St. Paul			Roseville		
	Observed	Estimated		Observed	Estimated	
Scenario	Unweighted sample	Weighted sample	Unweighted sample	Unweighted sample	Weighted sample	Unweighted sample
Students	803			413		
Travel distance						
Mean (km)	3.7	4.1	3.7	2.2	2.1	2.2
Median (km)	3.1	3.7	3.1	1.8	1.8	1.8
Dominant travel mode to-school						
Auto (%)	32	25	32	28	22	28
Bus (%)	53	62	52	63	69	65
Walk (%)	15	13	16	9	9	7
Dominant travel mode from-school						
Auto (%)	29	18	28	25	11	24
Bus (%)	54	64	54	65	72	65
Walk (%)	17	18	18	10	16	10
Total district travel to-school[a,b]						
Auto (km)	814	664	870	462	341	387
Walk (km)	90	85	116	43	63	30
Total district travel from-school[a,b]						
Auto (km)	805	480	788	486	177	356
Walk (km)	108	168	104	45	179	55
Total student km by bus[c]						
To-school	1.0	1.2	1.0	0.6	0.6	0.6
From-school	1.0	1.3	1.0	0.6	0.6	0.6

[a] Roseville travel increased proportionally to 803 students
[b] Sum of student travel distance by mode
[c] Bus travel is a measure of student kilometers by bus relative to St. Paul observed

5.2 Simplified Model: For the Citywide Sample

The simplified model uses only weighted survey sample variables available in the citywide sample (Table 5-4). The simplified model also includes only students in St. Paul; a similar data set was not available in Roseville. This explains how the simplified model has a slightly higher pseudo r-squared than the full model (0.542 vs. 0.528, respectively) and how both models correctly predict travel mode for 75% of the students. Variable beta coefficients largely share the same significance and effect size as in the full model (Table 5-1).

Table 5-4: Simplified Multinomial Logistic Regression Model Estimating Elementary-age Travel Mode Using Weighted Survey Sample

	Bus[a]				Walk[a]			
Variable	Coef.	Std. error	P >|z|	Odds	Coef.	Std. error	P >|z|	Odds
Intercept	-1.269	0.558	0.023		1.101	0.467	0.018	
Trip type								
To-school (0 = from-school)	-0.195	0.133	0.145	0.823	-0.497	0.224	0.027	0.609
School attributes								
Travel distance, 0.4-0.8 km	0.379	0.643	0.556	1.460	0.339	0.397	0.393	1.403
Travel distance, 0.8-1.2 km	0.292	0.611	0.633	1.339	-1.828	0.399	0.000	0.161
Travel distance, 1.2-1.6 km	1.729	0.573	0.003	5.637	-1.765	0.414	0.000	0.171
Travel distance, 1.6-2.4 km	1.851	0.551	0.001	6.366	-3.272	0.479	0.000	0.038
Travel distance, 2.4-3.2 km	2.465	0.559	0.000	11.764	-4.304	0.815	0.000	0.014
Travel distance, 3.2-4.8 km	2.279	0.546	0.000	9.763	-5.601	1.098	0.000	0.004
Travel distance, > 4.8 km	2.741	0.540	0.000	15.507	-4.268	0.594	0.000	0.014
Travel distance, < 0.4 km	0				0			
Type, magnet (0 = neighborhood)	0.939	0.145	0.000	2.557	-0.022	0.230	0.924	0.978
Child characteristics								
Child grade, 1	0.330	0.204	0.106	1.390	0.032	0.376	0.932	1.033
Child grade, 2	-0.190	0.216	0.379	0.827	0.339	0.360	0.347	1.403
Child grade, 3	0.568	0.229	0.013	1.765	-0.776	0.458	0.090	0.460
Child grade, 4	0.233	0.259	0.368	1.263	0.377	0.402	0.348	1.458
Child grade, 5	0.757	0.262	0.004	2.131	0.710	0.438	0.105	2.035
Child grade, 6	1.662	0.287	0.000	5.269	1.663	0.440	0.000	5.274
Child grade, kindergarten	0				0			
Race, white (0 = non-white)	-1.145	0.170	0.000	0.318	0.052	0.287	0.857	1.053
[a] Car is the reference mode								
Log-likelihood with constants only		1999.366			Nagelkerke pseudo-r^2		0.542	
Log-likelihood at convergence		1031.943			Number of observations		803	
Likelihood ratio chi-squared (32 d.f.)		967.423						
Prob > chi-squared		0.000						

6 Analysis: Effect of Alternate Education Policy

This section utilizes the two weighted travel models to quantify the influence of the alternate education policies outlined in section 3.8: (1) maximum travel distance, (2) no school choice, (3) random assignment, and (4) regional school choice.

