HHS Public Access

Author manuscript

*J Safety Res*. Author manuscript; available in PMC 2017 December 01.

Published in final edited form as:

*J Safety Res*. 2017 September ; 62: 245–251. doi:10.1016/j.jsr.2017.04.001.

# School transportation mode, by distance between home and school, United States, *ConsumerStyles* 2012☆

**Laurie F. Beck**[a,*] and **Daniel D. Nguyen**[b]

[a]Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, 4770 Buford Hwy NE, MS F62, Atlanta, GA 30341, USA

[b]Emory University Rollins School of Public Health, 1518 Clifton Rd NE, Atlanta, GA 30322, USA

## Abstract

**Introduction—**Motor-vehicle crashes are a leading cause of death among children in the United States, and almost one-fourth of all trips by school-aged children are trips to and from school. This study sought to determine how children (5–18 years) travel to and from school and, among those living ≤1 mile of school, to explore the role of school bus service eligibility on school travel mode.

**Methods—**We used national 2012 survey data to determine prevalence of usual school travel mode, stratified by distance from school. For those living ≤1 mile of school, multivariable regression was conducted to assess the association between bus service eligibility and walking or bicycling.

**Results—**Almost half (46.6%) of all children rode in passenger vehicles (PV) to school and 41.8% did so for the trip home. Results were similar among those living ≤1 mile (48.1%, PV to school; 41.3%, PV to home). Among those living ≤1 mile, 21.9% and 28.4% of children walked or bicycled to and from school, respectively. Ineligibility for school bus service was strongly associated with walking or bicycling to school [adjusted prevalence ratio (aPR: 5.36; $p < 0.001$)] and from school (aPR: 5.36; $p < 0.001$).

**Conclusions—**Regardless of distance from school, passenger vehicles were a common mode of travel. For children who live close to school, the role that school bus service eligibility plays in walking or bicycling deserves further consideration.

**Practical applications—**Given the large proportion of children who use passenger vehicles for school travel, effective interventions can be adopted to increase proper child restraint and seat belt use and reduce crash risks among teen drivers. Better understanding of conditions under which bus

---

☆Declaration of interest: We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention. The Journal of Safety Research has partnered with the Office of the Associate Director for Science, Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control at the CDC in Atlanta, Georgia, USA, to briefly report on some of the latest findings in the research community. This report is the 47th in a series of "From the CDC" articles on injury prevention. Submission declaration: We confirm that no papers have been published or are under review in other journals that are based on similar methods or data. Funding sources: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. CDC provided salary support for L. Beck. Rollins School of Public Health provided financial support via a work–study program for D. Nguyen.

*Corresponding author. LDF8@cdc.gov (L.F. Beck).

service is offered to children who live close to school could inform efforts to improve pedestrian and bicyclist safety for school travel.

**Keywords**

Motor vehicle; Child passenger safety; Children; Pedestrians; Bicyclists

## 1. Introduction

Motor-vehicle crashes are a leading cause of death among children in the United States. In 2014, there were 2,401 traffic crash-related deaths and 395,000 traffic crash-related emergency department-treated injuries among children aged 5–18 years (Centers for Disease Control and Prevention and National Center for Injury Prevention and Control, 2016). School travel is of special interest because it represents a significant proportion (22%) of total travel among school-aged children in the United States (McDonald, Brown, Marchetti, & Pedroso, 2011) and because recent efforts to increase children's physical activity have included programs to promote walking or bicycling to school [e.g., Safe Routes to School (SRTS)] (National Safe Routes to School Task Force, 2008).

Historically, walking and bicycling (i.e., active transportation) were common methods by which children traveled to school. Data from the first National Personal Travel Survey (NPTS) in 1969, now known as the National Household Travel Survey (NHTS), revealed that 41% of children aged 5–18 years usually walked or bicycled to school, with a higher percentage of younger children (aged 5–14 years) walking or bicycling to school (48%; McDonald, 2007; McDonald et al., 2011). By the early 2000s, estimates of usually walking or bicycling to school ranged from 13% to 14% among children aged 5–14 years (Beck & Greenspan, 2008; McDonald et al., 2011). In contrast, use of passenger vehicles for the trip to school has increased from 12% in 1969 to almost half in the 2000s (Beck & Greenspan, 2008; McDonald et al., 2011).

One well-documented predictor of using active transportation is the distance from one's place of origin to the destination. For example, Ham, Macera, and Lindley (2005) reported that 21% of adults walked to destinations within 1 mile, whereas only 9% of all trips were made by walking (Hu & Reuscher, 2004). Since the mid-1900s, the distance between home and school has increased in the United States (Environmental Protection Agency, 2003; Federal Highway Administration, 2008). McDonald (2007) has found that this increased distance likely accounts for a large proportion, but not all, of the shift from active transportation to travel via motorized vehicle (e.g., passenger vehicles or school buses) in recent decades. While 86% of U.S. children living within 1 mile of school walked or biked in 1969, only 50% did so in 2001 (McDonald, 2007).

The purposes of this investigation were to determine how children aged 5–18 years usually travel to and from school and, among those who live within 1 mile of school, to explore the role that school bus service eligibility plays in travel mode used. Findings can inform ongoing efforts at the federal, state, and local levels to improve school transportation safety.

## 2. Materials and methods

Data used in our study came from the first summer wave of Porter Novelli's 2012 *ConsumerStyles* database (Weber, 2012). The survey was fielded from June 19 to July 3, 2012 and was sent to a random sample of 6,402 adults (ages 18 years or older) drawn from approximately 50,000 panel members who consented to participate in the panel and were representative of the U.S. population. In total, 4,170 adults completed the survey with a response rate of 65%. Data were weighted to match the 2012 U.S. Current Population Survey (CPS) proportions for gender, age, household income, race/ ethnicity, overall household size, level of education, census region, metropolitan status, and access to the Internet prior to joining the panel. The Centers for Disease Control and Prevention (CDC) licensed the de-identified results of the 2012 *ConsumerStyles* survey from Porter Novelli. CDC determined the analysis to be exempt from human subject regulations because existing data were used for secondary analysis and information was recorded in such a way that participants could not be personally identified.

