SCHOOL TRAVEL BEHAVIORS IN RURAL COMMUNITIES: PANDEMIC-RELATED IMPACTS

FINAL PROJECT REPORT

by

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for

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rural ◦ isolated ◦ tribal ◦ indigenous

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16. Abstract

The global pandemic, which started around early 2020, significantly disrupted life for many families, and the trip to and from school was not immune to these disruptions. Parents and children alike made travel adjustments depending on their preferences with regard to personal health and safety, social distancing, and aversion to risk. Each school district and individual school also made decisions with regard to in-person or remote learning during this period of uncertainty.

In this study, the research team examines how the pandemic affected school transportation for hundreds of families across the Pacific Northwest. An online survey was developed and administered with the help of Qualtrics, an experience management company. Over 600 responses were gathered to assess school transportation-related travel decisions. In addition to collecting demographic data about the respondents, the survey also asked about travel mode choices and characteristics of the trip to and from school. The collective results were then analyzed to determine which factors directly contributed to pandemic-related changes in travel behavior.

The study concluded that the demographic factors of parent education level, household income, and age of child were all statistically significant variables that affected behavioral change, though the place of household residence, whether rural or urban, was determined to be an insignificant variable. Additionally, common travel assumptions associated with rural students, when compared with urban students, were confirmed. These factors included a greater reliance on a yellow school bus and lesser availability of critical infrastructure.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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EXECUTIVE SUMMARY

On each school day, millions of children from all corners of the United States travel to and from school. Depending on several factors including distance to school, availability of infrastructure, and parental decision-making, the child will typically walk, bike, ride a yellow school bus, get a ride from a parent or guardian, or drive themselves as a means of traveling to school.

The global pandemic, which started in early 2020, significantly disrupted life for many families, and the trip to and from school was not immune to these disruptions. Parents and children alike needed to make adjustments depending on their preferences with regard to personal health and safety, social distancing, and aversion to risk and react to the policies set forth by local communities and state governments. Each school district and individual school also made decisions with regard to in-person or remote learning during this period of uncertainty.

In this study, the research team builds on past research by examining how the pandemic affected school transportation for hundreds of families across the Pacific Northwest. An online survey was developed and administered with the help of Qualtrics, an experience management company. Over 600 responses were gathered. In addition to collecting demographic data about the respondents, the survey also asked about travel mode choices and characteristics of the trip to and from school. The collective results were then analyzed to determine which factors directly contributed to pandemic-related changes in travel behavior.

The study concluded that the demographic factors of education, household income, and age were all statistically significant variables that affected change, though the place of residence of the household, whether rural or urban, was determined to not be a significant variable. However, many of the common travel assumptions assumed with rural students, as compared with urban students, were confirmed. These factors included motorized transport such as using a personal vehicle or a greater reliance on a yellow school bus, due in part to a lack of critical infrastructure and travel distance.

It is hoped that the period of time during which the pandemic was an unknown and unpredictable entity will have been a one-time event. However, the impacts of the pandemic, and the decision-making processes that uniquely occurred, have allowed researchers to explore travel and behavioral patterns that otherwise would not have been possible. The results from this study can be used to further inform researchers and practitioners alike and to continue efforts that ensure the safety of all children as part of their daily trip to and from school.

CHAPTER 1. INTRODUCTION

On a typical school day, over 55 million school children across the United States attend an elementary, middle, or high school. Approximately 49 million attend public schools, and 33 million students from this subset are comprised of pre-kindergarten to grade 8 students (NCES, 2024). Since a large percentage of these students live and go to school in cities and metropolitan areas, decision and policy makers often choose to “focus their attention and efforts on improving education where it will have the largest impact” (Lavalley, 2018). However, approximately one-third of all schools and nearly one-fifth of all students (over 10 million young men and women) in the United States reside in rural areas. For these students, the trip to and from school in the form of riding a school yellow bus or walking and bicycling to school is arguably of greater concern than their urban counterparts under certain circumstances; longer travel distances may be present and siting concerns typically result in a rural school located on a busy highway or major thoroughfare that experiences higher traffic volumes and speeds.

In Figure 1.1, one example of a rural school crossing is shown. In this case, the crossing is located on a higher speed, higher volume highway (US Route 26) and only pavement markings are present to identify this school crossing.

Figure 1.1 School Crossing in Richfield, ID

1.1. Pandemic

Starting in late 2019 and continuing into early 2020, the world was turned upside-down with the introduction of COVID-19. Preventative measures in the form of social distancing and personal protection affected lifestyles that included when and how students attended schools in person and personal preferences associated with travel to and from school. A brief timeline of the pandemic, as detailed by the U.S. Department of Defense (2024), is shown in Table 1.1.

Table 1.1 Pandemic Timeline

DATE	EVENT
January 2020	First US coronavirus case is reported in Washington State.
February 2020	First COVID-19 death in the United States.
March 2020	All 50 US states have confirmed cases.
	Nearly all US states have declared a state of emergency in response to COVID-19.
April 2020	CDC advises the public to wear face coverings in public.
	All 50 states report at least one COVID-19 related death.
	US COVID-19 related deaths surpass 60,000.
May 2020	All 50 states begin to partially lift stay-at-home restrictions.
	US COVID-19 deaths surpass 100,000.
June 2020	US reaches 2M confirmed COVID-19 cases.
July 2020	US reaches 4M confirmed COVID-19 cases.
August 2020	US surpasses 2M recovered COVID-19 cases.
September 2020	US surpasses 7M confirmed COVID-19 cases.
October 2020	New US COVID-19 cases surpass 80K in a day for the first time.
November 2020	US confirmed cases reach 10M.
December 2020	First COVID-19 vaccines begin distribution in the United States.
January 2021	US COVID-19 confirmed cases surpass 25M.
February 2021	US COVID-19 related deaths surpass 500K.
August 2021	70% of US adults take at least one dose of COVID-19 vaccine.
October 2021	FDA authorizes emergency use of Pfizer-BioTech COVID-19 vaccine for children ages 5 to 11.
November 2021	CDC updates its guidance; recommends that everyone ages 5+ get a COVID-19 vaccine.
June 2022	CDC recommends COVID-19 vaccines for young children 6 months through 5 years of age.