6.1 Travel Survey Sample

The comparison to estimated observed travel underscores the effect on travel of the four alternate education policies. The maximum travel scenario has far greater average travel distance and total district travel than does observed travel. As expected, walking in the maximum travel scenario is nearly zero in both districts, replaced largely by auto in St. Paul and bus in Roseville. The relative increase in St. Paul auto km traveled and expected bus km far exceeds the relative increase in the percent of students busing and riding in an auto, reflecting longer travel distances. In comparison, total Roseville auto and bus travel did not increase as much as in St. Paul.

The no school choice scenario demonstrates again the influence of school choice and school siting policies on travel. St. Paul walking is 3.5 times higher to-school and 3.2 times higher from-school in the no school choice scenario than in observed travel. Roseville walking is the same to-school and 1.1 times greater from-school in the no school choice than observed scenario. Thus, observed walking in Roseville is nearer the no choice scenario than in St. Paul, indicating Roseville is closer to its theoretical maximum walking, reinforcing the influence of school siting and school choice policies on facilitating walking. Although auto use increased slightly (except for from-school travel in St. Paul), bus use, total auto travel, and expected bus travel is far less in the no choice than observed scenario, demonstrating the potential outcome of increasing walking and reducing vehicle emissions and school transportation costs. Expectedly, walking is lower in the random assignment scenario as students are less likely to attend the school closest to their home.

Implementing the regional school choice policy in St. Paul has an influence on travel behavior. Median travel distance among the 144 students attending a new school decreased from 3.7 km to 3.2 km. To-school and from-school busing is lower in the regional choice scenario than observed travel while auto use is higher because more students live in the ‘no busing’ zone. Walking is equal to-school and merely 2% higher from-school in the regional choice scenario. The nature of the regional choice scenario and its strict assumption limit the effect of such policy as only 18% of students switch schools and most of those children do not attend the closest school in the choice region. Greater incentives encouraging students to attend the closest school may be necessary, even in a regional choice system, if policymakers wish to increase walking rates, decrease district busing costs, and decrease vehicle emissions. Providing fewer or no citywide magnet schools could have a similar effect.

Table 6-1: Travel Survey Sample Comparison of Estimated Observed and Alternate Policy Scenarios

	St. Paul					**Roseville**			
		Estimated					Estimated		
Scenario	Observed	Maximum travel distance	No school choice	Random assignment	Regional school choice	Observed	Maximum travel distance	No school choice	Random assignment
Students	803					413			
Travel distance									
Mean (km)	4.1	14.2	0.8	7.3	3.5	2.1	8.3	1.6	5.3
Median (km)	3.7	14.0	0.7	6.9	3.2	1.8	8.1	1.5	5.0
Dominant travel mode to-school									
Auto (%)	25	36	28	25	33	22	13	26	14
Bus (%)	62	62	27	72	55	69	87	65	85
Walk (%)	13	2	45	3	13	9	0	9	1
Dominant travel mode from-school									
Auto (%)	18	28	16	20	24	11	9	14	9
Bus (%)	64	67	27	75	56	72	89	69	87
Walk (%)	18	5	57	5	20	16	2	17	4
Total district travel to-school[a,b]									
Auto (km)	664	4 095	200	1 397	809	341	844	305	482
Walk (km)	85	206	216	52	73	63	19	57	5
Total district travel from-school[a,b]									
Auto (km)	480	3 285	119	1 108	595	177	585	169	319
Walk (km)	168	542	298	167	191	179	144	138	80
Total student km by bus[c]									
To-school	1.0	2.8	0.1	1.7	0.7	0.5	2.3	0.4	1.5
From-school	1.0	2.9	0.1	1.7	0.8	0.5	2.3	0.4	1.5

[a] Roseville travel increased proportionally to 803 students

[b] Sum of student travel distance by mode

[c] Bus travel is a measure of student bus kilometers relative to St. Paul observed

6.2 Citywide Sample

Estimated observed travel mode differs between the citywide (Table 6-2) and travel survey (Table 6-1) samples. Differences between the survey and citywide sample populations likely explain this finding. The survey sample is more likely to attend a neighborhood school than the citywide sample; the ratio of magnet/neighborhood students is 1.9 for the survey sample and 2.2 for the citywide sample. The survey sample students are also more likely to attend their assigned school; 82% of the survey sample does so compared to 73.5% of the citywide population. Walking and auto use are greater among students attending their neighborhood and/or assigned school and thus higher for the survey sample than citywide sample.

Examining the influence of alternate policy on citywide sample travel leads to similar conclusions as found for the survey sample for the ‘maximum travel distance’, ‘no school choice’, and ‘random assignment’ scenarios (Table 6-2). Walking in the no school choice scenario is 3.4 times greater to-school and from-school than in the observed scenario.

Comparing the regional school choice scenario to observed travel results in the same conclusion as for the survey sample, meaning this policy might not have its desired effect given the assumptions. Walking rates increased slightly, 1% to-school and 2% from school, in the regional choice scenario and auto use replaces the remaining decrease in busing. There is great potential, however, to change travel behavior among the citywide sample; 31% of students attend a school outside their choice region and switch schools in this scenario.