A total of 1,170 adult respondents reported that they had at least one child aged 5–18 years enrolled in school in the previous year. Those with more than one enrolled child were instructed to answer a series of questions about school transportation for their youngest child (5–18 years) enrolled in school. School transportation characteristics included self-reported usual mode of travel to and from school, distance from home to school, and school bus eligibility. Usual modes of travel to and from school were categorized as walking or bicycling, school bus, passenger vehicle, or other (including public transportation). Walking and bicycling were combined for analyses because small numbers, especially for bicycling, prevented reporting these two modes separately. Distance from home to school was categorized as less than or equal to 1 mile or greater than 1 mile. School bus service eligibility was defined as eligible or ineligible. Sociodemographic and geographic variables were selected on the basis of previous research on active transportation. These variables included child's age group, annual household income, type of residence, census region, and metropolitan status. Children's ages were categorized as 5–11, 12–14, or 15–18 years. Annual household income was categorized as less than $25,000, $25,000–$49,999, $50,000–$74,999, or $75,000 or more. Type of residence was defined as single or multiple family residence. Census region was categorized as Northeast, Midwest, South, or West. Metropolitan status was categorized as metropolitan or non-metropolitan residence using the U.S. Census Bureau standards (Zients, 2013).

Weighted proportions and standard errors (SEs) were calculated for categorical variables and stratified by distance between home and school. Data were suppressed when based on sample counts less than twenty respondents. Due to the small numbers of children who lived more than 1 mile from school and walked or bicycled to or from school, all subsequent analyses focused on children who lived within 1 mile of school (sample n = 365). Crude analyses estimated associations between school bus service eligibility, as well as selected sociodemographic and geographic characteristics, and walking or bicycling to school. Results that had a p-value $<0.05$ were considered statistically significant. Multivariable regression was performed using a modified Poisson regression model with robust error variances and the log link function to estimate the adjusted prevalence ratio (aPR) and 95%

confidence interval (CI) (Deddens & Petersen, 2008; Petersen & Deddens, 2008) for school bus service eligibility and walking or bicycling to school, adjusting for those characteristics that were significantly associated with walking or bicycling in crude analyses. The same crude and multivariable analytic strategy was conducted for walking or bicycling home from school. All analyses were conducted using Statistical Analysis Software (SAS) version 9.3 (SAS Institute, Inc., Cary, North Carolina).

## 3. Results

In 2012, approximately one-third (35.2%) of children aged 5–18 years lived within 1 mile of school (Table 1). For children who lived within 1 mile, the most common mode of travel to school was by passenger vehicle (48.1%), followed by school bus (23.9%) and walking or bicycling (21.9%). For children who lived within 1 mile of school, the most common mode of travel home from school was by passenger vehicle (41.3%), followed by walking or bicycling (28.4%) and school bus (24.2%; Table 1). The proportion of children who traveled by passenger vehicle was similar among those who lived within 1 mile of school (48.1% to school and 41.3% from school) and those who lived more than 1 mile from school (45.9% to school and 42.4% from school). Eligibility for school bus service was less common among those who lived within 1 mile of school (41.8%) than among those who lived more than 1 mile from school (74.1%).

Among children who lived within 1 mile of school, crude analyses revealed that ineligibility for school bus service and region were the only variables that were significantly associated with walking or bicycling to school (Table 2). In the multivariable regression model, these variables remained significantly associated with walking or bicycling to school. Children who were ineligible for school bus service were 5.36 times more likely to walk or bicycle to school than those who were eligible ($p < 0.001$). Those who lived in the Northeast (aPR 2.04, $p < 0.05$) were more likely to walk or bicycle to school than those who lived in the South. Differences in walking or bicycling to school between children in the Midwest or West, compared to those in the South, were no longer significant after controlling for school bus service eligibility (Table 2).

Results of regression models for walking or bicycling home from school among those who lived within 1 mile of school were very similar to those for walking or bicycling to school. In crude analyses, the only variables that were significantly associated with walking or bicycling home from school were ineligibility for school bus service and region (Table 3). In the multivariable regression model, ineligibility for school bus service remained a strong predictor of walking or bicycling home from school (aPR 5.36, $p < 0.001$). Residents of the Northeast and West were more likely to walk or bicycle home from school than those in the South (aPR 1.97, $p < 0.05$; and aPR 2.00, $p < 0.05$; respectively).

## 4. Discussion

While there has been a lot of attention on walking and bicycling to school in recent years, it is important to note that approximately 85% of children in our study traveled to and from school in motorized vehicles (i.e., passenger vehicles or school buses). Overall, almost half

(47%) of children traveled to school and 42% traveled home in passenger vehicles. Efforts to improve school transportation safety should take these students' needs into account.

### 4.1. Passenger vehicle travel

Among younger school-aged passengers (i.e., ages 5 to 12 years), injury prevention strategies include the use of age- and size-appropriate restraints in rear seating positions (Committee on Injury, Violence, and Poison Prevention and Durbin, 2011). Among children ages 4 to 8 years, booster seats in the rear seating position can reduce the risk of nonfatal injury by 45%, compared to seat belts alone (Arbogast, Jermakian, Kallan, & Durbin, 2009). Child restraint laws mandating that children who have outgrown child safety seats use booster seats through the age of 8 years have been shown to increase the use of booster seats, increase the numbers of children riding in rear seats, and reduce serious injuries and fatalities (Eichelberger, Chouinard, & Jermakian, 2012). Among older children for whom seat belts fit properly (Committee on Injury, Violence, and Poison Prevention, & Durbin, 2011), primary enforcement laws that cover all seating positions in the vehicle can improve seat belt use and reduce crash-related deaths (Carpenter & Stehr, 2008). High-visibility enforcement of child restraint laws and seat belt laws is also effective at increasing restraint use and reducing injuries and fatalities for the targeted populations (Dinh-Zarr et al., 2001; Goodwin et al., 2015; Zaza et al., 2001). These interventions are population-based and apply to all motor vehicle travel (with a few exceptions, e.g., taxi passengers are exempt from restraint use laws in some states), and they can be expected to also be effective for trips to and from school.