1.2. Study Objectives

The purpose of this study was to examine how the pandemic affected, or did not affect, travel to school, and to determine the factors that may have influenced that decision. A comparison of school travel between rural and urban communities was also conducted, along with travel changes that may have occurred before and after the pandemic.

The remainder of this report is presented as follows. A literature review focused on the pandemic and its impact to school travel is provided in Chapter 2. In Chapter 3, a brief discussion of the data collection process is described. The results and analysis from these methods are shared in Chapter 4. Lastly, in Chapter 5, the conclusions from this study and a discussion for future work in this area are provided.

CHAPTER 2. LITERATURE REVIEW

Given the relatively recent introduction and global spread of the COVID pandemic, only a limited number of studies have looked at how the pandemic affected personal mobility and travel behaviors. Even fewer studies have focused exclusively on the impacts to school transportation as experienced by K-12 (kindergarten to grade 12) students, with most of the studies conducted outside of the United States.

The studies that have been completed sought to compare behavioral changes before and during the pandemic and the personal reasons for those changes. A 2021 study from India investigated parental preferences and perceptions regarding their children's commuting practices to educational institutions during the COVID-19 pandemic [Bari et al, 2021]. Utilizing an online questionnaire, data were gathered from parents with a child from grade 1 to 12. The analysis revealed a trend towards heightened reliance on personal vehicles over public transport and school-provided transportation, indicative of a heightened emphasis on safety and reduced exposure to a virus.

The significant variables from the Bari et al. (2021) study included monthly income, education level, and gender of the responding parent. Similar studies have been conducted in Vietnam, Canada, Egypt, and Italy [Nguyen et al., 2021; Larouche et al., 2024; Abouelela et al., 2024; Rotaris et al., 2023]. These studies noted that factors such as household vehicle ownership, mother's work flexibility, home to school distances, school location, outdoor temperature, parental engagement in active commuting, lower household vehicle ownership, commuting habits of parents, residence in a walkable neighborhood, parental concerns regarding safety measures, and proposed class capacity reductions influenced mode choice decisions post-lockdown.

Personal health and safety on school buses has been a specific pandemic-related focus area. Transporting children on school buses presents unique challenges for implementing COVID-19 control measures. Several studies focused on cabin design and child anthropometrics due to close seating and children's specific characteristics. Recommendations included adhering to CDC guidelines, implementing structured loading/unloading, enforcing face covering usage, employing bus monitors (i.e., someone who sits at the front and watches the children), and considering cabin modifications such as cocoon shields [Abulhassan and Davis, 2021; Ramirez et al., 2021]. Ventilation was another key strategy. Maximizing air flow by opening doors, windows, and ceiling hatches, activating hatch fans, and utilizing the fresh air defroster fan system significantly reduced cumulative exposure risks in stationary buses [Ramirez et al., 2021; Van Dyke et al., 2022; Ho and Binns, 2021].

Schools are often located next to busy arterial streets causing heavy vehicular pollution in the area. One United Kingdom study monitored different pollutants as well as the weather to track the pollution changes during COVID-19. Researchers found that the pollution levels dropped after the COVID-19 lockdown was announced, and gradually increased as restrictions lifted. Air pollution levels also dramatically changed throughout the day, often peaking during morning drop-off hours [Kumar et al., 2023].

There may be opportunities to promote active school transportation and walkable neighborhoods for children's physical activity and develop strategies for policymakers, urban planners, and public health workers to support active school transportation, especially in the context of a pandemic like COVID-19 [Larouche et al., 2024]. Previous studies have revealed opportunities to support school travel and transportation in the forms of limiting car and motorcycle ownership, investing in active transport infrastructure, expanding school bus services, and improving access to bicycles [Nguyen et al., 2021]. By exploring the interplay between socio-demographic factors, parental attitudes, and emerging travel patterns, future research opportunities exist to develop targeted interventions and technology-driven solutions to optimize school trip routes, enhance mode choice options, and promote sustainable transportation practices [Abouelela et al., 2024]. There is an inherent need for community engagement, education on the benefits of active commuting, and infrastructure improvements to promote sustainable transportation choices [Rotaris et al., 2023], and consideration of environmental factors alongside socio-demographics for equitable school travel [Thomas et al. 2022].

These insights help to glean some insight into how school travel was reshaped during the pandemic, which hopefully will be a generational episode that does not repeat itself in the near future. While these previous studies help to better understand the mitigation strategies used by families and schools to minimize the spread of COVID and to create an environment sensitive to individual health, opportunities remain to further examine the contributing factors of each household’s personal travel decisions and explore travel differences between rural and urban families.

CHAPTER 3. METHODS

This study developed and conducted a survey to assess how the pandemic affected school transportation. The survey, in its entirety, is provided in the Appendix.

3.1. Survey Distribution and Data Collection

For this survey, the Pacific Northwest states of Idaho, Washington, and Oregon were targeted.

An online company was used to create and distribute the survey. This company, Qualtrics, was hired to find respondents that matched criteria set by researchers. The criteria included the following parameters:

- minimum of 800 respondents
- at least 20% of survey takers from each targeted state
- at least 40% of the households with at least one child in school
- 18 years of age or older

Before the survey was sent to respondents, our research university's Institutional Review Board (IRB) reviewed and approved the survey.

The survey included multiple choice questions, single choice questions, and matrix style questions. There was one fill in the blank question which asked for the respondents' zip code. The survey was administered in May 2023. Based on this time frame, the research team assumed that all respondents could sufficiently recall their travel practices before the pandemic occurred. In a similar vein, the research team also assumed that responders would conclude that the pandemic was in the rear-view mirror at the time of their survey responses.