Another observation is median average travel distance remained constant at 3.4 km between the observed and regional school choice scenarios. This result is a bit counterintuitive but has a straightforward explanation. The 31% changing school receive a random new school in their choice region, though travel distance is not necessarily changed. Additional tests of regional school choice assignment might lead to different travel deviations from observed values. Thus, while the outcome in Table 6-2 might be a ‘worst case scenario’ in terms of expected travel benefits, it reemphasizes an important point; without policies encouraging students to attend their closest school or redesigning the choice policy itself, the transportation benefits of a regional choice system may be less than anticipated.

Table 6-2: St. Paul Citywide Sample Comparison of Estimated Observed and Alternate Policy Scenarios

	Estimated travel						
Scenario	Observed			Maximum travel distance	No school choice	Random assignment	Regional school choice
	Magnet	Neighborhood	Total				
Students	12 694	5 915	18 609	18 609			
Travel distance							
Mean (km)	4.6	2.6	4.0	13.5	0.8	7.1	4.0
Median (km)	4.1	1.7	3.4	13.1	0.8	6.8	3.4
Dominant travel mode to-school							
Auto (%)	15	32	21	22	31	16	27
Bus (%)	77	46	67	77	28	82	60
Walk (%)	7	22	12	1	41	2	13
Dominant travel mode from-school							
Auto (%)	13	26	17	19	25	14	23
Bus (%)	79	47	69	80	27	84	62
Walk (%)	9	26	14	1	48	2	16
Total district travel to-school[a]							
Auto (km)	7 003	4 132	11 136	55 779	5 064	20 251	16 361
Walk (km)	1 029	1 027	2 056	2039	4 691	832	2 030
Total district travel to-school[a]							
Auto (km)	5 862	3 519	9 381	47967	4 176	17308	14 027
Walk (km)	1 211	1 240	2 451	2916	5 613	1137	2 546
Total student km by bus[b]							
To-school	0.8	0.2	1.0	3.2	0.1	1.8	0.9
From-school	0.8	0.2	1.0	3.2	0.1	1.8	0.9

[a] Sum of student travel distance by mode

[b] Bus travel is a measure of student kilometers by bus relative to total observed

7 Conclusions and Policy Implications

This research adds to current literature on school travel, exploring two elementary-age (grades kindergarten-6) data sets in St. Paul and Roseville, MN. St. Paul and Roseville, although adjacent, offered a unique opportunity to understand and model school travel in locations of contrasting school choice policy, busing policy, and school siting policy in addition to varying dominant urban form (urban St. Paul and suburban Roseville). This research administered a child travel survey and answered several questions, concluding the interplay between school choice policy and school transportation policy influences the travel patterns of children and parents and the transportation budgets of school districts.

What is the current state of elementary-age school travel in St. Paul and Roseville? Overall differences in observed travel mode are most noticeable at distances less than 1.6 km to school. Total walking (14% vs. 12%) and school bus (56% vs. 55%) travel is slightly greater from-school than to-school. As a function of distance, walking is similar between magnet and neighborhood schools; however, district-level effects exist. Magnet schools draw from broader geographic regions than neighborhood schools and students are less able to walk, not because of differences in parent attitudes towards travel mode choice, but simply because they live too far to do so. School district transportation costs are also greater for magnet schools than for neighborhood schools because more magnet school students ride in a bus.

St. Paul students walk more frequently than Roseville students do at distances less than 0.8 kilometers, suggesting a possible influence of urban form. Adding support, a spatial investigation of travel mode in light of urban form suggests—though no firm conclusions can be made—that elementary schools in residential areas with greater street connectivity and few, if any, major roads could facilitate greater walking. St. Paul busing rates are lower than Roseville at distances less than 1.6 km because of St. Paul's transportation policy to limit service at that distance while Roseville policy limits service at distances less than 0.8 km.

Results suggest parents in the survey sample make similar decisions for both male and female children; differences in travel mode by child sex are negligible. Non-white students bus more than white students do, as do students from households with '0 or 1' household vehicle (compared to those households with '2+' vehicles) and household income below the district average (compared to those households with income above the district average).

Parent reasons for selecting school and travel mode also differ by race, though this manuscript did not focus on differences using the weighted survey sample. Non-white parents (who are more often poorer than white parents are and whose children are more likely to attend magnet schools) are more concerned than white parents are about bus service availability and safety while both waiting for and riding the bus. Families below the poverty line also lived farther away from school than wealthier ones, though this may be a function of school choice program goals.

