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Factors Which Predict the Use of Active Transportation to School Among Children in Clark County, NV

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FACTORS WHICH PREDICT THE USE OF ACTIVE TRANSPORTATION TO SCHOOL AMONG CHILDREN IN CLARK COUNTY, NV

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Abstract

Introduction: Active transportation to school (ATS) shows promise for increasing activity levels in children, but prevalence and correlates vary widely in cities and regions with different barriers and supports for active travel. Classification of ATS users is a current issue in the field. The purpose of this study was to determine the prevalence of ATS use and develop a predictive model of ATS for the novel population of children enrolled in grades K-8 in Clark County School District, a large metropolitan school district in Southern Nevada. **Methods:** This study used a secondary data from the National Center for Safe Routes to School's Parent Survey collected in 17 school communities by Clark County School District in 2013 (*n*=2,054). Variables representing demographic characteristics, socio-economic status, distance from school, and barriers to the use of ATS were assessed for correlations and normality. Logistic regression for survey data was used to develop predictive models for two measures of ATS. **Results**: The returned surveys represent a response rate of 13.5%. ATS use was categorized as some use (use of active methods of transportation for either the morning or afternoon commute or both on most days) and exclusive use (use of ATS for both trips on most days). Logistic regression revealed that some ATS use was predicted by distance from school, parental level of education, child's request to use ATS, and the number of barriers reported by the parent. Exclusive ATS use was also predicted by these characteristics, but was also predicted by the number of children in grades K-8 in the family. Both models explained about one third of the variation in ATS use in the sample. **Discussion:** Results suggest that ATS use among K-8 students in Clark County is predicted by distance and socio-

economic status, as with other populations. Requesting permission to use ATS and the number of K-8 students in the family also predicted the use of ATS, but the implications of these findings require further analysis.

Table of Contents

List of Tables

List of Figures

Chapter 1 - Introduction

Regular physical activity (PA) for children supports healthy body composition, cardiovascular fitness, and mental health, and protects against Type 2 diabetes and hyperlipidemia (Davis et al., 2012; Janssen & Leblanc, 2010). The Centers for Disease Control and Prevention (CDC) recommend that children perform a minimum of 60 minutes of moderate to vigorous aerobic physical activity (MVPA) every day (U.S. Department of Health and Human Services, 2008). Despite these guidelines and the well documented benefits of PA, only 42% of young children and 8% of adolescents meet these recommendations (Troiano et al., 2008). These low rates of physical activity, combined with excess calorie consumption (Han, Lawlor, & Kimm, 2010), have created a situation where 31.8% of children in the U.S. are considered overweight.

In previous decades, efforts to address obesity among both children and adults targeted individual behaviors and characteristics without success (Booth, Pinkston, & Carlos Poston, 2005). More recently, researchers have begun to investigate the effect of broader influences, such as the built environment and public policy, on U.S. obesity rates (Frank, Engelke, & Schmid, 2003). This research has led to a broader understanding of the causes of childhood overweight and obesity (Lobstein, Baur, & Uauy, 2004), including changes in neighborhood design, school placement, and social norms (McDonald, 2008a, 2008c; McDonald & Alborg, 2009). More forms of sedentary entertainment, less built environment support for walking and play, and changes in parenting styles have emerged as important influences on the decline in childhood physical activity (Binns et al., 2009; O'Connor & Brown, 2013).

For previous generations of American children, active travel was an important contributor to daily levels of PA (McDonald, 2007). In the past children were more likely to travel autonomously on foot or by bicycle to neighborhood destinations. More recently, building codes and zoning regulations have contributed to sprawling neighborhood designs, often without sidewalks or other protections for pedestrians, which place destinations like schools, playgrounds, and libraries beyond the reach of children (Frumkin, Frank, & Jackson, 2004). This physical separation of children from their destinations occurred simultaneously with societal changes which further discouraged active travel. The rise in the number of families with multiple cars and changes in parenting norms which discourage independent activities for children also contributed to the decline in active travel for children (Binns et al., 2009).

As obesity rates increased over the past several decades, researchers investigating PA in children have turned to active transportation to school (ATS) as a missed opportunity to both document and encourage daily PA. ATS, or commuting to school by walking, bicycling, or any other non-passive mode of travel, was overlooked in early research in favor of more vigorous forms of activity like organized sports or school-based physical education, along with active travel to other destinations. In societies where car ownership is less common, ATS can account for 40-50% of children's weekly minutes of MVPA (Tudor-Locke, Ainsworth, & Popkin, 2001). As research in this field has matured, it has become clear that the built environment is a strong influence on ATS (Sallis & Glanz, 2006).

Distance from school has emerged as the strongest predictor of ATS across multiple studies (Pont, Ziviani, Wadley, Bennett, & Abbott, 2009). As societal trends have encouraged larger schools which are built further away from students' homes on the edges of communities, instead of the valuable property in their centers, distances from home to school have increased (Miles, Adelaja, & Wyckoff, 2011). Other built environment characteristics, such as the presence of sidewalks and trails, and proximity to parks and recreational facilities, have also been associated with the use of ATS (Pont et al., 2009).

Since PA can support healthy body weight, numerous studies have investigated the relationship between ATS and weight status. A recent systematic review of 32 studies reported inconsistent results for ATS and weight loss or reduced BMI. The authors also noted that most studies of ATS and weight status were cross-sectional, so causation could not be determined even if the results were more clear (Lee, Orenstein, & Richardson, 2008). Since childhood overweight is a complex phenomenon with strong ties to the food environment (Lobstein et al., 2004), other researchers have chosen instead to study the relationship between ATS and measures of physical fitness. A 2011 systematic review included 27 studies which assessed fitness measures such as cardiovascular fitness and flexibility. The authors reported a positive relationship between ATS and cardiovascular fitness among four of five studies and noted stronger relationships between cycling and cardiovascular fitness, as opposed to walking (Lubans, Boreham, Kelly, & Foster, 2011).

Both Lee et al. (2008) and Lubans et al. (2011) noted issues with measurement in the field. Studies often use child or parental self-report to assess ATS use, which may introduce recall or social desirability bias. Also, students may have a commute with multiple legs, such as biking to a friend's house for a ride in a car or being dropped off several blocks from school and walking the remainder of the trip. These multiple leg trips are difficult to categorize and may further complicate study results. Some researchers have chosen to use accelerometers to measure actual PA in addition to self-report. The use of objective measures may reduce inaccuracy in study results, but accelerometer use in children is not without complications (Freedson, Pober, & Janz, 2005). The categorization of children as regular active commuters also varies among studies. These issues make it difficult to draw broad conclusions about the potential benefits of ATS. The authors called for more research on ATS, especially longitudinal studies and interventions.

Like children in other states, most children in Nevada do not meet PA guidelines. Only 24.9% of adolescents report regularly performing at least 60 minutes of PA each day (Centers for Disease Control, 2012). Most children in the Las Vegas area attend schools administered by the Clark County School District (CCSD). This school district in Las Vegas, Nevada is a large and diverse community with over 300 schools and 300,000 students. Las Vegas is a newer, autocentric community, and its schools are often located in neighborhoods with environmental barriers to ATS. Despite growing interest in ATS and its role in contributing to childhood PA, the ATS habits of this population have not been studied. The purpose of this research to understand the ATS habits of Las Vegas children and the prevalence of ATS in this population.

Chapter 2 - Literature Review

Active transportation to school and health benefits

As obesity rates increase and childhood PA declines, researchers have been investigating ATS for insight into its role in helping children meet PA guidelines. Most work in the field has been completed since the turn of the century, following an influential article in 2001 proposing ATS as an "overlooked source" (Tudor-Locke et al., 2001, p. 309) of regular PA for children. Early studies investigated whether ATS increases overall PA, i.e., whether children who use ATS accumulate more daily PA than their peers, or compensate for their active commutes by being less active during other parts of their days.

Researchers then extended those studies into investigations of the relationship between ATS and body composition, or whether children who used passive forms of travel, such as family car or school bus, were more likely to be overweight or obese. As few clear answers emerged about that relationship, other studies have instead explored the role of ATS in various measures of physical fitness. All of these important questions have been affected by the lack of clear standards for measuring ATS and for categorizing students with variations in their modes of travel. The state of the literature regarding these issues will be reviewed in the following sections, along with studies of the effect of the built environment on ATS in school-aged children.

ATS and activity level

Since childhood obesity has emerged as a serious health problem, research into its prevalence and correlates has tied this phenomenon to decreasing rates of childhood

PA, among other influences (Lobstein et al., 2004). In order to understand the influence of ATS on total PA in children, many studies have investigated the relationship between commuting method and activity level. Most studies in this area are cross-sectional, limiting their ability to determine causation, but the research does tend to support a link between the use of ATS and increased PA in children.

Researchers have used various measures and standards of comparison to evaluate the use of ATS. A common study design uses surveys to collect information from parents, children, or both, regarding ATS habits. Tudor-Locke's seminal work with Russian children was based on a large survey sample of over 6,400 parent-child pairs. She and her colleagues reported on the prevalence of meeting childhood PA guidelines when including and excluding data from ATS. They found that the percentage of children meeting PA guidelines increased from 12% to 20% when PA from ATS was included. They recommended including investigating this type of utilitarian or commuting-based PA in future studies of childhood PA (Tudor-Locke, Neff, Ainsworth, Addy, & Popkin, 2002).

Other international studies have used surveys to collect ATS information in Australia (Dollman & Lewis, 2007; Schofield, Gianotti, Badland, & Hinckson, 2008; Spinks, Macpherson, Bain, & McClure, 2006), the United Kingdom (Baig et al., 2009), Germany (Landsberg et al., 2008), Portugal (Santos, Gomes, & Mota, 2005), Norway (Sjolie & Thuen, 2002), and Canada (Loucaides, Plotnikoff, & Bercovitz, 2007; Morency & Demers, 2010). Most of these studies supported the link between use of ATS and higher levels of MVPA, but Baig et al. (2009), Santos et al. (2009) and Sjolie & Thuen (2002) found no association. Sjolie and Thuen worked with a small sample (*n*=88), and Santos et al. used a new questionnaire-based index of PA to sort subjects into adequate and inadequate PA groups.

Among studies supporting the link between ATS and increased PA, Dollman et al. (2007) analyzed activity patterns in a large (*n*=1,643) sample of middle school-aged students and reported increased PA among ATS users, but no differences in free time PA, suggesting that ATS accounts for the increase. Landsberg et al.'s 2007 study in Germany showed higher increases in PA for females using ATS than males (4.9 and 3.3 additional hours per week, respectively) among his sample of 626 high school students. Morency and Demers (2010) used a different approach and analyzed car trips. Their results indicated that 31% of reported car trips were less than 1 km in length. If replaced by active travel, these trips could constitute 16.6% of daily PA for the elementary and middle school-aged subjects.

Surveys of ATS behavior in the U.S. have also supported an association between active commuting to school and increased levels of PA. Populations of junior high and high school students in Utah (Bungum, Lounsbery, Moonie, & Gast, 2009) and Nebraska elementary school students (Heelan et al., 2005) have reported higher levels of PA than their peers who use passive modes of transit. These two groups reported substantially different rates of ATS, with 24.7% of the Nebraska students using active modes of commuting to school and only 4.6% of the Utah respondents reporting use of ATS. The Nebraska study used a daily PA recall instrument with its younger population, while the Utah study asked its older students to report their usual mode of transportation. The method of assessment, the difference in age of the subjects, or other factors related to the built environment could explain the variation in rates of ATS in these groups.

When researchers have surveyed broader national samples, trends related to age and the use of ATS in the U.S. have emerged. A national phone survey with a representative sample (*n*=1,395) reported an overall ATS rate of 14% based on the student's "usual" mode of transportation. Younger children reported more frequent use of ATS, with 20.5% usually travelling to school by walking or cycling, while only 8.0% of high school students usually used ATS (Fulton, Shisler, Yore, & Caspersen, 2005). Gordon-Larsen et al. (2005) used data from the National Longitudinal Study of Adolescent Health to analyze a larger group (*n*=10,771) and reported that 24.7% of respondents ages used ATS. This study only included older students in grades 7-12, and its sample was weighted for urbanization, school size, and ethnicity. The methods for this survey did allow respondents to select more than one mode of transportation, so this higher percentage may reflect students who used ATS occasionally, rather than regularly.

Rather than relying on survey instruments which may not accurately assess ATS habits with slight but important differences, other researchers investigating the link between ATS and PA have combined survey data with information collected from instruments. Some studies have used pedometers (Abbott, Macdonald, Nambiar, & Davies, 2009; Borrestad, Ostergaard, Andersen, & Bere, 2013; Duncan, Scott Duncan, & Schofield, 2008; Pabayo et al., 2012; Trapp et al., 2013), but pedometers do not typically register the activity level of cyclists (Borrestad et al., 2013).

To address this gap, other researchers have collected ATS data with accelerometers (Alexander et al., 2005; Chillon et al., 2010; Cooper, Andersen, Wedderkopp, Page, & Froberg, 2005; Ford, Bailey, Coleman, Woolf-May, & Swaine, 2007; Metcalf, Voss, Jeffery, Perkins, & Wilkin, 2004; Nilsson et al., 2009; Owen et al., 2012; Rosenberg, Sallis, Conway, Cain, & McKenzie, 2006; Saksvig et al., 2007; Sirard, Riner, McIver, & Pate, 2005; Tudor-Locke, Ainsworth, Adair, & Popkin, 2003; van Sluijs et al., 2009). While not without their own limitations (Freedson et al., 2005), accelerometers can provide more detailed information on PA patterns than surveys. Subjects typically wear an accelerometer during all waking hours, except while bathing or engaged in water-based PA like swimming. Data is downloaded from the devices then analyzed for counts per minute (cpm) which exceed specific cut points, and can be classified as moderate or vigorous PA (MPA or VPA). Often counts of both intensities are grouped together as MVPA to allow researchers to compare participants' activity patterns to national guidelines and recommendations for 60 daily minutes of MVPA.

International studies of ATS and PA using accelerometers have reported higher overall activity levels for ATS users in Scotland (Alexander et al., 2005), for boys in Estonia and Sweden (Chillon et al., 2010), for students of both genders in England (Cooper, Page, Foster, & Qahwaji, 2003; Ford et al., 2007; Owen et al., 2012; van Sluijs et al., 2009), and for high school students in the Phillipines (Tudor-Locke et al., 2003). One study of first grade students in England (*n*=275) reported no association between ATS and accelerometer-based MVPA. A larger study (*n*=1,327) of 9- and 15-year olds from Norway, Estonia, and Portugal also reported no association among their participants. A lack of clear standards for classifying active commuters may contribute to these discrepancies.