While a total of 927 responses were gathered for this study, only 639 responses were from households with at least one school-aged child. Qualtrics also performed a professional data scrub to identify and remove inadequate quality responses. This scrub was manually conducted by looking for responders who chose the same response for every question, only provided partial responses, or submitted duplicate responses. There was no time limit placed on the survey.

CHAPTER 4. RESULTS AND ANALYSIS

4.1. Descriptive Results

Representative data of the survey respondents were compiled and grouped into several broad categories. Table 4.1 provides an initial summary of the demographic data. The respondents were mostly female (n=459, 71.8%), between the ages of 36 years old and 49 years old (n=318, 49.8%), married or legally paired (n=359, 56.2%), and white or Caucasian (n=509, 79.7%). Over forty percent of the respondents considered themselves to be politically moderate (n=256, 40.1%), with others split between liberal (n=215, 33.7%) and conservative ideologies (n=168, 26.3%). In terms of education level, nearly half (n=312, 48.8%) did not earn a degree beyond high school or did not graduate from high school, while just over one-third (n=229, 35.9%) stated that their highest education level was either a bachelor’s, master’s or doctorate/professional degree. Over half of the respondents (n=354, 55.4%) were employed on a full-time basis, and over a quarter of the respondents (n=164, 25.7%) stated that their household income was at least $100,000 per year. In terms of residency, 54.8% of the respondents (n=350) lived in Washington state, followed by Oregon (n=211, 33.0%) and Idaho (n=78, 12.2%). When provided with a definition of rural area residency, 29.6% of the respondents (n=189) self-identified with this characterization, with the remaining 70.4% (n=450) indicating that they either lived in an urban area or were uncertain.

Table 4.1 Demographics of Survey Responders

Gender			**Education Level**		
Male	174	27.2%	Did not graduate high school	22	3.4%
Female	459	71.8%	High school diploma or GED	142	22.2%
Other/Did not reply	6	0.9%	Some college, no degree	148	23.2%
			Vocational / Technical Degree	38	5.9%
Age			Associate Degree	60	9.4%
18 to 25 years old	56	8.8%	Bachelor's Degree	136	21.3%
26 to 35 years old	195	30.5%	Master's Degree	77	12.1%
36 to 49 years old	318	49.8%	Doctorate/Professional Degree	16	2.5%
50 to 64 years old	66	10.3%			
65 years old or higher	4	0.6%	**Employment Status**		
			Employed, full-time	354	55.4%
Marital Status			Employed, part-time	84	13.1%
Single	106	16.6%	Unemployed	113	17.7%
Married/Legally paired	359	56.2%	Retired	14	2.2%
Long-term partnership	89	13.9%	Student	14	2.2%
Divorced	59	9.2%	Other	60	9.4%
Widowed	11	1.7%			
Separated	15	2.3%	**Household income**		
			Less than $50,000	234	36.6%
Race			$50,000 to $74,999	136	21.3%
White/Caucasian	509	79.7%	$75,000 to $99,999	89	13.9%
Hispanic/Latino	37	5.8%	$100,000 to $149,999	109	17.1%
Asian	30	4.7%	$150,000 or higher	55	8.6%
Black/African American	27	4.2%	Prefer not to answer	16	2.5%
American Indian/Alaskan Native	18	2.8%			
Native Hawaiian/Pacific Islander	7	1.1%	**State of Residence**		
Other	11	1.7%	Idaho	78	12.2%
			Washington	350	54.8%
Political Ideology			Oregon	211	33.0%
Liberal	129	20.2%			
Moderately Liberal	86	13.5%	**Live in Rural Area?**		
Moderate	256	40.1%	Yes	189	29.6%
Moderately Conservative	86	13.5%	No/Unsure	450	70.4%
Conservative	82	12.8%			

Additional demographic data were collected for vehicle accessibility and usage (see Table 4.2). For this survey, almost all of the respondents owned a vehicle (n=592, 92.6%) and had a driver's license (n=593, 92.8%). Nearly three-quarters of the respondents owned either one or two vehicles (n=506, 79.2%), with 13.5% (n=86) owning at least three or more vehicles. When asked if health issues affected driving ability, 8.8% of the respondents (n=56) acknowledged some form of an impairment.

Table 4.2 Additional Demographics of Survey Responders

Vehicle Ownership			**Driver's License**		
Yes	592	92.6%	Yes	593	92.8%
No	47	7.4%	No	46	7.2%
Number of Vehicles			**Health Issues affect Driving?**		
1	285	44.6%	No	574	89.8%
2	221	34.6%	Yes	56	8.8%
3 or more	86	13.5%	Prefer not to answer	9	1.4%
Other	47	7.4%			

Since this study focused on K-12 school travel behaviors, the survey also collected child demographic data. These results are summarized in Table 4.3. If the parent or guardian had multiple children in their household, then they were asked to arbitrarily choose one child for the purposes of answering the survey questions.

When asked about the number of children in their household, 48.4% of the respondents (n=309) stated that they only had one child, with the remaining respondents indicating either two children (n=236, 36.9%) or three or more (n=94, 14.7%). The age of the child selected for this study (or of the only child) varied, with the age groups of 6 to 9 years old (n=174, 27.2%), 10 to 13 years old (n=178, 27.9%), and 14 to 17 years old (n=173, 27.1%) each having almost an equal number of responses. For over half of the cases, the child selected for the purposes of this survey was either an only child (n=157, 24.6%) or the youngest in the family (n=211, 33.0%). There were slightly more male children (n=326, 51.0%) selected than female children (n=306, 47.9%). A broad distribution of the child's grade level, with Grade 1 to Grade 5 (n=223, 34.9%) representing the highest percentage, was expected based on the earlier results describing the child's age. Just over 15% of the respondents indicated that their child was home-schooled (n=98, 15.3%). This outcome may have been attributed to the fact that a younger child was still not yet eligible to enter kindergarten. Lastly, 21 parents or guardians (3.3%) acknowledged that their child had some form of disability.