What are the factors that determine elementary-age school travel mode? This research employed multinomial logistic regression to identify the relative effect of variables in determining child travel mode. It created two models of travel behavior, utilizing the survey sample weighted by U.S. Census income and race data: (1) a 'full' model to best explain travel mode choice when a full survey and detailed geographic information system data is available, and (2) a 'simplified' model necessary for the citywide data set containing limited student information. The full model calculated that, relative to the reference mode auto, the odds are greater a student will: (1) walk at the shortest travel distance, (2) bus when service is available, (3) walk and bus more when traveling from-school than to-school, (4) bus more in Roseville than St. Paul, (5) bus more for magnet schools than neighborhood schools, (6) walk or bus more if they are older, (7) walk or bus more if they are from a larger household, (8) bus if they are non-white, and (9) ride in an auto as household income increases. The simplified model had comparable results for like variables, though it predicted greater busing in St. Paul than the full model, likely because of greater magnet school and less assigned-school attendance in the citywide sample. While one urban form variable (street connectivity) is significant in the full model, the research is unable to discern how important neighborhood-scale urban form is in influencing travel mode. Travel differences between St. Paul and Roseville could result from parent attitudes and preferences, urban form, school policy, or other factors.

What is the influence of alternate education policy on elementary-age school travel mode? The research utilized the two travel models to compare estimated travel to four alternate policy scenarios: (1) maximum travel distance, (2) no school choice, (3) random assignment, and (4) regional school choice. Quantifying the effect of each policy led to comparable conclusions between the travel survey and citywide samples. The no school choice scenario found Roseville to be far nearer its theoretical maximum walking than St. Paul, demonstrating the influence of school choice and school siting policies on school travel. Namely, smaller neighborhood schools create more opportunities for walking than do larger magnet schools. The maximum travel distance scenario had more auto and bus travel while the random assignment scenario had lower walking as students are less likely to attend the school closest to their home.

Most prominently, implementing regional school choice policy in St. Paul has an influence on travel behavior. The policy tested increased walking slightly (0-2%) and reduced district transportation costs through less busing, though at the expense of greater auto use. Given an increase in auto use and decrease in bus travel, the net change in vehicle emissions is unclear. While the potential to change travel further exists—18% of the travel survey sample and 31% of the citywide sample switched schools—the nature of the regional choice concept tested, namely the politically saleable decision to maintain five magnet schools and allow attendance of any school in the choice region, limits the potential impact on transportation. Policymakers could realize further benefits if they couple regional school choice with a policy encouraging students to attend the school closest to their home or provide fewer or no citywide magnet schools.

Researchers, policymakers, school district officials, and parents benefit from this work in several ways. Researchers now have a better understanding of how school choice policy, school bus policy, and school siting policy influence travel mode in addition to commonly studied variables such as travel distance, child and household characteristics, and urban form. The results can also serve as a local comparison against national results.

The principal benefit for policymakers and school district officials is quantifying the transportation effects of their policies, attained through the travel models and policy scenario testing. For instance, school choice and larger schools may reduce walking opportunities, increase auto travel, and increase school district transportation budgets because of greater average travel distance. Consequently, school choice policy might conflict with initiatives aiming to facilitate active school travel, such as Safe Routes to School, or efforts to reduce transportation budgets and/or reduce greenhouse gas emissions. School choice initiatives also have likely educational advantages; careful consideration is necessary to blend the separate benefits of these policies.

This manuscript provides researchers and planners in other cities a framework for further evaluation. They can use this approach to examine different school choice or transportation policies and evaluate their impact on the school district budget, school choice opportunities, and active transportation. Parents will be encouraged knowing the allocation of scare resources available to transport their children will be better informed and tailored to the school district.

As with any cross-sectional study, this research is unable to definitively establish causal relationships. Future studies can analyze longitudinal behavior to determine causality and consider in greater detail factors differentiating to- and from-school trips (i.e., the qualities that make walking and busing greater in the afternoon), identify actual student route, quantify perceived route characteristics, and develop a more complete understanding of modal preferences. While partnering with the local school districts eased survey administration and boosted response rate, future studies could survey several cities to better generalize results beyond the two districts considered here. The survey instrument provides valuable information as well. The design of the travel mode question (three) led to some uncertainty in those respondents whose to-school and from-school trip total was eight (e.g., did the respondent not understand the question or was their child sick). Future studies can ask for clarification.

Future research in multiple cities could reap further gains, facilitating the development of tools to evaluate child travel in multiple contexts. Inter- and intra-district coordination will improve as districts utilize general metrics to quickly evaluate the efficacy and cost of proposed education policies. Combined with the framework outlined in this manuscript, these tools will help quantify the impact of proposed policies on the school district budget, school choice opportunities, and active transportation.

An intriguing and uncharted policy question is the influence of altering bus routes and/or the distance at which districts offer bus service in light of other policies such as school choice. St. Paul's decision to limit bus service within 1.6 km (0.8 km in Roseville) of school influences available mode options. This investigation does not allow robust analysis of this issue because bus routes were unavailable. New travel models could examine the impact of decreasing or increasing this threshold. The first option could substantially increase school district transportation costs while the second would raise auto travel and related emissions, and perhaps increase travel risk among students that walk. A maximum bus distance could be tested, though equity concerns quickly surface. For example, if the district chooses to not provide service outside five km, a bus dependent student living six km from a specific language school would be unable to attend that school. Coupling such an analysis with an investigation into new technology could be of great value to the school district.