Accelerometer studies in the U.S. have yielded mixed results. Saksvig et al. (2007) analyzed survey and accelerometer data for adolescent girls in six states, and found that 14% of their respondents walked to school. Students who used ATS had 13.7 more minutes of daily PA and 4.7 more minutes of MVPA than their peers who used passive modes of transport. Sirard et al.'s study of 219 5th graders in South Carolina reported 24 more minutes per day of MVPA for active commuters, but their sample was small and not diverse (2005). Rosenberg et al. (2006) measured daily PA levels by accelerometer for 926 5th grade students in California, but found no relationship between commuting mode and PA level in this population.

Many researchers now support the link between use of ATS and increased levels of PA for most populations (Lee et al., 2008). It is important to note, however, that most studies in this field are cross-sectional. As such, researchers cannot determine if use of ATS increases PA levels in students who walk and cycle, or if students who are more active for other reasons are more likely to choose active methods of transport.

ATS and weight status

As the link between ATS and increased PA levels has become more established, the research community has also investigated the relationship between ATS and weight status. Studies in the U.S. and other parts of the world have used surveys, clinical measures of anthropometric characteristics, and instrument data from pedometers and accelerometers to research this relationship. As might be expected from a condition with the complex etiology of childhood obesity, clear answers have not yet emerged from this body of research. Efforts over the past decade, though, have served to define the research question more clearly and highlight issues with measurement in the field.

Cross-sectional studies with survey-based PA reports and measures of weight status in other parts of the world have yielded a variety of results. A study of German high school students reported lower body fat percentages (BF%) for students who used ATS (Landsberg et al., 2008), and risk of overweight was lower for students aged 7-17 in China who used active modes of transportation to school (Li et al., 2007). Klein-Platat et al. (2005) found an unexpected relationship among 12-year old students in France and reported increased waist circumference among students who used ATS. Other studies have found no association between ATS and measures of weight status in England (Baig et al., 2009) and Portugal (Mota et al., 2007). Several studies have reported relationships only for certain subgroups, such as boys who cycle in Norway with lower BF% (Ostergaard, Kolle, Steene-Johannessen, Anderssen, & Andersen, 2013) and smaller waist circumference only in girls in Spain (Ortega et al., 2007).

When international studies include accelerometer data to assess activity level, the results do not appear to support a relationship between ATS use and weight status. Cooper performed cross-sectional studies in England (2003) and Denmark (2005) and found no relationship between ATS use and body mass index (BMI) in either population. Ford et al. (Ford et al., 2007) also reported no significant relationship between ATS and BF% among elementary school students in the U.K., but did not collect accelerometer data for their entire sample. One study did report lower BMI among 14-16 year old students in the Phillipines who used ATS (Tudor-Locke et al., 2003).

Studies in the U.S. have also yielded results which tend not to support a relationship between ATS and weight status for most populations. Cross-sectional studies with self-reported PA have found no association with self-reported BMI in a nationally representative sample (Fulton et al., 2005) and with clinically measured BMI among 5th graders (Saksvig et al., 2007). Self-reported BMI was lower among high school ATS users in New Hampshire and Vermont, but team sports participation was a stronger predictor of healthy weight status (Drake et al., 2012). Evenson, Huston, McMillen, Bors, and Ward (2003) found lower self-reported BMI among middle school ATS users, but no relationship among high school students. In the largest study, with data from a nationally representative sample of over 10,000 high school students, students who reported using ATS had lower clinically measured BMIs (Gordon-Larsen et al., 2005).

Adding PA from instrumentation and strengthening study design does not appear to support a relationship between ATS and BMI. Accelerometer-based PA data and clinically measured BMI were not associated among 10-year olds in South Carolina (Sirard et al., 2005), nor were GIS-mapped distances between home and school in a recent study of 4,379 elementary and middle school students in Nebraska (Heelan, Combs, Abbey, Burger, & Bartee, 2013). One 2-year prospective study of over 1,000 older elementary students in California reported no association between ATS and BMI, but did not control for distance (Rosenberg et al., 2006). Another prospective study which followed 9-year olds for 2 years found a significant positive correlation between the use of ATS and BMI, but that study used self-reported PA measures and did not account for distance between home and school (Heelan et al., 2005). As this field of study continues to mature and its measurements become more standardized, the relationship between ATS use and weight status may become more clear.

ATS and fitness

Since PA has health benefits for children independent of weight status, other researchers have investigated the relationship between ATS use and various measures of cardio-respiratory fitness (CRF). In this area of the literature, distinctions begin to emerge between students who walk to school and those who cycle, with higher levels of CRF typically observed in cyclists. Again, clear standards for measurement have not emerged, with various studies using different measures to operationalize CRF. Measures such as timed ergometer trials, mile times, shuttle runs, and VO_2max may be analyzed independently or combined with blood levels into an index of fitness. Some of the disparity in results for different modes of ATS may be attributable to emerging standards of measurement.

Most work in this area has been conducted in Europe, often as part of the European Youth Heart Study (EYHS). Cooper et al.'s study in Denmark (2006), the earliest to investigate ATS and fitness, assessed heart rate (HR) during a structured ergometer trial as its measure of CRF. Among their 919 participants, both cyclists and walkers achieved higher levels of CRF compared to their peers who used passive modes of transit, though cyclists were five times more likely to score in the top quartile for fitness. In a related prospective study, 384 Danish students were followed from 3^{rd} to 9^{th}

grade (Cooper et al., 2008). Students in that study who cycled to school at both ages had higher CRF than their peers, and those who switched from passive transport to cycling reported larger improvements in CRF than those who switched from passive transport to walking.

Andersen, Lawlor, Cooper, Froberg, and Anderssen (2009) reported similarly improved fitness for cyclists from their large sample of Danish adolescents (*n*=1,249), but their analysis indicated that CRF scores for students who walked to school resembled those of students who used passive transport to school (PTS). This significant variation in fitness levels was also reported by Chillon et al. (2010) among their sample of over 2,000 4th and 10th graders in Estonia and Sweden. A smaller prospective study which followed 262 Swedish girls from 4th grade to 10th grade observed that those who changed from PTS or walking to cycling increased their fitness scores 14% more than those who remained passive travelers or walkers (Chillon et al., 2012).

Ostergaard et al. (2013) reported improved fitness for adolescents using ATS only among male cyclists, but improved fitness for all groups of ATS users in elementary school, suggesting that the relationship between ATS and fitness changes with age, but Voss and Sandercock (2010) did not detect this pattern among their large sample of English 10- to 16-year olds. They categorized their 6,000 participants as ‘fit’ or ‘unfit’ based on the results of a 20 m shuttle run, and reported that both walkers and cyclists were more likely to be considered ‘fit’ than their peers who used PTS.

When researchers assess other measures of health, mixed results have been reported. In a cross-sectional study of 1,570 elementary school students in Brazil, no relationship between blood pressure and ATS was detected. This study did use clinically measured blood pressure but relied on self-report for ATS and included no assessment of distance between home and school (Silva & Lopes, 2008). In a smaller sample of Danish students (*n*=334), blood pressure was also not associated with use of ATS. Cyclists in this prospective study, though, were observed to have improved glucose, insulin, and cholesterol profiles when compared to their peers who used PTS (Andersen et al., 2011).

One large study of CRF and ATS has been performed in the U.S. by Madsen, Gosliner, Woodward-Lopez, and Crawford (2009). They analyzed mile times for over 9,000 7- and 9-year olds in California, and found that ATS use was associated with improved mile times in their population. Interestingly, ATS use was associated with poorer body composition. Since students who walked or cycled to school in their population were also more likely to purchase food while in transit, the researchers suggested that ATS use may be associated with higher fitness levels but more consumption of nutritionally deficient convenience foods. This complicated interplay between PA patterns and diet may shed light on the mixed results for ATS and weight status reported above.

Measurement issues

Research into ATS and its health benefits is still a relatively recent area of investigation. As reviewed above, the relationships between ATS and PA, weight status, and fitness level have been investigated with various study designs and assessment tools over the past decade. The development of this field of research has revealed some important issues with measurement of ATS. Clear standards have not yet emerged for classifying students as active or passive commuters, nor for accounting for the distance between home and school and its impact on PA duration and intensity.

Classification of active commuters

Many studies of ATS habits dichotomize students as either active or passive commuters based on self- or parent-report of the student's "usual" mode of transport. These self-reported behaviors may be subject to recall or social desirability bias. Evenson, Neelon, Ball, Vaughn, and Ward (2008) assessed the reliability and validity of a student travel survey recording the "usual" mode of transportation. They reported high test-retest reliability among 4^{th} and 5^{th} graders (kappa values ranged from 0.79 to 1.00). They also assessed criterion validity for the survey by administering the survey to the students' parents and reported high levels of agreement (kappa=0.80).

Requesting a "usual" mode of transport, however, may not accurately reflect travel patterns. Students may use multiple modes of transport each week, or even within a single day's commute. For instance, a student may walk some days, cycle other days, and get dropped off in the family car instead of walking alone to a before-school activity all within a single week. Even among students with more consistent commuting patterns, one student may walk over .5 mi to a bus stop but be considered a passive traveler while another student may walk less than .25 mi to school and be classified as an ATS user. This reliance on the "usual" mode of commuting may limit the findings of studies which do not account for this variability in commute mode and length (Lee et al., 2008).

Some researchers are beginning to account for this type of variation by designing assessment tools which allow students to report multiple modes of transport by day or by week, then using those data to build more complex models of the relationships between ATS and health. For example, Borrestad et al. (2013) reported the number of cycling and walking trips per week among their participants and classified students into a commuting mode only if more than half of their trips fell into one category. Asking for a "usual" method or the mode used on "most" days appears more often in earlier work (Baig et al., 2009; Metcalf et al., 2004) and larger studies (Fulton et al., 2005; Gordon-Larsen et al., 2005). Some recent studies, though, such as Ostergaard et al. (2012) still classify students based on "usual" travel mode. Discrepancies such as these can play a role in the inconsistent results regarding ATS and health benefits described above.

Distance between home and school

Another variable which may introduce uncertainty into studies of ATS is the distance between home and school. If a study does not collect data on the distance a student travels while using ATS, students who cycle three miles in each direction can be categorized in the same group as students who walk .5 mi round trip. This variability in duration and intensity may confound any dose-response relationship that is expected to appear for the health benefits of ATS. Studies which use pedometers or accelerometers can more precisely quantify the amount of PA students achieve during their commutes, but these instruments can be expensive and difficult to use with larger groups (Lee et al., 2008).

Researchers have addressed this by assessing the distance between home and school in several different ways. Some studies ask students or parents to report the distance between home and school (Martin & Carlson, 2005) or the time duration of the journey (Cooper et al., 2008; Santos et al., 2009). Other researchers collect home addresses for participants and use online tools to map the distance between residence and school for each student (Heelan et al., 2005), or use GIS to calculate distances (Heelan et al., 2013), but these methods may be cumbersome for large samples.

The National Center for Safe Routes to School (SRTS), which administers ATS surveys around the country, requests both distance from home and trip duration. Duration for the trips to school and from school is assessed separately since travel mode may vary at different times of day. In a recent study, the test-retest reliability for these items was high (kappa=0.77 for distance, kappa=0.76 for morning trip duration, kappa = 0.77 for afternoon trip duration), but the validity of these items was not tested (McDonald, Dwelley, Combs, Evenson, & Winters, 2011). Until a definitive standard for assessing distance from home to school emerges, the ability to generalize findings about ATS and health benefits across multiple studies will remain limited.

Cycling

Another measurement issue in the field concerns the treatment of students who cycle to school. Cyclists may be grouped as ‘active commuters’ with those who walk (Baig et al., 2009; Mota et al., 2007) or treated as a separate group (Bungum et al., 2009; Cooper et al., 2003), while other studies only consider students who walk (Saksvig et al., 2007). Researchers may not include cycling as a separate category because, especially in the U.S., rates of students who cycle to school are very low. McDonald (2007) reported that 0.8% of U.S. trips to school in 2001 were completed by bicycle. Since cycling may have a greater effect on PA and BMI than walking to school (Borrestad et al., 2013), considering these groups together may affect statistical analyses.

Another measurement issue related to cycling was reported in a recent small but interesting study of 78 5th graders in Norway. In this study, PA levels were assessed through multiple methods (questionnaire, accelerometer, and cycle computer) then validated. The researchers found that the accelerometers underestimated PA during cycling by as much as 1/20 when compared to cycle computers, although agreement between the cycle computers and self-reported PA was much higher (Borrestad et al., 2013). Since differences in PA level, weight status, and CRF appear to vary between walkers and cyclists (Chillon et al., 2012), underreporting of PA by accelerometers may be confusing the results of studies which use these instruments, which are typically considered more reliable than self-report and more comprehensive than pedometers.

Prevalence and correlates of ATS

With increasing evidence of a link between ATS and increased PA levels, and continuing investigation into its relationship with weight status and CRF, researchers have also begun to characterize those students who use ATS and those who do not. Studies of the prevalence and correlates of ATS use have been published from countries around the world, but due to differences in living standards, social norms, and built environment, studies from other countries may not reflect the habits of students in the U.S. (Tudor-Locke et al., 2001). For the purposes of clarity and brevity, this literature review will focus on studies of the prevalence and correlates of ATS among school children in the U.S.

In the early stages of ATS research, Fulton et al. (2005) performed a national telephone survey of 1,458 households with children in the U.S. The calls were made to a random sample which was weighted to reflected U.S. demographic characteristics. They reported a nationwide prevalence of ATS use of 14%. Walkers and cyclists were reported together. ATS use was more common among males (adj. OR=1.8) and younger students (adj. OR= 3.3 for grades 4-6, 1.8 for grades 7-9) when compared to high school students. Adjusted OR showed no significant variation in commuting patterns by race/ethnicity or parental level of education. Students who lived in suburbs (adj. OR = 2.4) were most likely to report ATS, and higher rates were observed in small city or town residents (adj. OR = 2.3) and city dwellers (adj. OR = 2.2). Students in single parent households were also more likely to use ATS (adj. OR = 4.3), perhaps out of necessity. No significant variation was detected by self-reported BMI of the parent or child.

Since distance from home to school has increased over the period that ATS use has decreased, Martin, Lee, and Lowry (2007) reported more specifically on ATS use among students who lived within one mile of their schools. They surveyed a large, nationally representative sample (*n*=7,433) and reported that 34.7% of students reported living within one mile of school, which they considered a reasonable radius for ATS use. The mean self-reported distance from home to school was 3.9 mi. Among the students living within one mile of school, they reported a prevalence of ATS use at least once per week of 47.9% and ATS use five days per week of 35.5%.