Given the population served, schools could play a role in promoting restraint use for children and teens. While educational programs alone are unlikely to have an impact on restraint use, comprehensive strategies such as incentives and education combined with communications efforts to support enhanced enforcement campaigns may be effective (Zaza et al., 2001). Site-specific strategies such as mandating seat belt use for occupants of vehicles with student parking permits have also shown promise, particularly in communities with low levels of seat belt use (McCartt, Geary, & Solomon, 2005).

Our data did not capture driver characteristics (e.g., driver age) and thus we cannot estimate the proportion of students in our study who drove or rode with a teen driver. However, national statistics consistently show high rates of fatal or injury crash involvement for teen drivers (National Highway Traffic Safety Administration, 2016), and a Transportation Research Board (TRB) school transportation study found that crash-related fatality and injury risks on the ride to or from school were strongly influenced by the age of the driver (Transportation Research Board, 2002). Estimated annualized death rates were eight times higher with teen drivers versus adult drivers (13.2 per 100 million student trips with teen drivers and 1.6 per 100 million student trips with adult drivers; Transportation Research Board, 2002). A recent North Carolina study of school transportation risks confirmed the higher risk of injury or death for passenger vehicle trips with teen drivers, compared with adult drivers (McDonald et al., 2015). These data highlight an opportunity to improve school transportation safety for students who may drive themselves or ride with teen drivers to and from school. Modifiable risk factors that are perhaps most relevant for school travel and teen

drivers include the presence of teen passengers in the vehicle, driver inexperience, and lack of seat belt use for teen drivers and their passengers (Shope & Bingham, 2008). Comprehensive graduated driver licensing systems, which provide a staged, incremental approach to gaining experience with progressively more difficult driving situations, are an effective strategy for reducing overall crash involvement, as well as fatal crash involvement, among young drivers, particularly among 16- and 17-year-old drivers (Masten, Thomas, Korbelak, Peck, & Blomberg, 2015; Williams, McCartt, & Sims, 2016).

Among high school students, inadequate sleep duration is associated with a higher prevalence of risk-taking behaviors such as non-use of seat belts and driving or riding with a drinking driver (Wheaton, Olsen, Miller, & Croft, 2016). School policies that delay school start times for adolescents may reduce teen driver crashes by increasing the amount of sleep that adolescents get, thereby reducing the potential for drowsy driving (Danner & Phillips, 2008; Owens, Au, Carskadon, Millman, & Wolfson, 2014; Vorona et al., 2011).

### 4.2. School bus travel

Almost 40% of children in our study traveled to school and 42% traveled home on school buses. Buses have the lowest injury and fatality rates among school travel modes (Transportation Research Board, 2002; Yang et al., 2009). The National Highway Traffic Safety Administration (NHTSA) monitors school transportation-related crashes, which include crashes involving school buses (including “non-school buses functioning as school buses”) in the transportation of children to or from school or school-based activities such as field trips or sporting events. Over the 10-year period from 2006 to 2015 in the United States, an average of 5 school-aged children per year died as school bus occupants, while 11 per year died as pedestrians in crashes involving school buses (National Highway Traffic Safety Administration, 2017). To put this in perspective, an average of 3,138 school-aged children died annually from all traffic crashes during this same time period (National Highway Traffic Safety Administration, 2016).

### 4.3. Pedestrian and bicyclist travel

While physical activity is associated with multiple positive health outcomes (U.S. Department of Health and Human Services, 2008), active transportation for any purpose has been well documented to have higher crash-related injury and fatality risks than travel by bus or passenger vehicle (Beck, Dellinger, & O’Neil, 2007; Teschke et al., 2013). An elevated risk for injuries and fatalities among child pedestrians and bicyclists during school travel has been observed as well (Lavoie, Burigusa, Paurice, Hamel, & Turmel, 2014; Transportation Research Board, 2002). Our study found that most children who usually walked or bicycled to school were those who lived close to (i.e., within 1 mile of) school, which supports previous studies’ findings in this regard (Ewing, Schroeer, & Greene, 2004; Federal Highway Administration, 2008; McDonald, 2007; McDonald et al., 2011; Trapp et al., 2012). Parents have previously reported that distance is a common barrier to walking or bicycling to school (Dellinger & Staunton, 2002; Martin & Carlson, 2005), with 71% of parents in a 2001–2003 U.S. survey indicating that distance was the primary reason that their children did not normally walk to school (Beck & Greenspan, 2008).

