Special Report 269

The Relative Risks of School Travel

A NATIONAL PERSPECTIVE AND GUIDANCE FOR LOCAL COMMUNITY RISK ASSESSMENT

TRANSPORTATION RESEARCH BOARD

OF THE NATIONAL ACADEMIES

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Committee on School Transportation Safety

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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Preface

School transportation safety issues have been of concern for many years. Interest in these issues has recently been heightened by congressional testimony, as well as by reports and recommendations issued by the National Highway Traffic Safety Administration (NHTSA), the National Transportation Safety Board (NTSB), and others. Hearings held in the U.S. Senate in 1996 on school transportation safety, for example, raised the question of what is known about the safety of children who use public transit to travel to and from school. It was noted at the time that more than 20 percent of school children in California were using public transportation to travel to school, and that in other areas, such as Ohio, the use of public transit for school transportation was increasing. During the hearings, the focus of interest was broadened beyond school versus transit buses to include the various other modes used to transport students, and was expanded to include school-related trips in addition to trips to and from home and school.

The Transportation Equity Act for the 21st Century mandated that the Secretary of Transportation commission the Transportation Research Board (TRB) of the National Research Council (NRC) to examine available crash injury data, along with vehicle design and driver training requirements and routing, operational, and other relevant factors, to study "the safety issues attendant to the transportation of school children to and from school and school-related activities by various transportation modes." If the data were deemed unavailable or insufficient, a new data collection regimen and implementation guidelines were to be recommended. (A copy of the relevant legislation is provided in the appendix.) The purpose of this report is to fulfill this mandate by assessing the relative risks of each major mode used for school travel and to provide insights into the potential effects on safety of changes in the distribution of school trips by mode.

To conduct this study, NRC convened a 14-member committee with appropriate scientific and technical expertise in highway safety, data analysis, safety statistics, risk perception and communication, policy analysis, pediatrics, public health and exposure estimation, integration of transportation services, school bus operations, transit operations, driver training, and pedestrian/bicycling safety (see the study committee biographical information at the end of this report). Reflecting the origins of the study request, the study approach was as comprehensive as possible, encompassing all practical modes of school travel.

In addressing the safety issues associated with the travel of school-age children to and from school and school-related activities by various modes, the committee interpreted its charge to include the following:

- A review of available data and information on injuries, fatalities, exposure, operational factors, vehicle design, operator training, and other factors relevant to school travel;
- Consideration of the basic characteristics of the modes used by students, the operational differences among the modes, and any relevant infrastructure or environmental conditions;
- Assessment of issues relevant to determining the risk associated with each mode in the context of both occupant and pedestrian injuries and fatalities, with consideration of the behavioral and developmental characteristics of children;
- Assessment of the efficacy of drawing conclusions from the available data, based on the statistical confidence in the data and the relevancy of the data to the issues being reviewed; and
- Evaluation of the availability and adequacy of the salient data, and recommendation of new data collection and implementation guidelines if applicable.

Upon undertaking the study, the committee examined the available databases and identified only three that could be used to examine the relative risk of the various school travel modes. Analysis of these data revealed some very clear differences in travel risks across the modes. Because of data limitations, however, only comparisons at the national level were possible; the data did not provide the detail needed to help specific school districts assess their risks.

The complexity and sensitivity of the issues involved, coupled with the sparseness of comparable data, presented challenges to the committee. Nonetheless, the committee endeavored to consolidate all the existing information on the issues of interest, document what is currently known, analyze the available data (both qualitative and quantitative) to the extent possible, and produce findings and recommendations that would have practical application to decision making with regard to the safety of school travel. In addition, to help communities identify steps that could be taken to reduce the risks particular to their school transportation systems, the committee created checklists of risk mitigation options based on a review of the relevant research literature and accepted best practices. The committee recognizes that those responsible for making school transportation decisions must consider many factors aside from safety, but believes that these checklists, used in conjunction with the national-level statistical risk analysis, provide a framework with which communities can undertake a systematic evaluation of school travel alternatives.

The committee as a whole met five times between July 2000 and July 2001, and subgroups met periodically throughout that period. The early meetings included extensive presentations in sessions open to the public, during which experts from government, academia, advocacy organizations, and industry presented a variety of issues and views to the committee. This final report provides a synthesis of the information gathered by the committee, which encompassed the data, analytical tools, and methods currently available for the development of a risk management framework for assessing the relative safety of the various modes used for school travel.

ACKNOWLEDGMENTS

During the course of this study, the committee and staff received numerous briefings and presentations, consulted with experts, and requested detailed data analyses. The committee wishes to thank the many individuals who contributed their time and effort to this project. In particular, the committee wishes to thank Patricia Hu and Timothy Reusch of Oak Ridge National Laboratory, who analyzed data from the Nationwide Personal Transportation Survey; Anders Longthorne of the National Center for Statistics and Analysis at NHTSA, who performed analyses of data from the General Estimates System; and Betsy Benkowski [formerly of NHTSA, now with the Truck and Bus Crash Information Center, Federal Motor Carrier Safety Administration (FMCSA)], Judy Hilton (NHTSA), and Lindsay Griffin III (Texas Transportation Institute), who conducted analyses of data from the Fatality Analysis Reporting System; and Clarence Cheung of Carnegie Mellon University, who provided support to Paul Fischbeck for the risk analyses.

We are also indebted to Lidia Kostyniuk and Hans Joksch of the University of Michigan Transportation Research Institute, who provided briefings on the Data Collection Effort for Pupil Safety on Transit Bus Systems project. Appreciation is expressed as well to the many individuals and organizational representatives who provided information, including Robert Bambino, Director of Risk Management, New York Schools Insurance Reciprocal; Tamara Broyhill, Federal Highway Administration (FHWA); Andrew Clarke, Chair, TRB Technical Activities Committee on Bicycling; Rob Foss, Highway Safety Research Center; Charles Gauthier, National Association of State Directors of Pupil Transportation Services; Phil Hanley, Commercial Passenger Safety Division, FMCSA; Charlie Hott, NHTSA; Ken House, staffer for the House Committee on Transportation and Infrastructure; Greg Hull, American Public Transportation Association; William Hunter, Highway Safety Research Center; Terry Klein, Bureau of Transportation Statistics; Robin Leeds, National School Transportation Association; Susan Liss, FHWA; Iyon Lyles, Federal Transit Administration; Mike Martin, National Association of Pupil Transportation; Nancy McGuckin, FHWA; Angela Mickalide, The National SAFE KIDS Campaign; Bill Paul, *School Transportation News;* Joe Osterman, NTSB; Jeanmarie Poole, NTSB; Bill Wilkinson, National Center for Bicycling and Walking; and Chris Zeilinger, Community Transportation Association of America. Thanks are due in particular to the liaison representatives from NHTSA—Eleanor Hunter, Maria Vegega, and Diane Wigle—who responded promptly and with a generous spirit to the committee's many requests for information.

The study was performed under the overall supervision of Stephen R. Godwin, TRB's Director of Studies and Information Services. The committee gratefully acknowledges the work and support of Beverly Huey, who served as project director and drafted many sections of the report; Paul Fischbeck, who conducted the risk analyses and drafted other sections of the report; and Suzanne Schneider, Associate Executive Director of TRB, who managed the review process. The report was edited by Rona Briere and prepared for publication under the supervision of Nancy A. Ackerman, Director of Reports and Editorial Services.

The report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

The committee thanks the following individuals for their review of this report: Dan Burden, Walkable Communities, Inc., High Springs, Florida; James H. Hedlund, Highway Safety North, Ithaca, New York; Karl E. Kim, University of Hawaii at Manoa, Honolulu, Hawaii; William Mallett, Battelle Memorial Institute, Washington, D.C.; Michael Malloy, Cleveland Municipal School District, Cleveland, Ohio; Penny Page, Yellow Transportation, Baltimore, Maryland; and Frederick P. Rivara, University of Washington School of Medicine, Seattle, Washington. Although these reviewers provided many constructive comments and suggestions, they were not asked to endorse the findings and conclusions, nor did they see the final draft before its release.

The review of this report was overseen by L. G. (Gary) Byrd, Consulting Engineer, Mill Spring, North Carolina, and Lester A. Hoel, University of Virginia, Charlottesville. Appointed by NRC, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

H. Douglas Robertson, Chair
Committee on School Transportation Safety

Contents

Executive Summary

Children in the United States travel to and from school and school-related activities by a variety of modes. Because parents and their school-age children have a limited understanding of the risks associated with each mode, it is unlikely that these risks greatly influence their school travel choices. Public perceptions of school transportation safety are heavily influenced by school bus (i.e., "yellow bus") services. When children are killed or injured in crashes involving school buses, the link to school transportation appears obvious; when children are killed or injured in crashes that occur when they are traveling to or from school or school-related activities by other modes, however, the purpose of the trip is often not known or recorded, and the risks are not coded in a school-related category. Despite such limitations and the fact that estimates of the risks across school travel modes are confounded by inconsistent and incomplete data, sufficient information is available to make gross comparisons of the relative risks among modes used for school travel and to provide guidance for risk management.

Each year approximately 800 school-aged children are killed in motor vehicle crashes during normal school travel hours.[1] This figure represents about 14 percent of the 5,600 child deaths that occur annually on U.S. roadways and 2 percent of the nation's yearly total of 40,000 motor vehicle deaths. Of these 800 deaths, about 20 (2 percent)—5 school bus passengers and 15 pedestrians—are school bus–related.[2] The other 98 percent of school-aged deaths occur in passenger vehicles or to pedestrians, bicyclists, or motorcyclists. A disproportionate share of these passenger vehicle–related deaths (approximately 450 of the 800 deaths, or 55 percent) occur when a teenager is driving. At the same time, approximately 152,000 school-age children are nonfatally injured during normal school travel hours each year. More than 80 percent (about 130,000) of these nonfatal injuries occur in passenger vehicles; only 4 percent (about 6,000) are school bus–related (about 5,500 school bus passengers and 500 school bus pedestrians), 11 percent (about 16,500) occur to pedestrians and bicyclists, and fewer than 1 percent (500) are to passengers in other buses.

In the Transportation Equity Act for the 21st Century (TEA-21) of 1998, Congress mandated that the Transportation Research Board undertake a study "of the safety issues attendant to the transportation of school children to and

[1] Normal school travel hours were defined by the committee to be 6 a.m. to 8:59 a.m. and 2 p.m. to 4:59 p.m. each weekday from September 1 through mid-June.

[2] The committee notes that fatality and injury data related to loading and unloading were available only for the school bus mode.

from school and school-related activities by various transportation modes." In the process, the study was to take into account available crash injury data, as well as vehicle design and driver-training requirements, routing, and other operational factors that affect safety. If crash injury data were found to be unavailable or insufficient, a new data collection regimen and implementation guidelines were to be recommended.

In response to this mandate, this report provides estimates of the relative risk among school travel modes using available information collected at the national level. Because data on trip purpose are not included in the available datasets for all modes, the data analyzed represent deaths and injuries that occurred during normal school travel hours as defined earlier. This approach to estimating exposure to risk is obviously different than an analysis based on trips taken specifically to and from school; because of the varied schedules and many activities of today's school children, however, the generic trip to and from school is difficult to define even with complete data. Regardless, as illustrated below, the substantial differences in risk across modes that are illuminated with these risk estimates cannot easily be explained away by any biases that might result from using this time-based estimating procedure.

As noted above, the focus of the study was not restricted to children traveling to and from school, but also encompassed their travel to and from school-related activities.[3] However, as discussed more fully in Chapters 2 and 3, crash data for school-related trips—which comprise roughly 4 percent of all school transportation—are not directly available. In a limited number of instances, these data may be inferred from other information that is recorded on police accident reports, but this is the exception. Compounding the difficulty of drawing conclusions from such data, different types and mixes of vehicles are often used for school-related purposes, and some trips do not occur during the above-defined school travel hours. Hence, the data and analyses presented in this report are restricted to crashes that occurred during normal school travel hours. Those school-related activity trips that took place during normal school travel hours are included in the analyses, but could not be separated out for more focused analysis.

Because specific data (e.g., crash, injury, fatality, miles traveled, trip) for comparing the relative safety of narrowly defined individual travel modes are either unavailable, insufficient, or inadequate, the committee grouped the various modes used for school travel into six broad categories for which sufficient data could be obtained to support the required analyses: (*a*) school buses (i.e., regular and special education pupil transportation services), (*b*) all other buses (e.g., transit, paratransit, and motorcoach service), (*c*) passenger vehicles driven by operators 19 years of age and older (primarily personal vehicles, but also taxicab and child transport services deploying non–yellow buses or vans),

[3] A *school-related activity,* also known as an *activity trip,* is defined as "the transportation of students to any event sanctioned for pupil attendance or authorized by an officer, employee or agent of a public or private school, other than to-and-from school transportation" (NCST 2000, 163).

(*d*) passenger vehicles driven by operators younger than 19 years of age,[4] (*e*) bicycles,[5] and (*f*) walking.

Many risk factors (e.g., child behavior, infrastructure design, and the use of safety equipment) play a role in determining school travel risk, and the relative importance of these factors varies significantly not only across the different travel modes, but also among communities and school districts. Long lists of risk factors would not promote or allow a systematic comparison of the various transportation modes. To simplify and better inform the risk comparison process, the committee grouped the various risk factors into five categories: (*a*) human, (*b*) vehicular, (*c*) operational, (*d*) infrastructure/environmental, and (*e*) societal. Although much of the information on these factors presented in this report is nonquantitative, research findings provide insights that may affect risk from mode to mode and on interventions that may be used to improve safety.

FINDINGS

The data used throughout this report were extracted from three main sources:

- Nationwide Personal Transportation Survey (NPTS)—contains travel information used to estimate the number of trips taken and miles traveled by school-age children for all modes.
- Fatality Analysis Reporting System (FARS)—contains data on all police-reported fatal traffic crashes that occur on public roadways in the United States, used to analyze student fatalities.
- National Automotive Sampling System (NASS) General Estimates System (GES)—contains data on a nationally representative stratified sample of police-reported traffic crashes that occur on public roadways in 60 geographic sites across the United States and that result in property damage, injury, or death, used to analyze student injuries.

Some problems of data quality and quantity were addressed by grouping the data into age categories, by averaging data across multiple years, and by combining injury categories. Doing so allowed the committee to smooth out data anomalies caused by small sample sizes and to construct more robust estimates. This was necessary because of the relatively infrequent occurrence of severe injuries and deaths for particular travel modes in any given year during normal school travel hours. Because NPTS and GES data are based on samples from much larger populations, the national risk estimates derived from these samples are uncertain. Therefore, the committee modeled this uncertainty throughout all risk calculations. For some travel mode/crash categories, the uncertainty can be large because of rare events and sampling biases.

[4] The term *passenger vehicles* is used here to refer to motor vehicles excluding school buses and other buses.

[5] The term *bicycle* is used here to include all pedalcycles (one, two, and three wheels).

TABLE ES-1 Estimated Annual Trips and Student-Miles Traveled by Mode During Normal School Travel Hours

Mode	100 Million Student Trips (%)	100 Million Student-Miles (%)
School bus	58 (25)	313 (28)
Other bus	5 (2)	38 (3)
Passenger vehicle, adult driver	105 (45)	580 (51)
Passenger vehicle, teen driver	34 (14)	184 (16)
Bicycle	5 (2)	4 (<1)
Walking	28 (12)	15 (1)
Total	**235 (100)**	**1,134 (100)**

Source: 1995 NPTS.

Exposure to Risk

Using the NPTS dataset, it is possible to estimate the total trips and distances traveled by various modes during normal school travel hours (see Table ES-1). These estimates were derived from the most recent survey completed and available at the time of this study (the 1995 survey). On the basis of this survey, school bus services account for 25 percent of trips[6] and 28 percent of student-miles traveled[7] during normal school travel hours. Other buses, typically but not exclusively transit buses, account for another 2 to 3 percent of school trips and student-miles during these same time periods,[8] while trips by passenger vehicles, whether the driver is an adult (defined as age 19 or older) or teen (defined as younger than age 19), represent about 60 percent of trips and two-thirds of student-miles. Naturally, the distance traveled per trip varies by mode. For example, even though student pedestrian travel accounts for 12 percent of trips,

[6] These numbers may be different from those reported by others because the committee used time of day as a surrogate for purpose of trip. Although some databases do contain school bus ridership data, no other national databases exist that contain ridership data for all the modes of interest. To enable comparisons among the modes, one standard definition had to be used; time of day was the variable determined to be most useful for this purpose. Because all modes except school buses may be used for both school and nonschool travel during normal school travel hours as defined earlier, and data in the analyses are for a total of 205 days (which includes 20 to 25 weekday holidays and other weekday nonschool days during the typical school year), non–school bus modes are likely overrepresented in terms of actual school trips.

[7] Throughout this report, distance traveled or miles traveled refers to passenger- or student-miles; it does not refer to vehicle-miles, which is the distance typically reported in pupil transportation journals. Moreover, while the terms *student trips* and *student-miles* are used throughout the report, it must be noted that all children aged 5 to 18, inclusive, are considered students in this report, whereas in fact school attendance is mandatory only to age 16.

[8] As with pupil transportation trip estimates, other sources suggest these figures may be different. Unlike the pupil transportation community, the transit community does not compile the percentage of total transit trips attributable to school-age travelers' home-to-school or school-related travel (even though different fare increments make estimates possible in individual metropolitan areas).

TABLE ES-2 Average Annual Student Injuries and Fatalities by Mode During Normal School Travel Hours

Mode	Injuries (%)	Fatalities (%)
School bus	6,000 (4)	20[a] (2)
Other bus	550 (<1)	1 (<1)
Passenger vehicle, adult driver	51,000 (33)	169 (20)
Passenger vehicle, teen driver	78,200 (51)	448 (55)
Bicycle	7,700 (5)	46 (6)
Walking	8,800 (6)	131 (16)
Total	**152,250 (100)**	**815 (100)**

[a] Includes 5 passenger and 15 pedestrian fatalities.
Source: 1991–1999 FARS and GES.

these trips represent just 1 percent of all miles traveled. These differences are important to consider when analyzing risk measures.

Injuries and Fatalities

Injuries and fatalities to children traveling to or from school occur infrequently enough that a single year of data can be misleading. Therefore, data from 9 years (1991–1999) were combined. Average yearly counts of deaths and estimates of injuries during this period for the six modal classifications used in this study are depicted in Table ES-2. Approximately 75 percent of the deaths and 84 percent of the injuries in crashes occurred in the two passenger vehicle categories. Fatalities and injuries to student bicyclists and pedestrians involved in crashes represent the next-largest share—22 percent of fatalities and 11 percent of injuries.[9]

When school travel modes are compared, the distribution of injuries and fatalities (shown in Table ES-2) is found to be quite different from that of trips and miles traveled (shown in Table ES-1). Three modes (school buses, other buses, and passenger vehicles with adult drivers) have injury estimates and fatality counts below those expected on the basis of the exposure to risk implied by the number of trips taken or student-miles traveled. For example, school buses represent 25 percent of the miles traveled by students but account for less than 4 percent of the injuries and 2 percent of the fatalities. Conversely, the other three modal classifications (passenger vehicles with teen drivers, bicycling, and walking) have estimated injury rates and fatality counts disproportionately greater than expected on the basis of exposure data. For example, passenger vehicles with teen drivers account for more than half of the injuries and fatalities, a much greater proportion than the 14 to 16 percent that would be expected on the basis of student-miles and trips.

[9] These student bicyclist and pedestrian crashes represent only those accidents in which a motor vehicle is involved because of the nature of the databases that contain this information. Pedestrian and bicyclist fatalities and injuries that occur without the involvement of a motor vehicle are not included.

Injury and Fatality Rates

By combining the data presented in Tables ES-1 and ES-2, it is possible to develop measures of risk that permit gross comparisons of relative safety among modes. The highest rate of student injuries and fatalities per trip during normal school travel hours occurs for passenger vehicles with teenage drivers, followed by student cyclists (see Table ES-3). On a per-mile basis, however, school-aged bicyclists have the highest injury and fatality rates, followed by school-aged pedestrians, then students who travel in passenger vehicles with teenage drivers. The fatality rates for passenger vehicles driven by teenagers is roughly 8 times higher than the rate for those driven by adults. School buses and other buses have the lowest injury and fatality rates.

Figures ES-1 through ES-4 show how uncertainty in the underlying data affects the estimates of risk for each mode. The horizontal bars represent the best estimates. (The numerical values for these bars are shown in Table ES-3). The vertical bars represent a 90 percent confidence interval for each estimate (that is, there is a high likelihood that the actual fatality or injury rate falls within this interval). For some modes (e.g., school buses and other buses in Figures ES-3 and ES-4), the interval is very tight and cannot easily be seen on the graphs. In some cases, the confidence intervals for the modes overlap, implying that it is not possible to determine whether the risks associated with the modes (e.g., bicycles and passenger vehicles with teen drivers in Figure ES-2) are actually different.

Despite this report's focus on crashes during normal school travel hours, the committee thought it important to report for comparison the risks faced by school-age children during non–school travel hours. On a per-trip basis and across the four age groupings, travel risks during non–school travel hours are approximately twice what they are during normal school travel hours. On a

TABLE ES-3 Estimated Student Injury and Fatality Rates by Mode During Normal School Travel Hours

	Injuries		Fatalities	
Mode	**Per 100 Million Student Trips**	**Per 100 Million Student-Miles**	**Per 100 Million Student Trips**	**Per 100 Million Student-Miles**
School bus	100	20	0.3	0.1
Other bus	120	20	0.1	<0.1
Passenger vehicle, adult driver	490	90	1.6	0.3
Passenger vehicle, teen driver	2,300	430	13.2	2.4
Bicycle	1,610	2,050	9.6	12.2
Walking	310	590	4.6	8.7
Overall rate	**650**	**130**	**3.5**	**0.7**

Source: 1991–1999 FARS and GES.