Among students who were possible active travelers (those living with one mile of school), the researchers noted different trends in ATS use. Active commuting to school was more common among 12-13 year olds (adj. OR = 1.45, 1.72) and lower in the South (adj. OR = 0.52, ref. Northeast) and all non-urban regions. Higher levels of parental education predicted less use of ATS even after adjustment, but household income did not. Students who were possible active travelers were less likely to participate in organized sports (adj. OR = 0.79) but more likely to have daily PE in schools (adj. OR = 1.45). In early evidence of the role of parents, children whose parents reported PA on ≥ 5 days in the previous week were more likely to use ATS (adj. OR = 1.31).

Surveys of local populations have reported rates of ATS ranging from 4.6% (Bungum et al., 2009) to 54% (Deweese, Yedidia, Tulloch, & Ohri-Vachaspati, 2013), but classification of ATS users varied, as did the studied populations. McDonald's work with the National Personal Travel Survey (NPTS), a nationally representative survey of household travel habits, analyzed trips instead of students and reported a national prevalence of ATS use of 12.9%, with 12.1% of active commuting trips performed by walkers and 0.8% by cyclists (2007). At this time, no published peer-reviewed studies have addressed ATS rates in Clark County or Nevada.

Role of gender

Studies of ATS from locations around the U.S. have reported a disparity in ATS rates between boys and girls (Babey, Hastert, Huang, & Brown, 2009; Evenson et al., 2003; Fulton et al., 2005; McDonald, 2007). Since striking differences have been reported between active commuting rates for adult males and females, this disparity was not surprising (McDonald, 2012). Possible explanations have ranged from personal hygiene concerns (Bungum et al., 2009) to different parenting norms for girls (Kerr et al., 2006. A recent study used NHTS trip data from 1977 to 2009 to analyze this gender difference and reported that gender differences in walk to school rates were actually negligible, with significant differences reported only in 1990. Cycling rates, however, varied widely with gender, with boys biking to school two to three times more often than girls over the decades studied (McDonald, 2012), which could account for differences observed in other studies.

Socio-economic status

Since childhood obesity and lack of PA is more common among children of lower SES, researchers have carefully investigated possible links between SES and ATS use. ATS has been inversely tied to measures such as household income (Babey et al., 2009; McDonald, 2007) and level of parental education (Evenson et al., 2003; Martin & Carlson, 2005; Zhu, Arch, & Lee, 2008; Zhu & Lee, 2009). Other researchers report that ATS is more common among children from single parent households (Fulton et al., 2005; Martin & Carlson, 2005) and students who report non-White race/ethnicity (Babey et al., 2009; Fulton et al., 2005; McDonald, 2007; Park, Noland, & Lachapelle, 2013; Zhu & Lee, 2009). However, in an analysis of over 14,000 trips from the NHTS, all variation by race/ethnicity was removed when the model controlled for household income, vehicle access, distance to school, and population density (McDonald, 2008b).

Built environment

As studies around the country have reported varying rates of ATS among students, researchers have looked to characteristics of the built environment to help explain why some families choose ATS and others do not. Built environment, or “the form and character of communities”, is composed of the “transportation systems, land use patterns, and urban design characteristics” (Frank et al., 2003) which make up our communities. When a student or family decides to use ATS, that decision may take into account factors such as distance from school, the presence or absence of sidewalks, trails, or other protected areas for walking and cycling, the presence of wide or high speed streets, lighting, population density, street connectivity, and other built environment factors which can make the trip to school seem more dangerous, less direct, too lengthy, or less desirable for other reasons. These factors may impact travel mode choice through objective decision making or perceived influence.

Many studies which have investigated ATS and built environment influences have reported that distance from schools is the single most powerful predictor of ATS in the U.S. When Falb, Kanny, Powell, and Giarrusso (2007) estimated the number of children who lived close enough to school to use ATS, they established <.5 mi as the boundary for elementary school students and 1 mi as the boundary for older students. Other studies rely on perceptions of distance, such as the national survey published by Martin and Carlson (2005), in which 61.5% of the respondents considered school too far away for ATS.

In reality, the distance between schools and most homes has been increasing over the past several decades, while the use of ATS has been declining. Factors contributing to this increasing distance include changes in land use, with schools being placed on the edges of communities where property is less valuable instead of in the center where ATS is more convenient (Frumkin et al., 2004). Educational policies have also begun to encourage larger schools with larger catchment areas instead of smaller neighborhood schools, resulting in an decrease in the number of schools in the U.S. from 1969 to 2001, even though the number of students increased (Martin & Carlson, 2005). Distance between home and school has also been affected by policies such as school choice and magnet school programs, which may increase commute distance beyond a practical length for ATS (Frumkin et al., 2004). Since perceived distance is the most powerful determinant of ATS use, the unintended consequences of policies such as these may have contributed to the nationwide decline in ATS.

Other built environment factors are frequently cited as correlates of ATS in the U.S. Greater population density, which may decrease both distance to school and the practicality of private car transportation, has been linked to ATS use among elementary school students (Braza, Shoemaker, & Seeley, 2004; Dalton et al., 2011) and older students (Deweese et al., 2013). Measures of street connectedness, such as the number of intersections per square mile, have also been associated with ATS (Braza et al., 2004; Bungum et al., 2009; Dalton et al., 2011), as have measures of urbanicity, which may represent similar development patterns (Babey et al., 2009; Fulton et al., 2005).

Role of parents

Since ATS is, by definition, used by children, the role of parents in travel mode choice is important and has been assessed in multiple studies. Parents often cite schedule constraints or convenience as motivators for trips by car instead of ATS (Faulkner, Buliung, Flora, & Fusco, 2009; McDonald & Alborg, 2009; Stewart, Moudon, & Claybrooke, 2012). One study of 8,231 home-to-school trips among children aged 5-18 found that younger children (ages 5-14) with mothers who commuted to work in the morning were less than half as likely (OR = 0.42) to use ATS than children whose mothers were not commuting at that time. This effect attenuated with age, perhaps with increased independent driving or other independent travel. No significant effect was observed for fathers' commuting patterns (McDonald, 2008c). Since over half of parents driving their children short distances to school reported that they would not allow their child to walk to school without an adult escort (McDonald & Alborg, 2009), it is important to recognize that the trip to school then back home would take twice as long for the adult escort. This may increase the perception that ATS is inconvenient and drive down ATS rates for what appears to be a short one-way trip.

Another barrier to ATS commonly cited by parents is fear, either of traffic or of crime. One study of 259 randomly selected parents in King County, WA found that parental concerns about safety were more influential than any built environment factor in predicting ATS use. Children whose parents had few safety concerns were five times more likely to use ATS (OR = 5.2) (Kerr et al., 2006). Since parental fears can be a motivator for requiring an adult escort, concerns about safety can make ATS seem more inconvenient for the responsible adult (McDonald, 2008c). Ironically increased ATS rates may both lower danger from traffic (Dimaggio & Li, 2013) and perceptions of other dangers by increasing the number of people walking and cycling (McDonald, Yang, Abbott, & Bullock, 2013), so barring children from using ATS may reinforce these very same parental fears.

Legislation and policy

The interest in ATS and its benefits for children's health and PA in the research community has been accompanied by efforts to promote active commuting to school in practice through legislation and policy work. The largest movement in support of ATS in the U.S. is called Safe Routes to School (SRTS). The origins of this program are traced to Denmark in the 1970s. The first SRTS efforts in the U.S. occurred in the 1990s in New York, California, and Massachusetts. Programs are now active in all 50 states and the District of Columbia. The national SRTS effort has traditionally been funded through national transportation bills (SAFETEA-LU and MAP-21), and to date has distributed over $1 billion to fund projects at over 15,000 schools (Boarnet, Day, Anderson, McMillan, & Alfonzo, 2005).

SRTS programs are organized around principles called the 5 'E's – Education, Enforcement, Encouragement, Engineering, and Evaluation (National Center for Safe Routes to School, n.d.). Recent discussions from the National Center have included discussions of a "6th E", or equity in the distribution of resources. In communities with funded projects, the National Center distributes a survey regarding ATS practices and perceptions, which has been tested for reliability and validity, to assess community characteristics and needs (McDonald et al., 2011). Projects funded by SRTS monies can be as simple as an encouragement program distributing token incentives or as complex and permanent as building a pedestrian bridge over a dangerous intersection (McDonald et al., 2013).

Although the National Center suggests that each project include an evaluation component, most evaluations are not rigorous. In two cities with active and well-funded SRTS programs, research teams have performed comprehensive evaluations. An early evaluation of SRTS efforts in Marin County, CA considered the effect of traffic improvements, including the installation of traffic signals, sidewalks, crosswalks, and paths, with a multiple case study design. Measures included the SRTS survey of attitudes and behaviors, as well as observations of pedestrian, bicycle, and automobile traffic at each of 10 participating school sites. The evaluators considered projects which closed gaps in sidewalks and improved traffic signals from four-way stops to traffic sign as successful, with observed increases in ATS rates at these sites. Improvements which did not appear to impact ATS rates in Marin County communities included crosswalk improvements, crosswalk signaling, and the installation of designated bike lanes. The researchers noted that some effects of these engineering improvements would be better assessed over a longer time frame (Boarnet et al., 2005).

A more recent SRTS evaluation was conducted in Eugene, Oregon. Using a quasi-experimental design, the researchers compared walking and cycling rates at 14 schools, nine SRTS communities and five controls, between 2007 and 2011. This study was the first to compare SRTS program schools with control schools. ATS rates were assessed through the National Center's survey and a contemporaneous classroom tally, where teachers record daily travel mode by a show of hands in the classroom. The researchers reported that schools which implemented education- and encouragement-based SRTS programming observed a five percentage point increase in cycling rates compared to control schools. If the SRTS program included engineering improvements, walking and cycling rates increased 5 to 20 percentage points. This more rigorous evaluation highlights the potential for SRTS projects to increase ATS, but also suggests that more costly engineering projects may provide more benefit than education and encouragement programs (McDonald et al., 2013).

Walking school bus

One intervention which may be implemented as part of a SRTS program is a walking school bus (WSB). A WSB is a strategy to increase ATS where a group of students walk to school along a fixed route with adult supervision. This intervention can simultaneously address two barriers to ATS commonly cited by parents – inconvenience and safety fears. A WSB allows children to use ATS with an adult escort but without inconveniencing parents or requiring them to walk both ways. Different versions of a WSB intervention involve using trained adult volunteers or paid staff if funding is available.

The WSB is a recent addition to SRTS projects, and most evaluations are quasi-experimental at best (Heelan, Abbey, Donnelly, Mayo, & Welk, 2009; Kong et al., 2009). An early qualitative study from New Zealand reported social benefits to both children and adults who accompanied the WSB (Kingham & Ussher, 2007). Kong et al. (2009)

offer ‘lessons learned’ from implementation in their process evaluation. Sirard, Alhassan, Spencer, and Robinson (2008) analyzed a small, short term pilot study of a WSB program (*n*=12) and found that study participants increased their daily MVPA by 14 minutes ($p \leq 0.02$).

In a more recent study from Texas, researchers randomly assigned eight schools to experimental and control groups, with four experimental schools receiving a WSB intervention for 4th graders only. Participating students were required to live within one mile of their school, unless their parents were willing to bring them to a designated WSB “stop”. Several routes were established for each school, and students were accompanied by study staff members who had received safety training. The WSB was available each school day for five weeks, although children were not required to use it every day. The researchers reported that ATS rates at the study schools increased from 23.8% to 54% while control schools decreased ($p<0.0001$), and children involved in the intervention increased their daily MVPA 46.6 minutes to 48.8 while control schools decreased ($p=0.029$) (Mendoza et al., 2011).

A recent survey of a nationally representative sample of U.S. elementary schools found that 6.2% of schools reported having a WSB in 2009-10, an increase over 4.2% in 2008-9. WSB programs were more common in districts with SRTS policies (OR = 2.72), supporting a role for district-level policy concerning safe ATS (Turner, Chriqui, & Chaloupka, 2013). The National Center also promotes a similar intervention for cyclists called a ‘bike train’, but at this time, no peer-reviewed studies have assessed this type of intervention.

Other interventions

ATS interventions are not widely reported in the peer-reviewed literature. Several studies have provided process evaluations of community-wide active travel programs including ATS components (TenBrink, McMunn, & Panken, 2009; Thomas, Sayers, Godon, & Reilly, 2009). Merom, Rissel, Mahmic, and Bauman (2005) provided a process evaluation for an annual walk-to-school day but did not report changes in ATS rates.

A project with a sustainability focus in Scotland encouraged children to use ATS for environmental reasons and increased the mean distance travelled by active commuters at the intervention school from 198 m to 772 m while decreasing mean car trip length from 2018 m to 933 m. Health indicators were not assessed (McKee, Mutrie, Crawford, & Green, 2007). Rowland, DiGuiseppi, Gross, Afolabi, and Roberts (2003) reported on the effect of school travel coordinators, a practice more common in the U.K. which was intended to allay parental fears about safety during the school commute. School travel coordinators assisted students and families with creating travel plans at eleven intervention schools. Analysis indicated that students at the experimental schools created more travel plans but were no more likely to use ATS than students at the control schools.

SRTS and ATS in Clark County

To my knowledge, no studies of ATS in Clark County or in Nevada appear in the peer-reviewed literature at this time. The sprawling, auto-centric nature of the built environment in Clark County suggests that the prevalence and correlates of ATS would be different than in older, more established or more pedestrian-friendly locations where ATS has previously been studied. Without data on the current state of ATS in Clark County, it is difficult to draw conclusions about its prevalence or the need for interventions.

Conclusion

ATS has emerged in the past decade as an opportunity to increase PA among children. Although associations between ATS use and BMI are not yet clear, students using ATS are regularly reporting significantly higher levels of MVPA than their peers who use passive commuting modes. The prevalence and correlates of ATS use vary widely around the U.S., although distance from school is the most powerful influence. Few interventions have been reported in the peer-reviewed literature, but WSB programs do show promise for increasing ATS. With more data on the ATS habits of Clark County youth, interventions to improve ATS rates and increase PA can be provided for target populations.

Chapter 3 – Methods

Introduction

The primary goal of this study was to determine which characteristics predict the use of ATS in elementary and middle school students in Las Vegas, NV. The aim is to develop a predictive model for ATS which would be specifically applicable to this population, since ATS habits vary widely in different areas of the country. Several characteristics which are commonly cited in the literature were hypothesized to influence ATS in Las Vegas. Those characteristics are distance from school, male gender, parental level of education, and increasing age. Other characteristics which were hypothesized to affect ATS behaviors but are not commonly investigated include level of acculturation, child's desire to use ATS, and the number of school-aged children in the family. Additionally, it was hypothesized that characteristics influencing ATS would differ between elementary and middle school students. To investigate the relationship between ATS use and these variables, data collected from 13 Clark County School District (CCSD) elementary and 4 middle schools from a survey of parents were used. Logistic regression models were developed to determine if these characteristics predicted the use of ATS by students.