In analyses limited to those who lived within 1 mile of school, children who were ineligible for school bus service were five times more likely than those who were eligible for bus service to walk or bicycle both to and from school. This finding is consistent with research conducted among elementary school students in a metropolitan school district in Texas (Zhu & Lee, 2009). Zhu and Lee (2009) found that children who were eligible for school bus service were less likely to walk to or from school than those who were not eligible (OR 0.31), after controlling for factors including perceived distance to school. In the United States, school bus service is typically provided to students who live beyond a prescribed distance from school, although the specifics of the policies vary by state and local jurisdiction. One study of elementary schools in seven states found that five of those states had statewide policies mandating bus service for students who lived either more than 1 mile or more than 1.5 miles from the school (Eyler et al., 2008). Many jurisdictions also have exceptions for students who live close to school but for whom traffic safety concerns make it unsafe to walk or bicycle (Everett Jones & Sliva, 2016; Eyler et al., 2008). This situation is sometimes referred to as “hazard busing.” In our study, it is possible that bus service eligibility for those within 1 mile of school may have served as a proxy for unmeasured transportation environment characteristics and that these students were less likely to walk or bicycle due to real or perceived traffic safety concerns. Self-reported data from parents have found that traffic concerns are an important reason that their children do not walk or bicycle for school travel (Beck & Greenspan, 2008; Dellinger & Staunton, 2002; Martin & Carlson, 2005). In addition, several studies have found that built environment factors, including the traffic environment, are associated with active school transportation (Ewing et al., 2004; McMillan, 2007; Schlossberg, Greene, Paulsen Phillips, Johnson, & Parker, 2006).

Programs that seek to promote children’s physical activity through active school transportation can recognize and address these injury risks for pedestrians and bicyclists using evidence-based injury prevention strategies. These strategies may include, but are not limited to, sidewalks and bicycle lanes to separate pedestrians and bicyclists from motor vehicle traffic, infrastructure to improve safety of road crossings (e.g., pedestrian crossing signals, pedestrian hybrid beacons, refuge islands), reducing motor-vehicle speeds (e.g., speed limit enforcement, traffic calming measures; Pulugurtha & Thakur, 2015; Retting, Ferguson, & McCartt, 2003; Schuurman, Cinnamon, Crooks, & Hameed, 2009; World Health Organization, 2013), and increasing bicycle helmet use for bicyclists (Bambach, Mitchell, Grzebieta, & Olivier, 2013; Cripton, Dressler, Stuart, Dennison, & Richards, 2014; Lee, Schofer, & Koppelman, 2005; McNally & Whitehead, 2013; Pardi, King, Salemi, & Salvator, 2007).

The U.S. Safe Routes to School program, originally established with federal funding in 2005, supports both infrastructure improvements and implementation of non-infrastructure elements (e.g., education and encouragement) while targeting elementary and middle schools. Few evaluations of SRTS or similar programs have examined injury outcomes; evaluations that have been undertaken suggest either a reduction in pedestrian injuries (DiMaggio & Li, 2013) or at least no increase in pedestrian or bicyclist injuries or crashes in program areas (Blomberg, Cleven, Thomas, & Peck, 2008; Orenstein, Gutierrez, Rice, Cooper, & Ragland, 2007). The latter finding is important because increasing exposure (i.e., the numbers of schoolchildren who walk or bicycle) without improving the traffic

environment could lead to an increase in child pedestrian or bicyclist injuries. An evaluation of California SRTS programs found a similar decline in pedestrian and bicyclist injury rates in program versus non-program areas without accounting for changes in walking and bicycling rates (Orenstein et al., 2007). Investigators also estimated that, given increases in walking and bicycling in program areas, the SRTS programs were likely associated with net safety benefits in certain circumstances, namely in areas that observed greater increases in walking and bicycling, in crashes that resulted in minor injuries (versus severe or fatal injuries), and among children aged 5–12 years (versus 13–17 years; Orenstein et al., 2007).

### 4.4. Limitations

There were several limitations with the data used for our study. First, distance from home to school was self-reported by the adult respondent and may not be accurate. Our estimate that 35% of children aged 5–18 years lived within 1 mile of school was similar to other self-reported estimates, which ranged from 31% to 35% of U.S. children living within 1 mile of school (Martin, Lee, & Lowry, 2007; McDonald et al., 2011). Comparison of these self-reported national estimates to objectively measured distances is difficult because objectively measured home-to-school distances in the published literature are limited to local settings and home-to-school distances can vary across localities (Schlossberg et al., 2006). Second, we were unable to examine transportation characteristics by distances within the one-mile cut-off. Walking to school has been shown to vary within a one-mile buffer (Federal Highway Administration, 2008; McDonald et al., 2011). It is possible that school bus service eligibility could vary within a one-mile buffer as well, which could have the effect of overestimating the observed association between walking or bicycling and school bus service. Third, walking and bicycling were combined in our study because small numbers prevented us from reporting these modes separately. Small numbers also prevented us from reporting prevalence of walking or bicycling among those who lived more than 1 mile of school. Fourth, the *ConsumerStyles* data set did not include environmental or attitudinal measures that have been previously reported to affect mode choice. For example, parental attitude that driving children to school is more convenient or faster than walking or bicycling has been shown to be associated with higher rates of driving (Lee, Zhu, Yoon, & Varni, 2013; McDonald & Aalborg, 2009). Environmental features such as amount of traffic and sidewalk conditions have also been shown to affect mode choice (Lee et al., 2013).

## 5. Conclusions

Understanding how children travel to and from school can help inform crash-related injury prevention efforts. Almost half of children travel to or from school in passenger vehicles. Steps to prevent crash-related injuries and deaths for this group of children include increasing the correct use of age- and size-appropriate restraints in rear vehicle seats for children less than 13 years of age, (Committee on Injury, Violence, and Poison Prevention, & Durbin, 2011; Sauber-Schatz, West, & Bergen, 2014), increasing seat belt use for children 13 years of age and older (Carpenter & Stehr, 2008; Committee on Injury, Violence, and Poison Prevention, & Durbin, 2011), and reducing the risk of crashes among teen drivers through measures such as comprehensive graduated driver licensing systems (Masten et al., 2015; Williams et al., 2016).

Federal, state, and local programs that promote walking and bicycling as a means of school travel can monitor the prevalence of active transportation to and from school and utilize proven strategies to reduce crash-related injuries and deaths (Lee et al., 2005; Pardi et al., 2007; Pulugurtha & Thakur, 2015; Retting et al., 2003; Schuurman et al., 2009; World Health Organization, 2013). Bus service eligibility for children living close to school should be further investigated in order to understand its potential role as a proxy for the safety of the transportation environment, which could highlight areas that need to implement appropriate pedestrian and bicyclist injury prevention interventions.