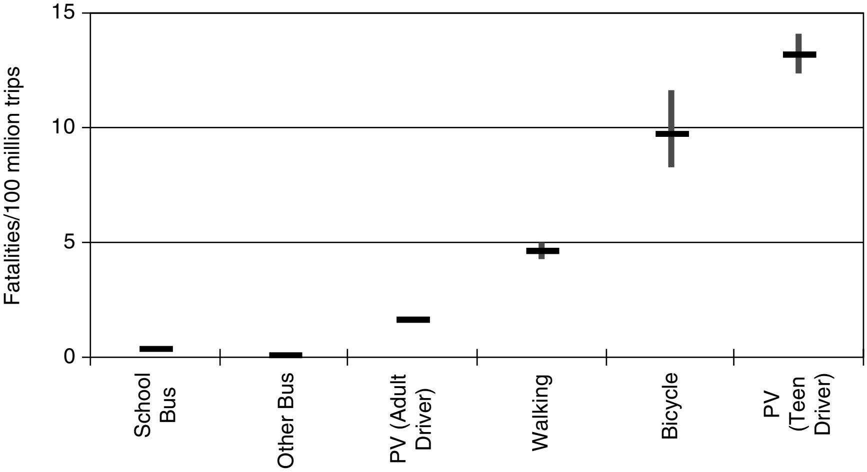

FIGURE ES-1 Student fatality rates per 100 million trips by mode during normal school travel hours with 90 percent confidence intervals (PV = passenger vehicle).

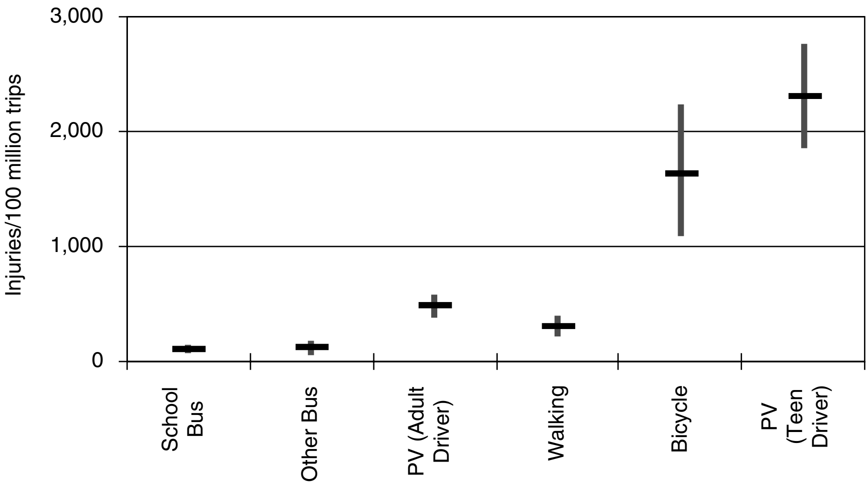

FIGURE ES-2 Student injury rates per 100 million trips by mode during normal school travel hours with 90 percent confidence intervals (PV = passenger vehicle).

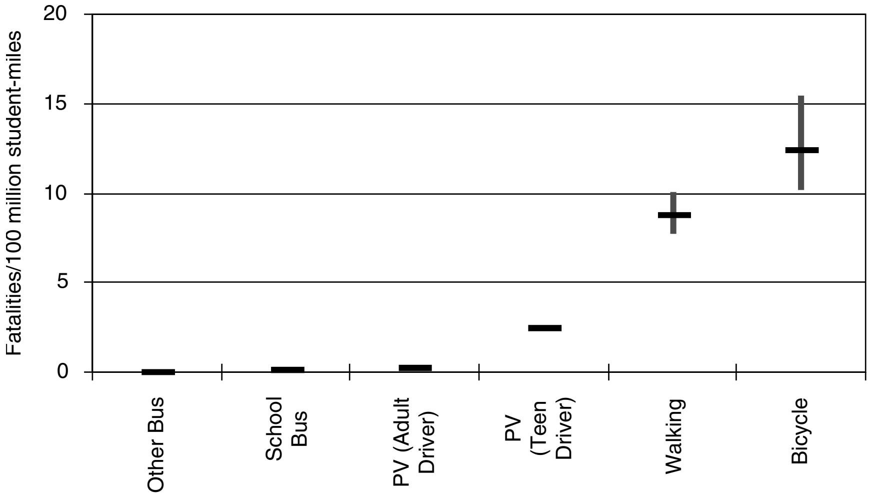

FIGURE ES-3 Student fatality rates per 100 million miles by mode during normal school travel hours with 90 percent confidence intervals (PV = passenger vehicle).

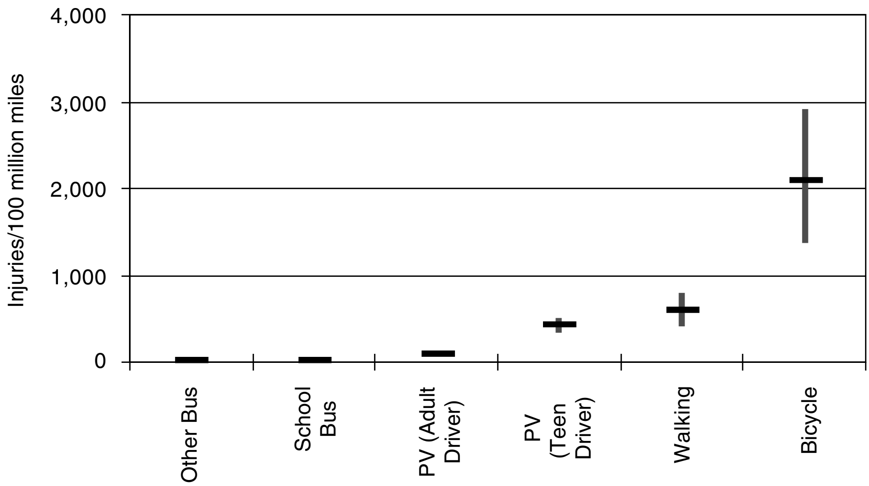

FIGURE ES-4 Student injury rates per 100 million miles by mode during normal school travel hours with 90 percent confidence intervals (PV = passenger vehicle).

per-mile basis, the risks are approximately 20 percent higher during non–school travel hours, but vary slightly with different age categories.

CONCLUSIONS AND RECOMMENDATIONS

Risk management of school travel is complex. School officials, parents, and students often choose or encourage the use of modes of travel for reasons other than maximizing safety or minimizing risk (e.g., convenience, flexibility, budget). Moreover, in the committee's judgment, there is considerable variation among U.S. communities in the accommodations and levels of protection afforded to students using the various modes with regard to the human, vehicle design and equipment, operational, infrastructure/environmental, and societal factors that influence safety. The estimates of risk provided in Table ES-3, therefore, do not reflect fully the variations in safety and relative risk that exist at the local or school district level. Nonetheless, the large differences in risks faced by school-aged children across travel modes suggest that some modes, in general, are safer than others. Different results among communities that have implemented specific risk mitigation programs suggest that more can be done to manage these risks.

Managing Risk

The committee developed a risk assessment process in which quantitative estimates of travel mode risk derived from national statistics (or other sources) can be combined with local student demographics and travel mode distributions to calculate risk estimates for a school or region. Using this process, school officials, parents, and students can better understand, prioritize, and manage the risks of school travel. Moreover, the effects of changing the relative safety of a mode or shifting students among modes can be appreciated. In particular, the committee's approach can highlight when policy changes intended to improve one aspect of safety inadvertently increase risks in other areas.

Because the committee's findings are based on national averages and current modal experience, exact risk reductions that would occur for a local school district using various risk mitigation measures cannot be determined. Each district has unique environmental and operational characteristics that result in different levels of risk associated with each mode. Shifting students from those modes that are overrepresented in crashes (bicycling, walking, and passenger vehicles with teenage drivers) to those that are underrepresented (school buses, other buses, and passenger vehicles with adult drivers) is one way of lowering risks that should be considered. This is not, however, the only way to manage the risks associated with school travel; measures designed to enhance the safety of particular modes—e.g., changing school bus pick-up and drop-off locations, changing passenger vehicle pick-up and drop-off locations, enforcing bicycle helmet laws, and implementing and enforcing graduated driver licensing programs—can also be employed. To help inform the risk mitigation evaluation process, the committee has also created for each school travel mode safety checklists that delineate opportunities that have been shown to reduce risk or are accepted as best practice. Combining quantitative risk assessment measures with these safety checklists creates a risk management framework that can be used to provide guidance to those who must make many types of safety-related school travel decisions.

This risk management framework can help inform local decisions on such matters as school siting, student parking policies, and changes in the minimum walking distance (the distance from school below which school bus service is not provided). The framework reveals, for example, that the absence of adequate infrastructure for pedestrians and bicyclists, measures that make it easier for high school students to park, or a simple change in the minimum walking distance could easily increase the overall student travel risk. Alternatively, providing additional after-school bus service or restricting off-campus trips during school hours could improve safety significantly.

Risk estimates developed using the committee's risk management framework can also be helpful to local and state transportation agencies in making more informed decisions regarding the allocation of available funds for infrastructure improvements designed to reduce situations in which motor vehicles, pedestrians, and bicyclists conflict with one another. These estimates can assist as well in determining the advisability of policies to address bicycling safety (such as helmet laws), strategies to improve occupant safety (such as laws mandating use of safety belts), and strategies to reduce the risks of teen driving (such as graduated licensing programs already enacted in many states). At the federal level, estimates developed in this report indicate that more evaluation and research are needed to assist state and local decision makers in reducing student risk in the most cost-effective manner.

To increase the likelihood of implementing effective policies, it is important to have input and support from all stakeholders. To this end, there must be open communication in sharing information on policies, procedures, and guidelines that enhance safety. If the participants in such a process understand the risks associated with the various modes and the means by which those risks can be reduced, they can work cooperatively to achieve safety improvements. Knowledge of the relative risks of the various modes can be used by communities to focus resources on those modal improvements for which the expenditure of resources can effect the greatest safety improvements. A well-thought-out risk management program that measures the risks and benefits of the various modes and identifies a set of risk mitigation alternatives for each mode would facilitate relevant discussions among the stakeholders.

Recommendation 1: School transportation planners and policy makers at all levels should analyze transportation risks comprehensively in their decision making related to school travel.

Application of the results of risk analyses—a major component of the committee's risk management framework that is illustrated in Chapter 5—reveals how decisions affecting one mode of school travel influence the risks faced by users of other modes. Decisions about such issues as increasing or decreasing student parking, changing the minimum walking distance, and providing bus services can significantly affect overall risk in ways that may not appear obvious. The risk management framework can highlight the importance of such choices and allow a full appreciation of their implications. It does not, however, stand alone. School transportation planners and policy makers must also take into account budget constraints, local conditions and values, local data, and judgments about the relative safety and cost-effectiveness of alternative policies.

> **Recommendation 2: Using a systematic risk management framework, school districts should identify the risk factors most salient for the modes of school travel used by children in their community and identify approaches that can be used to manage and reduce those risks, including shifts to safer modes and safety improvements within each mode.**

Each school district, and even schools within a district, will have different conditions and requirements that will affect school travel risks and the choices of officials and parents for reducing those risks. When resources permit, districts should support strategies that promote safety, such as reducing the number of teen drivers, designing bus services to better meet needs (e.g., offering early and late bus services, and providing bus services to different morning and afternoon locations), as deemed appropriate for that school or district. Districts can also adopt policies designed to support walking and bicycling to school in order to promote healthy lifestyles after carefully assessing the adequacy of sidewalks, bicycling paths, crosswalks, and other supporting infrastructure and safety measures, and making improvements where needed.

> **Recommendation 3: The U.S. Department of Transportation (USDOT) should disseminate information presented in this study on the relative risks of using various modes of travel for school and school-related activities and on possible ways to mitigate the risks. USDOT should also use this information to assess what role, if any, federal policy makers should have in efforts to improve the transportation safety of school children and the cost-effectiveness of specific safety measures.**

State and local legislators, school boards, parent–teacher associations, private and church schools, parents, students, and the media all play a role in decisions about school transportation. The national-level data presented in this report provide a starting point for such decision making by highlighting the considerable differences in risk across modes of travel. Local risk estimates will differ from these national estimates, however. School officials, as well as state and local officials responsible for transportation facilities and operations, parents, and others, need information on how to assess the adequacy of their school transportation systems. They also need information on the relative risks and cost-effectiveness of various safety measures, and on how to promote safety across and within modes in the most cost-effective ways. Such information is currently lacking.

Data

Numerous databases contain information related to transportation safety. Most of these databases, however, were not useful for this study because they do not allow comparison across modes so that exposure to risk can be analyzed in a consistent manner. One of the primary responsibilities and contributions of the agencies whose mission encompasses issues related to school transportation is to collect good, accurate, reliable data. Current data are illuminating, but not complete. Yet obtaining more thorough and complete data is not without cost. Given the large number of fatalities and injuries that occur on highways in the United States and the relatively small proportion that involve students during normal school travel hours, the benefits of additional data collection efforts focused solely on school travel should be carefully considered before such efforts are recommended or implemented.

At present, the lack of uniformity in local- and state-level data collection requirements and methodology, together with the lack of consistency in definitions and interpretations across and within datasets, makes it difficult and often impossible to address student as well as other transportation issues of interest. An integrated data system (one in which different databases would use many of the same variables, definitions, and data collection procedures) is needed to enable a better understanding of the risks associated with the various modes of travel, not just for school transportation safety, but for highway safety in general. If performed correctly, a consistent, comprehensive data collection effort could benefit school transportation as well.

Recommendation 4: The compatibility and completeness of existing databases should be examined and improved by USDOT and other agencies to allow development of better risk estimates. To the extent possible, critical data elements (e.g., vehicle classifications, roadway classifications) should be included and defined consistently in all the datasets.

The three data sources relied upon in this report—NPTS, FARS, and GES—are the best available but are not fully compatible because of different variables, definitions, and classifications. A first step would be for USDOT and other appropriate agencies to explore the possibility of changing definitions and classifications to make them more consistent. Doing so would enable the development of more precise risk estimates than could be accomplished in this study. Similarly, it may be possible to adjust for weaknesses in one or more of these datasets by examining other datasets. For example, GES excludes non-traffic injuries, such as a fall from a bicycle when no motor vehicle is involved, thus introducing a bias in the estimates. Sample data from hospital records on bicycling injuries might allow for adjustments to correct for such bias.

Recommendation 5: USDOT and appropriate agencies, in consultation with outside experts, should analyze the advisability and cost-effectiveness of establishing and maintaining any new school transportation–related database.

The committee encountered many difficulties in developing estimates of risk by mode for school travel and could develop only national-level estimates. Moreover, it was not possible to estimate the risk of travel for school-related activities because of a lack of relevant data. However, the magnitude of the school transportation safety problem does not appear to warrant major expenditures for new data collection efforts. Rather, cost-effective means of collecting new data using existing structures, both governmental and nongovernmental, should be explored and identified. The national school bus loading zone fatality survey conducted annually by the Kansas Department of Education, for example, is a volunteer data collection structure that has provided valuable information for more than 30 years at minimal cost.

It is also important to know the purpose for which data are to be used before they are collected. It may be that estimates of cost-effectiveness and better estimates of risk can be derived by carrying out Recommendations 3 and 4 without the need for extensive new data collection; if not, it may be prudent to collect more and better data. Such choices, however, should be based on the policy decisions the data are expected to inform.

SUMMARY

Without doubt, travel of children to and from school is a complex and sensitive issue. Each travel mode has its attendant risks, which vary from community to community and school to school, and any shifts from one mode to another can have a marked effect on the overall safety of school travel for a particular community or school. A risk management framework can be used to identify, analyze, and prioritize the risks associated with student travel, and in turn to formulate interventions that can be used to manage these risks. Risk measures can be applied to analyze alternative policies at the state and local levels, and various existing countermeasures can be implemented to reduce the risks to students who use the various modes. Each state, school district, and private school must assess its own situation and circumstances and apply the information presented in this report to make sound, informed decisions. The goal is to improve safety for all children traveling to and from school and school-related activities and to provide communities with the information needed to make informed choices that balance their needs and resources.

REFERENCE

Abbreviation

NCST	National Conference on School Transportation

NCST. 2000. *National School Transportation Specifications and Procedures, 2000 Revised Edition.* Proceedings of the Thirteenth National Conference on School Transportation. Central Missouri State University, Warrensburg.

1 Introduction

Children in the United States travel to and from school and school-related activities by a variety of modes, including school bus, other types of buses (e.g., transit, motorcoach), rail and trolley, bicycle, walking, privately owned and operated vehicle (e.g., automobile, passenger van, sport utility vehicle, pickup truck), and vehicle for hire (e.g., taxicab, van service). Little is known, however, about the comparative safety of these various modes for trips to and from school and school-related activities. The purpose of this report is to assess the relative risks of each major mode used for school travel and to provide insights into the potential effects on safety of changes in the distribution of trips by mode.

CONTEXT

Nature of the Problem

On average, 20 school-age children—5 school bus occupants and 15 pedestrians—die each year in school bus–related crashes. Of the 15 school bus–related pedestrian fatalities, two-thirds of the victims are struck by the school bus itself, while the remaining third are struck by other vehicles, many of whose drivers pass the school bus illegally while it is stopped to load or unload students. Comparable statistics regarding the safety of students being transported by other modes are not readily available. National statistics for the period 1991–1999 indicate, however, that an average of 810 school-age children were fatally injured annually during normal school travel hours (weekdays 6 a.m. to 8:59 a.m. and 2 p.m. to 4:59 p.m.)[1] in typical school months (September through mid-June), while approximately 153,000 school-age children received nonfatal injuries. Just over 3.5 percent of these injured children were passengers on school buses, while only 0.025 percent were student pedestrians injured in school bus–related crashes, and 72 percent were riding in motor vehicles that were not buses of any type.

The way in which children travel to and from school is influenced in part by school transportation policies and guidelines developed at the federal, state, and local levels; in part by parental choice; and in some cases, particularly with older schoolchildren, by student choice. At each level, decisions that are made can have a profound effect on the risks incurred. For example, students who live closer to the school than the minimum walking distance are necessarily depen-

[1] The available data do not permit a breakdown of school travel–related injuries and fatalities according to whether they occurred en route to or from school. In this report, therefore, the term *normal school travel hours,* as defined here, is used to denote the overall period of interest.

dent on other travel modes—most commonly walking, bicycling, or driving or riding in a passenger vehicle. Since the various travel modes are associated with different safety risks, any shift in modes—e.g., from school buses to walking, bicycling, or riding in a passenger vehicle—that results from changing the minimum walking distance will have an effect on school travel safety.

Federal, state, and local lawmakers, as well as state and local administrators who implement school-related transportation policies, place great importance on the safety of children traveling to and from school. However, if adequate information about the risks of alternative modes is not available when policy decisions are made or if this information is ignored, policies and regulations designed to support this goal may in fact increase risks. Further, the data most useful to federal lawmakers may not be the same as those most useful for state and local policy makers (including state legislators and school board members). And the data most helpful to local administrators (e.g., local school district officials, school principals, transportation directors, Individuals with Disabilities Education Act coordinators) may be quite different from those needed by others involved in making school-related transportation decisions (e.g., parents, students), often at a student-specific level.

Legislative History

Faced with reduced funding and pressures to spend available funds on non-transportation-related items, some school districts and transit agencies are examining the potential for relying more heavily on transit services for school transportation. Transit services in large urban areas have long been used to transport students, particularly those in high school and junior high school. Some smaller communities, particularly in rural areas, have integrated a variety of pupil transportation, social service transportation, and public transit services to improve efficiency and lower costs. Similarly, school districts and elected officials in other communities have begun to explore the potential for coordinating transportation services for students with those for the elderly, the disabled, and other special-needs groups.

Such approaches have been debated in several state legislatures during the last 20 years. At the behest of its legislature, for example, the state of Iowa sponsored six pilot projects during the 1980s to test various models of coordinated service. Likewise, the state of Washington provided grants to 12 communities for such projects in 1999 and 2000, although not all of these projects involved transit or pupil transportation services.

Many small urban, suburban, and rural transit agencies, experiencing declining ridership and increasing costs, are attracted to the possibility of adding schoolchildren to their ridership. Similarly, many communities without transit services view coordination with pupil transportation services as an opportunity to provide service to other riders for whom public transportation would otherwise be unaffordable.

In this context, hearings in the U.S. Senate in April 1996 on school transportation safety raised questions regarding what is known about the safety of children who use public transit to travel to and from school. It was estimated that at the time, approximately 20 percent of school children in California were using public transit or paratransit to travel to and from school, and that in other states (e.g., Ohio), the use of public transit for this purpose was increasing. During the Senate hearings, interest in the safety of students traveling by school bus versus transit bus was broadened to include other, non-bus modes used to transport students to and from school. The focus was also expanded to include school-related trips in addition to those taken between home and school. It was noted that safety comparisons among the various modes could not be made because the data needed for such comparisons were not readily available.

In 1998, a provision of the Transportation Equity Act for the 21st Century (TEA-21) (see the appendix) mandated that the Transportation Research Board (TRB) undertake a study "of the safety issues attendant to the transportation of school children to and from school and school-related activities by various transportation modes." In the process, the study was to take into account available crash-injury data, as well as vehicle design and driver-training requirements, routing, and operational factors that affect safety. If crash-injury data were found to be unavailable or insufficient, a new data collection regimen and implementation guidelines were to be recommended.

Since the Senate hearings were held, interest in the issue of school transportation safety has been heightened even further by reports and recommendations issued by the National Transportation Safety Board (NTSB 1998; NTSB 1999a; NTSB 1999b; NTSB 2000) and others, including the National Highway Traffic Safety Administration (NHTSA) (NHTSA 1998) and the Transit Cooperative Research Program (TCRP) (TRB 1999). Yet many questions remain unanswered.

CHARGE TO THE COMMITTEE

The Committee on School Transportation Safety was formed to conduct the study mandated by TEA-21. The committee was charged to address safety issues related to the transportation of school-age children to and from school and school-related activities by various modes, and in the process to review available injury, fatality, and exposure data. The committee was also tasked to examine other, related factors, including operating characteristics, vehicle design, and driver and passenger training. In addition, the committee was directed to assess the efficacy of drawing conclusions from the available data, given the statistical confidence in the data and their relevance to the issues being addressed. The study charge included considering the basic characteristics of the modes used for student travel; their operational differences; and the infrastructure, environmental, and other conditions that affect them. If data were deemed unavailable or insufficient, the committee was asked to recommend new data collection methods and implementation guidelines. In undertaking these tasks, the committee was to examine both occupant and nonoccupant (i.e., pedestrian) injury and fatality rates, taking into account the behavioral and developmental characteristics of children, which affect their travel skills and vulnerability.