Research question: Which characteristics predict the use of active transportation to school in Las Vegas, NV elementary and middle school students?

H1: Characteristics associated with socio-economic status will predict the use of ATS.

P1: Lower levels of parental level of education will predict the use of ATS.

P2: Lower levels of acculturation will predict the use of ATS.

H2: Demographic characteristics will predict the use of ATS.

P1: Lower grade level will predict the use of ATS.

P2: Male gender will predict the use of ATS.

P3: Increasing numbers of children in elementary and middle school will predict the use of ATS.

P4: Shorter distance from school will predict the use of ATS.

P5. More students will use ATS on the PM trip than the AM trip.

H3: Age, gender, and distance from school will be associated with the use of cycling among students who use ATS.

P1: Higher grade level will be associated with the use of cycling for ATS.

P2: Male gender will be associated with the use of cycling for ATS.

P3: Greater distance from school will be associated with the use of cycling for ATS.

H4: Perceptions and attitudes about ATS will predict the use of ATS.

P1: A child's request to use ATS will predict the use of ATS.

P2: Belief that the school encourages ATS will predict the use of ATS.

P3: Belief that ATS is enjoyable for children will predict the use of ATS.

P4: Belief that ATS is healthy for children will predict the use of ATS.

H5: Factors associated with the use of ATS will differ between elementary and middle school students.

P1: Middle school students will use ATS to commute from longer distances.

P2: Commuting by cycling will be more common among middle school students than among elementary school students.

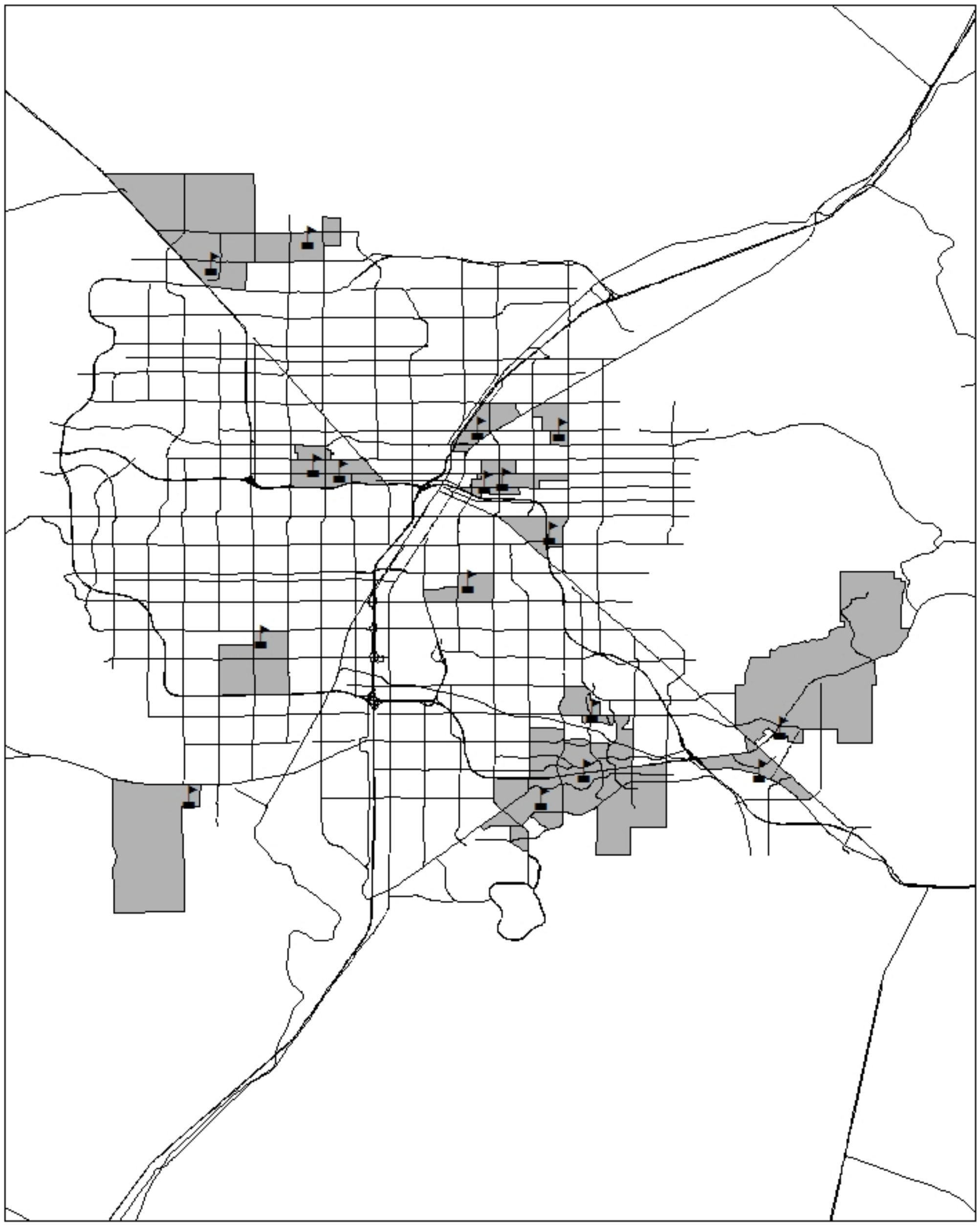
P3: More middle school students will ask for permission to use ATS within the year.

Participating schools

CCSD is the fifth largest school district in the U.S. It contains over 200 elementary schools and over 50 middle schools. At the beginning of each year, schools are invited by the school district's School-Community Partnership office to participate in the Safe Routes to School program. Those schools which choose to participate are given access to planning workshops with local experts. These workshops include representatives from city planning offices, law enforcement, UNLV, and the Regional Transportation Commission (RTC). Some small incentives are typically distributed at the workshops, such as key chains, pencils, or child-sized helmets.

All CCSD schools have equal opportunity to participate, unless they have attended a SRTS workshop in the past two years, in which case schools which have never attended are given priority for available spots (S. Moore, personal communication, October 16, 2013). Schools may choose to attend because of concerns about PA or traffic safety, but these reasons are not collected or reported. In the fall of 2013, representatives from 13 elementary schools and 4 middle schools attended SRTS workshops, representing a total student population of 15,385 students. High schools were not invited to attend because they are not covered by the SRTS program.

Fig. 1. Map of locations of participating schools



SRTS Survey

Schools which elect to participate in the SRTS workshops are asked to distribute the SRTS Parent Survey to their school populations. The survey is sent home in English and Spanish with each student. If a parent or caregiver has more than one child attending the school, he or she is asked to complete it only for the child with the next birthday from the date it is received. Surveys are returned to the school administration, then forwarded to the School-Community Partnership Office.

The SRTS survey was developed by the National Center for Safe Routes to School and is administered throughout the U.S. since 2008. As of 2013, over 525,000 surveys have been collected by the National Center (Nicholas, 2013). It is available in English and Spanish. CCSD schools have been collecting survey data since 2008, but this study is based on a subset of over 2,000 surveys from those schools which participated in the SRTS workshops in 2013. The survey is sent home in both English and Spanish, and the parent or caregiver selects which survey to complete. The survey does not collect identifying information. It was designed to be completed within five to ten minutes and states that responses will remain anonymous. The 50-item survey requests information on child's grade level, gender, parental education, and family size, as well as the home's nearest cross streets. It also requests the distance to school in quarter- to half-mile increments and information on the usual commuting method separately for the AM and PM trips.

The survey assesses perceived barriers to the use of ATS and scores school encouragement of ATS, enjoyment of ATS, and perceived health benefits of ATS on 5-

point Likert scales. It concludes with an open-ended item for comments. See Appendix A for the complete survey.

This survey was assessed for reliability and validity by McDonald et al. (2011). Reliability and validity were assessed for a sample of 262 surveys from parents or caregivers of elementary school students from two different schools in North Carolina. To calculate test-retest reliability, matched pairs of surveys over a two week period were obtained from 112 parents. Kappa coefficients for demographic data were substantial to almost perfect (0.65 – 0.85), according to the cutpoints established by Viera and Garrett (2005).

Scores for the Likert scale items regarding school-based encouragement, enjoyment, and health benefits of ATS were moderate to substantial (kappa = 0.47 to 0.61). For items regarding AM/PM commute method and duration, kappa coefficients were substantial to almost perfect (0.76 – 0.97). The authors noted some confusion between the “family vehicle” and “carpool” choices for travel mode. These items will be combined into one category, “Car”, for this analysis.

Previous research has noted reliability issues with the barriers section of the survey (McDonald et al., 2011). This section of the survey is the only portion which collects information on modifiable factors. In an effort to extract consistent data from this section, Question 10 (“What of the following issues affected your decision to allow, or not allow, your child to walk or bike to/from school? (Select ALL that apply.)”) was not analyzed. This question asked respondents to mark twelve constructs which could support or deter ATS, such as sidewalks and crossing guards, but it does not allow them to indicate whether the construct was a positive or negative influence. That is, it does not distinguish between the presence or absence of sidewalks and crossing guards while collecting this data.

The next question, Question 11, refers to the same list of twelve potential barriers and supports but with a different prompt – “Would you probably let your child walk or bike to school if this problem were changed or improved?” This phrasing more clearly indicates that the respondent considers the construct a barrier to be “improved”. For each of the twelve constructs, the respondent may choose “Yes”, “No”, or “Not Sure”. In an effort to best capture the group of participants who might be willing to consider ATS if the barrier was addressed, new dichotomous variables were created to represent only those respondents who marked “Yes” for these constructs. These new dichotomous variables represent the only information from the barriers section which was included in the analysis.

Statistical approach

This study uses the data from 2,054 surveys completed by parents at the 17 schools which participated in the CCSD Safe Routes to School Workshop in 2013. The surveys yielded 25 variables including demographic information, ATS habits, and attitudes and beliefs about ATS. Throughout the study, cases with missing data were excluded from the analysis.

The proportion of students who reported the use of ATS as their usual mode of transport was calculated and analyzed in several different ways. One categorical variable was created to represent students who reported using ATS, i.e. walking, biking, or other (scooter, skateboard, etc.) or choices 1, 2, or 7 from the survey (see Appendix A), for both morning and afternoon commutes on most days (All_ATS). Another more general categorical variable (Some_ATS) was created to represent those students who used ATS (choices 1, 2, or 7) for either the morning or afternoon commute, or for both, capturing a wider range of ATS users. Throughout the statistical analysis, models were created for both the more restrictive and the more general variables and will be clearly reported as such. Since cycling is an emerging area of interest, an additional categorical variable was created to represent those students who cycled to and/or from school.

Correlations between demographic characteristics, attitudes about ATS, socio-economic status, and the use of ATS were determined for both ATS levels (Some and All). Independent continuous variables with a significant ($p<.05$) correlation to either ATS variable were tested for a linear relationship with the logit of dependent variable with the Box-Tidwell method of including the variable and an interaction term (predictor * Ln(predictor)) in a logistic regression model. If the results of the Box-Tidwell test were significant, the variable was transformed by squaring and the Box-Tidwell test was repeated to verify that the variable met the assumptions of logistic regression (Kutner, Nachtshelm, Neter, & Li, 2005).

After creating separate logistic regression models for each independent variable and both outcome variables, the variables were entered into a multiple logistic regression model for each outcome variable to assess their predictive role for use of ATS (both Some and All). Several variables, including distance, cycling, and asking permission to use ATS, were assessed for differences between elementary and middle school students using t-tests and χ^2 tests as appropriate.

Data analyses were conducted using IBM SPSS version 22, except for the construction of logistic regression models. Since logistic regression assumes that the studied data are gathered from a random sample, the use of this technique is not appropriate for survey data. Instead logistic regression models were constructed using the SURVEYLOGISTIC procedure in SAS 9.2. This procedure produced more accurate standard errors for this survey-based dataset than comparable procedures which do not account for non-random samples in logistic regression (An, 2002). Results were weighted by grade based on 2013 enrollment numbers for K-8 in Clark County School District (S. Moore, personal communication, 2/21/2014) (Table 1.)

Table 1

2013 enrollment totals for Clark County School District, Clark County, NV, Grades K-8.

Grade level	Total enrollment	Surveys returned
K	24,464	191
1	24,830	221
2	24,041	291
3	23,553	284
4	23,564	279
5	23,750	243
6	24,009	264
7	24,046	49
8	23,836	168

Missing values

Missing values were analyzed for patterns with Little's MCAR test. Results of this test were not significant (p=.484). The highest percentage of missing data for a variable was 2.3%, for the variable indicating number of K-8 children in the family. Since the missing data were randomly distributed, the highest percentage of missing data was below 5%, and the sample size is large, listwise deletion was used, and only complete cases were included in the logistic regression analyses (Field, 2009).

Chapter 4 - Results

Response rate

The National Center for Safe Routes to School's Parent Survey About Walking and Biking to School (Appendix A) was distributed in English and Spanish to all of the students at 17 Clark County schools, 13 elementary and 4 middle schools, by school administrators. Schools distributed 15,385 surveys in the fall of 2013 which were brought home by students to their parents or guardians. Some then selected a language version and completed the survey. The students then returned the surveys to the schools, which, in turn, forwarded them to the SRTS program office. Overall response rate for the survey was 13.46%, with 2,054 surveys returned. Response rates per school varied from 6.60% to 36.83% (Table 2.)

Table 2

Response rates for Safe Routes to School survey at participating schools in Clark County, NV, 2013

School ID	Surveys returned	Total enrollment	Return rate
Middle schools			
1	81	1,227	6.60%
2	144	1,369	10.52%
11	127	1,688	7.52%
13	136	1,500	9.07%
Elementary schools			
3	54	784	6.89%
4	81	918	8.82%
5	133	691	19.25%
6	49	652	7.52%
7	314	1,188	26.43%
8	123	708	17.37%
9	129	554	23.29%
10	91	703	12.94%
12	71	711	9.99%
14	56	602	9.30%
15	58	765	7.58%
16	154	638	24.14%
17	253	687	36.83%
Total	2,054	15,385	13.35%

Demographic characteristics

The demographic characteristics of the sample are presented in Table 3. More surveys were returned by elementary school students, so the logistic regression models presented below were weighted by grade level. One participating school had a preschool program, and 26 surveys were completed by the parents of preschool children. Because this study examines the predictors of ATS in elementary and middle school children, those surveys were excluded from further analyses. Females were slightly overrepresented in the samples (54.9%). Some respondents indicated that they had no children in grades K-8 (*n*=45). However, participants would only have received a survey if they had a child or a ward enrolled in a SRTS school. Those surveys may have been completed by guardians who literally interpreted the question, "How many children do you have in Kindergarten through 8th grade?" as referring to only biological children, so they were kept in the analysis.