Table 4.3 Demographics of School-Aged Child

Children in Household			Gender		
1	309	48.4%	Male	326	51.0%
2	236	36.9%	Female	306	47.9%
3 or more	94	14.7%	Other / Prefer not to answer	7	1.1%
Age of Selected Child			**Grade Level**		
5 years old or under	110	17.2%	Pre-K or kindergarten	126	19.7%
6 to 9 years old	174	27.2%	Grade 1 to Grade 5	223	34.9%
10 to 13 years old	178	27.9%	Grade 6 to Grade 8	151	23.6%
14 to 17 years old	173	27.1%	Grade 9 to Grade 12	139	21.8%
18 years or older	4	0.6%			
			Home-Schooled		
Birth Order of Selected Child			Yes	98	15.3%
Only Child	157	24.6%	No	541	84.7%
Youngest	211	33.0%			
Somewhere in the middle	62	9.7%	**Disability**		
Oldest	209	32.7%	Yes	21	3.3%
			No	611	95.6%
			Prefer not to answer	7	1.1%

The school travel characteristics of the children are summarized in Table 4.4. While just over a third (n=221, 34.6%) had a trip to school with a distance of one-half mile or less, 41.9% (n=268) of the children had a trip over one mile. Sidewalks were available for 45.9% of the students (n=293), and crossing guards were present for 36.2% of the students (n=231). Over half of the students (n=336, 52.6%) were able to walk to school.

Travel behaviors both before and after the pandemic were collected. When asked to identify their child's travel mode to school before the pandemic, 42.1% of the parents or guardians (n=269) indicated that their child traveled by car, and 32.6% (n=208) traveled by bus. Other students either walked or biked (n=91, 14.3%), drove themselves (n=1, 0.2%), or used another means of transport (n=71, 11.1%). After the pandemic, 42.3% of the parents or guardians (n=270) indicated that their child traveled by car, and 29.3% (n=187) traveled by bus. The remaining students either walked or biked (n=92, 14.4%), drove themselves (n=18, 2.8%), or used another means of transport (n=72, 11.3%). Just under 30% of the parents or guardians (n=183, 28.6%) indicated that their travel mode was affected as a result of the pandemic.

For the parents or guardians who indicated that the child walked or biked before the pandemic, vehicle traffic affected their decision to allow their son or daughter to walk or bike at least to a moderate or large extent in nearly half of the families (n=52, 49.5%). Additionally, most students who traveled by bus experienced trip times ranging from less than 30 minutes (n=168, 68.3) to trips lasting 30 minutes to an hour (n=69, 28.0%).

Table 4.4 School Transportation Characteristics

Distance to School			**Travel Mode Before Pandemic**		
1/4 mile or less	133	20.8%	Walk / Bike (by themselves)	56	8.8%
1/2 mile	88	13.8%	Walk / Bike (with adult)	35	5.5%
3/4 mile	53	8.3%	Car ride	269	42.1%
1 mile	97	15.2%	Drove themselves	1	0.2%
More than 1 mile	268	41.9%	Bus ride	208	32.6%
			Other	71	11.1%
Presence of Sidewalks					
Yes	293	45.9%	**Pandemic Affect Travel Mode?**		
No	123	19.2%	Yes	183	28.6%
Some / Partial	223	34.9%	No	456	71.4%
Presence of Crossing Guards			**Travel Mode After Pandemic**		
Yes	231	36.2%	Walk / Bike (by themselves)	62	9.7%
No	258	40.4%	Walk / Bike (with adult)	30	4.7%
Some / Partial	150	23.5%	Car ride	270	42.3%
			Drove themselves	18	2.8%
Traffic Affect Travel Decision? (if Walk/Bike)			Bus ride	187	29.3%
Not at all	21	20.0%	Other	72	11.3%
To a little extent	18	17.1%			
To some extent	14	13.3%	**Bus Ride Length**		
To a moderate extent	27	25.7%	Less than 30 minutes	168	68.3%
To a large extent	25	23.8%	30 minutes to 1 hour	69	28.0%
			1 hour to 2 hours	9	3.7%
Able to Walk					
Yes	336	52.6%			
No	303	47.4%			

The research team sought to explore potential travel differences between families who lived in rural and urban areas. These results are compared side by side in Table 4.5. For this study, rural children predominately traveled by bus (n=70, 37.0%) or by car (n=57, 30.2%), and 19.5% (n=37) walked or biked. By comparison, urban children predominately traveled by car (n=212, 47.1%) or by bus (n=138, 30.7%), and 12.0% (n=54) walked or biked. The pandemic affected slightly more rural families, with 36.0% of rural families (n=68) indicating that the pandemic affected their travel mode while 25.6% of urban families (n=115) answered in the affirmative. After the pandemic, there were only slight changes in the mode split for both rural and urban families, although the percentage of students who rode a bus declined by 6.8% and 1.8%, respectively. This study also noted an uptick in the number of students who drove themselves, with percentage increases of 1.6% and 3.1% for rural and urban families, respectively.

The study also sought to better understand whether walking to school was an option for rural and urban families. Just over half of the respondents in both groups indicated that their child was able to walk to school (n=102, 54.0% and n=234, 52.0% for rural and urban, respectively). Urban families (n=211, 46.9%) were slightly more likely to indicate that sidewalks were available for their son or daughter when compared with rural families (n=82, 43.4%).