STUDY SCOPE

In conducting this study, the committee did not specifically address issues and risks associated with the transportation of special-needs students or infants, toddlers, and preschool children. These two categories of children often have unique needs and must be considered individually. For example, children with special needs (such as those in wheelchairs) may need to be picked up directly at their doorway and be attended to while en route to school. Infants, toddlers, and preschool children must ride in child safety seats (even in school buses), a requirement that presents unique problems based on the type of vehicle being used. The committee also did not examine separately the risks associated with transportation to and from nonpublic schools because information about pupil transportation for such schools is not available in many states. However, given the committee's use of the concept of normal school travel hours, which is based on time of day without respect to purpose of trip, the exposure data employed for the study (i.e., number of trips and passenger-miles) include travel for all children between 5 and 18 years of age, regardless of type of school or purpose of trip, during this period.

The committee also did not examine the coordination and integration of pupil transportation and transit services. For a comprehensive discussion of issues relevant to this practice (including 15 case studies of nonurban communities in which such coordination or integration has been effected), the reader is referred to the TCRP report *Integrating School Bus and Public Transportation Services in Non-Urban Communities* (TRB 1999).

As noted above, the focus of this study was not restricted to children traveling to and from school, but encompassed their travel to and from school-related activities.[2] As discussed more fully in Chapters 2 and 3, however, crash data for school-related trips—which comprise roughly 4 percent of all school transportation (R. Leeds, personal communication, Feb. 27, 2001)—are not directly available. In most instances, these data must be inferred from other information that may be recorded on police accident reports. Compounding the difficulty of drawing conclusions from such data, different types and mixes of vehicles are often used for school-related purposes, and some trips do not occur during the above-defined school travel hours. Hence, the data and analyses presented in this report are restricted to crashes that occurred during normal school travel hours. Those school-related activity trips that occurred during normal school travel hours are included in the analyses, but could not be separated out for more focused analysis.

A recent procedural change effected in some local school districts has added to the difficulty of collecting and analyzing injury data related to school travel. Should a crash involving a school bus occur, many students may be transported to a medical facility for evaluation and later determined to have sustained minor or no injuries (L. Kostyniuk, presentation to the committee at its first meeting,

[2] A *school-related activity*, also known as an *activity trip*, is defined as "the transportation of students to any event sanctioned for pupil attendance or authorized by an officer, employee or agent of a public or private school, other than to-and-from school transportation" (NCST 2000, 163).

July 14, 2000). The "required medical attention" classification on the police accident report may include the total number of students transported to the hospital, or possibly all bus passengers, among them those who were not injured in any way. The result in such cases is an inflated number of reported "pupil passenger injuries."

Furthermore, there is no documented correlation between school bus crashes and medically documented injuries at the scene. Linkage to emergency department data could provide this missing information. As noted in *Special Report 222* (TRB 1989, 46):

> The number of persons injured each year in school bus–related accidents and the severity of the injuries they sustain are not well known. There is no national census or representative sample of school bus–related accidents, no systematic count of injuries suffered in these accidents, and no rigorous assessment of the degree to which passengers are injured. In the absence of such information, only gross estimates of the frequency and severity of injuries resulting from school bus–related accidents are available.

This discrepancy is also true of other modes used to transport students. Though the committee acknowledges the gaps in and poor quality of some of the data, it believes insights can be gleaned through analysis of existing datasets. Indeed, for this study, the committee used existing data to refine risk estimates so they can be used to inform policy discussions.

Finally, the committee recognizes that personal safety or security issues are important to a comprehensive assessment of student transportation safety. The major concern is that trips to and from school may place students at risk from older, larger students or predatory adults on all modes of travel (TRB 1999). However, an assessment of these issues is beyond the scope of this report.

ANALYZING THE SAFETY OF SCHOOL TRAVEL

Ideally, a detailed risk analysis should be used to aid decision makers at all levels of government in making choices about school travel alternatives and establishing policies and guidelines to effect such choices. A risk analysis that identifies crash scenarios, probabilities of occurrence, and potential outcomes can enable decision makers to identify and evaluate effective and efficient risk mitigation options and to choose those options that minimize risk commensurate with their practicality and affordability. To conduct this type of analysis, one must identify the various modes used for school travel, obtain and analyze quantitative data on the relative safety of these modes, obtain better injury data, identify the risk factors associated with travel to and from school, develop a perspective that integrates the many components of the school transportation system, and apply a risk management framework. Such a comprehensive effort was not possible for the committee. Instead, this report presents an effective and feasible risk management framework, whereby modal comparisons using a quantitative risk assessment based on national statistics are used to identify important risks, and checklists, based on empirical research and recognized best practices, are used to suggest options for reducing these risks commensurate with local needs and resources.

Modes Used for School Travel

Depending on the level of detail used, it is possible to define many travel modes for children going to and from school (e.g., sport utility vehicle, pickup truck, taxi, subway, 10-passenger bus). For many of these individual modes, however, crash, injury, fatality, trip, and other data needed to make relative safety comparisons are unavailable, insufficient, inadequate, or impossible to correlate. Thus the committee grouped the modes used for school travel into six broad categories for which sufficient data could be obtained to support the required analyses:[3]

- *School bus*—A vehicle designed for carrying more than 10 persons,[4] including the driver, that is operated by a public or private school or a private school bus contractor for the purpose of transporting children (prekindergarten through grade 12) to and from school and school-related activities (excluding chartered[5] and transit buses). A school bus must meet all applicable federal motor vehicle safety standards (FMVSSs).
- *Other bus*—A vehicle designed to carry more than 10 persons, including the driver. Included are transit buses, coaches or motorcoaches, and other bus types that generally provide transportation services under contract. A transit bus is defined as a bus with front and back-center doors and low-back seating, which is operated on a fixed schedule and route to provide public transportation at designated bus stops. Other buses meet all applicable FMVSSs, but do not meet school bus FMVSSs.
- *Passenger vehicle*[6] *with adult driver (i.e., driver age 19 and over)*—A motorized vehicle owned or operated by an individual or company that is designed for carrying fewer than 10 passengers, goods, or equipment. For purposes of this report, this category includes passenger cars, passenger vans (both minivans and full-size vans), sport utility vehicles, pickup trucks, other trucks, recreational vehicles, and taxicabs (vehicles for hire that carry passengers).
- *Passenger vehicle with teen driver (i.e., driver below age 19)*—A motorized vehicle driven by a driver younger than 19 years of age and designed for carrying fewer than 10 passengers, goods, or equipment. For purposes of this report, this category includes the same vehicle types cited for the preceding category.

[3] It should be noted that the definitions of these categories are general descriptions. For the analyses carried out in this report, the particular definitions for the various vehicle types were specific to the databases employed.

[4] Under federal law, each wheelchair location in a vehicle is equivalent to four seating positions.

[5] A school-chartered bus is defined as "a 'bus' that is operated under a short-term contract with State or school authorities who have acquired the exclusive use of the vehicle at a fixed charge to provide transportation for a group of students to a special school-related event" (NHTSA 1998).

[6] The term *passenger vehicle* refers to motor vehicles excluding school buses and other buses.

- *Bicycle*—Includes all pedalcycles (one, two, or three wheels). Scooters are not included in this category, but in the next.
- *Walking*—Travel from one location to another on foot; also includes scooters, rollerblading, and skateboarding.

Although the detailed analyses discussed in Chapter 3 make modal comparisons only among the six classes of modes identified above, this is not to imply that other modes are not used for travel to and from school. These other modes include passenger rail (heavy rail, light rail, and trolley service) operated either underground (i.e., subway), above ground (i.e., elevated), or "at grade."

It is also important to note that, although students often go directly to school in the morning, they may take very different trips returning home in the afternoon. Not only may the modes used be different, but the routing, timing, and actual destinations may vary from day to day and season to season across the school year because of extracurricular activities, jobs, friends, and the like. This variation greatly complicates the analysis and makes it difficult to define what is meant by a school trip.

Moreover, most trips to and from school are divided into segments that use different modes. For example, a student who rides a school bus or other bus to and from school must also get to and from the bus stop. These trip segments are often made by walking or riding in a passenger vehicle. Since each of these segments involves a different mode, each has unique risks. Therefore, different means of reducing or managing the risks associated with the various trip segments will be needed.

Quantitative Data Analyses

NHTSA has stated that "school bus transportation is one of the safest forms of transportation in the United States" (NHTSA 1998, 1). This statement is based in part on a strict comparison of the fatality rates (fatalities per 100 million vehicle-miles traveled) for school buses versus all other vehicles used for all purposes. Though the fatality rate per vehicle-mile is the most commonly used measure of motor vehicle safety, by itself it does not provide sufficient insight into the relative safety of school buses and other modes used for school travel, including other vehicle types, bicycling, and walking. To perform this type of analysis, which is central to the committee's charge, in-depth analyses using other risk measures (e.g., injuries or fatalities per student-mile or student trip) were conducted using the available quantitative data.

The national crash databases that the committee found useful for these analyses were the Fatality Analysis Reporting System (FARS) for fatality counts and the General Estimates System (GES) for injury counts. These databases include only data on crashes in which a motor vehicle is involved. The committee found no accessible, comprehensive national databases that reflect pedestrian and bicycling fatalities and injuries not involving a motor vehicle. Despite this and other limitations of these databases, which are discussed in Chapter 2, FARS and GES do provide insights into the relative safety of walking and bicycling when they interact with the other modes.

To provide a context (in terms of exposure) for the information obtained from FARS and GES, the committee used data from the 1995 Nationwide Personal Transportation Survey (NPTS). This survey contains information on the 1-day travel behavior of members of thousands of households in the United States. It can be used to obtain national-level estimates of the number of trips taken and number of miles traveled by children during school travel hours, broken down by mode, age of students, and geographic location (urban versus rural). The committee conducted its analyses using the 1991–1999 data contained in FARS and GES to obtain national estimates of the numbers of fatalities and injuries, respectively, among students traveling during normal school travel hours (as defined above), using the same categorizations as those employed by NPTS. The results of these analyses are presented in detail in Chapter 3.

Risk Factors Related to School Travel Safety

The committee identified five categories of risk factors associated with student travel to and from school: (*a*) human, (*b*) vehicular, (*c*) operational, (*d*) infrastructure/environmental, and (*e*) societal. Human factors for both passengers and drivers include elements such as age, experience, training, and qualifications. Vehicle factors include mass; design characteristics (e.g., structure, suspension systems); color and conspicuity; and vehicle operating characteristics, such as power steering and braking. Operational factors include characteristics of the trip itself, such as trip length, time of day, origin, and destination, as well as policy and procedural factors, such as training, monitoring, evaluation, supervision, and enforcement. Infrastructure/environmental factors include weather, roadway conditions, and traffic. Finally, societal factors include general health and fitness issues, as well as quality of life, security, liability, and diversity. All of these factors have implications for the safety of each mode used for student travel to and from school. To highlight these implications and to help decision makers recognize opportunities for risk reduction, the committee consolidated important risk factors into safety checklists for each mode. Discussion of these risk factors and the safety checklists are presented in Chapter 4.

System Perspective

To determine how to maximize safe and efficient school travel, the complete system, including the vehicle, the driver, the traveler, and the route or path, must be considered. Doing so provides a balanced view of the interaction among the various components involved in school travel. To apply this approach, the many complex relationships among modes, particular vehicles, passengers, drivers, and the operating environment must be understood. A range of other factors must also be considered, including safety, security, and other societal concerns (e.g., liability, equity); policy directives, planning, and leadership; infrastructure and environmental conditions (including issues related to the facility or school); and vehicle design and equipment. Moreover, managing the risks associated with school travel requires involvement and a shared commitment among the various interested parties—policy makers, transportation planners and system design experts, traffic engineers and public works officials, school administrators, transportation officials, management and staff, parents, and students. Effective communication among these parties, a well-documented training program, and procedures for managing risk are also necessary.

Risk Management Framework

A risk management framework that combines quantitative risk assessment with use of the more qualitative safety checklists described above and that reflects a system perspective can be used to examine the safety of all major modes used for school and school-related travel. Using this framework, the safety/risk issues related to travel for school and school-related activities can be identified, prioritized, and used to make informed policy decisions at the federal, state, and local levels. The committee believes implementation of this framework can help ensure that new policies will be justifiable, well focused, and unlikely to cause changes in the distribution of travel modes that will unintentionally increase risk.

ORGANIZATION OF THE REPORT

In this report, crash and injury data and risk estimates for school transportation by the six categories of modes detailed above are presented. Key risk factors are summarized, and potential safety countermeasures to address these factors are identified, although recommendations about specific countermeasures are not made. A brief description of the national datasets (NPTS, GES, and FARS) used by the committee in its risk assessment is provided in Chapter 2. In Chapter 3, risk measures based on injury and fatality rates calculated using the national data described in Chapter 2 are developed. In Chapter 4, five categories of risk factors associated with school travel are presented, and safety checklists that can be used by decision makers to identify intervention opportunities for addressing those factors are provided. Three scenarios involving hypothetical schools are offered in Chapter 5 to demonstrate how quantitative analyses in the risk management framework can be applied and to illustrate how changes in transportation policy can affect the overall risk for a particular school. The committee's findings and its recommendations to federal, state, and local policy makers and administrators for reducing risks and enhancing safety for students traveling to and from school are contained in Chapter 6.

REFERENCES

Abbreviations

NCST	National Conference on School Transportation
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
TRB	Transportation Research Board

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2 Quantitative Analyses: Data and Methods

There are two basic categories of safety data—exposure data and outcome data (BTS 1999). Exposure data, which measure the susceptibility of an individual or class of individuals to the undesired outcome, include number of trips taken, distance traveled (e.g., vehicle-miles or passenger-miles), and number of travelers; outcome data, which measure untoward or undesirable events, such as crashes, include numbers of accidents, fatalities, and injuries. The committee selected exposure and outcome datasets that could be used to shed light on the issues of concern. Because of the relatively infrequent occurrence of fatalities and severe injuries among children on trips during normal school travel hours, it was necessary to combine multiple years of statistics to obtain reasonable sample sizes. In addition, some otherwise promising datasets were not usable because they lacked the specificity needed to identify incidences or trips related to students going to and from school, or because they could not be paired with the corresponding exposure or outcome data. For example, as noted by Stutts and Hunter (1999, 505):

> Traditionally, the U.S. Department of Transportation has relied on state motor vehicle crash data, based on reports completed by police and other law enforcement officers, as their primary source of information on events causing injury to pedestrians and bicyclists. While these data provide considerable information to help guide safety program and countermeasure development, they have often been referred to as 'the tip of the iceberg' because they are limited almost entirely to motor vehicle-related events that occur on public roadways. Specifically, they exclude (1) many bicycle-motor vehicle and pedestrian-motor vehicle crashes that occur in non-roadway locations such as parking lots, driveways, and sidewalks; and (2) bicyclist and pedestrian falls or other non-collision events that do not involve a motor vehicle, regardless of whether they occur on a roadway or in a non-roadway location. Even using emergency-room data will not fill in the gaps because many of the injuries may not result in visits to the emergency room, and if they do, the forms that are filled out will not include information on the purpose of the transportation (e.g., pleasure, to/from work, to/from school, etc.).

The various datasets that were examined for possible use in the committee's analyses are briefly described in this chapter. A detailed description of the three datasets selected, the analyses conducted with each, and the limitations of each for the purposes of this study is then provided. Finally, conclusions are presented.

DATA SOURCES

The committee identified a number of databases that could be used in assessing the safety of the various student transportation modes; unfortunately, most of the datasets are highly limited, contain data that cannot be used to generalize to the population of interest (i.e., all students in kindergarten through grade 12), or do not include the data categories needed to conduct the analyses of interest (e.g., purpose of trip or time of day). Only one dataset, the Nationwide Personal Transportation Survey (NPTS), provides any usable exposure data at the national level. The database of the National Association of State Directors for Pupil Transportation Services (NASDPTS), recorded annually in industry journals and *School Bus Fleet* and *School Transportation News* magazines, contains the most accurate data available on school bus ridership on a state-by-state basis.[1] However, the underlying data collected by the states, in many cases, is used to reimburse school districts for school bus services resulting in an overestimation of the number of student riders. In addition, the database does not contain data on the other modes used by children traveling to and from school. In addition, as with the other datasets, there is a lack of consistency in terminology. For example, some states report ridership based on actual head counts, others base their counts on the number of students "authorized" to use the school bus in their daily commute to and from school, and some also include private school ridership. In this dataset, it should be noted, ridership numbers are attached to trip purpose; however, this dataset could not be linked to others because it does not use the data selection criterion of normal school travel hours that is applied for the other modes. Therefore, the NASDPTS data could not be used for cross-mode comparisons.

Nine national outcome (or crash) datasets were considered by the committee: (*a*) the National Automotive Sampling System (NASS) General Estimates System (GES), (*b*) the NASS Crashworthiness Data System (CDS), (*c*) the NASS Pedestrian Crash Data System (PCDS), (*d*) the Crash Outcome Data Evaluation System (CODES), (*e*) the Highway Safety Information System (HSIS), (*f*) the Kansas Department of Education school bus loading/unloading fatality dataset, (*g*) the National Transit Database (NTD), (*h*) the National Electronic Injury Surveillance System (NEISS), and (*i*) the Fatality Analysis Reporting System (FARS).[2]

[1] On the basis of this dataset, *School Transportation News* estimates annual school bus ridership to be approximately 10.5 billion. Using the Annual Student Ride Formula, this calculation incorporates estimates for student rides on regular route to-and-from K-12 school service, school-related activity trips, some private and parochial school transportation service, summer school transportation service, and Head Start transportation service. Unlike the data used in the committee's analyses, this estimate is not restricted to children 5 to 18 years of age, specific time periods during the day, and specific months of the year.

[2] The committee was interested in examining state fatality and injury data, as well as insurance industry data, but did not have time or resources available to do so for all 50 states. The committee did select two states (Texas and California) for which available fatality and injury data were obtained and analyzed; however, the data could not be compared directly with the national data because of the lack of data for nonbus modes and the small counts. In addition, the committee could not easily access crash and injury data from the Department of Education. These data and data from local school districts could also prove valuable.

GES, which became operational in 1988, contains data from a nationally representative sample of police-reported motor vehicle crashes of all types. The reports are chosen from 60 areas that reflect the geography, roadway mileage, population, and traffic density of the United States. Data are collected weekly from approximately 400 police jurisdictions, from which about 50,000 police accident reports (PARs) are randomly sampled each year. PARs are completed by police officers investigating crashes that result in personal injury and/or property damage above the state's reporting threshold. For example, in the state of Texas, if a vehicle involved in a crash is towed, a PAR must be completed, while in the state of California, one must be completed if property damage is estimated to be $500 or more. Each state, the District of Columbia, Puerto Rico, and the Virgin Islands has a unique crash report form. The reader is referred to the *State Crash Report Forms Catalog 1999 Update* (NHTSA 1999), which contains a copy of each state's form, as well as the state crash reporting threshold. The National Highway Traffic Safety Administration (NHTSA) encourages uniformity across states in the data elements contained on the crash report form, and for this purpose encourages the use of American National Standards Institute (ANSI) D-16 (*Manual on Classification of Motor Vehicle Traffic Accidents*) and D-20 (*Data Element Dictionary for Traffic Records Systems*). NHTSA, in collaboration with the Federal Highway Administration (FHWA) and the National Association of Governors' Highway Safety Representatives, has also developed a guideline for collection of crash data, referred to as the Model Minimum Uniform Crash Criteria (NHTSA 1998). Although states do not generally record data from crashes (either on- or off-highway) in which a motor vehicle is not involved, GES is the most complete injury database available.

CDS, which covers about 5,000 accidents in depth annually, contains data on vehicle occupants and is used to study injury mechanisms; precrash events are not examined in detail. This shortcoming is moot for purposes of the committee's analysis, however, as there are not enough cases involving school and transit vehicles for this dataset to be useful.

PCDS contains data on pedestrian crashes. It is essentially an update (or continuation) of earlier pedestrian data files, such as the Pedestrian Injury Causation Study of 1977 and the special pedestrian data collected for NASS from 1979 through 1987. PCDS data for 1995–1997 relate to only 280 cases, too few for the purposes of this study. Although there is a code for school buses and other buses, none of the 280 cases in the file involved these types of vehicles.

CODES contains linked statewide crash and injury data for 20 states that match vehicle, crash, and human characteristics with final medical and financial outcomes. The purpose of the dataset is to improve decision making related to highway safety and injury control. CODES studies often tend to be in-depth examinations of special problems; however, they usually cover highly limited geographical areas.

HSIS, which contains selected data for eight states (California, Illinois, Maine, Michigan, Minnesota, North Carolina, Utah, and Washington), is a roadway-based system that includes data on a large number of accident, roadway, and traffic variables. The data are collected annually from the participating states, processed, documented, and prepared for analysis. The dataset contains little information specifically about travel to and from school, and thus could not be used to address the issues of concern to the committee.

The Kansas Department of Education conducts an annual national survey of school bus loading and unloading fatalities. As with the NASDPTS dataset, however, it does not contain data for the other modes, making comparison with other studies difficult, if not statistically invalid. For example, there are no comparable loading and unloading data for the other modes.

NTD, which is maintained by the Federal Transit Administration (FTA), contains performance, operational (such as miles traveled, passenger-miles, and passengers carried), and financial information, as well as injury data stratified by mode [motor bus, trolley bus, light rail (passenger rail operating on exclusive or separated guideways)] reported by all transit agencies receiving federal assistance.[3] This database, which is used for management and planning by transit systems, as well as for policy analysis and investment decision making, also contains data on numbers of fatalities and injuries by transit system; however, data on age of victim and purpose of trip are not included. The data collected make it possible to compute injury rates for each transit mode for each agency, as well as national rates by mode. However, the data are not reported by passenger age, and this greatly restricts use of the data in school transportation analyses.