Table 3

Demographic characteristics of SRTS survey respondents in Clark County, NV in 2013

Characteristic		*n*	%
Grade			
	PK	26	1.3
	K	191	9.3
	1	222	10.8
	2	291	14.2
	3	284	13.8
	4	279	13.6
	5	243	11.8
	6	264	12.9
	7	49	2.4
	8	168	8.2
	Missing	37	1.8
Student Gender			
	M	904	44.0
	F	1,128	54.9
	Missing	22	1.1
Number of children in grades K-8 (as reported by parents)			
	0	45	2.2
	1	778	37.9
	2	793	38.6
	3	269	13.1
	4	70	3.4
	5+	22	1.1
	Missing	77	3.7

Socio-economic characteristics

Characteristics of the sample associated with SES are presented in Table 4. Surveys in Spanish were returned by 18.2% of the respondents. This rate is similar to the rate of English Language Learner (ELL) students reported by CCSD for 2013 of 16.5% (Clark County School District, 2013). Levels of education reported by the respondents were low compared to general statistics for Clark County (U.S. Census Bureau, 2012), with 18.7% indicating that they had not completed high school or obtained a GED. Almost 6% of the sample indicated that they preferred not to answer this question.

Table 4

Characteristics related to SES of SRTS survey respondents in Clark County, NV in 2013

Characteristic	*n*	%	Clark County % (25+ yrs)
Language			
English	1680	81.8	
Spanish	373	18.2	
Parent's level of education			
Grades 1-8	222	10.8	6.2
Grades 9-11	163	7.9	9.2
Grade 12 or GED	342	16.7	29.7
College 1-3 yrs	544	26.5	32.8
College 4+ yrs	547	26.6	22.1
Prefer not to answer	121	5.9	
Missing	88	4.3	
Multiple	27	1.3	

Distance from school

Table 5 presents the self-reported distance from school score for the entire sample and also for those respondents who indicated that they used ATS for either the morning or afternoon trip or both (Some ATS). Distance was reported as one of five incremental choices on an ordinal scale, with a sixth choice for "Don't know". Chi-square analysis of the distance responses indicates that they differ for students who use some ATS and those who do not (χ^2 (5, N = 1,995) = 340.637, p <.001), with more students who use some ATS reporting shorter distances to school. Slightly more than half (51.53%) of respondents live within 1 mile of school.

Table 5

Self-reported distance from school by travel mode and school level among SRTS survey respondents in Clark County, NV in 2013

Mode	All respondents (*n*=1995)		ATS users (Some) (*n*=558)	
	n	%	*n*	%
Less than ¼ mile	377	18.90	218	39.07
¼ mile to ½ mile	233	11.68	89	15.95
½ mile to 1 mile	418	20.95	118	21.15
1 mile to 2 miles	461	23.11	54	9.68
More than 2 miles	347	17.39	17	3.05
Don't know	159	7.97	62	11.11
	Elementary (*n*=1995)		Middle school (*n*=1995)	
Any ATS users	*n*	Mean (SE)	*n*	Mean (SE)
Mean distance score[a]	399	2.03 (0.057)	97	2.47 (0.131)
All ATS users				
Mean distance score[a]	298	1.97 (0.066)	61	2.43 (0.173)

[a]Differences significant at p<.05.

Travel mode

Travel mode choice for the respondents for arrival at and departure from school as reported for "most days" is presented in Table 6. For both the arrival and departure trips, transportation by private family car was the most commonly reported mode. Use of public transit and "other" methods of ATS, such as scooters and skateboards, were reported infrequently (0% for arrival and 0.4% for departure for transit and 0.6% for arrival and 0.5% for departure for "other" ATS). When the ATS rates for the arrival and departure trips were compared using chi-square analysis, these rates (22.25% for arrival, 25.66% for departure) were significantly different (χ^2 (1, N = 2,054) = 325.055, p <.001).

Table 6

Travel mode choice for arrival at and departure from school among SRTS survey respondents in Clark County, NV in 2013

Mode	Arrive		Depart	
	n	%	*n*	%
Walk	395	19.2	465	22.6
Bike	50	2.4	52	2.5
School bus	259	12.6	269	13.1
Family vehicle	1111	54.1	924	45.0
Carpool	93	4.5	96	4.7
Transit	0	0	8	0.4
Other (skateboard, scooter, inline skates, etc.)	12	0.6	10	0.5
Missing	17	0.8	92	4.5
Multiple	117	5.7	138	6.7
Active commuters	457	22.25	527	25.66

Gender

Table 7 presents responses for survey questions 8 and 9 ("Has your child asked you for permission to walk or bike to/from school in the past year?" and "At what age would you allow your child to walk or bike to/from school without an adult?") by gender, as well as several measures of ATS use and cycling by gender. There was no variation by gender in rates of ATS for the arrival trip or the departure trip, nor for those students reporting some ATS on most days or all ATS on most days. The only measure of ATS which shows significant variation by gender in this sample is the gender distribution of students who cycle to and/or from school (p <.001).

Some evidence of gender differences does appear for the grade at which parents allow independent use of ATS (mean=5.24 for males and mean=5.71 for females, p <.001) and in the percentage of parents who would not be comfortable allowing independent use of ATS at any age (59.39% of parents of female children and 39.62% of parents of male children, p <.001). Parents of male children also reported more frequently (47.01% for males, 42.55% for females) that their child had requested permission to use ATS within the past year (p <.001).

Table 7

Request for permission to use ATS, acceptable grade for independent ATS, and selected ATS rates by gender among SRTS survey respondents in Clark County, NV in 2013

Characteristic	Female		Male		Results for test for significance for variation by gender
	n	%	*n*	%	
Has requested permission to use ATS within the past year	480	42.55	425	47.01	χ^2 (6, N = 2,054) = 26.185, *p*<.001
	Mean	(SE)	Mean	(SE)	
Acceptable grade for independent ATS use	5.71	0.098	5.24	0.094	t(899)=-3.511, *p* <.001
	n	%	*n*	%	
Not comfortable with independent ATS at any age	601	59.39	401	39.62	χ^2 (2, N = 2,054) = 16.111, *p* <.001
AM ATS	232	50.77	221	48.36	χ^2 (2, N = 1,920) = 5.317, *p* =.070
PM ATS	275	52.18	249	47.25	χ^2 (2, N = 1,824) = 3.977, *p* =.137
Some ATS (either trip, most days)	297	51.74	273	47.56	χ^2 (2, N = 2,054) = 4.784, *p* =.091
All ATS (both trips, most days)	210	51.22	197	48.05	χ^2 (2, N = 1,808) = 4.464, *p* =.107
Cycling	15	27.27	39	70.90	χ^2 (2, N = 2,054) = 17.449, *p* <.001

Barriers

As discussed above, the barriers section of the SRTS survey has been problematic in earlier studies. In order to extract information of value, the analysis of this section was limited to respondents who indicated that they would probably allow their child to walk or bike to school if a particular barrier were changed or improved. Since several of these barriers, such as crossing guards and sidewalks, are related to the environment surrounding the school, chi-square analysis was used to test the reporting of barriers for variation by school (Table 8).

Table 8

Reported barriers to the use of ATS and variation among schools among respondents among SRTS survey respondents in Clark County, NV in 2013

Barrier	Times cited *n*	Times cited %	Min % (by school)	Max % (by school)	χ^2 test for variation among schools
Distance	598	29.1	14.3	52.2	χ^2 (16, N = 2,054) = 78.182, *p* <.001
Convenience of driving	280	13.6	8.2	23.9	χ^2 (16, N = 2,054) = 20.938, *p* =.181
Time	400	19.5	4.1	28.2	χ^2 (16, N = 2,054) = 32.770, *p* =.008
Child's before or after school activities	278	13.5	8.2	20.6	χ^2 (16, N = 2,054) = 18.868, *p* =.276
Speed of traffic along route	548	26.7	11.1	37.5	χ^2 (16, N = 2,054) = 48.773, *p* <.001
Amount of traffic along route	529	25.8	10.4	36.0	χ^2 (16, N = 2,054) = 54.854, *p* <.001
Adults to walk or bike with	441	21.5	7.6	29.6	χ^2 (16, N = 2,054) =43.166, *p* <.001
Sidewalks or pathways	408	19.9	8.6	26.8	χ^2 (16, N = 2,054) = 31.968, *p* =.010
Safety of intersections and crossings	662	32.2	20.1	41.2	χ^2 (16, N = 2,054) = 29.279, *p* =.022
Crossing guards	450	21.9	12.5	29.4	χ^2 (16, N = 2,054) = 27.415, *p* =.037
Violence or crime	526	25.6	16.3	39.0	χ^2 (16, N = 2,054) = 33.278, *p* =.007
Weather or climate	438	21.3	12.2	31.5	χ^2 (16, N = 2,054) = 20.355, *p* =.205

Several barriers appeared to have similar levels of importance across the 17 school populations. The role of weather, the convenience of driving, and the impact of children's before and after school activities did not vary by school site. The rate at which parents cited characteristics related to the built environment, such as the speed and amount of traffic along the commute route, the safety of intersections and crossings, and the role of sidewalks and pathways, did vary among schools. Since the participating schools were located in different types of neighborhoods, this variation is consistent with those characteristics varying by area. The most frequently cited barrier was safety of intersections and crossing (32.2%). Other commonly cited built environment barriers were distance (29.1%), the speed of traffic along the commute route (26.7%), and the safety of intersections and crossings (32.2%).

Likert scales

Several questions on the survey address attitudes and perceptions about ATS using 5-item Likert scales. These items asked whether the respondent believes that the child's school encourages the use of ATS, whether ATS is enjoyable for children, and whether ATS is healthy for children (Questions 12, 13, and 14). For all three questions, the most positive answer is the lowest number (1) and the most negative is the highest number (5). The distributions of these responses did not meet standards of normality for parametric means testing, so the responses of those who used ATS and those who did not were compared using the Mann-Whitney U test (Table 9).

Table 9

Mean scores for ATS attitude and perception scales by various measures of ATS among SRTS survey respondents in Clark County, NV in 2013

Scale	Mean score (SE)		Mann Whitney U results
	Passive commuters	Active commuters	
<u>Some ATS</u>			
School encourages ATS	2.46 (0.022)	2.28 (0.036)	U=322875.5, *p* <.001
Enjoyable	2.52 (0.043)	2.26 (0.043)	U=308787.5, *p* <.001
Healthy	1.74 (0.030)	1.63 (0.021)	U=353503.0, *p* =.001
<u>Cycling</u>			
School encourages ATS	2.41 (0.019)	2.46 (0.097)	U=46194.5, *p* =.538
Enjoyable	2.47 (0.022)	1.81 (0.109)	U=30859.5, *p* <.001
Healthy	1.71 (0.018)	1.44 (0.073)	U=41859.5, *p* =.018

The Likert scales scores for the group of students who used ATS for most trips for arrival and/or departure were lower than the scores of their peers who used passive transport for all three scales, indicated a stronger belief that the school encouraged the use of ATS, that ATS is enjoyable for children, and that ATS is healthy for children among ATS users. When the scores of parents whose children cycled to school were compared those who did not, there was no difference in the school support score, but the active commuters' parents reported more favorable attitudes about the enjoyment and health benefits of ATS.

Cycling

Because of the emerging relationship between cycling to school and fitness, relationships between cycling and selected demographic factors among students who use ATS were also explored. Cycling was defined as a response of "Bike" as the travel mode for "most days" for either the morning or afternoon commute or for both. Table 10 presents the correlations between cycling and age, gender, and distance from school with both ATS variables, some ATS and all ATS.

Table 10

Correlations between cycling and selected demographic factors of students who use ATS among SRTS survey respondents in Clark County, NV in 2013

Independent variable	Valid N	Pearson's R	Significance
Some ATS			
Grade	489	.128	*p* =.005
Male gender	494	.155	*p* =.001
Distance	496	.210	*p* <.001
All ATS			
Grade	354	.169	*p* =.001
Male gender	357	.142	*p* =.007
Distance	359	.246	*p* <.001

Logistic regression models

In order to construct logistic regression models which predict the use of ATS among students in Clark County, the independent variables developed from the survey were analyzed for correlation with both dependent variables, for Some and All ATS. If the correlations were significant, the variables were tested for linearity with the logit of the outcome variable to meet the assumptions of logistic regression. Those variables which did not meet the assumption of linearity were transformed by squaring and retested. Variables with significant correlations and a linear relationship with the logit of the outcome variable were next entered into simple and multivariate logistic regression models for survey data to find unadjusted and adjusted odds ratios for ATS use.

Correlations

Correlations between the independent variables and the use of ATS for the morning and/or afternoon trips on most days (Some ATS) are reported in Table 11.

Table 11

Correlations between selected characteristics and the use of ATS for morning and/or afternoon commute among SRTS survey respondents in Clark County, NV in 2013

Independent variable	Valid N	Pearson's R	Significance
Language	2,054	.148	p <.001
Parent's level of education	1,939	-.151	p <.001
Grade	1,900	.037	p =.100
Male gender	2,032	.043	p =.054
Number of children in family in K-8	1,932	.085	p <.001
Distance	1,995	-.310	p <.001
Asked for permission to use ATS within the year	1,969	.211	p <.001
Barriers (number cited)	2,054	-.103	p <.001
School encouragement (Likert score)	1,915	-.094	p <.001
ATS is enjoyable (Likert score)	1,914	-.126	p <.001
ATS is healthy (Likert score)	1,927	-.066	p =.004

Based on the significance of the correlation, the variables in Table 11 were tested for the assumptions of logistic regression on the dependent variable, some use of ATS on most days, except for Grade and Gender, which were not correlated with ATS use.

Correlations between the independent variables and the use of ATS for both the morning and afternoon trips on most days (All ATS) are reported in Table 12.

Table 12

Correlations between selected characteristics and the use of ATS for both the morning and the afternoon commute among SRTS survey respondents in Clark County, NV in 2013

Independent variable	Valid N	Pearson's R	Significance
Language	2,054	.161	*p* <.001
Parent's level of education	1,939	-.139	*p* <.001
Grade	1,900	-.004	*p* =.854
Male gender	1,799	.046	*p* =.049
Number of children in family in K-8	1,716	.085	*p* <.001
Distance	1,769	-.320	*p* <.001
Asked for permission to use ATS within the year	1,747	.187	*p* <.001
Barriers (number cited)	2,054	-.110	*p* <.001
School encouragement (Likert score)	1,701	-.115	*p* <.001
ATS is enjoyable (Likert score)	1,914	-.165	*p* <.001
ATS is healthy (Likert score)	1,927	-.082	*p* =.004

Based on the significance of the correlation, the variables in Table 13 were tested for the assumptions of logistic regression on the dependent variable, use of ATS for both trips on most days, except for Grade, which was not correlated with ATS use.