Table 4.5 Pandemic-Related School Transportation Characteristics (rural vs. urban)

RURAL (n = 189)			**URBAN (n = 450)**		
Travel Mode Before Pandemic			**Travel Mode Before Pandemic**		
Walk / Bike (by themselves)	25	13.2%	Walk / Bike (by themselves)	31	6.9%
Walk / Bike (with adult)	12	6.3%	Walk / Bike (with adult)	23	5.1%
Car ride	57	30.2%	Car ride	212	47.1%
Drove themselves	0	0.0%	Drove themselves	1	0.2%
Bus ride	70	37.0%	Bus ride	138	30.7%
Other	25	13.2%	Other	45	10.0%
Pandemic Affect Travel Mode?			**Pandemic Affect Travel Mode?**		
Yes	68	36.0%	Yes	115	25.6%
No	122	64.6%	No	335	74.4%
Travel Mode After Pandemic			**Travel Mode After Pandemic**		
Walk / Bike (by themselves)	28	14.8%	Walk / Bike (by themselves)	34	7.6%
Walk / Bike (with adult)	9	4.8%	Walk / Bike (with adult)	21	4.7%
Car ride	67	35.4%	Car ride	203	45.1%
Drove themselves	3	1.6%	Drove themselves	15	3.3%
Bus ride	57	30.2%	Bus ride	130	28.9%
Other	25	13.2%	Other	47	10.4%
Able to Walk			**Able to Walk**		
Yes	102	54.0%	Yes	234	52.0%
No	87	46.0%	No	216	48.0%
Presence of Sidewalks			**Presence of Sidewalks**		
Yes	82	43.4%	Yes	211	46.9%
No	53	28.0%	No	70	15.6%
Some / Partial	54	28.6%	Some / Partial	169	37.6%

While the respondents may have indicated that the pandemic affected their child's travel mode, the identified mode both before and after the pandemic did not always change. In other words, there may have been short-term behavioral changes that were not retained over time. Additional discussion on this topic is provided in the conclusions section.

4.2. Study Analysis

To further evaluate why a child's primary method of travel changed as a result of the pandemic, a binomial regression model was developed. This section sequentially describes the process that was used to analyze the data set. An explanation as to how the statistically significant variables were determined precedes a discussion of how the variables were evaluated. The model fitting process is then outlined, and is followed by a detailed examination of the model outcomes and its meanings.

4.2.1. P-Values and Confidence Intervals

The data from the online survey was initially processed by converting the responses from each survey question into a histogram and observing the distribution. Using the histograms, the outcomes were reviewed and variables were condensed, as needed, from a wide range of options into two or three options, or separated from one outcome into multiple ones. For instance, the gender of the survey was lumped from five options to only female and non-female. The variable of state of residence (i.e., Idaho, Oregon, and Washington) was split into three independent variables. Each variable was integrated into a Chi-square test for p-values to estimate their significance. In the Chi-square test, the p-value represents the deviation of categorical variables from the observed data to hypothetical data. The higher the p-value, the greater deviation between the two data; the lower the p-value, the better the fit. Generally, a p-value less than 0.05 is considered significant, and the observed data is highly consistent with the hypothetical data. To support the demonstration of the significance of p-values, 95% confidence intervals (CI) were also calculated and are listed in Tables 4.6 to 4.8. The 95% CI stands for a method that estimates the whole value from a sample, and 95% of the sample involves the overall average. The table indicates that the statistically significant variables ($p < 0.05$), which have been italicized for clarity, were living in rural area, living in Washington state, parent gender, marital status, education level, annual household income, child's grade level, home-schooled child, health concerns, and presence of crossing guards.

Table 4.6 Characteristics of Parents

Variable	χ^2	SE	Z	P	95% CI
Rural resident	6.575	0.186	2.648	*0.010*	1.137, 2.358
ID resident	0.576	0.280	0.891	0.448	0.451, 1.341
OR resident	2.759	0.192	-1.750	0.097	0.491, 1.041
WA resident	4.650	0.179	2.238	*0.031*	1.051, 2.117
Gender	8.459	0.188	-2.988	*0.004*	0.395, 0.824
Age	0.772	0.134	0.786	0.680	0.854, 1.445
Marital status	9.184	0.103	2.922	*0.010*	1.104, 1.655
Number of school-aged children	2.401	0.121	0.799	0.301	0.869, 1.395
Race	0.243	0.214	0.602	0.622	0.748, 1.731
Education level	26.818	0.118	5.020	*<0.001*	1.435, 2.279
Annual household income	17.766	0.112	2.537	*<0.001*	1.067, 1.654

Variable	χ^2	SE	Z	P	95% CI
Political ideology	5.455	0.115	-1.761	0.065	0.653, 1.023
Employed adults in household	0.695	0.113	0.377	0.874	0.836, 1.302
Employment status	1.772	0.193	-1.423	0.183	0.520, 1.110
Employment industry	0.229	0.252	0.606	0.632	0.711, 1.909

Table 4.7 Characteristics of School-Aged Children

Variable	χ^2	SE	Z	P	95% CI
Age of child	4.719	0.105	1.955	0.094	0.999, 1.506
Child grade level	8.933	0.106	2.598	*0.011*	1.070, 1.621
Home-school status	35.210	0.226	5.809	*<0.001*	2.390, 5.802
Child birth order	2.716	0.176	-1.734	0.099	0.522, 1.041
Child gender	2.560	0.176	-1.685	0.110	0.526, 1.050
Child disability status	1.125	0.397	1.263	0.289	0.758, 3.598

Table 4.8 Characteristics of Additional Study Factors

Variable	χ^2	SE	Z	P	95% CI
School commute distance	2.691	0.180	-1.726	0.101	0.515, 1.043
Ability to walk to school	2.642	0.177	1.710	0.104	0.957, 1.912
Child's pre-pandemic commute type	3.470	0.237	1.976	0.063	1.004, 2.542
Health concerns cause travel change	73.127	0.194	8.288	*<0.001*	3.405, 7.273
Sidewalks along school route	1.339	0.175	1.244	0.247	0.882, 1.754
Presence of crossing guards	5.908	0.179	2.513	*0.015*	1.104, 2.229
Bus ride duration	0.000	0.276	0.034	1.000	0.588, 1.732
Vehicle ownership	0.432	0.356	0.822	0.511	0.667, 2.694
Number of household vehicles	0.003	0.181	0.146	0.956	0.720, 1.465
Possess driver's license	3.690	0.420	2.035	0.055	1.032, 5.358
Length of time at current residence	1.197	0.099	-0.999	0.550	0.745, 1.100

4.2.2. Assumptions Check

Models were fitted by initially integrating all the significant variables and decreasing the number of variables one by one to test the most suitable model. A binomial regression model requires assumptions to ensure that the variables are either not redundant to undermine the predicting function of the model or possess a fitting potential to the model. In this section, an overview with regard to variable correlation, multicollinearity, and the presence of outliers is briefly described.