Other analyses can test in greater detail the effect of regional school choice policies. New scenario testing might alter the number of school choice regions, the type and number of schools in each region, the type of curriculum offered at each school, and implement policies encouraging children to attend their closest school. Coupling these analyses with investigations into busing policy, school district planning efforts can work towards minimizing total busing and maximizing walking.

Additional analyses could also capture the second-order effects of school choice as the impacts relate to school and individual child performance. This analysis could not quantify net travel implications of school choice for children whose neighborhood school converted into a magnet school. For children in this position, commute distance would increase, and walking would therefore decrease (unless they sought admission to the converted school). Because many magnet schools attempted to transform substandard schools in poorer neighborhoods, this neighborhood-to-magnet-school conversion effect might be larger for poorer populations. Further investigation is necessary to substantiate such conjectures.

Continued examination of child school travel is necessary. Researchers, policymakers, school district officials, and planners should embrace the challenge and importance of better understanding these behaviors. This research and its analysis of school travel highlights the continued need to examine school district transportation policy, such as bus service distance and the location of Safe Routes to School investments, in light of school choice and school siting policies. Researchers should draw on school district interest and parent passion about these issues as motivation; 48% of returned child travel surveys had written comments. This research is an important step in guiding future studies as they examine the complex and difficult issues facing parents when deciding where to send their child to school and how to get them there.

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9 Appendix A: School Travel Survey

School transportation survey, page 1

INSTRUCTIONS: Please complete the below survey thinking about the child in your household in grades K-8 who had the **most recent birthday**. (If there are no K-8 children in public schools in your household, please disregard this survey.)

Q1 Does your school district or city allow students to attend a school outside your "neighborhood" school, a program sometimes known as School Choice? (*Check one*)
❑ Yes ❑ No ❑ Don't know

Q2 Please consider your child in grades K-8 with the most recent birthday. How important are the following in determining what school he or she attends? (*Check one box for each factor*)

Factors	Not at all important	Not very important	Somewhat important	Very important	Does not apply
School bus services available	❑	❑	❑	❑	❑
Close to home	❑	❑	❑	❑	❑
Quality of teachers	❑	❑	❑	❑	❑
Size of class	❑	❑	❑	❑	❑
Diversity	❑	❑	❑	❑	❑
Curriculum	❑	❑	❑	❑	❑
Close to work	❑	❑	❑	❑	❑
School Start Time	❑	❑	❑	❑	❑
Distance from your other child's school	❑	❑	❑	❑	❑
Other:________________	❑	❑	❑	❑	❑

Q3 TO SCHOOL: Please circle the number of days LAST WEEK your child traveled TO school using each type of transportation.

	Passenger vehicle (e.g. in a car with you or someone else)	School Bus	Walk	Bicycle	Other (please explain below)
Travel TO School	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5

Other:____

FROM SCHOOL: Please circle the number of days LAST WEEK your child traveled FROM school using each type of transportation.

	Passenger vehicle (e.g., in a car with you or someone else)	School Bus	Walk	Bicycle	Other (please explain below)
Travel FROM School	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5

Other:____

Q4 Did your child travel TO school in a passenger vehicle at least once LAST WEEK?

❑ YES
❑ NO → **IF NO, PLEASE SKIP TO Q7**

Q5 When your child traveled TO school in a passenger vehicle last week, which of the following occurred? (*Check all that apply*)

❑ We drove him/her on the way to work
❑ We drove him/her as a part of other non-work related household errands
❑ We made a special trip, with the sole purpose of driving him/her to school
❑ Our child carpooled with other children, in my or another person's vehicle
❑ An older sibling drove him/her to school

Q6 Please consider all people who drove your child TO school last week, such as an older sibling, friend, neighbor, relative, or childcare worker. Indicate their age, sex, and list the number of days LAST WEEK that this person drove your child TO school.

DRIVER #1: Age: ____ Sex (circle): M or F. Days per week:___ Relationship to CHILD__________
DRIVER #2: Age: ____ Sex (circle): M or F. Days per week:___ Relationship to CHILD__________
DRIVER #3: Age: ____ Sex (circle): M or F. Days per week:___ Relationship to CHILD__________

Q7 Did your child walk or bicycle TO school at least once LAST WEEK?