Linearity testing

For both models, continuous variables with significant correlations to the outcome variables were tested for linearity with the logit of the outcome variable with the Box Tidwell test, performed by entering the variable and an interaction term of the variable and its natural logarithm in a logistic regression model. Significant results for the interaction term indicate a non-linear relationship, which requires transformation of the variable. Variables were transformed by squaring as necessary, and then tested again. Logistic regressions were completed using the SURVEYLOGISTIC procedure in SAS for survey data. Results are presented in Table 13 for some ATS use and Table 14 for all ATS use.

Table 13

Results for linearity testing for variables correlated with any ATS use among SRTS survey respondents in Clark County, NV in 2013

Variable	Test	Results for interaction term		
		Wald statistic	Df	Sig.
Language	Categorical – not tested			
Parent's level of education	Box Tidwell	0.001	1	*p* =.992
Number of children in family in K-8	Box Tidwell	0.580	1	*p* =.446
Distance	Box Tidwell	2.961	1	*p* =.085
Asked for permission to use ATS within the year	Categorical – not tested			
Barriers (number cited)	Box Tidwell	0.199	1	*p* =.656
School encouragement (Likert score)	Box Tidwell	0.112	1	*p* =.737
ATS is enjoyable (Likert score)	Box Tidwell	1.606	1	*p* =.205
ATS is healthy (Likert score)	Box Tidwell	3.375	1	*p* =.066

Table 14

Results for linearity testing for variables correlated with all ATS use among SRTS survey respondents in Clark County, NV in 2013

Variable	Test	Results for interaction term		
		Wald statistic	Df	Sig.
Language	Categorical – not tested			
Parent's level of education	Box Tidwell	1.000	1	p =.317
Number of children in family in K-8	Box Tidwell	0.916	1	p =.338
Distance	Box Tidwell	0.298	1	p =.585
Asked for permission to use ATS within the year	Categorical – not tested			
Barriers (number cited)	Box Tidwell	0.382	1	p =.536
School encouragement (Likert score)	Box Tidwell	2.301	1	p =.129
ATS is enjoyable (Likert score)	Box Tidwell	4.172	1	p =.041
Enjoyable score transformed[a]	Box Tidwell	2.789	1	p =.095
ATS is healthy (Likert score)	Box Tidwell	0.682	1	p =.409

[a]Squared

When the continuous predictor variables were tested for linearity with the logit of the outcome variable, only one variable showed significant results and required transformation. The Likert scale score for enjoyment of ATS for all ATS did not have a linear relationship. That score was transformed by squaring. When retested, the transformed score met the assumptions for logistic regression.

Regression model

After testing the continuous predictor variables, those variables were entered into simple and multivariate regression models for each outcome variable using the

SURVEYLOGISTIC procedure in SAS 9.2, weighted for grade level. The simple regression results are presented for some ATS use in Table 15 and all ATS use in Table 16.

Table 15

Logistic regression results for individual predictors of some ATS weighted for grade level among SRTS survey respondents in Clark County, NV in 2013

	Valid N	Unadjusted OR	95% CI	Significance
Parent level of education (5 levels, ES-College)	1,767	0.708	[0.650,0.772]	*p* <.0001
Language (English, ref. Spanish)	1,990	0.415	[0.321, 0.538]	*p* <.0001
Number of K-8 children in family	1,897	1.237	[1.094, 1.400]	*p* =.0007
Distance (5 increments)	1,793	0.449	[0.407, 0.495]	*p* <.0001
Asked permission (No, ref. Yes)	1,916	0.341	[0.273, 0.427]	*p* <.0001
School Encouragement score	1,873	0.743	[0.648, 0.582]	*p* <.0001
Enjoyable score	1,871	0.728	[0.642, 0.825]	*p* <.0001
Health benefits score	1,881	0.844	[0.734, 0.969]	*p* =.0164

Table 16

Logistic regression results for individual predictors of all ATS weighted for grade level among SRTS survey respondents in Clark County, NV in 2013

	Valid N	Unadjusted OR	95% CI	Significance
Parent level of education (5 levels, ES-College)	1,577	0.712	[0.645,0.786]	*p* <.0001
Language (English, ref. Spanish)	1,764	0.387	[0.288, 0.520]	*p* <.0001
Gender (Female, ref. male)	1,758	0.712	[0.556, 0.911]	*p* =.0069
Number of K-8 children in family	1,685	1.275	[1.112, 1.462]	*p* =.0005
Distance (5 increments)	1,606	0.431	[0.387, 0.479]	*p* <.0001
Asked permission (No, ref. Yes)	1,707	0.358	[0.277, 0.462]	*p* <.0001
School Encouragement score (squared)	1,672	0.928	[0.892, 0.965]	*p* =.0002
Health benefits score	1,676	0.803	[0.683, 0.944]	*p* =.0078

Final model – Some ATS

A multivariate logistic regression model was constructed for Some ATS, the less restrictive outcome variable, indicating some use of ATS on most days. Respondents with missing or multiple responses to the variables included in the model were excluded (*n*=1,603). The results of the initial model with significance values are presented in Table 17.

Table 17

Initial logistic regression model results for some ATS among SRTS survey respondents in Clark County, NV in 2013

	Estimate	Wald statistic	Significance	Adj. OR
Parent level of education	2.156	0.708	*p* =.0034	0.819
Language	-.200	0.415	*p* =.0534	0.637
Number of K-8 children in family	.144	1.237	*p* =.0933	1.154
Distance	-.685	0.449	*p* <.0001	0.504
Asked permission	-.447	0.341	*p* <.0001	0.409
Number of barriers	-.084		*p* =.0005	0.920
School Encouragement score	-.016	0.743	*p* =.873	0.985
Enjoyable score	-.089	0.728	*p* =.366	0.915
Health benefits score	-.131	0.844	*p* =.237	0.877

The Likert score variables for school encouragement, enjoyment of ATS, and perceived health benefits of ATS were not significant, and they were dropped from the model. In the next iteration of the model, number of children in grades K-8 (p=.062) and language (p=.1012) were no longer significant and were removed from the model as well. The predictor variables which remained significant in the model are presented in Table 18, along with statistics indicating that multicollinearity among the predictor variables was low.

Table 18

Final logistic regression model results for some ATS among SRTS survey respondents in Clark County, NV in 2013

	Wald statistic	Significance	Adj. OR	95% CI	VIF
Parent level of education	22.960	p <.0001	0.772	[0.694, 0.858]	1.030
Distance	152.855	p <.0001	0.496	[0.443, 0.554]	1.102
Asked permission	44.641	p <.0001	0.622	[0.292, 0.511]	1.069
Number of barriers	11.904	p =.0005	0.925	[0.886, 0.967]	1.013

The regression results indicate that the odds of using some ATS on most days decreased with increasing levels of parental of education, distance from school, and number of reported barriers, and decreased if the child had not asked permission to use ATS in the past year, when controlling for the other variables in the model. The Nagelkerke's R Squared, a pseudo-r squared statistic reporting the percentage of variation in the sample explained by the model, was .294.

Final model – All ATS

A multivariate logistic regression model was constructed for the more restrictive outcome variable, indicating use of ATS for both the arrival and departure trips on most days. Respondents with missing or multiple responses to the variables included in the model were excluded (*n*=1,391). The results of the initial model with significance values are presented in Table 19.

Table 19

Initial logistic regression model results for all ATS among SRTS survey respondents in Clark County, NV in 2013

	Estimate (SE)	Wald statistic	Significance	Adj. OR
Parent level of education	-0.253 (0.487)	9.469	p =.0021	.776
Male gender	-0.148 (0.082)	3.244	p =.0717	.744
Language	-0.094 (0.136)	.474	p =.4914	.829
Number of K-8 children in family	0.275 (0.095)	8.450	p =.0037	1.317
Distance	-0.727 (0.065)	126.354	p <.0001	.483
Asked permission	-0.445 (0.088)	25.729	p <.0001	.411
Number of barriers	-0.108 (0.029)	15.508	p =.0001	.897
School Encouragement score (squared)	-0.086 (0.118)	.528	p =.4674	.918
Enjoyable score	-0.169 (0.114)	2.212	p =.1369	.845
Health benefits score	-0.193 (0.135)	2.026	p =.1546	.825

The Likert score variables for school encouragement, enjoyment of ATS, and perceived health benefits of ATS were not significant, along with survey language and male gender, so these variables were dropped from the model. In the next iteration of the model, the included variables remained significant. The predictor variables which remained in the final model are presented in Table 20, along with statistics indicating that multicollinearity among the predictor variables was low.

Table 20

Final logistic regression model results for all ATS among SRTS survey respondents in Clark County, NV in 2013

	Wald statistic	Significance	Adj. OR	95% CI	VIF
Parent level of education	23.420	p <.0001	0.751	[0.659, 0.857]	1.042
Number of K-8 children in family	8.167	p =.0043	1.296	[1.085, 1.543]	1.014
Distance	143.861	p <.0001	0.469	[0.415, 0.531]	1.106
Asked permission	37.125	p <.0001	0.360	[0.260, 0.501]	1.067
Number of barriers	15.151	p <.0001	0.899	[0.852, 0.948]	1.016

The regression results indicate that the odds of exclusively using ATS on most days decreased with increasing levels of parental of education, distance from school, and number of reported barriers, decreased if the child had not asked permission to use ATS in the past year, and increased with increasing numbers of K-8 children in the family, when controlling for the other variables in the model. The Nagelkerke's R Squared, a pseudo-r squared statistic reporting the percentage of variation in the sample explained by the model, was .316.

Chapter 5 – Discussion

The goal of this study was to determine which factors predict the use of ATS in elementary and middle school students in Las Vegas, NV. Survey data from parents of students in Clark County, NV were analyzed to create separate predictive models for the use of any ATS (morning or afternoon trip or both on most days) and exclusive use of ATS for most trips (morning and afternoon trips on most days).

Hypotheses and predictions

Socio-economic status

The survey data indicated that the measures of socio-economic status, parental level of education and language choice, were correlated with both measures of ATS, but in the final multivariate model only parental level of education remained in the model. This link between lower socioeconomic status and the use of ATS supports hypothesis 1. Use of ATS was associated with lower levels of parental education, as predicted. The prediction that use of ATS would also be predicted by lower levels of acculturation, as measured by language choice for the survey, was not supported. This finding is similar to the results observed by McDonald (2008b) in a large national sample, where variation by racial/ethnic background in ATS use was not significant in a model which controlled for variables related to SES, such as income and vehicle access.

The link between lower SES and use of ATS has been supported in multiple studies (Babey et al., 2009; Fulton et al., 2005; Martin et al., 2007; McDonald, 2008b; Park et al., 2013). This inverse relationship reverses the pattern established by other measures of physical activity (Troiano et al., 2008). This suggests that lower SES contributes to circumstances which require or encourage ATS. Since ATS has been reported to be higher among single-parent families and families without access to a vehicle (Martin et al., 2007; Park et al., 2013), active methods of transportation may be a practical or financial necessity. Families with higher levels of SES are more likely to live farther away from school and to have access to a vehicle (Fulton et al., 2005), which may also suppress rates of ATS in this group.

Demographic characteristics

Results from this analysis indicate that some demographic characteristics do predict the use of ATS among this population, while others do not. For “some use of ATS”, only distance from school remained in the final predictive model, supporting hypothesis 2. Lower grade level, male gender, and increasing numbers of K-8 children in the family were not predictors of some ATS as theorized. For use of ATS for both trips on most days (exclusive use of ATS), both distance from school and increasing numbers of K-8 children in the family were predictors, but lower grade level and male gender were not.

Distance

Distance from school has been widely reported as a determinant of ATS use (Martin & Carlson, 2005; McDonald, 2008b; Panter, Jones, & van Sluijs, 2008). As expected, distance was also a predictor of ATS in this population. Although the survey did not assess distance on a numeric scale, as scores on the distance measure increased, ATS decreased (r=-.310). Distance was a significant predictor of ATS use in the final multivariate model for both ATS variables.

Slightly more than half (51.53%) of respondents reported living within 1 mile of school, a commonly used radius for potential ATS users (Fulton et al., 2005; McDonald, 2008a). Researchers have suggested that the most effective strategies to increase ATS rates in the U.S. are rooted in zoning and transportation policy (Miles et al., 2011). If land use and school siting policies placed a priority on keeping children within a walkable distance to school, ATS rates should rise accordingly (Frumkin et al., 2004). Changes to the built environment, however, are expensive and difficult to implement, especially on the scale needed to decrease distance from home to school. Also, despite overwhelming correlational, and indeed logical, support for a link between distance and ATS, there is no evidence base to suggest that such a proposal would be successful. Other factors influencing ATS, such as safety concerns, may not be addressed by decreasing distance and could still suppress ATS rates if this barrier were overcome.

Gender

Gender has been reported to play a significant role in ATS decisions (Fulton et al., 2005; Martin et al., 2007), although recent research suggests that its role may be limited to cycling (McDonald, 2012). Similar to the results reported by McDonald (2012), this population reported no variation by gender in rates of ATS for the arrival trip or the departure trip, nor for those students reporting some ATS on most days or all ATS on most days. For students who cycled to school (*n*=54), however, less than one third of the cyclists were female. McDonald also reported a cycling rate for males which was two to three times higher than the rate for females, as did Bungum et al. (2009).

Research suggests that this discrepancy in cycling rates may be attributable to different parenting norms for girls and boys (Trapp et al., 2011) or to personal hygiene concerns more prevalent among girls (Marcus et al., 2006). Similar gender differences are observed among adult cyclists in the U.S. (Bopp, Kaczynski, & Wittman, 2011). In studies of European youth, however, gender differences in cycling to school are not widely reported (Cooper et al., 2008). This discrepancy suggests that gender differences in cycling in the U.S. are cultural, and that approaches to increase the use of cycling among girls should investigate the source of these behaviors.

Because of the strong relationship between cycling for ATS and fitness, these gender differences are excluding girls from an important opportunity for physical activity and improved health. Further research is needed to explore this issue and create evidence-based interventions to encourage cycling among female students. Although cycling rates are higher among male students, these rates are still quite low (4.3%). Broader interventions which promote cycling among students of both genders have the potential to increase PA and fitness levels in the student population.