When determining independent variables, correlations must be avoided, because if any of them are redundant, they will influence each other and cause inaccurate parameter estimation and expanded standard deviation. R-value is used for searching the correlation among two random independent variables from 0 to 1. Values equal to or greater than 0.8 are highly correlated, 0.5 to 0.8 are moderately correlated, 0.3 to 0.5 are lowly correlated, and below 0.3 are barely or not correlated. From the output, marital status with annual income had an R-value of 0.33 and education level with annual income had an R-value of 0.40; the rest of the combined variables were lower than 0.2. Therefore, it is concluded that there was no correlation among the variables.

Multicollinearity exists when the correlation coefficient is greater than 0.8. However, this rule does not always ensure that multicollinearity does not exist. The approach to diagnosing multicollinearity is the variance inflation factor (VIF), referring to the extent of one variable inflating under the influence of others. Typically, a score under five is accepted and requires no treatment. From the test, all variables were less than two, satisfying the assumption that no multicollinearity existed.

In statistics, outliers are abnormal values in the system that have distinct distances from others. Outliers can severely damage the average and standard deviation of the data, and may cause systematic errors. This research also applied the Cook's distance to examine if the model consisted of outliers. A greater value of the Cook's distance represents a greater level of leverage and residuals; thus, it was used to test the model's linearity. In general, an ideal Cook's distance should be less than 0.5. The maximum Cook's distance in this model was less than 0.01, so no significant outliers existed.

4.2.3. Model Fitting and Prediction

The next step was to compute the parameters of the model. The regression coefficients were calculated from the general logistic regression function under the binomial family. By taking the exponent of the coefficient, odd ratios (ORs) were obtained. The exponent characteristic determined that an option with a negative coefficient would have less probability of occurrence than the reference option. A positive coefficient meant that this option would be more likely to happen than the reference option because the exponent of this score, or odds ratio, was greater than 1. The 95% CIs for the range of the coefficient were then calculated. This calculation was followed by an evaluation for model fit. In this scenario, a linear regression model (LRM) for the likelihood ratio test was created. It is an index that reflects authenticity by comparing the likelihood values with constraining conditions to those without constraints. The LRM function leads us to the Chi-square values and a p-value. The p-value refers to the probability of getting the same Chi-square value with no predictor variables. In other words, if the p-value is less than 0.0001, at least one variable is valid.

The model prediction process involves creating a predicted variable within the dataset and drawing a receiver operating characteristic (ROC) curve. The ROC curve is used for determining the diagnostic ability of the system and plotting an optimal cutoff point. Meanwhile, the prediction is classified according to the optimal cutoff, and accuracy, sensitivity, and specificity are calculated.

To determine the best model, meaningful combinations of different variables were considered. For example, models exclusively featuring the demographics of the children, or of the parents, were considered during initial stages of testing to identify their prediction power. The segregation of model variables as related to only parents or children yielded comparably low accuracy and Cox-Snell R^2 values. As a result, any final model would benefit from the inclusion of variables that accounted for both parent and child factors.

Through processing down to the final set of variables, the accuracy ranged from 78.7% to 62.0%. Additionally, since sensitivity and specificity are reciprocal in nature, models around the crossing point were prioritized as the final model. Even though the Cox-Snell R^2 values are generally stable and do not exceed 20%, they were still regarded as a reference parameter to finalize the most suitable model. This model is shown in Table 4.9.

Table 4.9 Binomial Regression Model

Variables	Coeff.	S.E.	Wald Z	Pr(>|Z|)	OR	95% CI
Female	0.032	0.227	0.140	0.890	1.032	-0.407, 0.483
Long-term partnership	0.557	0.318	1.750	0.080	1.745	-0.071, 1.178
Married/Legally paired	0.196	0.254	0.770	0.439	1.217	-0.297, 0.699
Associate Degree or Bachelor's Degree	0.374	0.232	1.610	0.106	1.454	-0.082,0.828
Master's Degree or higher	0.748	0.303	2.470	0.014	2.112	-0.151,1.340
Household income ($75,000 to $149,999)	0.354	0.242	1.460	0.144	1.424	-0.123,0.828
Household income ($150,000 or higher)	0.319	0.382	0.830	0.405	1.375	-0.443,1.060
Child grade level (Grade 6 to 8)	0.401	0.241	1.660	0.096	1.493	-0.075,0.871
Child grade level (Grade 9 to 12)	0.583	0.247	2.360	0.018	1.792	-0.097,1.066
Child home-schooled	0.865	0.271	3.200	0.001	2.376	-0.332,1.395
Health concerns cause travel change	1.434	0.209	6.850	<0.001	4.195	-1.026, 1.847
Some or no crossing guards	-0.130	0.212	-0.620	0.538	0.878	-0.543, 0.288

The most suitable full-range model had an accuracy of 74.0%, a sensitivity of 55.2%, a specificity of 81.6%, and a Cox-Snell R^2 of 17.4%. The χ^2=122.38, $p < 0.001$, indicating that the odds ratio value of at least one variable in the fitted model was statistically significant, so the model is meaningful overall. The results suggest that individuals identifying as female were 1.03 times more likely to change their school-travel pattern as a result of the pandemic than non-females. Additionally, individuals in a long-term partnership or who were married or legally paired, who were more educated, and earning a higher household income were more likely to change. These results suggest that these households had the people-power, knowledge, or financial resources to accommodate such changes. Middle and high school students were more likely to make changes, suggesting that they had more flexibility in their trip to and from some school along with the modal options and opportunities to do so. Not surprisingly, those individuals who expressed health concerns were almost 4.20 times more likely to make such a change than those who did not.