NEISS, which has been maintained for approximately 30 years by the Consumer Product Safety Commission (CPSC), is a representative sampling of U.S. hospital emergency departments (Stutts and Hunter 1999). Its primary purpose has been to provide data on consumer product–related injuries occurring in the United States. In 2000, CPSC initiated an expansion of the system to collect data on all injuries. Thus, although not useful to the committee for the present study, NEISS may provide highly useful information in the future, depending on the data elements that are added.

FARS, established in 1975, provides a census of all highway fatalities (including deaths of school-age children by time of day and vehicle type) in all 50 states, the District of Columbia, and Puerto Rico. The data in FARS are obtained from existing state data: PARs, state vehicle registration files, state driver licensing files, state highway department data, vital statistics, death certificates, coroner/medical examiner reports, hospital medical reports, emergency medical service reports, and other state records. From these documents, data for more than 100 FARS data elements are obtained. Each year, specific data elements are modified in response to changing user needs, vehicle characteristics,

[3] According to the *2002 Public Transportation Fact Book* (APTA 2002) there were approximately 9.363 billion total transit trips in 2000; however, this number includes all trips by all transit modes (bus, commuter rail, demand response, light rail, heavy rail, trolley bus, and other). In the committee's analyses, only data for other buses were included. According to the *Fact Book,* of these 9.363 billion trips, 5.678 billion were taken by bus, and only about 10 percent of transit trips were provided to riders under 18 years of age. Thus, using NTD data, approximately 568 million trips were taken by children under 18 years of age. This number includes trips taken at all hours during the entire year and also includes children under 5 years of age. School-related trips relevant to this study would be a portion of these trips.

and highway safety emphasis areas. As specific as the data are, however, no personal identifying information (such as names or addresses) is recorded in FARS. Similar to GES, FARS was developed to provide an overall measure of highway safety, to identify traffic safety problems, and to provide a single objective basis for evaluating the effectiveness of motor vehicle safety standards and highway safety incentives. NHTSA annually provides descriptive statistics for traffic crashes of all degrees of severity in its *Traffic Safety Facts* series, based on GES and FARS data (see NHTSA 2000 for a recent report). (FARS data may also be accessed on the Internet at www.fars.nhtsa.dot.gov.)

DATASETS USED FOR THIS STUDY

Given the study objectives and the data available in the various datasets, the committee elected to use the following three datasets for its analyses:

- NPTS, the only national dataset that contains exposure/travel information, used to estimate the number of trips taken and miles traveled by school-age children;
- FARS, used to analyze student fatalities; and
- GES, used to analyze student injuries.

Information from all three datasets had to be filtered and grouped to extract relevant inputs for the committee's risk analyses. Three main generalizations had to be made: (*a*) time of day was used as a surrogate for school travel trips; (*b*) age groupings were created from individual age groups; and (*c*) general transportation mode categories were delineated.

The FARS and GES datasets do not reliably record purpose of trip for each incident. As a surrogate for purpose of trip, the committee defined school travel hours (i.e., hours during which most school-related trips would occur), as follows:[4]

- Months of year: September 1 through June 15[5, 6]
- Days of week: Monday through Friday
- Hours of day: 6:00 a.m. to 8:59 a.m. and 2:00 p.m. to 4:59 p.m.[7]

[4] All child fatalities not recorded during the months, days, and hours shown for school travel are referred to as occurring during non–school travel hours.

[5] The GES data analysis included the entire month of June because, while it is possible to select days of the week, it is not possible to break out or select part of a month (i.e., the first 2 weeks but not the last 2 weeks of the month).

[6] In this study, more than 180 days are included in the defined "school year" to capture school trips for children attending schools with different schedules. In addition, the GES and NPTS datasets do not allow one to identify holidays or other special days in order to remove data for these days from the analyses. The rates per school day are rough estimates that assume different travel behavior for children during vacations (i.e., significantly fewer trips during normal school travel hours while on vacation and minimal school bus use).

[7] The selection of these hours for school travel omits the transporting of kindergarten children to and from school during midday (for those school districts in which kindergarten is a half-day). A fatality or injury of a kindergartner or bus driver during such a midday trip would not be included in the reported risk calculations. Also omitted are injuries and fatalities that occur on school activity trips that take place during the school day between 9:00 a.m. and 1:59 p.m. or after 5:00 p.m. Thus, trip purpose and time of day are not perfectly correlated.

Because of the limited amount of data in the two output datasets (FARS and GES), an analysis for each age group was not possible. Therefore, the committee created the following four age groupings: 5–10 years of age, 11–13, 14–15, and 16–18. This categorization is associated with the ages at which children change schools (the break around 10–11 years is when children generally move from elementary to middle school; 11–13 years of age maps to middle-school ages, and 14–18 is the rough equivalent of high school ages). These groupings also correspond roughly to transition points in the developmental and behavioral characteristics of children. Further, while the last two age groupings both include high school students, those aged 16–18 are more likely to have a driver's license (or friends that have one), resulting in a different distribution of travel modes used. In addition, those aged 16–18 are more likely to hold after-school jobs or to participate in after-school activities that require transportation after regularly scheduled school bus service times. Therefore, the committee believed this last age group would be significantly different in both modes of travel used and number/length of trips during normal school travel hours, and thus should be examined separately.

There are many ways to classify injury and fatality data. Table 2-1 shows a classification consisting of 16 categories. FARS and GES provide data for 14 of these categories; categories 6 and 8 do not include motor vehicles. For much of the analysis, these 16 categories were combined into six more general categories:

- Categories 1 and 2—school bus–related crashes;
- Categories 3, 4, and 5—passenger vehicle crashes;
- Categories 6 and 7—pedestrian crashes;
- Categories 8, 9, and 10—bicyclist crashes;
- Categories 11 and 12—other bus crashes; and
- Categories 13, 14, and 15—motorcycle crashes.

Nationwide Personal Transportation Survey

Description

NPTS serves as the nation's inventory of daily personal travel. It is a computer-assisted telephone interview survey of households in the United States. For each trip made during a preselected 24-hour time period, data are gathered regarding purpose of trip, mode of travel, length of trip, day of travel, vehicle occupancy, driver characteristics (e.g., age, gender, worker status, education level), and vehicle attributes (e.g., make, model, model year, annual miles driven, odometer readings). These data are gathered for all areas of the country, all days of the week, and all months of the year. Data are collected only for the civilian, noninstitutionalized population in the United States aged 5 years and older. NPTS does not include responses from military personnel living on base or overseas, or from residents of nursing homes, assisted-living facilities, long-term medical institutions, college dormitories, or prisons.

NPTS has been conducted five times—in 1969, 1977, 1983, 1990, and 1995; the sixth survey was initiated in late 2001. Since the survey contents and method-

TABLE 2-1 Categories Used to Classify Injury and Fatality Incident Data

Category	Description
1	Child school bus passenger in a school bus–related crash[a]
2	Child pedestrian in a school bus–related crash
3	Child passenger in passenger vehicle driven by an adult
4	Driver younger than 19, passenger vehicle
5	Child passenger in passenger vehicle, driver younger than 19
6	Child pedestrian not involved in a motor vehicle crash[b]
7	Child pedestrian incident, not school bus–related[c]
8	Child bicyclist not involved in a motor vehicle crash[b]
9	Child bicyclist in a school bus–related crash
10	Child bicyclist not involved in a school bus–related crash
11	Other bus, driver younger than 19
12	Child passenger in other bus
13	Child passenger on motorcycle operated by an adult
14	Motorcycle, driver (operator) younger than 19
15	Child passenger on a motorcycle operated by a driver younger than 19
16	Unknown

[a] Includes any child riding in a vehicle being used as a school bus.
[b] Not included in FARS or GES.
[c] This category includes child pedestrian injuries and fatalities occurring in other bus-related crashes as well as in incidents with passenger vehicles driven by teens.

ology have been modified each time, data from multiple years cannot be used in one analysis without some type of data manipulation. Therefore, the committee used data from the most recent survey available at the time (the 1995 survey) for its analyses. In 1995, NPTS consisted of a national sample of 21,020 households and an additional 21,013 households in five add-on areas (New York; Massachusetts; Oklahoma City and Tulsa, Oklahoma; and Seattle, Washington). The data were collected from May 1995 through July 1996 (Chen et al. 2000). [See RTI and FHWA (1997) and Hu and Young (1999) for an in-depth description of the 1995 NPTS survey procedures and methodology.]

NPTS is a random sample of the nine census regions stratified by population size and other factors. The 1995 survey began with 160,000 telephone numbers, approximately 45 percent of which were dropped when there was no response. Because the stratification was done using telephone numbers, all households without a telephone—a group in which households at the poverty level are overrepresented—were excluded.

It was determined that approximately 72 percent of households that received the travel log filled it out. The overall response rates were 55.3 percent for household-level data and 34.3 percent for person-level data.

Analyses

Given the data fields available in NPTS, it is possible to extract data on trips made and miles traveled by transportation mode, age, date, time of day, purpose of trip, and type of geographic region (i.e., rural versus urban).[8] On the basis of this dataset, it was estimated that approximately 50 million students (Census Bureau 2000) made 9.7 billion trips (5.9 billion urban and 3.8 billion rural) to school during normal morning school travel hours and traveled approximately 44.0 billion student-miles (20.0 billion urban and 24.0 billion rural). Table 2-2 provides data on number of trips, and Table 2-3 shows student-miles traveled during normal morning and afternoon school travel hours. Tables containing detailed trip and student-mile data are provided in Annex 2-1. The data suggest that, on average, each student made approximately 194 trips during normal morning school travel hours throughout the school year—an average of 1.1 school trips per student each school morning.[9] The definition of a trip is one-way travel from one address to another. Thus, if a person travels from home to school to drop off a student, and then goes to work, the driver has made two trips and the student one. If a child walks to the bus stop and rides a bus to school, this is considered one trip.

It was estimated that during normal afternoon school travel hours, these same students made 13.8 billion trips (8.6 billion urban and 5.2 billion rural) and traveled approximately 69.3 billion student-miles (34.7 billion urban and 34.6 billion rural). The data suggest that, on average, each student made approximately 276 trips during normal afternoon school travel hours throughout the school year, which translates to approximately 1.5 trips per student each afternoon. Given that it is known, at least anecdotally, that more trips are taken in the afternoon than in the morning travel period (e.g., to run errands, go to the library, go to lessons, meet friends), one would expect there to be more afternoon than morning trips on average.

For each analysis, the sample size (N), the estimated statistic (trips or student-miles) based on the sample size, and the standard error are reported in the tables in Annex 2-1. These data are the basis for the analyses in Chapter 3 that compare the risk to students of traveling to and from school during normal school travel hours using the various modes.

Limitations

The committee's analyses were hampered by problems inherent in the quantity and quality of the data, especially difficulties in obtaining accurate and reliable enrollment and ridership data. This was especially the case when the committee tried to gather data at other than the aggregate level. As noted, the NPTS data are based on a sampling of some 42,000 households in the United States, and

[8] In the 1995 NPTS dataset, urbanized areas were defined as areas having population densities of at least 1,000 persons per square mile (RTI and FHWA 1997).

[9] As noted earlier, time of day rather than stated purpose of trip was used to determine school-related travel trips because the outcome datasets (i.e., FARS and GES) do not report purpose-of-trip information reliably.

TABLE 2-2 Population Estimates for Number of Student Trips Made During Normal Morning and Afternoon School Travel Hours by Mode

	Morning			Afternoon			
Mode	**Urban**	**Rural**	**Total**	**Urban**	**Rural**	**Total**	**Total**
Passenger vehicle	3,279,726,554	2,092,628,516	5,372,355,070	4,831,405,530	3,049,681,460	7,881,086,990	13,253,442,060
School bus	1,309,995,348	1,441,861,776	2,751,857,124	1,309,959,884	1,416,289,818	2,726,249,702	5,478,106,826
Other bus	163,558,718	36,486,530	200,045,248	198,811,400	40,970,533	239,781,933	439,827,181
Bicycle	58,188,176	16,409,185	74,597,361	220,961,475	156,812,750	377,774,225	452,371,586
Walk	777,336,383	133,346,747	910,683,130	1,428,155,719	358,272,221	1,786,427,940	2,697,111,070
Other	28,403,226	1,488,789	29,892,015	34,962,929	6,140,836	41,103,765	70,995,780
Unknown	263,551,965	68,015,175	331,567,140	567,138,229	189,249,284	756,387,513	1,087,954,653
Total	**5,880,760,371**	**3,790,236,718**	**9,670,997,089**	**8,591,395,167**	**5,217,416,902**	**13,808,812,069**	**23,479,809,158**

TABLE 2-3 Population Estimates for Student-Miles Traveled During Normal Morning and Afternoon School Travel Hours by Mode

Mode	Morning			Afternoon			Total
	Urban	Rural	Total	Urban	Rural	Total	
Passenger vehicle	11,878,985,126	13,133,834,292	25,012,819,418	27,063,682,981	23,290,793,916	50,354,476,897	75,367,296,315
School bus	5,512,961,165	10,175,511,847	15,688,473,012	5,142,320,970	10,130,758,328	15,273,079,298	30,961,552,310
Other bus	1,504,235,227	574,239,365	2,078,474,592	1,004,595,164	651,981,293	1,656,576,457	3,735,051,049
Bicycle	70,908,770	9,919,170	80,827,940	181,293,770	109,111,080	290,404,850	371,232,790
Walk	404,887,916	70,401,933	475,289,849	791,461,811	32,911,699	824,373,510	1,299,663,359
Other	256,003,012	1,544,134	257,547,146	288,301,481	43,662,333	331,963,814	589,510,960
Unknown	390,248,076	65,991,805	456,239,881	256,879,036	182,406,298	439,285,334	895,525,215
Total	**20,018,229,293**	**24,031,442,548**	**44,049,671,841**	**34,728,535,213**	**34,621,458,107**	**69,349,993,320**	**113,399,665,161**

they cannot be used reliably for analyses at the state and community levels with any degree of confidence. Thus the committee's ability to gauge the effects of state-by-state or local differences was constrained. While it was recognized that substantial variation exists in the modes of student travel according to location and such factors as climate, infrastructure, and local economic and demographic characteristics, the committee was unable to measure this variation directly. Without such data, conclusions concerning the direct effects of local conditions on the numbers of fatalities and injuries could not be drawn since rates and risk ratios could not be computed. In addition, the data in the NPTS database are self-reported, a feature associated with many well-known limitations. For example, there may be an undercount of trips because, in the case of pupil transportation, the bus trip to school may be documented, but not the trip between home and the bus stop. All travel data for children aged 5–13 are reported by their parents, while travel data for teens aged 14–17 may be either self-reported or reported for them by household adults. Teenagers may not report all afternoon trips they made, or parents responding for their older children may not be aware of all the trips the children made.

The NPTS survey is intended to gather information on personal travel of U.S. households, including why, how, when, where from, where to, how frequently, how long, and with whom trips were made. The survey is not limited to school-age children and not focused on school-related transportation—small facets of daily travel that are captured by the dataset only to a limited extent. This can be seen by the extremely small sample size (N) shown in the tables in Annex 2-1.

Fatality Analysis Reporting System

Description

Number of fatalities was one of two outcome measures examined by the committee. These data are contained in FARS, a database first developed in 1975 that contains only data on all fatal traffic crashes that occur on public roadways in the United States.[10] Data in this national database are extracted from medical examiner, coroner, emergency medical, and police accident reports, as well as from driver, vehicle, and roadway classification records. There is detailed information in the database on crash, vehicle, driver, and occupant characteristics.

Analyses

Analyses were performed using 9 years of FARS data (1991–1999). In these 9 years, a total of 51,350 children between the ages of 5 and 18 were killed in all traffic crashes in the United States (Table 2-4). Of these, 7,470 were killed during normal school travel hours,[11] 2,719 were killed during school session

[10] To be classified as a fatal crash, an incident must involve a vehicle occupant or nonmotorist who dies within 30 days of the crash from injuries caused by the crash.

[11] These tables include data for the previously defined 205 school travel days. Extra days include holidays and other weekday nonschool days. Because of the extra days included in the tables, fatalities for non–school bus modes may be overrepresented. See note 4.

TABLE 2-4 Child (5–18 Years of Age) Deaths in FARS by Year (1991–1999)

Year	Fatalities
1991	5,748
1992	5,397
1993	5,506
1994	5,772
1995	5,860
1996	5,847
1997	5,849
1998	5,690
1999	5,681
Total	**51,350**

hours, and 40,655 were killed during all nonschool hours. Table 2-5 breaks these values down by the 15 fatality categories used by the committee. Details on the school session time and non–school time categories can be found in Annex 2-2.

The FARS variable "roadway functional class" was used to distinguish between "rural" and "other" (basically urban) crash sites for mapping to the rural/urban classification used in the NPTS analyses. Table 2-6 shows the distribution of normal school travel time fatalities for urban versus rural geographic locations. Table 2-7 shows the distribution of fatalities by individual ages, and Table 2-8 shows the distribution by age group.

Limitations

The FARS database, being limited to fatalities, is likely to overstate or understate the incidence of uncommon events, such as fatalities not involving passenger vehicles, when only a single year of data is considered. An extremely rare event, such as an incident resulting in multiple fatalities to pupils aboard a school bus, can skew the data by inflating the risk for that mode during the year of occurrence and can change the interpretation or ranking of risk for that mode. For these reasons, fatality data were examined for a longer period.

As noted, moreover, the national databases used to examine the safety of children traveling to and from school—FARS for fatality counts and GES for nonfatal injury estimates—provide data only for incidents in which a motor vehicle is involved. There is no national database to record pedestrian and bicycling fatalities and injuries not involving a motor vehicle. The result is underestimation of the number of fatalities and injuries involving the non–motor vehicle modes, which hampered the committee's analyses of the relative safety of these modes. However, FARS and GES do provide some insight into the safety of these modes when they interact with the motor vehicle modes.

TABLE 2-5 Child Fatalities by Time of Day and Fatality Categories (9-Year Totals)

Category	Description	School Travel	School Session	Non-School Times	Total
1	Child school bus passenger fatality[a] in a school bus–related crash	41	6	8	55
2	Child pedestrian fatality in a school bus–related crash	136	16	8	160
3	Child passenger fatality in all other vehicles driven by an adult	1,517	660	10,775	12,952
4	16–18 year old driver fatality, all other vehicles	2,545	1,067	13,282	16,894
5	Child passenger fatality in all other vehicles driven by a 16–18 year old	1,483	591	8,512	10,586
6	Child passenger fatality (not a motor vehicle crash)[b]	–	–	–	–
7	Child pedestrian fatality, not school bus–related	1,177	188	4,661	6,026
8	Child bicyclist fatality (not a motor vehicle crash)[b]	–	–	–	–
9	Child bicyclist fatality in a school bus–related crash	12	0	2	14
10	Child bicyclist fatality not in a school bus–related crash	402	116	2,188	2,706
11	16–18 year old driver fatality, other buses	0	0	1	1
12	Child passenger fatality in other buses	5	2	25	32
13	Child passenger fatality on motorcycle operated by an adult	7	5	169	181
14	16–18 year old driver (operator) fatality, motorcycle	135	60	931	1,126
15	Child passenger fatality on motorcycle operated by a 16–18 year old	10	8	93	111
Total[c]		**7,470**	**2,719**	**40,655**	**50,844**

[a] This category includes any child riding in a vehicle being used as a school bus.
[b] Not in FARS data.
[c] Does not include 506 child fatalities that could not be classified because of incomplete information.