## Biographies

**Laurie F. Beck, MPH** Laurie Beck has served as an epidemiologist with the Division of Unintentional Injury Prevention in the National Center for Injury Prevention and Control (NCIPC) since 2003. She is responsible for research and programs in transportation safety, focusing primarily on seat belt use, safe transportation for older adults, and school transportation safety. Prior work has included surveillance of pregnancy-related behaviors and conditions. She holds a Master of Public Health in behavioral science and health education from Emory University Rollins School of Public Health and a Bachelor of Science in sociology (concentration in Health in Society) from Wake Forest University.

**Daniel D. Nguyen, MPH** Daniel Nguyen is a doctoral student in environmental health at Boston University School of Public Health. He has a Master of Science in Public Health in environmental epidemiology from Emory University Rollins School of Public Health and a Bachelor of Science in biology from the University of Connecticut. His current research focuses on aviation-related noise exposure and cardiovascular outcomes using longitudinal and cohort data. Daniel has also conducted research involving injury prevention, air pollution, and flame retardants.

## References

Arbogast KB, Jermakian JS, Kallan MJ, Durbin DR. Effectiveness of belt positioning booster seats: An updated assessment. Pediatrics. 2009; 124(5):1281–1286. http://dx.doi.org/10.1542/peds.2009-0908. [PubMed: 19841126]

Bambach MR, Mitchell RJ, Grzebieta RH, Olivier J. The effectiveness of helmets in bicycle collisions with motor vehicles: A case–control study. Accident Analysis and Prevention. 2013; 53:78–88. http://dx.doi.org/10.1016/j.aap.2013.01.005. [PubMed: 23377086]

Beck LF, Dellinger AM, O'Neil ME. Motor vehicle crash injury rates by mode of travel, United States: Using exposure-based methods to quantify differences. American Journal of Epidemiology. 2007; 166(2):212–218. http://dx.doi.org/10.1093/aje/kwm064. [PubMed: 17449891]

Beck LF, Greenspan AI. Special report from the CDC: Why don't more children walk to school? Journal of Safety Research. 2008; 39(5):449–452. http://dx.doi.org/10.1016/j.jsr.2008.07.002. [PubMed: 19010117]

Blomberg, RD., Cleven, AM., Thomas, D., Peck, RC. Evaluation of the safety benefits of legacy Safe Routes to School programs (report no. DOT HS 811 013). Washington, DC: National Highway Traffic Safety Administration; 2008.

Carpenter CS, Stehr M. The effects of mandatory seatbelt laws on seatbelt use, motor vehicle fatalities, and crash-related injuries among youths. Journal of Health Economics. 2008; 27(3):642–662. http://dx.doi.org/10.1016/j.jhealeco.2007.09.010. [PubMed: 18242744]

Centers for Disease Control and Prevention, & National Center for Injury Prevention and Control. Web-based Injury Statistics Query and Reporting System (WISQARS) [online]. 2016. [cited 2016 June 30]Available from http://www.cdc.gov/injury/wisqars/

Durbin DR. Committee on Injury, Violence, and Poison Prevention. Child passenger safety. Pediatrics. 2011; 127(4):788–793. http://dx.doi.org/10.1542/peds.2011-0213. [PubMed: 21422088]

Cripton PA, Dressler DM, Stuart CA, Dennison CR, Richards D. Bicycle helmets are highly effective at preventing head injury during head impact: Head-form accelerations and injury criteria for helmeted and unhelmeted impacts. Accident Analysis and Prevention. 2014; 70:1–7. http://dx.doi.org/10.1016/j.aap.2014.02.016. [PubMed: 24686160]

Danner F, Phillips B. Adolescent sleep, school start times, and teen motor vehicle crashes. Journal of Clinical Sleep Medicine. 2008; 4(6):533–535. [PubMed: 19110880]

Deddens JA, Petersen MR. Approaches for estimating prevalence ratios. Occupational and Environmental Medicine. 2008; 65(7):501–506. http://dx.doi.org/10.1136/oem.2007.034777.

Dellinger AM, Staunton CE. Barriers to children walking and biking to school — United States, 1999. MMWR. Morbidity and Mortality Weekly Report. 2002; 51(32):701–704. [PubMed: 12206284]

DiMaggio C, Li G. Effectiveness of a Safe Routes to School program in preventing school-aged pedestrian injury. Pediatrics. 2013; 131(2):290–296. http://dx.doi.org/10.1542/peds.2012-2182. [PubMed: 23319533]

Dinh-Zarr TB, Sleet DA, Shults RA, Zaza S, Elder RW, Nichols JL, et al. Reviews of evidence regarding interventions to increase the use of safety belts. American Journal of Preventive Medicine. 2001; 21(4S):48–65.

Eichelberger AH, Chouinard AO, Jermakian JS. Effects of booster seat laws on injury risk among children in crashes. Traffic Injury Prevention. 2012; 13(6):631–639. http://dx.doi.org/10.1080/15389588.2012.660663. [PubMed: 23137094]

Environmental Protection Agency. Travel and environmental implications of school siting (report no. EPA231-R-03-004). Washington, DC: Environmental Protection Agency; 2003.

Everett Jones S, Sliva S. School factors associated with the percentage of students who walk or bike to school, School Health Policies and Practices Study, 2014. Preventing Chronic Disease. 2016; 13:E63. http://dx.doi.org/10.5888/pcd13.150573. [PubMed: 27172258]

Ewing R, Schroeer W, Greene W. School location and student travel: Analysis of factors affecting mode choice. Transportation Research Record. 2004; 1895:55–63. http://dx.doi.org/10.3141/1895-08.