Based on this result from the best binomial regression model, the research team concluded that many of the key variables included were based strictly on the demographic characteristics of the household and individual, as evidenced by factors such as gender, education level, and the grade level of the child. For comparative purposes, a second model was generated which removed the variables of "health concerns cause travel change" and "some or no crossing guards". These results are shown in Table 4.10.

Table 4.10 Binomial Regression Model - Demographic Variables

Variables	Coeff.	S.E.	Wald Z	Pr(>|Z|)	OR	95% CI
In a long-term committed partnership	0.537	0.303	1.775	0.076	1.711	-0.061, 1.129
Married/Legally paired	0.141	0.242	0.583	0.560	1.151	-0.330, 0.619
Associate Degree or Bachelor's Degree	0.370	0.221	1.675	0.094	1.447	-0.065, 0.802
Master's Degree or higher	0.796	0.286	2.786	0.005	2.216	-0.233, 1.356
Household income ($75,000 to $149,999)	0.359	0.231	1.555	0.120	1.432	-0.095, 0.811
Household income ($150,000 or higher)	0.341	0.358	0.954	0.340	1.407	-0.370, 1.037
Child grade level (Grade 6 to 8)	0.405	0.228	1.781	0.075	1.500	-0.044, 0.850
Child grade level (Grade 9 to 12)	0.511	0.236	2.168	0.030	1.667	-0.046, 0.971
Child home-schooled	1.046	0.250	4.192	< 0.001	2.846	-0.556, 1.536

In this case, the variables yielded a demographic model with 67.6% accuracy, 53.6% sensitivity, 73.3% specificity, and 10.8% Cox-Snell R^2. The χ^2= 73.35, $P < 0.001$, indicating that the odds ratio value of at least one variable in the fitted model was statistically significant so the model was again meaningful overall.

This second model was not nearly as strong as the initial model, but suggests that if a survey needed to be conducted with time and budget constraints (i.e., "back-of-the-envelope" assessment), questions limited to demographic data alone could identify similar trends and outcomes when compared with a more extensive survey that sought to include additional measurement factors.

The takeaways from this study can be applied when accounting for and reacting to similar disruptive events in the future. From a policy perspective, additional outreach in the form of education and increased resources at a grass roots level to lower income and less-educated families may support or foster positive behavioral and transportation modal changes. Additionally, school transportation activities such as, but not limited to, prioritizing infrastructure improvements, exploring student walking behaviors, and implementing school bus safety enhancements may also serve as opportunities to contribute to impactful change (Sundstrom et al., 2010; Chang et al., 2018; Chang et al., 2015). Unique occurrences, such as the pandemic and future catastrophic events, also trigger a need for more awareness of transportation constraints or limitations, in addition to the impacts that will disrupt classroom learning.

CHAPTER 5. CONCLUSIONS

The pandemic served as a unique opportunity to examine how personal travel behaviors may have changed over time. In this study, the trip to and from school for children from kindergarten to Grade 12 was explored, and the modes used for travel were examined along with the potential factors that may have influenced any travel changes.

To collect this data, an online survey was developed and administered to households residing in the Pacific Northwest states of Idaho, Washington, and Oregon in May 2023. A total of 639 responses were gathered from households with at least one school-aged child. Binomial logistic regression models were then developed to determine whether or not there were changes in the mode used by children before and after the pandemic. The study concluded that factors such as children with more than one parent in the household, higher parent education level, higher household income, and older children (i.e., attending middle or high school versus elementary school) were some of the significant factors that contributed to travel behavior changes. These results suggest that households with the financial means to make changes and the knowledge to make informed decisions were more likely to adjust and adapt to how they transported their children to and from school. The place of household residence, whether rural or urban, was determined to not be a significant variable.

A reflection of this study concluded that capturing specific travel behaviors during the pandemic was difficult, since personal behaviors were constantly evolving. As an example, children who were taking the yellow school bus before the pandemic may have received a car ride from their parents for a short period of time when the pandemic first surfaced. As more health information became available, the parents may have transitioned their child back to the yellow school bus after a period of time, provided that the child was now wearing a face covering and following social distancing protocols. In this case, and likely in many cases, it would have been difficult to pinpoint the exact mode or modes of travel over time unless a daily travel diary or similar instrument was used during the pandemic.

This study has also concluded that travel behavior, as expected, bounced back to pre-pandemic modes as the significance of the pandemic waned. While active transportation modes, such as walking and bicycling, increased in popularity during the pandemic as individuals sought to incorporate travel methods that provided a means of social distancing, the popularity or preference of walking and bicycling does not appear to have enjoyed a significant spike amongst school-aged children as a result of the pandemic. In fact, based on the data collected, the net gain of walking and bicycling students was only one household before and after the pandemic.

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CHAPTER 7. APPENDIX

The survey used for this study is provided here.

Transportation Survey - University of Idaho

Researchers from the University of Idaho's Department of Civil and Environmental Engineering are conducting a study that examines public perceptions related to travel and the pandemic. Your participation will involve answering an online survey that should take about five to eight minutes to complete. Your involvement in the study is voluntary, and you may choose not to participate. You can refuse to answer any of the questions at any time. No names will be associated with your confidential responses. The findings from this project will provide information on various travel behaviors and perceptions. If published, results will be presented in summary form only with no personal identifiers. All data will be stored for a minimum of three years. If you have any questions about this research project, please feel free to call Kevin Chang at (208) 885-4028. If you have questions regarding your rights as a research subject, or if you want to obtain information or offer input you may call the Office of Research Assurances at (208) 885-6340 or irb@uidaho.edu. The terms of service and privacy policy for Qualtrics can be found online at [www.qualtrics.com/terms-of-service/] and [www.qualtrics.com/privacy-statement/]. By clicking the arrow, you certify that you are at least 18 years of age and agree to participate in the above-described research study. Thank you in advance.

Q1 Rural areas can be defined as settlements with less than 5,000 people or open-countryside. Based on this definition, do you live in a rural area?

o Yes
o No
o Maybe

Q2 Which state do you live in?

o Idaho
o Oregon
o Washington
o [Other]
o I do not reside in the United States

Q3 What is your home zip code?