TABLE 2-6 Child Fatalities During School Transport Hours by Fatality Category and Location (N = 7,470)

		Fatalities					
		Rural		Urban		Total	
Category	**Description**	**N**	**%**	**N**	**%**	**N**	**%**
1	Child school bus passenger fatality in a school bus–related crash	23	<1	18	1	41	1
2	Child pedestrian fatality in a school bus–related crash	64	1	72	3	136	2
3	Child passenger fatality in all other vehicles driven by an adult	1,057	22	460	17	1,517	20
4	Child driver fatality, all other vehicles	1,927	40	618	23	2,545	34
5	Child passenger fatality in all other vehicles driven by a child	1,046	22	437	16	1,483	20
6	Child passenger fatality (not a motor vehicle crash)	–	–	–	–	–	–
7	Child pedestrian fatality, not school bus–related	403	8	774	29	1,177	16
8	Child bicyclist fatality (not a motor vehicle crash)	–	–	–	–	–	–
9	Child bicyclist fatality in a school bus–related crash	3	<1	9	<1	12	<1
10	Child bicyclist fatality not in a school bus–related crash	172	4	230	<1	402	5
12	Child passenger fatality in other buses	4	<1	1	0.0	5	<1
13	Child passenger fatality on motorcycle operated by an adult	2	<1	5	<1	7	<1
14	Child driver (operator) fatality, motorcycle	77	2	58	2	135	2
15	Child passenger fatality on motorcycle operated by a child	7	<1	3	<1	10	<1
Total		**4,785**	**100**	**2,685**	**100**	**7,470**	**100**

TABLE 2-7 Child Fatalities During School Transport Hours by Fatality Category and Age (N = 7,470)

		Age (years)														
Category	**Description**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Total**
1	Child school bus passenger fatality in a school bus–related crash	0	0	3	5	7	0	1	4	7	3	7	3	0	1	41
2	Child pedestrian fatality in a school bus–related crash	35	25	17	16	7	5	9	4	6	6	3	0	1	2	136
3	Child passenger fatality in all other vehicles driven by an adult	170	136	126	128	87	100	81	78	79	80	81	90	113	168	1,517
4	Child driver fatality, all other vehicles	0	0	0	0	2	1	2	9	11	36	103	793	766	822	2,545
5	Child passenger fatality in all other vehicles driven by a child	10	11	4	9	17	10	19	36	64	168	291	357	311	176	1,483
7	Child pedestrian fatality, not school bus–related	88	128	113	91	99	104	92	101	71	91	67	55	49	28	1,177
9	Child bicyclist fatality in a school bus–related crash	1	1	0	1	2	0	2	2	1	0	0	1	0	1	12
10	Child bicyclist fatality not in a school bus–related crash	13	23	30	31	27	41	51	45	43	24	26	15	20	13	402
12	Child passenger fatality in other buses	0	0	1	0	0	0	1	1	0	0	1	1	0	0	5
13	Child passenger fatality on motorcycle operated by an adult	0	0	0	0	0	0	0	0	0	0	1	0	3	3	7
14	Child driver (operator) fatality, motorcycle	0	0	1	1	0	1	0	1	4	11	25	15	29	47	135
15	Child passenger fatality on motorcycle operated by a child	0	1	0	0	0	0	0	1	0	1	0	3	2	2	10
Total		**317**	**325**	**295**	**282**	**248**	**262**	**258**	**282**	**286**	**420**	**605**	**1,333**	**1,294**	**1,263**	**7,470**

TABLE 2-8 Child Fatalities During School Transport Hours by Fatality Category and Age Group (N = 7,470)

		Age Group (years)									
		5–10		11–13		14–15		16–18		Total	
Category	Description	N	%	N	%	N	%	N	%	N	%
1	Child school bus passenger fatality in a school bus–related crash	15	0.9	12	1.5	10	1.0	4	0.1	41	0.5
2	Child pedestrian fatality in a school bus–related crash	105	6.1	19	2.3	9	0.9	3	0.1	136	1.8
3	Child passenger fatality in all other vehicles driven by an adult	747	43.2	238	28.8	161	15.7	371	9.5	1,517	20.3
4	Child driver fatality, all other vehicles	3	0.2	22	2.7	139	13.6	2,381	61.2	2,545	34.1
5	Child passenger fatality in all other vehicles driven by a child	61	3.5	119	14.4	459	44.8	844	21.7	1,483	19.9
6	Child passenger fatality (not a motor vehicle crash)	–	–	–	–	–	–	–	–	–	–

7	Child pedestrian fatality, not school bus–related	623	36.0	264	32.0	158	15.4	132	3.4	1,177	15.8
8	Child bicyclist fatality (not a motor vehicle crash)	–	–	–	–	–	–	–	–	–	–
9	Child bicyclist fatality in a school bus–related crash	5	0.3	5	0.6	0	0	2	0.1	12	0.2
10	Child bicyclist fatality not in a school bus–related crash	165	9.5	139	16.8	50	4.9	48	1.2	402	5.4
12	Child passenger fatality in other buses	1	0.1	2	0.2	1	0.1	1	0.0	5	0.1
13	Child passenger fatality on motorcycle operated by an adult	0	0	0	0	1	0.1	6	0.2	7	0.1
14	Child driver (operator) fatality, motorcycle	3	0.2	5	0.6	36	3.5	91	2.3	135	1.8
15	Child passenger fatality on motorcycle operated by a child	1	0.1	1	0.1	1	0.1	7	0.2	10	0.1
Total		**1,729**	**100.0**	**826**	**100.0**	**1,025**	**100.0**	**3,890**	**100.0**	**7,470**	**100.0**

The committee encountered two other difficulties in attempting to analyze fatalities that occurred when students were being transported to and from school and school-related activities. First, it was not possible to determine that a trip was, in fact, a school trip (going either to or from school or to or from a school-sponsored activity), especially for the non–school bus modes. Second, pedestrian fatalities resulting from crashes involving other buses could not be identified. For example, if a student were fatally injured crossing the road to get to a transit stop, this would not be recorded as a transit bus–related fatality in the database.

General Estimates System

Description

Data in the GES database are subdivided into three levels of nonfatal injury—levels A, B, and C—and one fatal injury category. This ANSI-developed injury severity rating scale is used by most states:

- Level A: incapacitating injury—Any nonfatal injury that prevents the injured person from walking, driving, or normally continuing the activities he or she was able to perform before the injury occurred. Included are injuries such as severe lacerations, broken or distorted limbs, skull or chest injuries, abdominal injuries, unconsciousness at or when taken from the accident scene, and an inability to leave the accident scene without assistance. Momentary unconsciousness is excluded.
- Level B: nonincapacitating evident injury—Any injury, other than a fatal or incapacitating injury, that is evident to observers at the scene of the accident where the injury occurred. Included are injuries such as lumps on the head, abrasions, bruises, and minor lacerations. Limping (the injury cannot be seen) is excluded.
- Level C: possible injury—Any injury reported or claimed that is not fatal, incapacitating, or nonincapacitating evident. Included are such injuries as momentary unconsciousness; claims of injuries not evident; limping; and complaints of pain, nausea, or hysteria.

These categories are quite subjective, meaning that different individuals (e.g., police officers) who apply the scale may interpret the definitions differently. Further, because some states do not use this classification, a state's classification of injuries may not correlate with that in GES or with those used by other states. Finally, because only three categories are used, injuries of vastly different severity must, at times, be grouped at the same severity level: "For example, under the ANSI D16.1 scale, injuries ranging from broken arms to quadriplegia are all classified as incapacitating injuries" (TRB 1989, 54).

GES provides information on a nationally representative (stratified) sample of all severities of police-reported traffic crashes within 60 geographic sites across the United States. It is a probability sample of approximately 45,000 annual U.S. police-reported crashes on public roads that result in property damage, injury, or death. GES estimates are intended to provide information on a national level about motor vehicle crashes and the vehicles and people involved. The purpose of GES is to track trends in these national-level estimates so that highway safety problem areas can be identified, to provide a basis for regulatory and consumer initiatives, and to form the basis for cost–benefit analyses of highway safety initiatives. [See NHTSA (1991) for information on the set of crashes described by GES estimates, the sample selection procedures, the estimation procedure, and the reliability of those estimates in terms of sampling error.]

Analyses

The committee performed analyses on 9 years of GES nonfatal injury data (1991–1999) to determine the number of nonfatal injuries involving each mode of interest for the age groupings of interest during the defined normal school travel hours. Given that portions of a month (e.g., the first 2 weeks but not the last 2) could not be segregated, the analyses were conducted for the entire months of September through June.

Although the injuries in GES are classified into three levels, the small number of accidents and injuries for some of the age categories within a mode resulted in large standard error estimates. In addition, some category C injuries are severe (e.g., whiplash and concussion) and the committee wanted to be sure not to miss serious but unobservable injuries. Finally, for the travel modes that the committee used, the percentage of (A+B) injuries when compared to (A+B+C) were significant. For the school bus, other bus, and the two private vehicle categories, (A+B) was between 37 and 40 percent of the total. The effect of including C categories would not change the relative comparison among these modes. For the other two transportation categories (walking and bicycling), (A+B) was 68 to 70 percent of the total injuries. This is because of the higher lethality of accidents involving children not protected by a vehicle. An injury rate analysis based on categories (A+B) would look very similar to the one in the report with the exception of walking and bicycling. These two modes would have their injury rates increase relative to the other modes by approximately 70 percent. Therefore, although the range of injuries that are included in the A, B, and C categories is quite broad, the three injury levels were collapsed to ensure sufficient sample sizes within each category for the committee's analyses. Given the already significant differences in the risk rates and the committee's desire to capture all injuries, the committee felt that doing separate analyses based on (A+B) injuries were not warranted.

From 1991 through 1999, an estimated 5,714,048 school-age children were injured, 1,379,394 of whom received their injuries during normal school travel hours (see Tables 2-9 through 2-11).[12] Of the latter injuries, 40 percent

[12] These injuries occurred during normal school travel hours as defined previously, but the totals given are based on 230 days (not the approximately 180 school days each year) because of limitations in accessing only school days. Inclusion of these additional days leads to an overestimate of the number of injuries associated with school travel for the non–school bus modes.

TABLE 2-9 Estimated Total Child Injuries (1991–1999)

Category	Description	Population Estimate
1	Child school bus passenger injury in a school bus–related crash	60,883
2	Child pedestrian injury in a school bus–related crash	5,001
3	Child passenger injury in all other vehicles driven by an adult	2,151,848
4	16–18 year old driver injury, all other vehicles	1,869,850
5	Child passenger injury in all other vehicles driven by a 16–18 year old	1,037,154
7	Child pedestrian injury, not school bus–related	251,264
9	Child bicyclist injury in a school bus–related crash	735
10	Child bicyclist injury not in a school bus–related crash	274,235
11	16–18 year old driver injury, other buses	142
12	Child passenger injury in other buses	11,942
13	Child passenger injury on motorcycle operated by an adult	7,675
14	16–18 year old driver (operator) injury, motorcycle	38,010
16	Other	5,309
Total		**5,714,048**

occurred to pupils traveling in a passenger vehicle driven by an operator 19 years of age or older, and 32 percent to students aged 16–18 who were driving a motor vehicle. Just over 3.5 percent were student passengers on a school bus, and only 0.25 percent were student pedestrians injured in school bus–related crashes. Of the total student injuries, 5 percent are estimated to be to bicyclists in crashes not involving school buses. Table 2-10 shows the estimated total number of injuries to school-age children during normal school travel hours for the years 1991 through 1999, inclusive, broken down by age and mode categories.

It is interesting to note that for each of the four age groupings, numbers of injuries sustained in passenger vehicle crashes are consistently highest relative to the other modal categories. For example, of the injuries sustained by students 5–10 years of age, 72 percent occurred when they were riding in a passenger vehicle driven by an operator 19 years of age or older. For those aged 11–13, this category also represents the largest proportion of injuries—49 percent. Of the injuries sustained by students aged 14–15, 39 percent occurred when they were riding in a passenger vehicle driven by someone under age 19. And for those aged 16–18, the majority of injuries (62 percent) occurred when they themselves were driving a motor vehicle. Table 2-11 shows for comparison the estimated total number of injuries for the same breakdowns for non–school travel hours for the same years.

TABLE 2-10 Estimated Child Injuries During Normal School Travel Hours by Age Category

	Age (years)									
	5–10		11–13		14–15		16–18		Total	
Category	Estimate	%	Estimate	%	Estimate	%	Estimate	%	Estimate	%
1	14,388	4.86	15,321	8.82	9,758	5.05	10,899	1.52	50,366	3.65
2	1,283	0.43	1,287	0.74	857	0.44	436	0.06	3,863	0.28
3	213,935	72.27	84,854	48.85	64,341	33.30	96,038	13.40	459,168	33.29
4	1,476	0.50	2,548	1.47	14,019	7.26	447,522	62.46	465,565	33.75
5	9,259	3.13	16,860	9.71	75,718	39.19	136,482	19.05	238,319	17.28
7	33,217	11.22	24,122	13.89	12,113	6.27	9,686	1.35	79,138	5.74
9	169	0.06	140	0.08	35	0.02	335	0.05	679	0.05
10	20,833	7.04	25,077	14.44	14,115	7.31	8,949	1.25	68,974	5.00
11	0	0.00	0	0.00	0	0.00	122	0.02	122	0.01
12	1,262	0.43	2,315	1.33	669	0.35	669	0.09	4,915	0.36
13	107	0.04	161	0.09	40	0.02	274	0.04	582	0.04
14	36	0.01	403	0.23	1,524	0.79	5,088	0.71	7,051	0.51
16	38	0.01	614	0.35	0	0.00	0	0.00	652	0.05
Total	**296,003**	**100.00**	**173,702**	**100.00**	**193,189**	**100.00**	**716,500**	**100.00**	**1,379,394**	**100.01**

TABLE 2-11 Estimated Child Injuries During Non–School Travel Hours by Age Category

	Age (years)									
	5–10		11–13		14–15		16–18		Total	
Category	Estimate	%	Estimate	%	Estimate	%	Estimate	%	Estimate	%
1	3,797	0.43	1,646	0.33	3,495	0.59	1,578	0.07	10,516	0.24
2	354	0.04	645	0.13	86	0.01	54	0.00	1,139	0.03
3	679,334	77.65	326,024	64.76	237,207	40.27	450,114	19.01	1,692,679	39.05
4	3,141	0.36	9,575	1.90	57,555	9.77	1,334,016	56.35	1,404,287	32.40
5	31,854	3.64	56,564	11.24	216,570	36.77	493,848	20.86	798,836	18.43
7	78,389	8.96	38,185	7.58	23,677	4.02	31,872	1.35	172,123	3.97
9	0	0.00	56	0.01	0	0.00	0	0.00	56	0.00
10	72,025	8.23	64,743	12.86	39,091	6.64	29,403	1.24	205,262	4.74
11	0	0.00	0	0.00	0	0.00	20	0.00	20	0.00
12	2,117	0.24	1,030	0.20	1,338	0.23	2,544	0.11	7,029	0.16
13	1,177	0.14	987	0.20	1,283	0.22	3,644	0.15	7,091	0.16
14	1,185	0.14	3,334	0.66	7,851	1.33	18,590	0.79	30,960	0.71
16	1,482	0.17	662	0.13	872	0.15	1,642	0.07	4,658	0.11
Total	**874,855**	**100.00**	**503,451**	**100.00**	**589,025**	**100.00**	**2,367,325**	**100.00**	**4,334,656**	**100.00**

Limitations

Given the sampling procedures for the GES database, there are some limitations due to sampling error and standard error; there is also a potential lack of representativeness. For example, *Traffic Safety Facts* (NHTSA 2000) reports that there were 7,500 school bus passenger injuries, with a standard error of approximately 1,300, and there were 350 pedestrian injuries sustained in school bus–related crashes, with a standard error of 300. These standard error estimates are taken from the published generalized broad error estimates and are not derived individually for each individual estimate. This lack of statistical precision diminishes the confidence in the dataset. Again, however, GES is the best database available for analyzing transportation-related injuries to students and addressing the issues of concern to the committee.

According to NHTSA (2000), the GES data elements may be modified yearly, leading to some inconsistencies in the dataset. These inconsistencies may in turn limit the usability of the data for answering particular questions, especially if data for multiple years are being examined. Moreover, as with FARS, GES does not capture purpose of trip; therefore, analysis of the data for preselected time periods captures all types of trips occurring during those times, which may include non-school-related trips, especially in the afternoon time period.

Another limitation of this database is that there is an underreporting of injured passengers in some of the sampling units because only those crashes that resulted in a PAR and exceeded the particular state's reporting threshold level had the potential to be included in the dataset. There could also be underreporting of serious injury because internal injuries such as intra-abdominal and intracranial injury may not be detectable at the scene. On the other hand, given the imprecision of the category definitions, particularly Level C (possible injury), and the policy in some districts of transporting to the hospital all students involved in a bus crash, there could also be an overreporting of injuries in this category. Another limitation is that injury data for light rail transit, as well as for bicycling and walking, obtained from GES include only injuries occurring in crashes that involved a collision with a motor vehicle. For the purposes of the data, light rail vehicles are not considered to be motor vehicles because they do not operate on roadways; thus injuries sustained aboard that mode are not included in the dataset. Unfortunately, these data are largely absent in other sources as well.

CONCLUSIONS

Data problems occur with fatality and injury data for children traveling to and from school and school-related activities regardless of the mode used. For the issues addressed in this study, the available data have many limitations: needed data are not available, there are definitional inconsistencies across databases and across years for the same database, there are recording errors in the datasets, and there are unknowns and missing data in the datasets that need to be taken into account.

Although numerous datasets exist, few contain representative data in sufficient quantity to be used for the types of detailed analyses conducted by the committee. At the same time, sufficient data at the community level are not easily accessible, if they are available at all. This diminishes the completeness of assessments that may be conducted and in turn impedes the ability to manage the risks involved in school transportation appropriately.

Currently available data on fatalities and injuries associated with transportation to and from school and school-related activities are illuminating but incomplete. The committee also found it difficult to link the data from multiple databases, especially because of the lack of consistency in terminology and other limitations noted above. One of the primary responsibilities and contributions of the federal agencies whose mission encompasses issues related to school transportation is to collect good, accurate, reliable data. If done correctly, a consistent, comprehensive data collection effort would benefit all highway modes, including school transportation. However, obtaining more thorough and complete data is not without cost. Given the large numbers of fatalities and injuries that occur on highways in the United States and the fact that relatively few of these involve students during school travel hours, the benefits of any additional data collection efforts need to be fully considered before such efforts are recommended or implemented.

REFERENCES

Abbreviations

APTA	American Public Transportation Association
BTS	Bureau of Transportation Statistics
FHWA	Federal Highway Administration
NHTSA	National Highway Traffic Safety Administration
RTI	Research Triangle Institute
TRB	Transportation Research Board

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ANNEX 2-1 TABLE 1 Urban Number of Trips During Normal Morning School Travel Hours by Mode and Age

		Age (years)				
Mode		5–10	11–13	14–15	16–18	Total
Passenger vehicle	Population estimate	1,477,264,544	531,098,508	400,517,876	870,845,627	3,279,726,554
	N	1,651	607	422	841	3,521
	Standard error	86,534,714	39,381,074	33,741,888	59,542,291	131,232,579
School bus	Population estimate	563,855,526	412,838,530	214,978,726	118,322,566	1,309,995,348
	N	805	475	259	157	1,696
	Standard error	40,644,901	41,412,303	23,896,577	15,436,501	73,869,310
Other bus	Population estimate	36,755,175	33,949,898	39,948,869	52,904,776	163,558,718
	N	36	41	45	59	181
	Standard error	10,589,136	9,116,062	9,114,959	9,569,792	21,750,083
Bicycle	Population estimate	20,785,924	20,008,211	17,183,912	210,129	58,188,176
	N	13	22	13	1	49
	Standard error	8,590,618	5,895,656	6,806,737	210,129	13,423,861

Walk	Population estimate	382,922,367	177,262,345	131,747,013	85,404,658	777,336,383
	N	386	201	106	92	785
	Standard error	35,079,684	19,204,831	31,726,354	14,848,258	57,375,092
Other	Population estimate	3,619,997	1,643,831	5,070,090	18,069,308	28,403,226
	N	5	4	9	24	42
	Standard error	2,325,148	894,971	1,896,490	5,267,489	6,327,733
Unknown	Population estimate	127,369,982	81,319,258	30,098,173	24,764,552	263,551,965
	N	147	86	38	40	311
	Standard error	24,004,236	16,209,711	10,494,355	7,951,869	36,051,506
Total	Population estimate	2,612,573,515	1,258,120,581	839,544,659	1,170,521,616	5,880,760,371
	N	3,043	1,436	892	1,214	6,585
	Standard error	110,717,079	65,908,724	55,206,094	66,764,357	179,625,941

Note: N = actual number of persons who reported.

ANNEX 2-1 TABLE 2 Urban Student-Miles Traveled During Normal Morning School Travel Hours by Mode and Age

Mode		Age (years)				
		5–10	11–13	14–15	16–18	Total
Passenger vehicle	Population estimate	4,761,281,944	1,791,096,290	1,372,679,540	3,953,927,352	11,878,985,126
	N	1,633	595	405	825	3,458
	Standard error	86,407,831	39,129,419	33,452,673	58,839,703	130,576,242
School bus	Population estimate	2,045,973,075	1,701,853,260	1,191,692,999	573,441,831	5,512,961,165
	N	774	455	242	149	1,620
	Standard error	40,373,188	40,377,136	23,627,100	15,372,813	72,953,572
Other bus	Population estimate	101,856,220	335,248,751	822,252,619	244,877,637	1,504,235,227
	N	33	37	38	51	159
	Standard error	10,484,740	9,004,633	8,699,763	9,122,355	21,198,568
Bike	Population estimate	15,939,345	27,286,852	27,577,509	105,064	70,908,770
	N	13	22	13	1	49
	Standard error	8,590,618	5,895,656	6,806,737	210,129	13,423,861

Walk	Population estimate	138,788,540	90,571,125	113,672,823	61,855,428	404,887,916
	N	386	201	106	92	785
	Standard error	35,079,684	19,204,831	31,726,354	14,848,258	57,375,092
Other	Population estimate	43,808,700	9,985,665	40,867,471	161,341,177	256,003,012
	N	4	4	6	16	30
	Standard error	2,299,055	894,971	1,825,485	5,058,794	6,037,580
Unknown	Population estimate	193,034,998	132,875,825	13,464,980	50,872,274	390,248,076
	N	141	78	35	35	289
	Standard error	23,905,839	16,080,068	6,334,804	7,923,014	34,935,910
Total	Population estimate	7,300,682,821	4,088,917,768	3,582,207,941	5,046,420,763	20,018,229,293
	N	2,984	1,392	845	1,169	6,390
	Standard error	110,479,419	64,854,690	54,366,841	65,892,631	178,179,617

Note: N = actual number of persons who reported.

ANNEX 2-1 TABLE 3 Rural Number of Trips During Normal Morning School Travel Hours by Mode and Age

		Age (years)				
Mode		**5–10**	**11–13**	**14–15**	**16–18**	**Total**
Passenger vehicle	Population estimate	860,498,695	316,247,388	276,658,155	639,224,278	2,092,628,516
	N	932	344	300	644	2,220
	Standard error	64,461,356	33,092,480	29,690,045	49,379,249	105,798,541
School bus	Population estimate	683,319,840	443,993,597	219,232,462	95,315,877	1,441,861,776
	N	991	582	300	167	2,040
	Standard error	46,616,256	35,880,120	27,191,996	14,027,341	77,506,971
Other bus	Population estimate	17,925,546	7,869,828	8,524,793	2,166,362	36,486,530
	N	24	17	8	7	56
	Standard error	6,614,423	3,671,130	3,803,890	1,739,721	9,210,307
Bike	Population estimate	9,564,192	4,776,599	1,876,239	192,156	16,409,185
	N	8	7	1	4	20
	Standard error	4,408,397	3,260,056	1,876,239	135,007	7,666,113

Walk	Population estimate	63,287,714	49,173,766	9,352,461	11,532,807	133,346,747
	N	58	38	20	22	138
	Standard error	13,683,290	12,802,995	4,073,132	3,906,176	22,776,280
Other	Population estimate	0	0	0	1,488,789	1,488,789
	N	0	0	0	2	2
	Standard error	0	0	0	1,432,741	1,432,741
Unknown	Population estimate	26,452,451	13,428,648	12,672,985	15,461,090	68,015,175
	N	48	25	25	21	119
	Standard error	8,715,177	4,639,218	4,384,690	5,543,581	13,349,986
Total	Population estimate	1,661,048,438	835,489,825	528,317,095	765,381,360	3,790,236,718
	N	2,061	1,013	654	867	4,595
	Standard error	84,620,028	56,894,445	41,382,258	52,316,507	145,382,516

Note: N = actual number of persons who reported.