Age

Although younger children are typically more active than older children (Troiano et al., 2008), this pattern is not widely observed in studies of ATS. Martin et al.'s national survey (2007) reported that children ages 12-13 were more likely to use ATS than their older or younger peers. McDonald (2008b) reported varying trends by age group and racial/ethnic background, but did not report on the significance of those trends. The decision to use ATS may include factors such as the capacity for safe independent travel, which increases with age, and the availability of time for active travel, which may decrease with age as other responsibility levels rise (McDonald & Alborg, 2009). Elementary schools are typically smaller and closer to residences, while middle and high schools have larger catchment areas (Fulton et al., 2005). The complex interaction of these and other influences may explain the lack of clear trend involving age and the use of ATS.

Family size

Increasing numbers of children in grades K-8 in the household was a significant predictor of using ATS exclusively for both trips on most days, but not for the more generally defined ATS variable. Fulton et al. (2005) also reported increasing odds for the use of ATS with increasing family size in an unadjusted model, but the effect was not significant when the model controlled for measures of SES. In this study, the relationship remained significant in the final multivariate model. This relationship is not widely investigated, but it may be related to parental desires for children to travel with an escort. If an older sibling attends the same elementary school or a nearby middle or high school, he or she may meet the younger sibling and travel home together. This strategy may be more common among larger families since they may have more combinations of siblings and schools. Since crime (25.6%) and the lack of an adult to walk with (21.5%) were frequently cited as barriers to the use of ATS, an older sibling who acts as an escort may address these barriers and increase ATS rates. Further research should be conducted to investigate this phenomenon and its effect on ATS.

Cycling

When grade level, gender, and distance from school were analyzed for correlations with the ATS variables, hypothesis 3 was supported. Among students who used some ATS, older age (*r*=.128), male gender (*r*=.155), and greater distance from school (*r*=.210) were positively associated with the use of cycling. Among students who used ATS exclusively, these variables were also positively associated. Age (*r*=.169) and distance (*r*=.246) had slightly stronger relationships with all ATS, while the association with male gender was slightly weaker (*r*=.142).

Unlike ATS rates in general, an association between age and cycling to school is supported in the literature (Andersen et al., 2011; Chillon et al., 2012; Cooper et al., 2008), among both boys and girls. The studies cited above were conducted in Europe. Cycling to school has not been widely studied in the U.S., perhaps because cycling rates remain very low. The 2.5% cycling rate observed in this sample is higher than other U.S. studies, which cite rates as low as 1.3% for males and 0.1% for females (Bungum et al., 2009). Again, considering the stronger relationship between cycling and fitness levels, further research is needed to understand this phenomenon and increase cycling rates.

Cycling may be even more susceptible to built environment barriers than walking. Local ordinances typically prohibit cycling on sidewalks, but American neighborhoods also do not typically provide protected bikeways and slower speed limits, which are more common in Europe (Dannenberg, Frumkin, & Jackson, 2011). Improving bicycle infrastructure as part of a legislative approach such as Complete

Streets may be an effective approach to increasing cycling rates for ATS, as well as in the general population.

Complete Streets is a comprehensive transportation planning approach which recognizes a role for all types of transportation in the use of streets instead of prioritizing automobile travel. Localities with Complete Streets policies may require protected bike lanes, safe crossings for pedestrians, priority access for public transportation, or traffic calming measures designed to decrease automobile speeds (Newsome & Pleasant, 2014). Infrastructure changes such as these, although expensive, may be required before cycling rates in the U.S. begin to approach those reported in Europe.

Perceptions and attitudes

In hypothesis 4, it was predicted that perceptions and attitudes about ATS would predict its use. Only the first prediction, that a child's request to use ATS would predict its use, was supported. Compared to students who had requested permission to use ATS, and with the other variables being equal, children who had not requested permission were .622 times as likely to use some ATS and .360 times as likely to use exclusive ATS as their peers. The Likert scale scores representing school encouragement of ATS, enjoyment of ATS, and perceived health benefits of ATS did not remain in the final models and did not predict the use of ATS as hypothesized.

The significance of the child's request to use ATS in both models is surprising, considering that previous studies have characterized parents as the sole decision makers regarding the school commuting trip (Faulkner, Richichi, Buliung, Fusco, & Moola, 2010;

McDonald & Alborg, 2009). Male children were more likely to request permission to use ATS in this sample, as were middle school-aged children (57.01% and 62.55%, respectively, $p<.001$). Given the cross-sectional nature of this data, it is impossible to determine if the request of the child triggered the decision to use ATS, or if the same combination of circumstances which supported the use of ATS also supported the child's request. Because ATS is required in some families without vehicle access, making a request to use ATS may also be unnecessary. Further research into travel mode choice and the parental decision-making process may yield more information on the role of a child's request to use ATS.

Two of the Likert scales assessed in this section, the scales for perceived enjoyment and health benefits of ATS, showed small but significant variation between active and passive commuters, as well as significant correlation with both measures of ATS. The scores from these scales, however, were not predictors of ATS use in the final model. As with other health decision making processes, the perception of benefits in itself may not be a sufficient motivator to change behavior (Edberg, 2014). Also, in families without vehicle access, ATS may not be a volitional behavior, and attitudes and perceptions may be unrelated to ATS use.

The third scale, which measured school encouragement of ATS, showed no variation between current active and passive commuters. It is possible that school encouragement does not play a role in the use of ATS, but this outcome may be attributable to another cause. Research indicates that those who regularly walk in an area may be more familiar with built environment barriers, such as incomplete sidewalks or high speed limits, than those who do not (Timperio, Crawford, Telford, & Salmon, 2004). Those respondents who regularly use ATS may be more familiar with the impact of school policies in areas such as bicycle storage or dismissal patterns, and may find that these policies unintentionally discourage the use of ATS, resulting in lower scores on this survey item.

School level differences

Although grade level was not a significant predictor of ATS in either model, some differences in ATS use did appear when elementary school students were compared to middle schools students. Middle school students who used ATS reported greater commuting distances for both “some ATS” and “exclusive ATS” use ($p<.05$), as predicted in hypothesis 5. Increasing grade level was also correlated, as predicted, with increased commuting by cycling for both some ATS ($r=.128$, $p=.005$) and exclusive ATS ($r=.169$, $p=.001$), with a slightly stronger relationship observed for all ATS. Asking for permission to use ATS was also more common among middle school students (47.01%) than elementary school students (42.55%).

The early adolescent age of transition from elementary to middle school is cited by several researchers as an age of transition for ATS. In a national survey conducted by Martin et al. (2007), students in 6^{th} and 7^{th} grade were up to three times more likely to report ATS than high school students. Fulton et al. (2005) reported significant variation by age only for 12- to 13-year olds in his 5-18 year old sample. In a qualitative study of school travel decision making processes for elementary school students, parents suggested that they might offer their children more opportunity for independent travel in this same age range, the age of typical middle school students. Parenting norms and children's increasing desire for independence may come together to support increased rates of ATS for middle school youth. Once students reach high school, ATS rates tend to decline, possibly because driving becomes an option in this age range and because schedule constraints, such as after school employment, may increase.

Barriers

As discussed above and noted in the literature (McDonald et al., 2011), the barriers section of the survey presented some challenges for data collection and analysis. In the current format of the survey, Question 10 asks whether 12 items affected the respondent's decision to allow or not allow their child to use ATS. This phrasing of the item makes it difficult to determine if certain issues, such as the safety of intersections or the role of crossing guards, support or discourage the use of ATS. For example, a parent who allows their child to walk to school because crossing guards protect an intersection and a parent who does not allow their child use ATS because street crossings are not supervised would both check the "Crossing guards" box for Question 10.

Since ATS rates in the U.S. have dropped dramatically over the past few decades, accurate information on barriers to its use would be very valuable. The National Center for Safe Routes to School should consider redesigning this portion of the survey. A format similar to the Likert scales assessing school encouragement and the perceived benefits of ATS could be useful. The role of supports such as crossing guards and sidewalks could be assessed on a continuum from "Strongly Encourages" to "Strongly

Discourages". A format like this would allow parents to assess supports and barriers to ATS in a similar amount of space and may provide more intelligible information. With approximately half (n=910) of the respondents reporting at least one barrier, even in the current confusing format, improving the utility of this section should be a priority.

The literature would suggest that distance should be the most commonly cited barrier. Although nearly 30% of the sample did indicate that they would "probably allow" the use of ATS if distance to school were changed or improved, the most commonly cited barrier was safety of intersections and crossings (32.2%). The percentage of respondents marking "Yes" for this barrier did vary by school, along with other built environment barriers. This suggests that interventions which enhance perceived safety at intersections and crossings might be an effective tool for increasing ATS. McDonald et al. (2013) reported that engineering changes to improve safety at crossings did not increase ATS rates, but also suggested that their data collection timeframe might not have allowed enough time for an effective assessment.

Barriers associated with built environment factors, including the safety of crossings and intersections, did vary by individual school. More general barriers, such as the effect of weather or climate and the convenience of driving, were reported at consistent levels across schools. This finding illustrates the complex nature of travel choices for school trips. Although some barriers are common to most trips, others are more local and may vary widely within a metropolitan area. In their book *School Siting and Healthy Communities*, Miles, Adelaja, and Wyckoff Miles et al. (2011) suggest that the process of overcoming these built environment barriers begins with school site selection. They recommend that school sites should be selected with a coordinated approach which balances health impacts and traffic safety with sustainability, but recognize that few jurisdictions in the U.S. employ such a model.

One approach to evaluating potential school sites for relationships with health indicators like ATS is the use of a health impact assessment (HIA). An HIA is a systematic approach to analyzing the potential health effects of a policy or process (Dannenberg et al., 2008). In the context of choosing a site for a future school, the HIA process would encourage civic leaders and school district officials to extend the framework of school siting discussions beyond economic and zoning concerns, to include potential health effects. Placing schools in locations conducive to ATS, such as closer to community centers, or building smaller schools with smaller catchment areas, could be possible outcomes of an HIA for school siting. Although these types of decisions may not be the most economical in terms of facility and staffing costs, an HIA could help quantify the potential health impacts of increased ATS rates and increased PA for decision makers in these arenas and emphasize the total cost of passive transport in terms of vehicle costs and health risks.

Even if encouraging the use of ATS becomes a priority in the construction of new schools, many existing schools will still be located in challenging built environments. Distance from school and safety concerns about crossings and intersections were frequently cited by parents in this study and others (Larsen et al., 2009; McDonald, 2008a). One intervention which shows promise for increasing ATS at existing schools despite these barriers is the walking school bus (WSB). A WSB is a group of children which walks to school with an adult escort along a designated route at a scheduled time. Some WSB routes simulate actual school buses and pick children up at designated "stops", while others collect children at a remote drop off point and escort the students on the final leg of their school trip (Kong et al., 2009).

WSB interventions are a relatively recent phenomenon, and robust interventions and evaluations have yet to be published (Turner et al., 2013). Early assessments appear to indicate the WSB interventions increase the number of children using ATS and the PA level of children who participate. In a pilot study, using a cluster randomized controlled trial study design, children who participated in a WSB reported 7 more minutes a day of MVPA (p=.029) than control group children, which is 12% of the recommended daily MVPA for children, while commuting by car decreased 36% at intervention schools (Mendoza et al., 2011). Although the role of WSB interventions in addressing parental concerns about safety has not yet been addressed in the literature, this style of intervention does appear to mitigate safety concerns by providing an adult escort for the school trip. The number of schools reporting WSB interventions in the U.S. is increasing (Turner et al., 2013), and this intervention shows promise for addressing barriers to ATS and increasing PA among students at existing schools.

The convenience of driving is commonly cited as a reason to use passive modes of transport. Nearly 15% of the respondents in this study indicated that they "probably" allow their children to use ATS if this barrier were changed or improved. If school transportation plans make driving less convenient, such as through lot closures or parking restrictions, driving children to school could become less desirable. Coordinating these types of changes with a WSB-type intervention, which does address the issue of parental convenience, could support the increased use of ATS by simultaneously decreasing the desirability of driving and increasing the convenience of walking or cycling. Reducing automobile use near schools could also increase perceived and actual pedestrian safety.

Comments

The National Center for Safe Routes to School survey includes an open-ended comment section for parental feedback (see Appendix A). Although an analysis of the comments was not an original goal of this study, some notable trends emerged from this section. Comments were provided by 415 of the 2,054 respondents, 338 in English and 77 in Spanish. Of the 338 comments written in English, 31 comments (9.17%) mentioned the risk of kidnapping or child abduction as a barrier to the use of ATS. Child abduction by strangers is an extremely rare event, but abduction fears appear to be a powerful influence on parental decisions to allow independent travel for their children. Parental fears about stranger abduction may become self-supporting by depriving local neighborhoods of the incidental surveillance which occurs when more people walk and observe public occurrences (Foster, Villanueva, Wood, Christian, & Giles-Corti, 2014).

Examples of the comments concerning kidnapping and abduction fears include:

“If there were more police or people walking in our area I would allow my child to walk. Too many bad things happen to children who walk alone and I don't want that phone call something happened to my child.”

“With this day and age, we don't feel comfortable with our children walking to or from school at any age by themselves. People are different today and steal children in broad daylight.”

“The only reason I would not let her go is because of the risk of being taken by a stranger.”

Comments written in Spanish were provided by 77 respondents. When these comments were examined for concerns about abduction, no similar trend emerged. None of the parental comments explicitly mentioned kidnapping or abduction concerns, as among the comments made in English. Many of the comments written in Spanish concerned the traffic conditions near the school, which was a common theme of comments written in English as well. An analysis of disparities in neighborhood safety and walkability reported that Hispanic communities experience 3.6 more total crashes per mile of street each year than predominantly white communities ($p<.001$) (Zhu & Lee, 2008). It is possible that the actual increased risk of danger from traffic outweighed the perceived risk of danger from abduction for parents in these communities. Further research is needed to explore this interesting pattern in the open-ended comment responses.

Predictive models

The purpose of this study was to develop a predictive model for the use of ATS among K-8 students in Clark County, NV. In keeping with trends in the literature for varying definitions of ATS use, two models were developed. The first model predicted more general use of ATS, based on a dummy variable (Some ATS) which represented walking, cycling, or use of another means of active transport (scooter, skateboard, etc.) for either the morning or afternoon commute or both. Significant predictors of this type of ATS use included parental level of education, reported distance from school, whether the child had asked for permission to use ATS within the year, and the number of barriers reported by the parent (Table 18).

As expected from the literature, odds of using ATS declined with increasing parental level of education (OR=.772, 95% CI (.694, .858), p<.0001) and increasing distance from school (OR=.622, 95% CI (.443, .554), p<.0001). The other predictors, asking permission to use ATS and number of reported barriers, are not widely reported in the literature.