❑ YES
❑ NO → **IF NO, PLEASE SKIP TO Q10**

Q8 If yes, when your child walked and/or bicycled TO school, which of the following *BEST* describes their route? (*Check all that apply*)

❑ Main roads with significant vehicle traffic
❑ Small roads or side streets with less vehicle traffic
❑ Trails or paths away from the street
❑ The walking/bicycling route is the same route if we drove them (i.e., exact same streets)
❑ The walking/bicycling route is different from the route if we drove them

Q9 Please indicate if your child walks and/or bicycles TO school in each of the following situations? (*Check all that apply*)

❑ During the fall or spring (September through mid-November and March through June)
❑ During the winter (first snowfall/mid-November to first thaw/March)
❑ In dusk or evening, perhaps following an after school activity
❑ In the rain
❑ If their route is covered in snow
❑ If the temperature is below freezing
❑ With a group of other children
❑ With an adult chaperone

(Continued on next page)

Q10 What is the main reason your child has NOT walked or bicycled to school recently?
(*Check all that apply*)
❑ School is too far away
❑ Crossings and intersections are difficult and/or dangerous
❑ Too dark for child to walk or bicycle
❑ Fear of child's safety from other children
❑ Fear of child's safety from other adults
❑ Too much traffic around the school location
❑ Too many cars, or cars drive too fast through the neighborhood
❑ Your child participates in other activities before or after school
❑ Other (please explain)____

Q11 How important are the following factors in determining if your child rides the school bus?
(*Check one box for each factor*)

Factors	Not at all important	Not very important	Somewhat important	Very important	Does not apply
Distance to school bus stop	❑	❑	❑	❑	❑
Overall travel time using the bus	❑	❑	❑	❑	❑
Length of wait time at bus stop	❑	❑	❑	❑	❑
Cold temperatures at bus stop	❑	❑	❑	❑	❑
Safety of bus operation	❑	❑	❑	❑	❑
Personal safety of the child while waiting at the bus stop	❑	❑	❑	❑	❑
Personal comfort or wellbeing of the child while riding the bus	❑	❑	❑	❑	❑

Q12 Please specify the age, gender, and school of your K-8 child with the most recent birthday, who has been the subject of the earlier questions:

Age Gender Grade Full name of school (e.g., ABC Elementary School)

____ ____ _____ ____

Q13 How many motor vehicles (passenger cars, SUVs, vans, trucks and motorcycles) are kept at home for use by members of your household? Exclude vehicles used solely for business purposes.

[ ] *Number of vehicles*

Q14 Please tell us about the motor vehicles in your household that are used regularly. Start with the vehicle YOU drive most frequently.

Vehicle	Make (e.g., Ford)	Exact model (e.g., Taurus)	Year (e.g., 2000)
1			
2			
3			

Q15 Including yourself, how many people live in your household? Please do not include anyone who usually lives somewhere else or is just visiting, such as a college student.

☐ *Number of people in your household*

Q16 Including yourself, how many people in your household are licensed drivers? Please do not include anyone who usually lives somewhere else or is just visiting, such as a college student.

☐ *Number of licensed drivers*

Q17 Please mark an "X" on the scale below to indicate your age.

18 — 20 — 25 — 30 — 35 — 40 — 45 — 50 — 55 — 60 — 65 — 70 — 75 — 80+

Q18 What is your sex? ❑ F ❑ M

Q19 For statistical purposes, which best describes your race or ethnicity? (*Check all that apply*)

❑ White (non-Hispanic)
❑ Black or African American
❑ Asian
❑ American Indian or Alaskan Native
❑ Hispanic or Latino
❑ Other (specify): ______________________________

Q20 For statistical purposes, we need an approximate idea of your total household income. Please mark an "X" on the scale below to indicate the APPROXIMATE TOTAL COMBINED income for 2006 of all working adults in your household.

0 — $20,000 — $40,000 — $60,000 — $80,000 — $100,000 — $120,000 or more

Q21 Please provide the street name and nearest cross-street of your home:

____

Q22 We are interested in your concerns and suggestions about children's school-travel. Please include here any comments you might have, including about this survey. ________________________
____
____

Thank-you very much for your participation!

10 Appendix B: Further Methodology Discussion

10.1 Decision to Code Travel Distance as Categorical

This section outlines the decision to use a categorical as opposed to continuous measure of distance, as well as the number of distance categories. Section four of the thesis found travel distance does not have a linear relationship with travel mode, exampled well as walking shifts from dominant travel mode at the shortest distance to effectively zero outside 1.6 km. Bus travel is also non-linear; St. Paul and Roseville restrict heavily bus service inside 1.6 km and 0.8 km, respectively.

Logistic regression does not require a linear relationship between travel distance and the dependent variable travel mode, however; it assume a linear relationship between travel distance and the log odds (logit) of travel mode. A violation generates Type II errors. Two simple tests can verify non-linearity (or lack thereof): the Box-Tidwell Transformation Test and an examination of the 'logit graph' (Garson, n.d.).

Both tests readily demonstrated non-linearity between travel distance and the log odds of travel mode. Testing the cross product of travel distance ['travel distance*LN(travel distance)'] in the logit model as the Box-Tidwell test prescribes finds it significant at a 99% confidence level, signaling non-linearity. Creating a 'visual band' of equal travel distances, testing that band in the logit model, and graphing the beta coefficients ('logit graph') illustrate the beta coefficients to do not increase evenly, also signaling non-linearity. Further examination found employing a continuous measure of travel distance also decreases the success of the travel models in predicting travel mode.