Eyler AA, Brownson RC, Doescher MP, Evenson KR, Fesperman CE, Litt JS, et al. Policies related to active transport to and from school: A multisite case study. Health Education Research. 2008; 23(6):963–975. http://dx.doi.org/10.1093/her/cym061. [PubMed: 17956883]

Federal Highway Administration. NHTS Brief: National Household Travel Survey: Travel to school: The distance factor. Washington, DC: Federal Highway Administration; 2008.

Goodwin, A., Thomas, L., Kirley, B., Hall, W., O'Brien, N., Hill, K. Countermeasures that work: A highway safety countermeasure guide for state highway safety offices, eighth edition (report no. DOT HS 812 202). Washington, DC: National Highway Traffic Safety Administration; 2015.

Ham SA, Macera CA, Lindley C. Trends in walking for transportation in the United States, 1995 and 2001. Preventing Chronic Disease. 2005; 2(4):1–10. Retrieved from http://www.cdc.gov/pcd/issues/2005/oct/04_0138.htm.

Hu, PS., Reuscher, TR. Summary of travel trends: 2001 National Household Travel Survey. Washington, DC: Federal Highway Administration; 2004.

Lavoie M, Burigusa G, Paurice P, Hamel D, Turmel E. Active and safe transportation of elementary-school students: Comparative analysis of the risks of injury associated with children travelling by car, walking and cycling between home and school. Chronic Diseases and Injuries in Canada. 2014; 34(4):195–202. [PubMed: 25408178]

Lee BH, Schofer JL, Koppelman FS. Bicycle safety helmet legislation and bicycle-related non-fatal injuries in California. Accident Analysis and Prevention. 2005; 37(1):93–102. http://dx.doi.org/10.1016/j.aap.2004.07.001. [PubMed: 15607280]

Lee C, Zhu X, Yoon J, Varni JW. Beyond distance: Children's school travel mode choice. Annals of Behavioral Medicine. 2013; 45(S1):S55–S67. http://dx.doi.org/10.1007/s12160-012-9432-z. [PubMed: 23334763]

Martin S, Carlson S. Barriers to children walking to or from school — United States, 2004. MMWR. Morbidity and Mortality Weekly Report. 2005; 54(38):949–952. [PubMed: 16195692]

Martin SL, Lee SM, Lowry R. National prevalence and correlates of walking and bicycling to school. American Journal of Preventive Medicine. 2007; 33(2):98–105. http://dx.doi.org/10.1016/j.amepre.2007.04.024. [PubMed: 17673096]

Masten, SV., Thomas, FD., Korbelak, KT., Peck, RC., Blomberg, RD. Meta-analysis of graduated driver licensing laws (report no. DOT HS 812 212). Washington, DC: National Highway Traffic Safety Administration; 2015.

McCartt AT, Geary LL, Solomon MG. Requiring belt use as part of a school parking permit program: Does it increase students' belt use? Traffic Injury Prevention. 2005; 6(2):120–126. http://dx.doi.org/10.1080/15389580590931581. [PubMed: 16019397]

McDonald NC. Active transportation to school: Trends among U.S. schoolchildren, 1969–2001. American Journal of Preventive Medicine. 2007; 32(6):509–516. http://dx.doi.org/10.1016/j.amepre.2007.02.022. [PubMed: 17533067]

McDonald NC, Aalborg AE. Why parents drive children to school. Journal of the American Planning Association. 2009; 75(3):331–342. http://dx.doi.org/10.1080/01944360902988794.

McDonald NC, Brown AL, Marchetti LM, Pedroso MS. U.S. school travel, 2009: An assessment of trends. American Journal of Preventive Medicine. 2011; 41(2):146–151. http://dx.doi.org/10.1016/j.amepre.2011.04.006. [PubMed: 21767721]

McDonald NC, McGrane AB, Rodgman EA, Steiner RL, Palmer WM, Lytle BF. Assessing multimodal school travel safety in North Carolina. Accident Analysis and Prevention. 2015; 74:126–132. http://dx.doi.org/10.1016/j.aap.2014.10.006. [PubMed: 25463952]

McMillan TE. The relative influence of urban form on a child's travel mode to school. Transportation Research Part A: Policy and Practice. 2007; 41(1):69–79. http://dx.doi.org/10.1016/j.tra.2006.05.011.

McNally DS, Whitehead S. A computational simulation study of the influence of helmet wearing on head injury risk in adult cyclists. Accident Analysis and Prevention. 2013; 60:15–23. http://dx.doi.org/10.1016/j.aap.2013.07.011. [PubMed: 24005027]

National Highway Traffic Safety Administration. Traffic safety facts 2014: A compilation of motor vehicle crash data from the Fatality Analysis Reporting System and the General Estimates System (report no. DOT HS 812 261). Washington, DC: National Highway Traffic Safety Administration; 2016.

National Highway Traffic Safety Administration. Traffic safety facts 2006–2015 data: School-transportation-related crashes (report no. DOT HS 812 366). Washington, DC: National Highway Traffic Safety Administration; 2017.

National Safe Routes to School Task Force. Safe routes to school: A transportation legacy: A national strategy to increase safety and physical activity among American youth. Washington, DC: U.S. Department of Transportation; 2008.

Orenstein, MR., Gutierrez, N., Rice, TM., Cooper, JF., Ragland, DR. Safe routes to school safety and mobility analysis: Report to the California legislature. California: California Department of Transportation & University of California Berkeley Traffic Safety Center; 2007.