____

Q4 What is your gender?

o Male
o Female
o Non-binary
o Other
o Prefer not to say

Q5 How old are you?

o 18 to 25 years old
o 26 to 35 years old

- 36 to 49 years old
- 50 to 64 years old
- 65 years or older

Q6 What is your marital status?

- Single
- In a long-term committed partnership
- Married/Legally paired
- Seperated
- Divorced
- Widowed

Q7 How many school-aged children (under 18) live with you in your household?

- None
- 1
- 2
- 3 or more

Q8 What racial category do you most identify with?

- White/Caucasian
- American Indian/Alaskan Native
- Asian
- Native Hawaiian/Pacific Islander
- Black/African American
- Hispanic/Latino
- Other

Q9 What is the highest level of formal education you have completed?

- Did not graduate high school
- High school diploma or equivalent (GED)
- Some college, no degree
- Trade / Vocational Training / Technical Degree
- Associate Degree
- Bachelor's Degree
- Master's Degree
- Professional Degree
- Doctorate Degree

Q10 What is the expected annual income for your household?

- Less than $50,000
- $50,000 to $74,999
- $75,000 to $99,999
- $100,000 to $149,999
- $150,000 or higher
- Prefer not to answer

Q11 What political ideology do you mostly affiliate with?

- Liberal
- Moderately Liberal

- Moderate
- Moderately Conservative
- Conservative

Q12 How many adults in your household are currently employed including yourself?
- None
- 1
- 2
- 3 or more

Q13 Which of the following best describes your current employment status?
- Employed, full-time
- Employed, part-time
- Student
- Unemployed
- Retired
- Other

Q14 What type of industry do you work in?
- Private Sector
- Public Sector
- Self Employed
- Other

The next series of questions focus on school transportation. While answering these questions consider only ONE of your school-aged children.

Q15 What age is this child?
- 5 years old or under
- 6 to 9 years old
- 10 to 13 years old
- 14 to 17 years old
- 18 years or older

Q16 What is the grade level of this child?
- Pre-K or Kindergarten
- Grade 1 to Grade 5
- Grade 6 to Grade 8
- Grade 9 to Grade 12

Q17 Is this child home-schooled?
- Yes
- No

Q18 In what place in the birth order does this child fall?
- Youngest
- Somewhere in the middle
- Oldest
- Only Child

Q19 What is the child's gender?
o Male
o Female
o Non-binary
o Other
o Prefer not to answer

Q20 Is the child physically disabled?
o No
o Yes
o Prefer not to answer

For these questions please continue considering the same child for which you answered questions on the previous section.

Q22 What is the approximate distance in miles from your home to your child's school?
o 1/4 mile or less
o 1/2 mile
o 3/4 mile
o 1 mile
o More than 1 mile

Q23 Is it geographically possible for your child to walk to school?
o Yes
o No

Q24 Before the pandemic, what was your child's primary method of travel to school?
o They walked or biked to school on their own
o They walked or biked to school with adult supervision
o They were given a (car) ride
o They rode the bus
o They drove themselves
o Other

Q25 Since the start of the pandemic, has your child's primary method of travel changed?
o Yes
o No

Q26 What is the current method by which your child is transported to school?
o They walk or bike to school on their own
o They walk or bike to school with adult supervision
o They are given a (car) ride
o They ride the bus
o They drive themselves
o Other

Q27 Why did it change? (Select all that apply.)
o Personal preference

o Attending different school due to older age (i.e., was elementary and now middle, was middle and now high)
o Attending different school due to personal preference (i.e., enrolled in different school)
o Attending different school due to different home (i.e., moved or relocated)
o Now/was home-schooled

Q28 Did you change the way your child traveled to school at any time during the pandemic because of health concerns (i.e., increased social distancing)?
o Yes
o No

Q29 Are there sidewalks along your child's current route to school?
o Yes
o Some Sidewalks/Partial Coverage
o No

Q30 Are there crossing guards present at intersections along the route to school?
o Yes
o Some Crossing Guards/Partial Coverage
o No

Q31 To what extent does high traffic areas or busy intersections influence your decision to allow your child to walk or bike to school?
o Not at all
o To a little extent
o To some extent
o To a moderate extent
o To a large extent

Q33 Approximately how long is your child's bus ride to school?
o Less than 30 minutes
o Between 30 minutes and 1 hour
o 1 hour to 2 hours
o More than 2 hours

The last series of questions focus on your own travel patterns as a result of the pandemic.

Before the pandemic, how did you usually travel to where you needed to go within the community for work, shopping, errands, or medical appointments?
o I drove
o I walked
o I rode a bicycle
o I used public transportation
o I used a taxi/Uber/Lyft service
o A friend/family member drove me

Q40 Has this mode of transportation changed as a result of the pandemic?
o Yes
o No

Q41 As a result of the pandemic, how do you usually travel to where you need to go within the community for work, shopping, errands, or medical appointments?
- o I drive
- o I walk
- o I ride a bicycle
- o I use public transportation
- o I use a taxi/Uber/Lyft service
- o A friend/family member drives me

Q42 Do you own a vehicle?
- o Yes
- o No

Q43 What kind of vehicle is your primary vehicle?
- o Passenger car
- o Sport utility vehicle (SUV)
- o Van
- o Pickup truck
- o Semi-truck
- o Motorcycle
- o Other

Q44 How many vehicles do you own?
- o 1
- o 2
- o 3 or more

Q45 How many years of driving experience do you have?
- o 1 year or less
- o 2 to 5 years
- o 6 to 10 years
- o 11 to 15 years
- o 16 years or more

Q46 Do you have a driver's license?
- o Yes
- o No

Q47 Do you have any health issues or disabilities that affect your ability to drive?
- o Yes
- o No
- o Prefer not to answer

Q48 How long have you lived in your current community/neighborhood?
- o Less than 1 year
- o 1 to 3 years
- o 4 to 6 years
- o 7 to 10 years

o Longer than 10 years