ANNEX 2-1 TABLE 4 Rural Student-Miles Traveled to School During Normal Morning School Travel Hours by Mode and Age

Mode		Age (years) 5–10	11–13	14–15	16–18	Total
Passenger vehicle	Population estimate	5,202,954,714	1,688,664,853	1,813,576,387	4,428,638,338	13,133,834,292
	N	921	341	293	639	2,194
	Standard error	64,053,681	32,981,193	29,507,986	49,356,979	105,257,519
School bus	Population estimate	4,381,030,645	3,034,462,519	1,728,722,273	1,031,296,410	10,175,511,847
	N	977	573	288	164	2,002
	Standard error	46,282,788	35,773,715	26,859,248	13,960,988	76,995,724
Other bus	Population estimate	380,144,166	84,129,972	62,424,583	47,540,644	574,239,365
	N	23	15	7	6	51
	Standard error	6,614,245	3,670,095	3,803,648	1,739,486	9,209,217
Bike	Population estimate	3,615,815	4,152,614	1,876,239	274,503	9,919,170
	N	8	7	1	3	19
	Standard error	4,408,397	3,260,056	1,876,239	38,903	7,665,023

Walk	Population estimate	37,663,611	21,443,036	4,832,846	6,462,441	70,401,933
	N	58	38	20	22	138
	Standard error	13,683,290	12,802,995	4,073,132	3,906,176	22,776,280
Other	Population estimate	0	0	0	1,544,134	1,544,134
	N	0	0	0	1	1
	Standard error	0	0	0	57,190	57,190
Unknown	Population estimate	15,358,439	8,849,220	7,133,432	34,650,714	65,991,805
	N	48	25	25	21	119
	Standard error	8,715,177	4,639,218	4,384,690	5,543,581	13,349,986
Total	Population estimate	10,020,767,389	4,841,702,214	3,618,565,760	5,550,407,184	24,031,442,548
	N	2,035	999	634	856	4,524
	Standard error	83,879,804	56,765,042	41,038,177	52,148,126	144,420,916

Note: N = actual number of persons who reported.

ANNEX 2-1 TABLE 5 Urban Trips During Normal Afternoon School Travel Hours by Mode and Age

Mode		Age (years) 5–10	11–13	14–15	16–18	Total
Passenger vehicle	Population estimate	2,100,547,722	823,613,202	503,335,498	1,403,909,108	4,831,405,530
	N	2,336	891	580	1,445	5,252
	Standard error	138,363,375	64,026,003	44,369,474	93,996,342	201,723,482
School bus	Population estimate	608,424,472	430,405,436	169,841,582	101,288,394	1,309,959,884
	N	841	489	229	128	1,687
	Standard error	41,954,305	42,272,804	20,622,458	17,015,906	73,279,362
Other bus	Population estimate	42,159,982	37,396,804	68,739,169	50,515,445	198,811,400
	N	57	43	63	61	224
	Standard error	10,729,737	9,231,985	13,111,518	9,776,708	24,583,674
Bike	Population estimate	80,546,573	73,120,021	56,541,979	10,752,902	220,961,475
	N	74	85	56	21	236
	Standard error	17,458,178	15,314,210	14,561,135	4,026,727	29,647,814

Walk	Population estimate	601,905,019	335,022,308	262,441,000	228,787,393	1,428,155,719
	N	628	381	248	214	1,471
	Standard error	55,355,907	33,314,229	38,842,327	32,201,507	89,999,130
Other	Population estimate	9,104,262	1,796,007	4,845,801	19,216,859	34,962,929
	N	14	6	9	35	64
	Standard error	3,991,532	915,201	1,952,824	4,553,955	6,618,319
Unknown	Population estimate	239,549,523	155,337,801	95,690,770	76,560,136	567,138,229
	N	306	164	96	87	653
	Standard error	31,726,420	27,115,550	18,788,228	15,501,934	54,810,536
Total	Population estimate	3,682,237,553	1,856,691,578	1,161,435,800	1,891,030,236	8,591,395,167
	N	4,256	2,059	1,281	1,991	9,587
	Standard error	173,927,108	99,885,163	76,541,657	108,140,229	275,065,881

Note: N = actual number of persons who reported.

ANNEX 2-1 TABLE 6 Urban Student-Miles Traveled During Normal Afternoon School Travel Hours by Mode and Age

Mode		Age (years) 5–10	11–13	14–15	16–18	Total
Passenger vehicle	Population estimate	10,087,441,013	5,363,655,690	3,006,743,940	8,605,842,338	27,063,682,981
	N	2,309	881	569	1,400	5,159
	Standard error	137,724,551	63,905,782	43,893,749	91,412,339	199,853,917
School bus	Population estimate	2,158,279,293	1,643,264,349	765,475,091	575,302,237	5,142,320,970
	N	810	473	207	122	1,612
	Standard error	41,683,474	40,891,198	20,216,548	16,976,940	71,548,779
Other bus	Population estimate	256,876,004	151,352,944	340,811,331	255,554,884	1,004,595,164
	N	51	40	53	55	199
	Standard error	10,580,880	9,230,508	12,229,776	9,291,995	23,740,009
Bike	Population estimate	46,115,547	61,978,593	59,017,844	14,181,787	181,293,770
	N	74	84	55	20	233
	Standard error	17,458,178	15,307,499	14,560,954	4,026,383	29,644,242

Walk	Population estimate	277,345,080	187,385,153	185,594,148	141,137,430	791,461,811
	N	628	381	248	213	1,470
	Standard error	55,355,907	33,314,229	38,842,327	32,201,403	89,999,097
Other	Population estimate	70,084,133	9,446,290	63,564,015	145,207,042	288,301,481
	N	11	5	7	27	50
	Standard error	3,930,805	701,666	1,884,496	4,326,683	6,345,107
Unknown	Population estimate	90,342,199	71,548,632	56,365,805	38,622,401	256,879,036
	N	297	146	91	73	607
	Standard error	31,324,720	26,114,182	16,823,660	13,202,639	52,776,831
Total	Population estimate	12,986,483,269	7,488,631,651	4,477,572,174	9,775,848,119	34,728,535,213
	N	4,180	2,010	1,230	1,910	9,330
	Standard error	172,966,224	98,774,357	75,571,161	104,197,126	271,451,955

Note: N = actual number of persons who reported.

ANNEX 2-1 TABLE 7 Rural Trips During Normal Afternoon School Travel Hours by Mode and Age

Mode		Age (years)				
		5–10	11–13	14–15	16–18	Total
Passenger vehicle	Population estimate	1,262,007,134	526,195,012	337,493,451	923,985,863	3,049,681,460
	N	1,537	636	415	1,057	3,645
	Standard error	85,803,928	54,902,693	35,082,384	76,310,051	147,990,991
School bus	Population estimate	704,668,044	402,190,725	210,615,943	98,815,106	1,416,289,818
	N	986	551	279	146	1,962
	Standard error	50,608,861	33,656,569	28,360,167	14,581,573	80,265,950
Other bus	Population estimate	18,572,942	10,625,139	9,956,689	1,815,765	40,970,533
	N	21	17	11	4	53
	Standard error	7,151,299	4,165,226	4,034,195	1,721,616	10,068,077
Motorcycle	Population estimate	0	5,699,198	174,425	98,487	5,972,111
	N	0	1	1	1	3
	Standard error	0	5,699,198	174,425	98,487	5,702,717

Bike	Population estimate	63,805,430	33,146,403	44,104,187	15,756,729	156,812,750
	N	63	65	39	21	188
	Standard error	22,115,634	10,163,115	17,291,476	8,461,089	33,125,093
Walk	Population estimate	111,672,611	126,462,256	63,337,583	56,799,771	358,272,221
	N	120	106	67	50	343
	Standard error	16,856,776	23,997,844	14,102,296	17,701,040	41,256,346
Other	Population estimate	0	0	54,344	114,380	168,725
	N	0	0	1	2	3
	Standard error	0	0	54,344	114,380	126,634
Unknown	Population estimate	82,630,684	56,224,018	22,195,071	28,199,511	189,249,284
	N	110	81	53	46	290
	Standard error	16,628,314	13,465,320	6,117,990	8,513,106	26,576,330
Total	Population estimate	2,243,356,845	1,160,542,753	687,931,693	1,125,585,611	5,217,416,902
	N	2,837	1,457	866	1,327	6,487
	Standard error	121,530,784	83,271,133	62,645,399	84,942,904	210,113,300

Note: N = actual number of persons who reported.

ANNEX 2-1 TABLE 8 Rural Student-Miles Traveled During Normal Afternoon School Travel Hours by Mode and Age

		Age (years)				
Mode		5–10	11–13	14–15	16–18	Total
Passenger vehicle	Population estimate	10,610,752,700	3,769,543,109	2,939,597,211	5,970,900,897	23,290,793,916
	N	1,522	632	406	1,042	3,602
	Standard error	85,793,168	54,901,914	34,973,329	76,048,366	147,772,017
School bus	Population estimate	4,453,167,270	2,957,427,679	1,580,908,580	1,139,254,798	10,130,758,328
	N	965	543	261	138	1,907
	Standard error	50,299,560	33,558,932	27,739,974	14,383,715	79,486,373
Other bus	Population estimate	460,697,146	100,388,092	69,353,702	21,542,353	651,981,293
	N	21	14	10	4	49
	Standard error	7,151,299	4,163,474	4,033,968	1,721,616	10,066,891
Motorcycle	Population estimate	0	2,849,599	1,046,550	295,461	4,191,611
	N	0	1	1	1	3
	Standard error	0	5,699,198	174,425	98,487	5,702,717

Bike	Population estimate	33,295,438	31,922,931	23,347,981	20,544,729	109,111,080
	N	63	65	37	20	185
	Standard error	22,115,634	10,163,115	16,879,221	8,460,102	32,911,699
Walk	Population estimate	62,267,114	57,034,249	48,412,872	45,030,626	212,744,861
	N	120	106	67	50	343
	Standard error	16,856,776	23,997,844	14,102,296	17,701,040	41,256,346
Other	Population estimate	0	0	38,040,968	1,429,754	39,470,722
	N	0	0	1	1	2
	Standard error	0	0	54,344	57,190	78,892
Unknown	Population estimate	19,537,751	47,479,627	6,482,623	108,906,297	182,406,298
	N	103	81	50	44	278
	Standard error	16,233,135	13,465,320	5,988,193	8,410,821	26,148,341
Total	Population estimate	15,639,717,419	6,966,645,286	4,707,190,487	7,307,904,915	34,621,458,107
	N	2,794	1,442	833	1,300	6,369
	Standard error	121,158,850	83,231,843	62,056,103	84,629,599	209,281,574

Note: N = actual number of persons who reported.

ANNEX 2-2 TABLE 1 Child Deaths in FARS by Year (1991–1999)

Year	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1991	5,748	11.2	5,748	11.2
1992	5,397	10.5	11,145	21.7
1993	5,506	10.7	16,651	32.4
1994	5,772	11.2	22,423	43.7
1995	5,860	11.4	28,283	55.1
1996	5,847	11.4	34,130	66.5
1997	5,849	11.4	39,979	77.9
1998	5,690	11.1	45,669	88.9
1999	5,681	11.1	51,350	100.0

ANNEX 2-2 TABLE 2 Child Fatality Categories and Counts (1991–1999)

Category	Description	N
1	Child school bus passenger fatality[a] in a school bus–related crash	55
2	Child pedestrian fatality in a school bus–related crash	160
3	Child passenger fatality in all other vehicles driven by an adult	12,952
4	16- to 18-year-old driver fatality, all other vehicles	16,894
5	Child passenger fatality in all other vehicles driven by a 16- to 18-year-old	10,586
6	Child passenger fatality (not a motor vehicle crash) (not available in FARS)	–
7	Child pedestrian fatality, not school bus–related	6,026
8	Child bicyclist fatality (not a motor vehicle crash) (not available in FARS)	–
9	Child bicyclist fatality in a school bus–related crash	14
10	Child bicyclist fatality not in a school bus–related crash	2,706
11	16- to 18-year-old driver fatality, other buses	1
12	Child passenger fatality in other buses	32
13	Child passenger fatality on motorcycle operated by an adult	181
14	16- to 18-year-old driver (operator) fatality, motorcycle	1,126
15	Child passenger fatality on motorcycle operated by a 16- to 18-year-old	111
Total		**50,844**

[a] This category includes any child riding in a vehicle being used as a school bus.

ANNEX 2-2 TABLE 3 Total Child Fatalities by Fatality Group and Population (N = 50,844)

		Population					
		Rural		Urban		Total	
Category	Description	N	%	N	%	N	%
1	Child school bus passenger fatality in a school bus–related crash	30	0.1	25	0.1	55	0.1
2	Child pedestrian fatality in a school bus–related crash	69	0.2	91	0.5	160	0.3
3	Child passenger fatality in all other vehicles driven by an adult	8,784	27.1	4,168	22.6	12,952	25.5
4	Child driver fatality, all other vehicles	12,193	37.6	4,701	25.5	16,894	33.2
5	Child passenger fatality in all other vehicles driven by a child	7,141	22.0	3,445	18.7	10,586	20.8
7	Child pedestrian fatality, not school bus–related	2,169	6.7	3,857	20.9	6,026	11.9
9	Child bicyclist fatality in a school bus–related crash	4	0.0	10	0.1	14	0.0
10	Child bicyclist fatality not in a school bus–related crash	1,228	3.8	1,478	8.0	2,706	5.3
11	Child driver fatality, other buses	0	0	1	0.0	1	0.0
12	Child passenger fatality in other buses	20	0.1	12	0.1	32	0.1
13	Child passenger fatality on motorcycle operated by an adult	91	0.3	90	0.5	181	0.4
14	Child driver (operator) fatality, motorcycle	627	1.9	499	2.7	1,126	2.2
15	Child passenger fatality on motorcycle operated by a child	62	0.2	49	0.3	111	0.2
Total		**32,418**	**100.0**	**18,426**	**100.0**	**50,844**	**100.0**

ANNEX 2-2 TABLE 4 Total Child Fatalities by Fatality Group and Age Group (N = 50,844)

		Age Group (years)									
		5–10		11–13		14–15		16–18		Total	
Category	Description	N	%	N	%	N	%	N	%	N	%
1	Child school bus passenger fatality in a school bus–related crash	19	0.2	15	0.3	12	0.2	9	0.0	55	0.1
2	Child pedestrian fatality in a school bus–related crash	121	1.4	23	0.5	12	0.2	4	0.0	160	0.3
3	Child passenger fatality in all other vehicles driven by an adult	4,482	51.4	1,922	39.3	1,735	23.7	4,813	16.1	12,952	25.5
4	Child driver fatality, all other vehicles	69	0.8	233	4.8	1,123	15.4	15,469	51.7	16,894	33.2
5	Child passenger fatality in all other vehicles driven by a child	323	3.7	744	15.2	2,814	38.5	6,705	22.4	10,586	20.8
7	Child pedestrian fatality, not school bus–related	2,577	29.6	1,039	21.3	901	12.3	1,509	5.0	6,026	11.9
9	Child bicyclist fatality in a school bus–related crash	6	0.1	5	0.1	0	0	3	0.0	14	0.0
10	Child bicyclist fatality not in a school bus–related crash	1,065	12.2	789	16.1	452	6.2	400	1.3	2,706	5.3
11	Child driver fatality, other buses	0	0	0	0	0	0	1	0.0	1	0.0
12	Child passenger fatality in other buses	6	0.1	10	0.2	8	0.1	8	0.0	32	0.1
13	Child passenger fatality on motorcycle operated by an adult	23	0.3	17	0.3	22	0.3	119	0.4	181	0.4
14	Child driver (operator) fatality, motorcycle	16	0.2	74	1.5	197	2.7	839	2.8	1,126	2.2
15	Child passenger fatality on motorcycle operated by a child	6	0.1	16	0.3	35	0.5	54	0.2	111	0.2
Total		**8,713**	**100.0**	**4,887**	**100.0**	**7,311**	**100.0**	**29,933**	**100.0**	**50,844**	**100.0**

ANNEX 2-2 TABLE 5 Total Child Fatalities by Fatality Group and Age (N = 50,844)

		Age (years)														
Category	**Description**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Total**
1	Child school bus passenger fatality in a school bus–related crash	1	0	4	5	9	0	1	4	10	4	8	6	2	1	55
2	Child pedestrian fatality in a school bus–related crash	41	30	19	19	7	5	10	5	8	7	5	1	1	2	160
3	Child passenger fatality in all other vehicles driven by an adult	860	747	786	759	682	648	610	646	666	811	924	1,172	1,517	2,124	12,952
4	Child driver fatality, all other vehicles	1	2	7	10	21	28	36	66	131	323	800	4,216	5,021	6,232	16,894
5	Child passenger fatality in all other vehicles driven by a child	43	46	35	55	70	74	112	210	422	969	1,845	2,515	2,350	1,840	10,586
7	Child pedestrian fatality, not school bus–related	518	489	467	407	358	338	317	345	377	439	462	476	461	572	6,026

(*continued*)

ANNEX 2-2 TABLE 5 (continued) **Total Child Fatalities by Fatality Group and Age (N = 50,844)**

		Age (years)														
Category	**Description**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Total**
9	Child bicyclist fatality in a school bus–related crash	1	1	0	2	2	0	2	2	1	0	0	1	1	1	14
10	Child bicyclist fatality not in a school bus–related crash	110	137	195	204	197	222	273	237	279	253	199	160	133	107	2,706
11	Child driver fatality, other buses	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
12	Child passenger fatality in other buses	0	0	1	1	4	0	4	3	3	2	6	5	2	1	32
13	Child passenger fatality on motorcycle operated by an adult	2	3	3	2	7	6	3	6	8	10	12	32	39	48	181
14	Child driver (operator) fatality, motorcycle	0	0	4	1	1	10	10	26	38	79	118	118	244	477	1,126
15	Child passenger fatality on motorcycle operated by a child	0	1	0	2	1	2	1	4	11	17	18	21	12	21	111
Total		**1,577**	**1,456**	**1,521**	**1,467**	**1,359**	**1,333**	**1,379**	**1,554**	**1,954**	**2,914**	**4,397**	**8,723**	**9,783**	**11,427**	**50,844**

ANNEX 2-2 TABLE 6 Child Fatalities During Normal School Travel Hours by Fatality Category and Population (N = 7,470)

		Population					
		Rural		Urban		Total	
Category	Description	N	%	N	%	N	%
1	Child school bus passenger fatality in a school bus–related crash	23	0.5	18	0.7	41	0.5
2	Child pedestrian fatality in a school bus–related crash	64	1.3	72	2.7	136	1.8
3	Child passenger fatality in all other vehicles driven by an adult	1,057	22.1	460	17.1	1,517	20.3
4	Child driver fatality, all other vehicles	1,927	40.3	618	23.0	2,545	34.1
5	Child passenger fatality in all other vehicles driven by a child	1,046	21.9	437	16.3	1,483	19.9
7	Child pedestrian fatality, not school bus–related	403	8.4	774	28.8	1,177	15.8
9	Child bicyclist fatality in a school bus–related crash	3	0.1	9	0.3	12	0.2
10	Child bicyclist fatality not in a school bus–related crash	172	3.6	230	8.6	402	5.4
12	Child passenger fatality in other buses	4	0.1	1	0.0	5	0.1
13	Child passenger fatality on motorcycle operated by an adult	2	0.0	5	0.2	7	0.1
14	Child driver (operator) fatality, motorcycle	77	1.6	58	2.2	135	1.8
15	Child passenger fatality on motorcycle operated by a child	7	0.1	3	0.1	10	0.1
Total		**4,785**	**100.0**	**2,685**	**100.0**	**7,470**	**100.0**

ANNEX 2-2 TABLE 7 Child Fatalities During Normal School Travel Hours by Fatality Category and Age Group (N = 7,470)

		Age Group (years)									
		5–10		11–13		14–15		16–18		Total	
Category	**Description**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
1	Child school bus passenger fatality in a school bus–related crash	15	0.9	12	1.5	10	10	4	0.1	41	0.5
2	Child pedestrian fatality in a school bus–related crash	105	6.1	19	2.3	9	0.9	3	0.1	136	1.8
3	Child passenger fatality in all other vehicles driven by an adult	747	43.2	238	28.8	161	15.7	371	9.5	1,517	20.3
4	Child driver fatality, all other vehicles	3	0.2	22	2.7	139	13.6	2,381	61.2	2,545	34.1
5	Child passenger fatality in all other vehicles driven by a child	61	3.5	119	14.4	459	44.8	844	21.7	1,483	19.9
7	Child pedestrian fatality, not school bus–related	623	36.0	264	32.0	158	15.4	132	3.4	1,177	15.8
9	Child bicyclist fatality in a school bus–related crash	5	0.3	5	0.6	0	0	2	0.1	12	0.2
10	Child bicyclist fatality not in a school bus–related crash	165	9.5	139	16.8	50	4.9	48	1.2	402	5.4
12	Child passenger fatality in other buses	1	0.1	2	0.2	1	0.1	1	0.0	5	0.1
13	Child passenger fatality on motorcycle operated by an adult	0	0	0	0	1	0.1	6	0.2	7	0.1
14	Child driver (operator) fatality, motorcycle	3	0.2	5	0.6	36	3.5	91	2.3	135	1.8
15	Child passenger fatality on motorcycle operated by a child	1	0.1	1	0.1	1	0.1	7	0.2	10	0.1
Total		**1,729**	**100.0**	**826**	**100.0**	**1,025**	**100.0**	**3,890**	**100.0**	**7,470**	**100.0**

ANNEX 2-2 TABLE 8 Child Fatalities During Normal School Travel Hours by Fatality Category and Age (N = 7,470)