The number of travel distance categories should maintain sampling adequacy while maximizing the number of categories to capture greater variation among the dependent variable travel mode. All independent variable categories should have a frequency of greater than zero for all the dependent variable categories (bus, auto, and walk) and no more than 20% of total bins should have a frequency less than five. Subdividing traveling distance into eight categories satisfied these requirements.

10.2 Survey Sample Weighting

This thesis weights the survey sample using Census 2000 demographic information, accounting for differences in race and income between the survey sample and the general population residing within the school district. Weighting against the general population is necessary as the Census does not provide detailed income categories by race for households with elementary-age public school students.

The subpopulation is too small to divide the survey by detailed race (i.e. African American, American Indian, Hispanic, or other) at the census tract level. Thus, this research weights against the school district and accounts for differences between race (white/non-white) and seven income categories. Census 2000 demographic information for St. Paul is tabulated directly for the district (i.e. the city boundary); Roseville numbers are calculated as an average weighted mean of all census tracts intersecting the district boundary. Table 10-1 provides the Census 2000 information used to generate the survey sample weights. Table 10-2 provides the Observed and weighted survey populations.

Table 10-1: Census 2000 Base Information and Survey Sample Weights

	Census 2000 demographic information				Weights applied to survey sample			
	St. Paul		Roseville		St. Paul		Roseville	
Income ($)	White (%)	Non-white (%)	White (%)	Non-white (%)	White	Non-white	White	Non-white
0 - 19,999	19.4	34.3	13.9	20.5	4.683	1.788	7.220	3.409
20,000 - 39,999	27.7	29.7	23.7	22.1	2.760	0.978	4.295	1.104
40,000 - 59,999	20.8	18.5	20.6	20.7	1.239	0.829	1.825	0.939
60,000 - 74,999	11.2	7.3	11.9	11.3	0.745	0.708	0.709	0.515
75,000 - 99,999	10.2	5.8	13.6	14.4	0.459	0.616	0.555	1.027
100,000 - 119,000	3.9	2.1	5.4	4.5	0.283	0.526	0.357	0.445
120,000+	7.0	2.3	10.9	6.6	0.4	0.5	0.4	1.1
Total	100	100	100	100	NA	NA	NA	NA

Table 10-2: Observed and Weighted Survey Population Counts

	Existing survey population				Weighted survey population			
	St. Paul		Roseville		St. Paul		Roseville	
Income ($)	White	Non-white	White	Non-white	White	Non-white	White	Non-white
0 - 19,999	24	43	7	3	112	77	51	10
20,000 - 39,999	58	68	20	10	160	66	86	11
40,000 - 59,999	97	50	41	11	120	41	75	10
60,000 - 74,999	87	23	61	11	65	16	43	6
75,000 - 99,999	128	21	89	7	59	13	49	7
100,000 - 119,000	79	9	55	5	22	5	20	2
120,000+	106	10	90	3	40	5	40	3
Total	579	224	363	50	579	224	363	50

11 Appendix C: Additional Analysis Tables

This section provides tabular information detailing parent's stated importance of specific mode attributes in selecting that travel mode. Similar to section 4.4, this section examines St. Paul and Roseville students separately, disaggregating the students by school type and race. The purpose of these tables is to inform of parent's reasons for selecting certain travel modes for their child. The results are in the appendix because each parent did not answer these questions (limiting their usefulness in the travel models).

The key conclusions are: (1) distance is more likely to be a concern for walking among magnet students than neighborhood students in both St. Paul and Roseville and among non-white parents than white parents in St. Paul and (2) darkness, fear of child's safety from other children, fear child's safety from other adults, too much traffic around the school, and cars drive too fast is more likely to be a concern for walking among non-white parents than white parents in St. Paul.

Table 11-1: Comparison of St. Paul Neighborhood and Magnet School Parent Stated Importance of Mode Attribute in Selecting Travel Mode

	St. Paul School Type				
	Neighborhood (n=322)		Magnet (n=605)		Difference
Respondent Stated Behavior	(%)[a]	(n)	(%)[a]	(n)	Statistic[b,c]
Did your child walk to school at least once last week?	32	104	11	66	61.36**
Main reason child doesn't walk					
School is too far	47	152	76	146	75.57**
Crossing/intersections dangerous	38	123	41	249	0.77
Too dark	6	18	6	35	0.02
Fear of child's safety from other children	12	39	15	93	1.87
Fear of child's safety from other adults	30	96	31	189	0.20
Too much traffic around school location	20	65	23	141	1.20
Too many cars or cars drive too fast	30	95	27	162	0.78
Child participates in activities before/after school	8	27	7	40	0.97
Behavior of child traveling via auto at least once last week	Neighborhood (n=197)		Magnet (n=274)		
	(%)[a]	(n)	(%)[a]	(n)	
Drove him/her on the way to work	42	83	48	131	1.49
Drove him/her as part of other non-work errands	22	44	12	34	7.47**
Made special trip, solely to drive him/her	42	82	45	123	0.50
He/she carpooled with other children	12	23	7	20	2.14
Older sibling drove him/her	3	5	2	4	0.70