Asking for permission to use ATS within the year was modelled with "yes" as the reference category, so children who had not asked for permission to use ATS were less likely to use some ATS as a regular part of their weekly commuting schedule. Since the data for this study are cross-sectional, a causative relationship between asking permission and the use of ATS cannot be assumed. It is possible that the students who asked for permission to use ATS were from families which were more accepting of ATS, or that the students who did not ask were from families which faced significant barriers to the use of ATS. Family structures may vary in terms of parental susceptibility to a child's request and the agency of the child for transportation decisions. Although the role of this variable in transportation mode choice is not clear, it represents an interesting opportunity for further research.

The final predictor in the model for some ATS use is the number of reported barriers. With the other predictors being held constant, each 1-unit increase in the number of barriers reported resulted in a 7.5% decrease (p=.0005, 95% CI [.886, .967]) in the odds of the child using some ATS. This predictive relationship between reported barriers and ATS use may support this study's interpretation of the problematic barriers section of the survey. Further research is needed to assess the validity and reliability of this interpretation, and the National Center for Safe Routes to School should consider a redesign of this survey component. Overall, the predictive model for some regular ATS use explained 29.4% of the variation in the sample.

The second, more restrictive, model predicted the exclusive use of ATS for both the morning and afternoon trips on most days. This model retained five predictors, including the four predictors from the more general model. The effect of parental education was similar in this model (OR=.751, p<.0001, 95% CI [.659, .857]), speaking to a consistent role for SES in predicting ATS. In this model, distance had a more powerful effect (OR=.469, p<.0001, 95% CI [.415, .531]). Since children fitting this definition of ATS used active transport for both trips, parents may have used a more restrictive radius to determine whether the combined trip was too lengthy.

Similarly, the variable representing the child's request to use ATS had a larger effect in this model, with children who had not requested permission being 64.0% less likely to use ATS for both trips. The number of reported barriers also had a more pronounced effect in this model (OR=0.899, p<.0001, 95% CI [0.852, 0.948]). Since the definition of ATS used in the model was more restrictive, it is possible that the differences between ATS users and passive commuters were more pronounced.

An additional predictor of ATS emerged in this model. The number of K-8 students reported in the family was a positive predictor of exclusive ATS use (OR=1.296, p<.0001, 95% CI [1.085, 1.543]). Each one unit increase in the number of children in the family was associated with a 29.6% increase in the odds of exclusively using ATS on most days. It is possible that this increased use of ATS in larger families is associated with the availability of older siblings to provide an escort for younger children during the school commute. Parents may also be more willing to allow two younger children to walk together than either one alone. The survey as designed does not collect specific ages or information on joint trips. Further research is needed to determine if parents are more likely to allow their younger children to use ATS if an older child is available to supervise the trip.

The predictive model for exclusive use of ATS on most days explained a slightly larger share of the variability in the sample, 31.6%. It is possible that this is due to the more restrictive definition of ATS in this model, but both models still explain less than one third of the variation in ATS behavior in the sample. It appears that this instrument may be missing domains with influence on ATS behavior. Those domains could include built environment factors, such as the quantity and speed of traffic along the route, as well as the safety of intersections and crossings, which were reported at rates which varied by school in this sample. In addition to revising the barriers section of the survey, the National Center for Safe Routes to School should consider expanding the survey to include other items with influence on ATS behavior, such as measures of car access (Deweese et al., 2013) and measures of population or residential density (Braza et al., 2004; Dalton et al., 2011).

Limitations

This analysis and its conclusions are subject to some important limitations, including the response rate to the survey, the sample size, and the cross-sectional nature of the data. The response rate to the parent survey was 13.35%. Other surveys of parents regarding ATS behavior report response rates of 28% (Kerr et al., 2006) and 26% (McDonald & Alborg, 2009), but those surveys were conducted by telephone. Another study conducted using this instrument, and similarly distributed via students, reported a 24% return rate, but offered a small incentive upon return of the survey. This response rate may limit the generalizability of the analysis. To increase response rate, future researchers may want to consider collecting similar information by phone or offering incentives for completed surveys.

Also, as with any survey data, those who choose to complete the survey may be different than those who do not (Daniel, 2009). The nature of this data did not allow for the comparison of survey respondents to non-respondents. These groups may vary in significant ways. Another potential limitation is related to the large sample size (n=2,054). With larger samples, small differences may be reported as statistically significant even if the actual effect is small. While statistically significant, these results may be clinically or practically insignificant (Daniel, 2009).

These data are also cross-sectional. This limits the analysis to predictive modelling and restricts the ability to make causal statements about the correlates of ATS which are reported. Finally, this analysis does not include individual information on PA levels and relies on established relationships between ATS and PA in the literature.

Future research

The literature supports an important role for ATS in increasing MVPA in children. While the cross-sectional data presented in this analysis begins to characterize the ATS habits of children in Clark County, NV, several opportunities for further investigation remain. These opportunities include supporting survey data with instrumentation, working with older students, and developing interventions to increase ATS in this population.

This study relied on previous work supporting the link between ATS and PA. In order to support the role of ATS in increasing MVPA in children in Clark County, studies objectively measuring PA and ATS should be replicated with a subset of this population. Similar studies use instruments such as accelerometers or cycle computers to report MVPA levels, which can then be linked to reported ATS behavior, providing stronger evidence for the effect of ATS in this population.

Since the Safe Routes to School project is designed for children in grades K-8, no data are collected from high school students. Since these students are older, they may be allowed more flexibility for independent travel, and may have a longer commute to a larger school, but without data, this population cannot be characterized. Future research should determine the ATS habits of older students in Clark County to support interventions with the potential to increase MVPA in this population.

With information on population characteristics and predictors of ATS, interventions to increase the use of ATS in this population should be developed and evaluated. WSB interventions show promise in other locations and may be effective in

Clark County as well. The size of the CCSD and availability of similar schools as controls also provides an interesting opportunity to observe natural experiments. If bike lanes are added near a school, if traffic patterns are changed, or if a new off-street trail is added, researchers should consider assessing the effects of these changes on ATS rates in this population.

The use of ATS in Clark County and other areas of the U.S. is currently constrained by built environment factors associated with school location. Elected officials and school district leaders should consider the use of HIAs when evaluating potential sites for new schools. When schools are placed in the center of communities, in neighborhoods which are designed to support active transportation, more children may be able to experience the health benefits of increased physical activity, which may encourage the retrofitting of older schools and neighbors to support ATS.

The purpose of this study was to develop a predictive model for the use of ATS among children in grades K-8 in Clark County, NV. Separate models were developed to predict the use of some ATS and the exclusive use of ATS. More research is needed to characterize the ATS habits of local students more clearly, and to develop effective interventions to encourage ATS use. Increased use of ATS could increase PA and improve the health of Clark County children.

Appendix A – SRTS Survey

Parent Survey About Walking and Biking to School

Dear Parent or Caregiver,
Your child's school wants to learn your thoughts about children walking and biking to school. This survey will take about 5 - 10 minutes to complete. We ask that each family complete only one survey per school your children attend. If more than one child from a school brings a survey home, please fill out the survey for the child with the next birthday from today's date.

After you have completed this survey, send it back to the school with your child or give it to the teacher. Your responses will be kept confidential and neither your name nor your child's name will be associated with any results.
Thank you for participating in this survey!

+ CAPITAL LETTERS ONLY – BLUE OR BLACK INK ONLY +

School Name:

1. What is the grade of the child who brought home this survey? ☐☐ Grade (PK,K,1,2,3…)

2. Is the child who brought home this survey male or female? ☐ Male ☐ Female

3. How many children do you have in Kindergarten through 8th grade? ☐☐

4. What is the street intersection nearest your home? (Provide the names of two intersecting streets)

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ **and** ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Place a clear 'X' inside box. If you make a mistake, fill the entire box, and then mark the correct box.

5. How far does your child live from school?

☐ Less than ¼ mile ☐ ½ mile up to 1 mile ☐ More than 2 miles
☐ ¼ mile up to ½ mile ☐ 1 mile up to 2 miles ☐ Don't know

Place a clear 'X' inside box. If you make a mistake, fill the entire box, and then mark the correct box. +

6. On most days, how does your child arrive and leave for school? (Select one choice per column, mark box with X)

Arrive at school	Leave from school
☐ Walk	☐ Walk
☐ Bike	☐ Bike
☐ School Bus	☐ School Bus
☐ Family vehicle (only children in your family)	☐ Family vehicle (only children in your family)
☐ Carpool (Children from other families)	☐ Carpool (Children from other families)
☐ Transit (city bus, subway, etc.)	☐ Transit (city bus, subway, etc.)
☐ Other (skateboard, scooter, inline skates, etc.)	☐ Other (skateboard, scooter, inline skates, etc.)

+ Place a clear 'X' inside box. If you make a mistake, fill the entire box, and then mark the correct box +

7. How long does it normally take your child to get to/from school? (Select one choice per column, mark box with X)

Travel time to school	Travel time from school
☐ Less than 5 minutes	☐ Less than 5 minutes
☐ 5 – 10 minutes	☐ 5 – 10 minutes
☐ 11 – 20 minutes	☐ 11 – 20 minutes
☐ More than 20 minutes	☐ More than 20 minutes
☐ Don't know / Not sure	☐ Don't know / Not sure

+ +

8. **Has your child asked you for permission to walk or bike to/from school in the last year?** ☐ Yes ☐ No

9. **At what grade would you allow your child to walk or bike to/from school without an adult?**

(Select a grade between PK,K,1,2,3...) ☐☐ grade **(or)** ☐ I would not feel comfortable at any grade

Place a clear 'X' inside box. If you make a mistake, fill the entire box, and then mark the correct box

10. What of the following issues affected your decision to allow, or not allow, your child to walk or bike to/from school? (Select ALL that apply)

11. Would you probably let your child walk or bike to/from school if this problem were changed or improved? (Select one choice per line, mark box with X)

☐ My child already walks or bikes to/from school

10.	11.		
☐ Distance	☐ Yes	☐ No	☐ Not Sure
☐ Convenience of driving	☐ Yes	☐ No	☐ Not Sure
☐ Time	☐ Yes	☐ No	☐ Not Sure
☐ Child's before or after-school activities	☐ Yes	☐ No	☐ Not Sure
☐ Speed of traffic along route	☐ Yes	☐ No	☐ Not Sure
☐ Amount of traffic along route	☐ Yes	☐ No	☐ Not Sure
☐ Adults to walk or bike with	☐ Yes	☐ No	☐ Not Sure
☐ Sidewalks or pathways	☐ Yes	☐ No	☐ Not Sure
☐ Safety of intersections and crossings	☐ Yes	☐ No	☐ Not Sure
☐ Crossing guards	☐ Yes	☐ No	☐ Not Sure
☐ Violence or crime	☐ Yes	☐ No	☐ Not Sure
☐ Weather or climate	☐ Yes	☐ No	☐ Not Sure

Place a clear 'X' inside box. If you make a mistake, fill the entire box, and then mark the correct box

12. **In your opinion, how much does your child's school encourage or discourage walking and biking to/from school?**

☐ Strongly Encourages ☐ Encourages ☐ Neither ☐ Discourages ☐ Strongly Discourages

13. **How much fun is walking or biking to/from school for your child?**

☐ Very Fun ☐ Fun ☐ Neutral ☐ Boring ☐ Very Boring

14. **How healthy is walking or biking to/from school for your child?**

☐ Very Healthy ☐ Healthy ☐ Neutral ☐ Unhealthy ☐ Very Unhealthy

Place a clear 'X' inside box. If you make a mistake, fill the entire box, and then mark the correct box

15. **What is the highest grade or year of school you completed?**

☐ Grades 1 through 8 (Elementary)
☐ Grades 9 through 11 (Some high school)
☐ Grade 12 or GED (High school graduate)
☐ College 1 to 3 years (Some college or technical school)
☐ College 4 years or more (College graduate)
☐ Prefer not to answer

16. **Please provide any additional comments below.**

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Curriculum Vitae

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EDUCATION

University of Nevada, Las Vegas
PhD in Public Health, expected May 2014. Public Health (Social/Behavioral Health)

M.Ed. in Health Promotion, 2011.

Georgetown University, Washington, DC
B.A. in Classical Humanities, *magna cum laude,* 1992.

PEER-REVIEWED PUBLICATIONS

Clark, S., Bungum, T., Meacham, M., & Coker, L. (In press). Happy trails: The effect of a media campaign on urban trail use in Southern Nevada. *Journal of Physical Activity and Health.*

Bungum, T., **Clark, S**., & Aguilar, B. (In press). The effects of an active transport to school intervention at a suburban elementary school. *Journal of School Health.*

Clark, S. & Bungum, T. (2003). The benefits of breastfeeding: An introduction for health educators. *Californian Journal of Health Promotion*, 1, 158-163.

Clark, S., Bungum, T., Meacham, M., & Coker, L. (2014). The effect of incremental distance and way-finding signage on urban trail use in Southern Nevada. Manuscript submitted for publication.

PRESENTATIONS

Clark, S., Bungum, T., Coker, L., and Meacham, M. (2014). The effect of a promotional campaign and distance markings on urban trail use in Southern Nevada. Oral presentation at Active Living Research, San Diego, CA.

Clark, S., Bungum, T., Coker, L., and Meacham, M. (2013). Trail usage in Southern Nevada after the release of an informational website and media campaign. Poster session at Active Living Research, San Diego, CA.

Bungum, T., **Clark, S**., & Aguilar, B. (2013). Effects of an active transport to school program. Oral presentation at 2013 American Public Health Association Conference, San Francisco, CA. Abstract # 289134.

Clark, S. and Bungum, T. (2012). Effect of low-cost incentives on active transportation to school rates among elementary school students. Oral presentation at 2012 American Public Health Association Conference, San Francisco, CA. Abstract # 258821.

Clark, S. and Bungum, T. (2009). *Methicillin-resistant Staphylococcus aureus.* Poster session presented at 2009 Nevada Public Health Association Conference, Reno, NV.

TEACHING EXPERIENCE

UNLV School of Community Health Sciences

Methods in Health Education, PBH 427 (hybrid format) Spring 2014

AWARDS

2010 Mason Cup for Health Promotion graduate project, UNLV

1992 McKay Medal for undergraduate research in the Classics, Georgetown University.

AFFILIATIONS

American Public Health Association, Physical Activity Section
Nevada Public Health Association

RELATED PROFESSIONAL EXPERIENCE

4/12 – 12/12 **Graduate Assistant**
UNLV/Southern Nevada Health District

Developed and implemented evaluation plan for trail use using infrared counters.
Collected data on park path use for physical activity. Researched Complete Streets policies and promotional materials.

1/10 – 6/10 **Graduate Assistant**
UNLV/Nevada Institute for Children's Research and Policy
Recruited sites for evaluation research project. Wrote study protocols and coordinated site activities. Wrote reports and completed research projects as needed. Coordinated and transcribed focus group meetings.