Category	Description	Age (years)														
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
1	Child school bus passenger fatality in a school bus–related crash	0	0	3	5	7	0	1	4	7	3	7	3	0	1	41
2	Child pedestrian fatality in a school bus–related crash	35	25	17	16	7	5	9	4	6	6	3	0	1	2	136
3	Child passenger fatality in all other vehicles driven by an adult	170	136	126	128	87	100	81	78	79	80	81	90	113	168	1,517
4	Child driver fatality, all other vehicles	0	0	0	0	2	1	2	9	11	36	103	793	766	822	2,545
5	Child passenger fatality in all other vehicles driven by a child	10	11	4	9	17	10	19	36	64	168	291	357	311	176	1,483
7	Child pedestrian fatality, not school bus–related	88	128	113	91	99	104	92	101	71	91	67	55	49	28	1,177

(*continued*)

ANNEX 2-2 TABLE 8 (continued) **Child Fatalities During Normal School Travel Hours by Fatality Category and Age (N = 7,470)**

Category	Description	Age (years)														
		5	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Total**
9	Child bicyclist fatality in a school bus–related crash	1	1	0	1	2	0	2	2	1	0	0	1	0	1	12
10	Child bicyclist fatality not in a school bus–related crash	13	23	30	31	27	41	51	45	43	24	26	15	20	13	402
12	Child passenger fatality in other buses	0	0	1	0	0	0	1	1	0	0	1	1	0	0	5
13	Child passenger fatality on motorcycle operated by an adult	0	0	0	0	0	0	0	0	0	0	1	0	3	3	7
14	Child driver (operator) fatality, motorcycle	0	0	1	1	0	1	0	1	4	11	25	15	29	47	135
15	Child passenger fatality on motorcycle operated by a child	0	1	0	0	0	0	0	1	0	1	0	3	2	2	10
Total		**317**	**325**	**295**	**282**	**248**	**262**	**258**	**282**	**286**	**420**	**605**	**1,333**	**1,294**	**1,263**	**7,470**

ANNEX 2-2 TABLE 9 Child Fatalities During Non–School Travel Hours by Fatality Category and Population (N = 43,374)

		Population					
		Rural		Urban		Total	
Category	Description	N	%	N	%	N	%
1	Child school bus passenger fatality in a school bus–related crash	7	0.0	7	0.0	14	0.0
2	Child pedestrian fatality in a school bus–related crash	5	0.0	19	0.1	24	0.1
3	Child passenger fatality in all other vehicles driven by an adult	7,727	28.0	3,708	23.6	11,435	26.4
4	Child driver fatality, all other vehicles	10,266	37.2	4,083	25.9	14,349	33.1
5	Child passenger fatality in all other vehicles driven by a child	6,095	22.1	3,008	19.1	9,103	21.0
7	Child pedestrian fatality, not school bus–related	1,766	6.4	3,083	19.6	4,849	11.2
9	Child bicyclist fatality in a school bus–related crash	1	0.0	1	0.0	2	0.0
10	Child bicyclist fatality not in a school bus–related crash	1,056	3.8	1,248	7.9	2,304	5.3
11	Child driver fatality, other buses	0	0	1	0.0	1	0.0
12	Child passenger fatality in other buses	16	0.1	11	0.1	27	0.1
13	Child passenger fatality on motorcycle operated by an adult	89	0.3	85	0.5	174	0.4
14	Child driver (operator) fatality, motorcycle	550	2.0	441	2.8	991	2.3
15	Child passenger fatality on motorcycle operated by a child	55	0.2	46	0.3	101	0.2
Total		**27,633**	**100.0**	**15,741**	**100.0**	**43,374**	**100.0**

ANNEX 2-2 TABLE 10 Child Fatalities During Non–School Travel Hours by Fatality Category and Age Group (N = 43,374)

		Age Group (years)									
		5–10		11–13		14–15		16–18		Total	
Category	Description	N	%	N	%	N	%	N	%	N	%
1	Child school bus passenger fatality in a school bus–related crash	4	0.1	3	0.1	2	0.0	5	0.0	14	0.0
2	Child pedestrian fatality in a school bus–related crash	16	0.2	4	0.1	3	0.0	1	0.0	24	0.1
3	Child passenger fatality in all other vehicles driven by an adult	3,735	53.5	1,684	41.5	1,574	25.0	4,442	17.1	11,435	26.4
4	Child driver fatality, all other vehicles	66	0.9	211	5.2	984	15.7	13,088	50.3	14,349	33.1
5	Child passenger fatality in all other vehicles driven by a child	262	3.8	625	15.4	2,355	37.5	5,861	22.5	9,103	21.0
7	Child pedestrian fatality, not school bus–related	1,954	28.0	775	19.1	743	11.8	1,377	5.3	4,849	11.2
9	Child bicyclist fatality in a school bus–related crash	1	0.0	–	–	–	–	1	0.0	2	0.0
10	Child bicyclist fatality not in a school bus–related crash	900	12.9	650	16.0	402	6.4	352	1.4	2,304	5.3
11	Child driver fatality, other buses	–	–	–	–	–	–	1	0.0	1	0.0
12	Child passenger fatality in other buses	5	0.1	8	0.2	7	0.1	7	0.0	27	0.1
13	Child passenger fatality on motorcycle operated by an adult	23	0.3	17	0.4	21	0.3	113	0.4	174	0.4
14	Child driver (operator) fatality, motorcycle	13	0.2	69	1.7	161	2.6	748	2.9	991	2.3
15	Child passenger fatality on motorcycle operated by a child	5	0.1	15	0.4	34	0.5	47	0.2	101	0.2
Total		**6,984**	**100.0**	**4,061**	**100.0**	**6,286**	**100.0**	**26,043**	**100.0**	**43,374**	**100.0**

ANNEX 2-2 TABLE 11 Child Fatalities During Non–School Travel Hours by Fatality Category and Age (N = 43,374)

		Age (years)														
Category	Description	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
1	Child school bus passenger fatality in a school bus–related crash	1	0	1	0	2	0	0	0	3	1	1	3	2	0	14
2	Child pedestrian fatality in a school bus–related crash	6	5	2	3	0	0	1	1	2	1	2	1	0	0	24
3	Child passenger fatality in all other vehicles driven by an adult	690	611	660	631	595	548	529	568	587	731	843	1,082	1,404	1,956	11,435
4	Child driver fatality, all other vehicles	1	2	7	10	19	27	34	57	120	287	697	3,423	4,255	5,410	14,349
5	Child passenger fatality in all other vehicles driven by a child	33	35	31	46	53	64	93	174	358	801	1,554	2,158	2,039	1,664	9,103
7	Child pedestrian fatality, not school bus–related	430	361	354	316	259	234	225	244	306	348	395	421	412	544	4,849

(*continued*)

ANNEX 2-2 TABLE 11 (continued) **Child Fatalities During Non–School Travel Hours by Fatality Category and Age (N = 43,374)**

Category	Description	Age (years) 5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
9	Child bicyclist fatality in a school bus–related crash	0	0	0	1	0	0	0	0	0	0	0	0	1	0	2
10	Child bicyclist fatality not in a school bus–related crash	97	114	165	173	170	181	222	192	236	229	173	145	113	94	2,304
11	Child driver fatality, other buses	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
12	Child passenger fatality in other buses	0	0	0	1	4	0	3	2	3	2	5	4	2	1	27
13	Child passenger fatality on motorcycle operated by an adult	2	3	3	2	7	6	3	6	8	10	11	32	36	45	174
14	Child driver (operator) fatality, motorcycle	0	0	3	0	1	9	10	25	34	68	93	103	215	430	991
15	Child passenger fatality on motorcycle operated by a child	0	0	0	2	1	2	1	3	11	16	18	18	10	19	101
Total		**1,260**	**1,131**	**1,226**	**1,185**	**1,111**	**1,071**	**1,121**	**1,272**	**1,668**	**2,494**	**3,792**	**7,390**	**8,489**	**10,164**	**43,374**

ANNEX 2-2 TABLE 12 Child Fatalities During School Session Hours by Fatality Category and Population (N = 2,719)

		Population					
		Rural		Urban		Total	
Category	Description	N	%	N	%	N	%
1	Child school bus passenger fatality in a school bus–related crash	1	0.1	5	0.5	6	0.2
2	Child pedestrian fatality in a school bus–related crash	2	0.1	14	1.4	16	0.6
3	Child passenger fatality in all other vehicles driven by an adult	484	28.0	176	17.8	660	24.3
4	Child driver fatality, all other vehicles	723	41.8	344	34.8	1,067	39.2
5	Child passenger fatality in all other vehicles driven by a child	372	21.5	219	22.2	591	21.7
7	Child pedestrian fatality, not school bus–related	66	3.8	122	12.3	188	6.9
10	Child bicyclist fatality not in a school bus–related crash	49	2.8	67	6.8	116	4.3
12	Child passenger fatality in other buses	1	0.1	1	0.1	2	0.1
13	Child passenger fatality on motorcycle operated by an adult	1	0.1	4	0.4	5	0.2
14	Child driver (operator) fatality, motorcycle	28	1.6	32	3.2	60	2.2
15	Child passenger fatality on motorcycle operated by a child	4	0.2	4	0.4	8	0.3
Total		**1,731**	**100.0**	**988**	**100.0**	**2,719**	**100.0**

ANNEX 2-2 TABLE 13 Child Fatalities During School Session Hours by Fatality Category and Age Group (N = 2,719)

		Age Group (years)									
		5–10		11–13		14–15		16–18		Total	
Category	**Description**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
1	Child school bus passenger fatality in a school bus–related crash	3	0.7	1	0.5	1	0.3	1	0.1	6	0.2
2	Child pedestrian fatality in a school bus–related crash	12	2.6	2	0.9	1	0.3	1	0.1	16	0.6
3	Child passenger fatality in all other vehicles driven by an adult	265	57.9	110	49.5	94	24.5	191	11.5	660	24.3
4	Child driver fatality, all other vehicles	3	0.7	14	6.3	79	20.6	971	58.7	1,067	39.2
5	Child passenger fatality in all other vehicles driven by a child	23	5.0	33	14.9	159	41.4	376	22.7	591	21.7
7	Child pedestrian fatality, not school bus–related	98	21.4	30	13.5	23	6.0	37	2.2	188	6.9
10	Child bicyclist fatality not in a school bus–related crash	53	11.6	26	11.7	15	3.9	22	1.3	116	4.3
12	Child passenger fatality in other buses	0	0.0	0	0.0	0	0.0	2	0.1	2	0.1
13	Child passenger fatality on motorcycle operated by an adult	0	0	1	0.5	1	0.3	3	0.2	5	0.2
14	Child driver (operator) fatality, motorcycle	0	0	3	1.4	8	2.1	49	3.0	60	2.2
15	Child passenger fatality on motorcycle operated by a child	1	0.2	2	0.9	3	0.8	2	0.1	8	0.3
Total		**458**	**100.0**	**222**	**100.0**	**384**	**100.0**	**1,655**	**100.0**	**2,719**	**100.0**

ANNEX 2-2 TABLE 14 Child Fatalities During School Session Hours by Fatality Category and Age (N = 2,719)

Category	Description	Age (years)														
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
1	Child school bus passenger fatality in a school bus–related crash	0	0	1	0	2	0	0	0	1	0	1	0	1	0	6
2	Child pedestrian fatality in a school bus–related crash	6	3	1	2	0	0	0	1	1	1	0	1	0	0	16
3	Child passenger fatality in all other vehicles driven by an adult	62	46	41	45	38	33	28	38	44	39	55	45	63	83	660
4	Child driver fatality, all other vehicles	0	0	0	0	1	2	0	4	10	19	60	221	295	455	1,067
5	Child passenger fatality in all other vehicles driven by a child	4	6	2	3	4	4	5	7	21	54	105	145	141	90	591
7	Child pedestrian fatality, not school bus–related	28	25	17	11	12	5	15	1	14	10	13	10	14	13	188

(*continued*)

ANNEX 2-2 TABLE 14 (continued) **Child Fatalities During School Session Hours by Fatality Category and Age (N = 2,719)**

		Age (years)														
Category	**Description**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Total**
10	Child bicyclist fatality not in a school bus–related crash	5	8	13	5	9	13	8	9	9	6	9	8	7	7	116
12	Child passenger fatality in other buses	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
13	Child passenger fatality on motorcycle operated by an adult	0	0	0	0	0	0	0	0	1	1	0	0	1	2	5
14	Child driver (operator) fatality, motorcycle	0	0	0	0	0	0	0	0	3	4	4	7	17	25	60
15	Child passenger fatality on motorcycle operated by a child	0	0	0	0	0	1	1	0	1	2	1	0	1	1	8
Total		**105**	**88**	**75**	**66**	**66**	**58**	**57**	**60**	**105**	**136**	**248**	**437**	**541**	**677**	**2,719**

3 Analysis of Risk Measures

A relative risk comparison across the various school travel modes is provided in this chapter on the basis of national data. The committee was unable to collect sufficient data at either the local or statewide level that would have permitted similar comparisons and believes that only the national datasets described in Chapter 2 are sufficiently complete for conducting a statistical risk comparison.

Four risk measures (hazard rates) were studied: deaths/100 million student-miles, deaths/100 million trips, injuries/100 million student-miles, and injuries/100 million trips. To determine these hazard rates, ratios of values were calculated (outcome measure/exposure measure). The outcome measures were extracted from the FARS and GES databases; the exposure measures were based on values from the NPTS database.

In all cases, data were selected on the basis of normal school travel hours as defined in Chapter 1. Ideally, the committee would have liked to identify only those trips whose purpose was transporting children to and from school; however, because different databases use different criteria for recording trip purpose, it was not possible to determine accurately which trips were to or from school per se. Therefore, the committee used a time-of-day filter. As described earlier, this meant that only events (i.e., trips, injuries, and fatalities) occurring during the nominal school year (September through June) on weekdays between 6:00 a.m. and 8:59 a.m. and between 2:00 p.m. and 4:59 p.m. were included in the calculations. This assumption means that events not directly related to school travel (e.g., after-school trips to part-time jobs, the library, or a shopping center) that occurred during these hours are included in the analyses, and school-related events outside the defined times are excluded. The committee believes that these anomalies do not significantly detract from the analyses for two reasons: (*a*) the majority of trips taken by the target age groups during these times would be school-related, and (*b*) the accident rates for the non-school-related trips would not be very different from those for the actual trips to and from school (e.g., similar lighting and driving conditions).

Hazard rates were calculated for different subgroups of the student population depending on the quantity and quality of the data. Subgroup categories studied were male/female, urban/rural, a.m./p.m., and four groupings of ages (5–10, 11–13, 14–15, and 16–18). Finer (more detailed) categories are not supported by the data. For example, it would have been useful to calculate deaths/trip for rural, 17-year-old, female drivers and compare the results for this group and similar urban drivers. However, the rarity of some of the events of interest (the relatively low frequencies of severe injuries and deaths for particular travel modes in a given year during normal school travel times) and the variability of the sampled data did not allow for meaningful comparisons at this level.

Some of these data problems were handled by organizing the data into age groupings instead of considering single-year ages, by averaging across multiple years (e.g., 1991–1999), and by combining outcome categories (e.g., summing the three injury levels into one category). Doing so allowed the committee to smooth out data anomalies (e.g., unusually safe or dangerous years[1]) and derive more robust estimates of the average risks. Even with this collapsing of categories and averaging, however, some modes could not be included reliably. For example, even though motorcycles were responsible for seven student deaths in urban areas during normal school travel hours during 1991–1999, the 1995 NPTS data, which are based on a relatively small sample of surveys, show no corresponding motorcycle trips. For this reason, motorcycles were excluded from further analysis.

Further, because the GES and NPTS datasets are constructed from sample data, there is uncertainty about how closely the given values match the actual, but unknown, values. Uncertainties of the underlying GES and NPTS values are determined by the data-collecting agencies on the basis of the sampling techniques used. On the other hand, because FARS data are not a sample but a complete count of fatalities, there is no uncertainty in these values. Year-to-year variability was not modeled. Moreover, because the risk measures are hazard rates (ratios of GES and NPTS data and ratios of FARS and NPTS data), there is uncertainty in these estimates as well. The uncertainties in the ratios were calculated using standard simulation methods,[2] through which estimates of the average were derived by means of statistical sampling. Throughout this report, 90 percent confidence intervals are used to display the uncertainty of the risk estimates.

DATA CATEGORIES

In addition to the date and time definitions noted earlier that were used to capture events during normal school travel hours, data from the GES and FARS databases were sorted into 15 school travel categories. These categories, listed in Table 3-1, capture not only the travel mode involved in an accident, but also information about the driver's age. Because the data for fatalities and injuries were obtained from the FARS and GES datasets, they include only accidents involving motor vehicles. This means that injuries and fatalities sustained in walking and bicycling accidents not involving motor vehicles (e.g., solo bicycle or pedestrian accidents, bicycle–pedestrian accidents, bicycle–bicycle accidents)

[1] For example, a single accident involving two school buses transporting high school students accounted for 51 of 57 level A injuries among those aged 16–18 during the 9 years of data studied.
[2] The distributions of the numerator and denominator were sampled 10,000 times using Palisade Corporation's @Risk, an add-on to Microsoft Excel. The result was 10,000 estimates of the hazard rate that were used to determine the average values and the confidence bounds.

TABLE 3-1 Student Fatalities and Injuries by Travel Category Over a 9-Year Period (1991–1999) from the FARS and GES Databases

			Injuries			
Category	**Description**	**Fatalities**	**A**	**B**	**C**	**Total**
1	Child school bus passenger in a school bus–related crash	41	7,635	10,745	31,986	50,366
2	Child pedestrian in a school bus–related crash	136	1,248	1,459	1,156	3,863
3	Child passenger in passenger vehicles driven by an adult	1,517	43,322	118,671	297,176	459,168
4	Teen driver, passenger vehicles	2,545	57,055	144,371	264,139	465,564
5	Child passenger in passenger vehicles driven by a teen	1,483	29,543	73,402	135,373	238,318
6	Child pedestrian (not in a motor vehicle crash)	–	–	–	–	–
7	Child pedestrian, not school bus–related	1,177	17,428	34,921	26,791	79,140
8	Child bicyclist (not in a motor vehicle crash)	–	–	–	–	–
9	Child bicyclist in a school bus–related crash	12	146	486	47	679
10	Child bicyclist not in a school bus–related crash	402	9,820	39,026	20,127	68,974
11	Teen driver, other buses	–	–	–	122	122
12	Child passenger in other buses	5	412	1,407	3,096	4,915
13	Child passenger on motorcycle operated by an adult	7	80	502	–	582
14	Teen driver (operator), motorcycle	135	2,722	3,569	761	7,052
15	Child passenger on motorcycle operated by a child	10	–	–	–	–
Total		**7,470**	**169,411**	**428,559**	**780,773**	**1,378,743**

Note: Data shown are for normal school travel hours as defined in Chapter 1.

are not included; thus, categories 6 and 8 in Table 3-1 have no entries. Accurate counts of injuries/fatalities from these non–motor vehicle accidents were not available from other sources at the level of specificity needed for this study. Exclusion of these values results in underestimation of the risk for these two modes.

To determine the hazard rates for the different modes, the 15 categories shown in Table 3-1 were consolidated into 6, representing broad modes of travel. For example, categories 1 and 2 were combined to form a "school bus" category. The committee posited that pedestrians hurt or killed in school bus–related accidents were most likely using the school bus to get to and from school; that is, if they had not been using the school bus, they would not have been hurt. Similarly, categories 9 and 10 were combined into a "bicycling" category. In contrast with the pedestrian case, however, the committee reasoned that bicyclists injured or killed by school buses were not using the bus to get to and from school; that is, their primary mode was bicycling. Combining the categories in this manner means the school bus category will include "pedestrian" injuries and fatalities not included in the other categories, although conceivably pedestrian deaths are "directly" associated with every category except walking. For example, a student running to get into a friend's car could be injured or killed by a passing car; a student getting off a transit bus could walk in front of the bus and be run over; or a student who rode her bicycle to school could be injured while walking from the bicycle rack by a parent pulling away from the curb. Because neither the FARS nor GES databases contain this type of information, none of these incidents can be associated with their respective modes.[3] Nevertheless, the committee believed it appropriate to include school bus–related pedestrian injuries and fatalities under the school bus category for this study. The significant findings of this report are not affected by this limited consolidation.

Separate categories were maintained for two passenger vehicle driver age groups [adult (age 19 and older) and teen (younger than age 19)] when the number of fatalities and injuries permitted doing so. For example, the two driver-age categories were used for passenger vehicles, but only one category was used for fatalities and injuries involving other buses. Table 3-2 shows the final 6 categories and indicates how they map to the original 15 categories.

DATA ADJUSTMENTS

Each of the three primary datasets (GES, FARS, and NPTS) required adjustments to the raw data so the values could be integrated and the relevant hazard rates computed.

Age Cohort Calculation

Because multiyear age groupings had been created for all three datasets, the values for each age group had to be divided by the number of years in that group

[3] Readers trying to draw detailed conclusions beyond those stated in the report will want to keep this in mind when interpreting the data categories, especially when comparing risks between school bus and other bus categories.

TABLE 3-2 Creation of New Categories from Multiple Original Categories

New Category	Original Categories
School bus	1, 2
Passenger vehicle (adult driver)	3
Passenger vehicle (teen driver)	4, 5
Walking	6, 7
Bicycling	8, 9, 10
Other bus	11, 12

to calculate the expected number of fatalities (or injuries, trips, or miles traveled) per single-age cohort. The four age groupings were selected to reflect the three types of schools that children generally attend (those 5–10 years old attend elementary schools, those 11–13 attend middle/junior high schools, and those 14–15 and 16–18 attend high schools) and to differentiate between driving-age and non-driving-age high school students (separating those aged 14–15 from those 16–18). The committee assumed that members of each age group would have relatively homogeneous risk profiles (i.e., similar exposure and outcome measures). For example, among children attending elementary school, the average number and length of school bus trips per year for 5-year-olds would be similar to those of 6-, 7-, 8-, 9-, and 10-year-olds. Though the risks vary within each age group, the committee believes travel patterns (and risks) are strongly tied to the type of school attended (e.g., travel distances to elementary schools are generally shorter).