Owens JA, Au R, Carskadon M, Millman R, Wolfson A. School start times for adolescents. Pediatrics. 2014; 134(3):642–649. http://dx.doi.org/10.1542/peds.2014-1697. [PubMed: 25156998]

Pardi L, King B, Salemi G, Salvator A. The effect of bicycle helmet legislation on pediatric injury. Journal of Trauma Nursing. 2007; 14:84–87. http://dx.doi.org/10.1097/01.JTN.0000278793.28536.1c. [PubMed: 17579327]

Petersen MR, Deddens JA. A comparison of two methods for estimating prevalence ratios. BMC Medical Research Methodology. 2008; 8:9. http://dx.doi.org/10.1186/1471-2288-8-9. [PubMed: 18307814]

Pulugurtha SS, Thakur V. Evaluating the effectiveness of on-street bicycle lane and assessing risk to bicyclists in Charlotte, North Carolina. Accident Analysis and Prevention. 2015; 76:34–41. http://dx.doi.org/10.1016/j.aap.2014.12.020. [PubMed: 25576793]

Retting RA, Ferguson SA, McCartt AT. A review of evidence-based traffic engineering measures designed to reduce pedestrian–motor vehicle crashes. American Journal of Public Health. 2003; 93(9):1456–1463. [PubMed: 12948963]

Sauber-Schatz EK, West BA, Bergen G. Vital signs: Restraint use and motor vehicle occupant death rates among children aged 0–12 years — United States, 2002–2011. MMWR. Morbidity and Mortality Weekly Report. 2014; 63(5):113–118. [PubMed: 24500292]

Schlossberg M, Greene J, Paulsen Phillips P, Johnson B, Parker B. School trips: Effects of urban form and distance on travel mode. Journal of the American Planning Association. 2006; 72(3):337–346. http://dx.doi.org/10.1080/01944360608976755.

Schuurman N, Cinnamon J, Crooks VA, Hameed SM. Pedestrian injury and the built environment: An environmental scan of hotspots. BMC Public Health. 2009; 9:233. http://dx.doi.org/10.1186/1471-2458-9-233. [PubMed: 19602225]

Shope JT, Bingham CR. Teen driving: Motor-vehicle crashes and factors that contribute. American Journal of Preventive Medicine. 2008; 35(3S):S261–S271. http://dx.doi.org/10.1016/j.amepre.2008.06.022. [PubMed: 18702980]

Teschke K, Harris MA, Reynolds CCO, Shen H, Cripton PA, Winters M. Exposure-based traffic crash injury rates by mode of travel in British Columbia. Canadian Journal of Public Health. 2013; 104:e75–e79. [PubMed: 23618122]

Transportation Research Board. Transportation Research Board special report 269: The relative risks of school travel. Washington, DC: Transportation Research Board, National Academy of Sciences; 2002.

Trapp GSA, Giles-Corti B, Christian HE, Bulsara M, Timperio AF, McCormack GR, et al. Increasing children's physical activity: Individual, social, and environmental factors associated with walking to and from school. Health Education & Behavior. 2012; 39(2):172–182. http://dx.doi.org/10.1177/1090198111423272. [PubMed: 21990572]

U.S. Department of Health and Human Services. 2008 physical activity guidelines for Americans (report no. U0036). Washington, DC: US Department of Health and Human Services; 2008.

Vorona RD, Szklo-Coxe M, Wu A, Dubik M, Zhao Y, Ware JC. Dissimilar teen crash rates in two neighboring southeastern Virginia cities with different high school start times. Journal of Clinical Sleep Medicine. 2011; 7(2):145–151. [PubMed: 21509328]

Weber, D. ConsumerStyles 2012 methodology. Washington, DC: Porter Novelli Public Services; 2012.

Wheaton AG, Olsen EO, Miller GF, Croft JB. Sleep duration and injury-related risk behaviors among high school students — United States, 2007–2013. MMWR. Morbidity and Mortality Weekly Report. 2016; 65(13):337–341. http://dx.doi.org/10.15585/mmwr.mm6513a1. [PubMed: 27054407]

Williams AF, McCartt AT, Sims LB. History and current status of state graduated driver licensing (GDL) laws in the United States. Journal of Safety Research. 2016; 56:9–15. http://dx.doi.org/10.1016/j.jsr.2015.11.006. [PubMed: 26875159]

World Health Organization. Pedestrian safety: A road safety manual for decision-makers and practitioners. Geneva, Switzerland: World Health Organization; 2013.

Yang J, Peek-Asa C, Cheng G, Heiden E, Falb S, Ramirez M. Incidence and characteristics of school bus crashes and injuries. Accident Analysis and Prevention. 2009; 41(2):336–341. http://dx.doi.org/10.1016/j.aap.2008.12.012. [PubMed: 19245893]

Zaza S, Sleet DA, Thompson RS, Sosin DM, Bolen JC. Task Force on Community Preventive Services. Reviews of evidence regarding interventions to increase use of child safety seats. American Journal of Preventive Medicine. 2001; 21(4S):31–47. [PubMed: 11691560]

Zhu X, Lee C. Correlates of walking to school and implications for public policies: Survey results from parents of elementary school children in Austin, Texas. Journal of Public Health Policy. 2009; 30(Suppl 1):S177–S202. [PubMed: 19190573]

Zients, J. Revised delineations of metropolitan statistical areas, micropolitan statistical areas, and combined statistical areas, and guidance on uses of the delineations of these areas (OMB bulletin

no. 13-01). Washington, DC: Executive Office of the President, Office of Management and Budget; 2013.

### Practical applications

- Given the large proportion of children who use passenger vehicles for school travel, community-based and school-based strategies that increase child restraint and seat belt use can be adopted to reduce the likelihood of crash-related injuries and deaths.
- Community-based strategies (e.g., graduated driver licensing) can be more widely adopted to reduce the likelihood of crashes (and associated injuries and deaths) among teen drivers.
- Approximately one in four children who live within 1 mile of school walks or bicycles to or from school. Comprehensive interventions that improve pedestrian and bicyclist safety can be implemented within 1 mile of schools to protect these students.
- For children who live within 1 mile of school, school bus service eligibility can be further investigated to determine its role in whether children walk or bicycle for school travel.