[a] Each response is independent and each set of questions will not add to 100%

[b] Reporting likelihood ratio from Chi-squared test (2-tailed significance)

[c] * $p < 0.05$ ** $p < 0.01$

Table 11-2: Comparison of St. Paul White and Non-white Parent Stated Importance of Mode Attribute in Selecting Travel Mode

	St. Paul Race				
	White (n=633)		Non-white (n=294)		Difference
Respondent Stated Behavior	(%)[a]	(n)	(%)[a]	(n)	Statistic[b,c]
Did your child walk to school at least once last week?	21	130	14	40	13.11**
Main reason child doesn't walk					
School is too far	64	403	71	208	4.55*
Crossing/intersections dangerous	38	239	45	133	4.65*
Too dark	3	19	12	34	25.00**
Fear of child's safety from other children	10	61	24	71	32.42**
Fear of child's safety from other adults	26	166	40	119	18.71**
Too much traffic around school location	18	111	32	95	24.33**
Too many cars or cars drive too fast	24	155	35	102	10.21**
Child participates in activities before/after school	7	`	8	23	0.23
Behavior of child traveling via auto at least once last week	White (n=363)		Non-white (n=108)		
	(%)[a]	(n)	(%)[a]	(n)	
Drove him/her on the way to work	27	170	16	46	1.01
Drove him/her as part of other non-work errands	10	63	5	16	0.17
Made special trip, solely to drive him/her	26	166	14	41	2.43
He/she carpooled with other children	5	31	4	13	1.35
Older sibling drove him/her	0	1	3	8	18.24**

[a] Each response is independent and each set of questions will not add to 100%

[b] Reporting likelihood ratio from Chi-squared test (2-tailed significance)

[c] * $p < 0.05$ ** $p < 0.01$

Table 11-3: Comparison of Roseville Neighborhood and Magnet School Parent Stated Importance of Mode Attribute in Selecting Travel Mode

	Roseville School Type				
	Neighborhood (n=414)		Magnet (n=103)		Difference
Respondent Stated Behavior	(%)[a]	(n)	(%)[a]	(n)	Statistic[b,c]
Did your child walk to school at least once last week?	13	53	3	3	13.18**
Main reason child doesn't walk					
School is too far	49	201	64	66	8.07**
Crossing/intersections dangerous	51	211	57	59	1.32
Too dark	1	6	10	10	14.35**
Fear of child's safety from other children	11	44	11	11	0.00
Fear of child's safety from other adults	33	136	38	39	0.91
Too much traffic around school location	36	147	46	47	3.54
Too many cars or cars drive too fast	32	131	27	28	0.78
Child participates in activities before/after school	7	93	10	10	0.67
Behavior of child traveling via auto at least once last week	Neighborhood (n=214) (%)[a]	(n)	Magnet (n=45) (%)[a]	(n)	
Drove him/her on the way to work	47	101	56	25	1.041
Drove him/her as part of other non-work errands	15	31	13	6	0.04
Made special trip, solely to drive him/her	42	90	44	20	0.09
He/she carpooled with other children	2	4	2	1	0.02
Older sibling drove him/her	0	0	0	0	-

[a] Each response is independent and each set of questions will not add to 100%

[b] Reporting likelihood ratio from Chi-squared test (2-tailed significance)

[c] * $p < 0.05$ ** $p < 0.01$

Table 11-4: Comparison of Roseville White and Non-white Parent Stated Importance of Mode Attribute in Selecting Travel Mode

	Roseville Race				
	White (n=439)		Non-white (n=80)		Difference
Respondent Stated Behavior	(%)[a]	(n)	(%)[a]	(n)	Statistic[b,c]
Did your child walk to school at least once last week?	11	50	8	6	11.33**
Main reason child doesn't walk					
School is too far	51	223	55	44	0.43
Crossing/intersections dangerous	53	231	49	39	0.46
Too dark	3	11	6	5	2.58
Fear of child's safety from other children	9	41	18	14	4.14*
Fear of child's safety from other adults	33	143	40	32	1.57
Too much traffic around school location	38	164	38	30	0.00
Too many cars or cars drive too fast	30	130	36	29	1.31
Child participates in activities before/after school	8	35	6	5	0.31
Behavior of child traveling via auto at least	White (n=231)		Non-white (n=28)		
once last week	(%)[a]	(n)	(%)[a]	(n)	
Drove him/her on the way to work	50	115	39	11	1.11
Drove him/her as part of other non-work errands	14	32	18	5	0.31
Made special trip, solely to drive him/her	41	94	57	16	2.73
He/she carpooled with other children	2	5	0	0	1.16
Older sibling drove him/her	0	0	0	0	-

[a] Each response is independent and each set of questions will not add to 100%

[b] Reporting likelihood ratio from Chi-squared test (2-tailed significance)

[c] * $p < 0.05$ ** $p < 0.01$