*J Safety Res*. Author manuscript; available in PMC 2017 December 01.

**Table 1**

Prevalence of school transportation characteristics, stratified by distance between home and school, *ConsumerStyles* 2012.

| | Distance between home and school | | | | | |
|---|---|---|---|---|---|---|
| | ≤1 mile | | >1 mile | | Total | |
| | Sample n[a] | Weighted % (SE) | Sample n | Weighted % (SE) | Sample n | Weighted % (SE) |
| Travel mode to school | | | | | | |
| Walk or bicycle | 94 | 21.9 (2.9) | – | – | 101 | 8.0 (1.1) |
| School bus | 72 | 23.9 (3.4) | 364 | 47.4 (2.6) | 440 | 39.4 (2.1) |
| Passenger vehicle | 169 | 48.1 (3.8) | 397 | 45.9 (2.6) | 569 | 46.6 (2.1) |
| Other | 30 | 6.0 (1.6) | 28 | 6.1 (1.6) | 58 | 6.0 (1.2) |
| Travel mode home from school | | | | | | |
| Walk or bicycle | 122 | 28.4 (3.3) | – | – | 136 | 10.9 (1.3) |
| School bus | 76 | 24.2 (3.3) | 383 | 51.3 (2.6) | 463 | 42.0 (2.1) |
| Passenger vehicle | 136 | 41.3 (3.8) | 368 | 42.4 (2.5) | 506 | 41.8 (2.1) |
| Other | 30 | 6.0 (1.6) | 26 | 5.0 (1.4) | 57 | 5.4 (1.1) |
| School bus service eligibility | | | | | | |
| Yes | 131 | 41.8 (3.8) | 569 | 74.1 (2.2) | 704 | 62.8 (2.0) |
| No | 232 | 58.2 (3.8) | 225 | 25.9 (2.2) | 459 | 37.2 (2.0) |
| Age group | | | | | | |
| 5–11 years | 221 | 74.5 (3.1) | 368 | 59.8 (2.4) | 593 | 65.0 (1.9) |
| 12–14 years | 71 | 14.0 (2.5) | 204 | 20.3 (1.9) | 276 | 18.0 (1.5) |
| 15–18 years | 63 | 11.5 (2.0) | 214 | 19.9 (1.8) | 279 | 17.0 (1.4) |
| Total[b] | 365 | 35.2 (2.1) | 797 | 64.8 (2.1) | 1,170 | 100.0 |

SE = standard error.

−Data have been suppressed where sample n < 20.

[a]Unweighted sample size.

[b]Sample n's for some variables may not sum to the total sample count due to missing data.

## Table 2

Factors associated with walking or bicycling ≤1 mile to school, *ConsumerStyles* 2012.

| | Crude PR (95% CI) | Adjusted PR[a] (95% CI) |
|---|---|---|
| School bus service eligibility | | |
| Eligible | Referent | Referent |
| Not eligible | **5.60 *** (2.81, 11.18)** | **5.36 *** (2.63, 10.92)** |
| Age group | | |
| 5–11 years | Referent | |
| 12–14 years | 1.41 (0.75, 2.66) | |
| 15–18 years | 1.40 (0.73, 2.67) | |
| Household income (annual) | | |
| <$25,000 | Referent | |
| $25,000–$49,999 | 0.75 (0.32, 1.72) | |
| $50,000–$74,999 | 0.65 (0.26, 1.60) | |
| ≥$75,000 | 1.05 (0.52, 2.09) | |
| Household residence type | | |
| Multiple family residence | Referent | |
| Single family residence | 1.10 (0.55, 2.20) | |
| Region | | |
| South | Referent | Referent |
| Northeast | 2.16 (0.97, 4.82) | **2.04 * (1.00, 4.15)** |
| Midwest | **2.27 * (1.08, 4.76)** | 1.59 (0.78, 3.25) |
| West | **3.15 ** (1.52, 6.55)** | 1.62 (0.80, 3.27) |
| Metropolitan status | | |
| Non-metropolitan | Referent | |
| Metropolitan | 2.39 (0.99, 5.76) | |

CI, confidence interval; PR, prevalence ratio.

Boldface indicates statistical significance

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$

[a] Adjusted for school bus service eligibility and region.

## Table 3

Factors associated with walking or bicycling ≤1 mile home from school, *ConsumerStyles* 2012.

| | Crude PR (95% CI) | Adjusted PR[a] (95% CI) |
|---|---|---|
| School bus service eligibility | | |
| Eligible | Referent | Referent |
| Not eligible | **6.16 *** (3.35, 11.31)** | **5.36 *** (2.86, 10.05)** |
| Age group | | |
| 5–11 years | Referent | |
| 12–14 years | 1.22 (0.68, 2.16) | |
| 15–18 years | 1.58 (0.94, 2.65) | |
| Household income (annual) | | |
| <$25,000 | Referent | |
| $25,000–$49,999 | 0.95 (0.44, 2.07) | |
| $50,000–$74,999 | 1.09 (0.49, 2.43) | |
| ≥$75,000 | 1.34 (0.69, 2.60) | |
| Household residence type | | |
| Multiple family residence | Referent | |
| Single family residence | 1.37 (0.71, 2.62) | |
| Region | | |
| South | Referent | Referent |
| Northeast | 2.09 (0.98, 4.45) | **1.97 * (1.03, 3.77)** |
| Midwest | **2.47 ** (1.26, 4.86)** | 1.73 (0.91, 3.30) |
| West | **3.88 *** (2.04, 7.41)** | **2.00 * (1.08, 3.67)** |
| Metropolitan status | | |
| Non-metropolitan | Referent | |
| Metropolitan | 1.21 (0.61, 2.37) | |

CI, confidence interval; PR, prevalence ratio.

Boldface indicates statistical significance

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$

[a] Adjusted for school bus service eligibility and region.