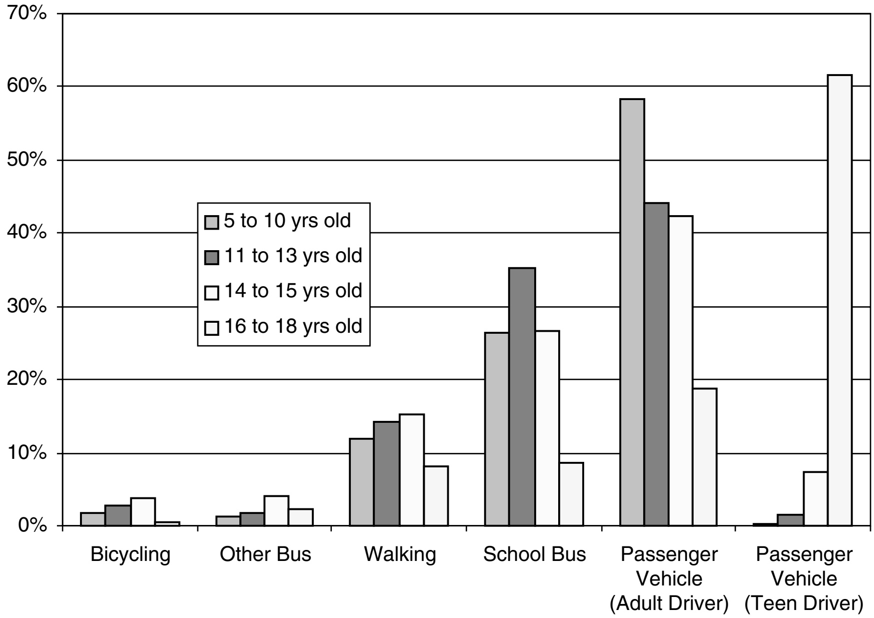
Figure 3-1 shows how the use of the various school travel modes differs by age group. Among those aged 11–13, 35 percent take a school bus, but among those aged 16–18, only 8 percent do so. Parents driving children to school declines steadily across the age groups. And teen drivers account for more than 60 percent of the trips for the oldest age group.

Multiyear Summation Adjustment

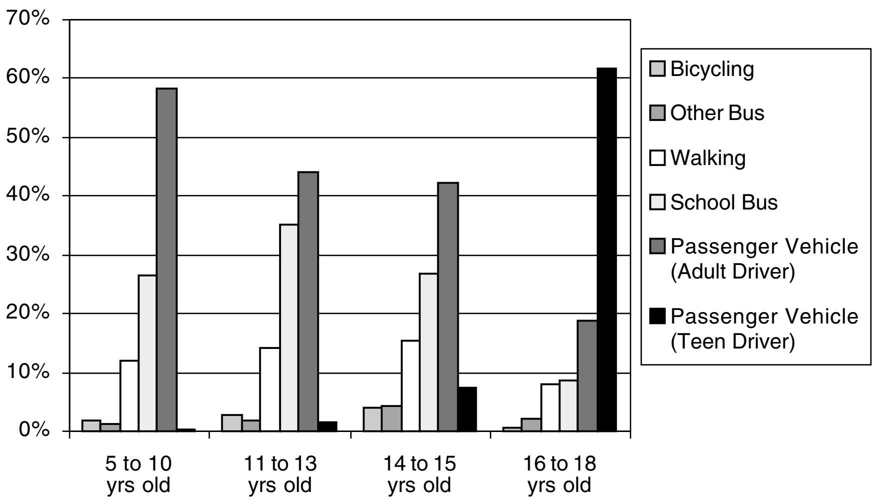
Because of the relative rarity of events for some of the modes examined and the need to smooth out the effects of some anomalies, the committee used 9 years of data to compute the fatality and injury counts from the FARS and GES datasets. To determine the average number of injuries and fatalities per year, the total values were divided by 9. As noted, the committee did not collect or analyze year-to-year variations for these two datasets; it was assumed that the averages captured the best estimates of the underlying values.

Adjustment for Missing or Unknown Data

All three datasets report missing or incomplete data using "other" and "unknown" categories. The "other" category represents only a very small percentage of the data (less than 0.05 percent) and was not included in this analysis. The



(a)



(b)

FIGURE 3-1 Percentage of trips during normal school travel hours: (a) age categories shown across travel modes and (b) travel modes shown across age categories.

"unknown" category is far more significant. Unknown values were found for two critical portions of the NPTS data: mode of travel and age of driver. To adjust for these missing values, which could account for more than 10 percent of the total counts in some cases, counts in the "unknown" category were distributed across the other categories in proportion to the recorded values.

RISK MEASURES

Table 3-3 shows a summary of the data from the three national databases (i.e., FARS, GES, and NPTS) and the risk measures for the six school travel modes [i.e., school bus, other bus, passenger vehicles (two categories based on age of driver), bicycling, and walking]. The GES and FARS data are the averages for the years 1991–1999, and the NPTS data are for 1995.

The six modes vary considerably in both number of trips and number of miles per year. Passenger vehicles with adult drivers (19 years of age and older) make up 45 percent of the trips and 51 percent of the miles logged by students during normal school travel hours. Next are school buses with approximately 25 percent of trips and miles, and then passenger vehicles with teen drivers (younger than 19 years of age), which account for approximately 15 percent of the trips and miles. Walking makes up 12 percent of the trips but only 1 percent of the miles traveled (i.e., students who walk do not walk very far). Other buses and bicycling each make up about 2 percent of the trips, but bicycling represents relatively fewer miles because of the shorter distances traveled per trip. These data form the denominator values (i.e., exposure measure) in the hazard rate calculations. It should be remembered that these values are estimates based on a sample and are therefore uncertain. The impact of this uncertainty is discussed later.

The distributions of injuries and fatalities (outcome measures) across travel modes are very different. School buses, which make up 25 percent of the exposure measures, account for less than 4 percent of the injuries and 2 percent of the fatalities. Likewise, passenger vehicles with teen drivers account for more than half of the injuries and fatalities, a much greater percentage than the 15 percent suggested by the exposure measures. This divergence can best be seen in the percentage comparisons shown in Figure 3-2.[4] Three modes (school buses, other buses, and passenger vehicles with adult drivers) have injury and fatality counts below those expected from their exposure values (percentages for their outcome measures are lower than percentages for their exposure measures). Likewise, three modes (bicycling, walking, and passenger vehicles with teen drivers) have injury and fatality counts much higher than those expected from their exposure values (percentages for their outcome measures are greater percentages for their exposure measures). These relationships lead to the different hazard rates shown in Table 3-3.

When hazard rates are based on trip counts, passenger vehicles with teen drivers have the highest risk; when the rates are based on miles driven, however, bicycling and walking have the highest values. The difference is due to the

[4] A graph based on number of trips instead of student-miles traveled highlights the same differences.

TABLE 3-3 Summary of Student Injury and Fatality Data per Year

			Injuries			Fatalities		
	100 Million Trips (%)	100 Million Miles (%)	Count (%)	Per 100 Million Trips	Per 100 Million Miles	Count (%)	Per 100 Million Trips	Per 100 Million Miles
School bus	58 (25)	313 (28)	6,000 (4)	100	20	20 (2)	0.3	0.1
Other bus	5 (2)	38 (3)	550 (<1)	120	20	1 (<1)	0.1	<.1
Passenger vehicle (teen driver)	34 (14)	184 (16)	78,200 (51)	2,300	430	448 (54)	13.2	2.4
Passenger vehicle (adult driver)	105 (45)	580 (51)	51,000 (33)	490	90	169 (20)	1.6	0.3
Bicycling	5 (2)	4 (<1)	7,700 (5)	1,610	2,050	46 (6)	9.6	12.2
Walking	28 (12)	15 (1)	8,800 (6)	310	590	131 (16)	4.6	8.7
Total	**235**	**1,134**	**152,250**	**650**	**130**	**815**	**3.5**	**0.7**

Note: Data shown are for normal school travel hours as defined in Chapter 1. Injury and fatality counts are averages based on 9 years of data (1991–1999).

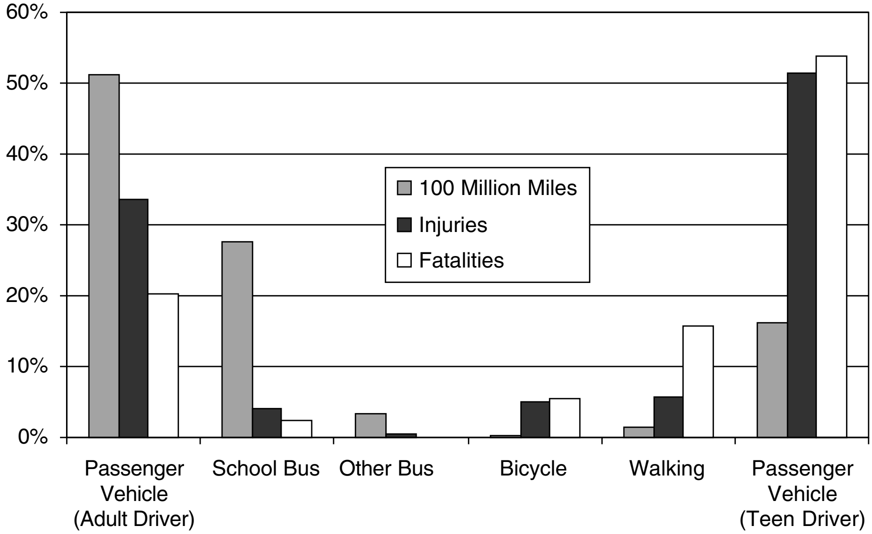


FIGURE 3-2 Comparisons of percent miles, percent injuries, and percent student fatalities by travel mode.

distances traveled for each of these modes. This observation is borne out if the data in Table 3-3 are used to calculate the average distance per trip (simply dividing the total number of miles by the number of trips for each mode). The distance per trip is approximately 5.5 miles for the school bus and two passenger vehicle categories, 0.75 mile for bicycling, and 0.50 mile for walking. On the basis of the NPTS data, the average trip length for other buses is around 8 miles. To put these values in perspective, Figure 3-3 shows a comparison of miles per trip for the four age groups for normal school travel hours and all other times of the year. Trip distances during normal school travel hours are shorter (averaging 5 miles as compared with 8 miles). Also, length of trip increases with age of student (from an average of 4.5 miles for the youngest students to 5.5 for the oldest students).

UNCERTAINTY

As noted earlier in this chapter, because the GES and NPTS datasets are based on samples from a much larger population than school-age children, hazard rates developed from these datasets are uncertain. It is important to appreciate the extent of these uncertainties when formulating new policies. Just because a particular mode has a lower average hazard rate than another does not mean that the difference is significant or interesting. The uncertainties in the estimates could cloud the interpretation of the data and make it impossible to draw definitive conclusions.

Figures 3-4 through 3-7 show the uncertainty behind the risk estimates shown in Table 3-3. The horizontal bar represents the average hazard rate for

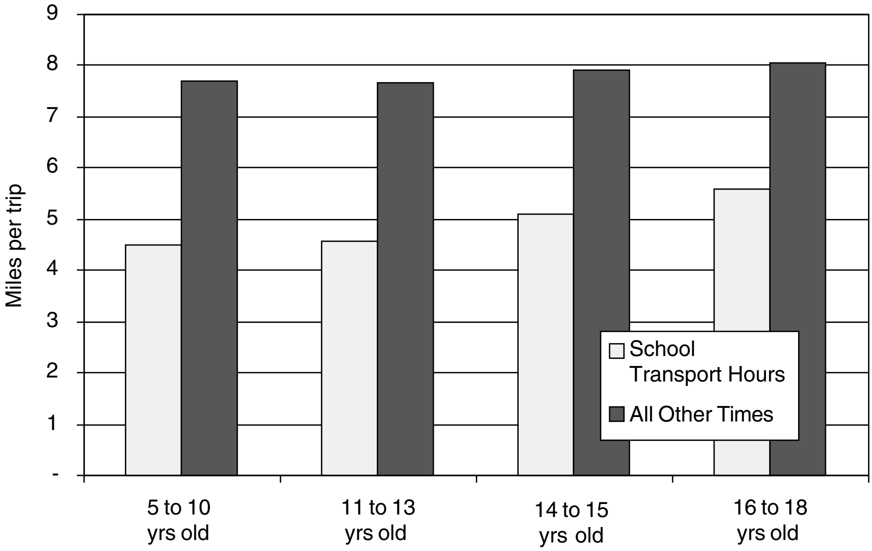


FIGURE 3-3 Comparison of trip length, school travel hours and all other times.

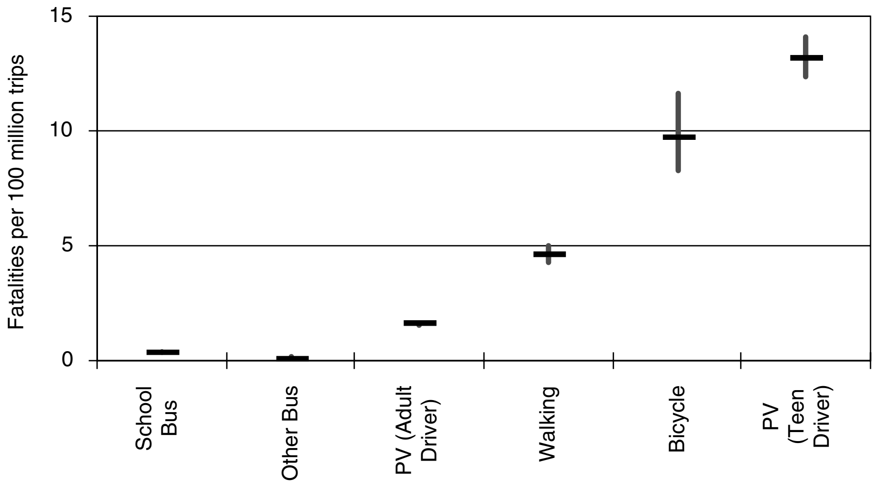


FIGURE 3-4 Student fatality rates per 100 million trips by mode during normal travel hours with 90 percent confidence intervals (PV = passenger vehicle).

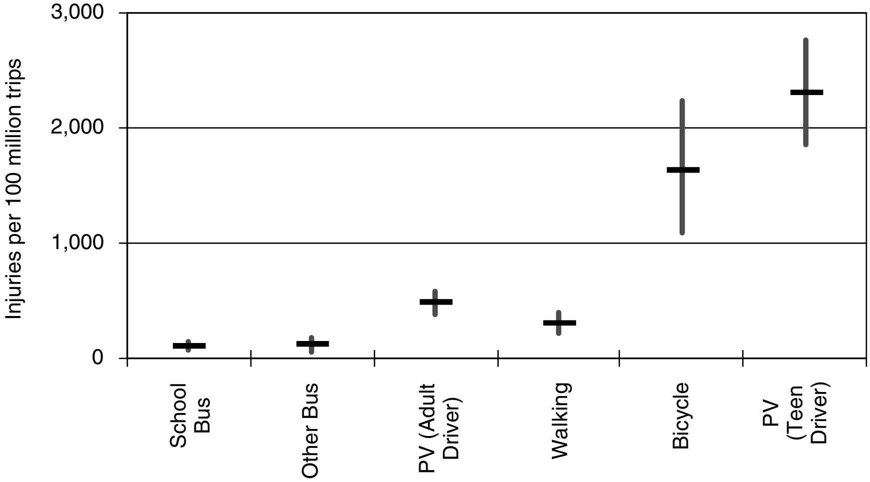


FIGURE 3-5 Student injury rates per 100 million trips by mode during normal travel hours with 90 percent confidence intervals (PV = passenger vehicle).

each mode. The vertical bars represent a 90 percent confidence interval for each estimate (that is, there is a high likelihood that the actual fatality or injury rate falls within this interval). For some modes, the interval is very tight and really cannot be seen on the graphs (for example, school buses or other buses in Figure 3-6). In some cases, the confidence intervals for the modes overlap. This implies that it is not possible to determine whether the risks associated with the

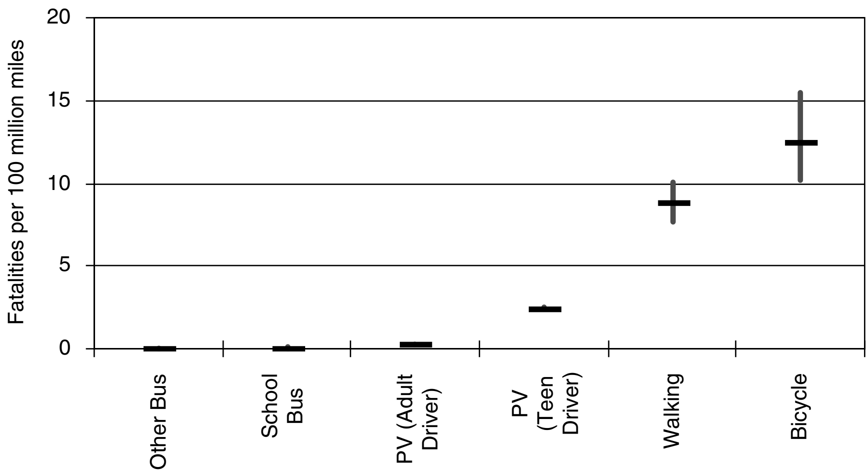


FIGURE 3-6 Student fatality rates per 100 million student-miles by mode during normal travel hours with 90 percent confidence intervals (PV = passenger vehicle).

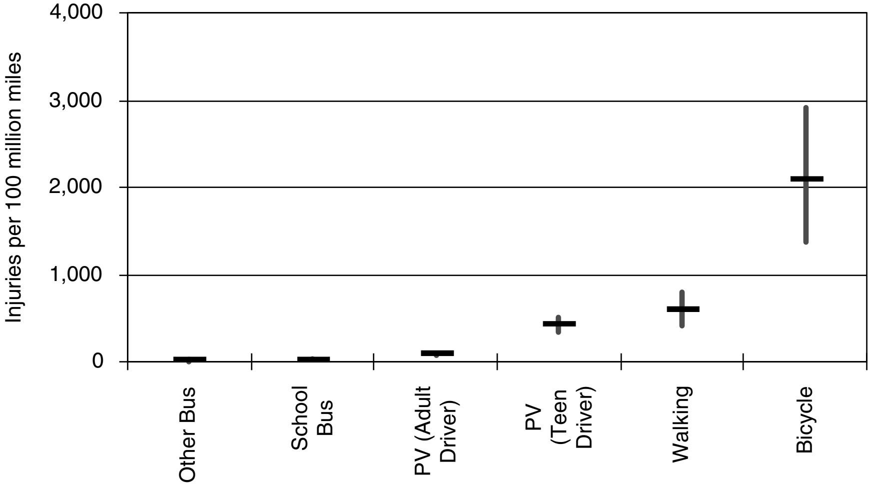


FIGURE 3-7 Student injury rates per 100 million student-miles by mode during normal travel hours with 90 percent confidence intervals (PV = passenger vehicle).

modes (for example, bicycling and student drivers in Figure 3-5) are actually different. School buses and other buses have the lowest injury and fatality rates and are statistically indistinguishable from each other.

Tables 3-4 though 3-9 show how the uncertainties in the exposure and outcome measures combine to create uncertainty in the hazard rates sorted by age group and travel mode. All of these tables present the average and the lower (5 percent) and upper (95 percent) confidence bounds for various risk measures. Tables 3-4 and 3-5 show the injury and fatality rates per 100 million student-miles, whereas Tables 3-6 and 3-7 show the rates per 100 million student trips. A graphical depiction of these results appears in Figures 3-8 through 3-11. The uncertainty results are repeated in table and figure form for both risk measures (per 100 million trips and per 100 million student-miles) for the data sorted by gender, time of day, and location categories (see Tables 3-8 through 3-17 and Figures 3-12 through 3-23). Note that injury rates are not broken out by location (urban and rural) because the GES dataset is not coded in this manner.

Generally, categories with high hazard rates have wider confidence ranges. The coefficients of variation (the standard error divided by the average) for the travel mode and age groupings are shown for fatalities/100 million trips and injuries/100 million student-miles in Figures 3-22 and 3-23, respectively. These values are calculated from the same values shown in Figures 3-5 and 3-6 and Tables 3-4 and 3-7. The coefficients of variation for the injury rates are relatively consistent (between 20 and 30 percent) across the different age and travel mode combinations with the exception of that for the other bus category, which is higher than the others. For the fatality rates, the coefficients indicate where the underlying trip data are scarce. For most travel mode categories, there is a "stair step" across the age groupings: higher coefficients of variation indicate smaller

TABLE 3-4 Injuries per 100 Million Student-Miles: Confidence Bounds on Average Estimates by Age Group and Transportation Mode

Age Group and Transportation Mode	5th	Mean	95th
Ages 5–10			
School bus	5	13	21
Other bus	0	12	24
Passenger vehicle (adult driver)	50	77	104
Walking	324	726	1,182
Bicycling	886	2,625	5,310
Passenger vehicle (teen driver)	787	2,549	4,618
Ages 11–13			
School bus	9	20	30
Other bus	7	38	69
Passenger vehicle (adult driver)	48	76	104
Walking	370	759	1,198
Bicycling	1,096	2,267	3,624
Passenger vehicle (teen driver)	347	716	1,092
Ages 14–15			
School bus	10	22	34
Other bus	0	6	11
Passenger vehicle (adult driver)	60	94	128
Walking	177	385	622
Bicycling	651	1,458	2,497
Passenger vehicle (teen driver)	396	596	795
Ages 16–18			
School bus	16	37	59
Other bus	0	13	26
Passenger vehicle (adult driver)	97	152	206
Walking	164	426	729
Bicycling	1,103	3,158	6,120
Passenger vehicle (teen driver)	300	396	493

Note: Data shown are for normal school travel hours as defined in Chapter 1.

underlying samples in the NPTS survey. For example, few of those aged 16–18 take a school bus, walk, or ride bicycles, but many more drive themselves to school. Similar patterns are found for the other categories (i.e., gender, time of day, and geographic region).

Because of the uncertainty of the estimates, not all differences in average hazard rates are significant. Table 3-18 shows which differences from Tables 3-4

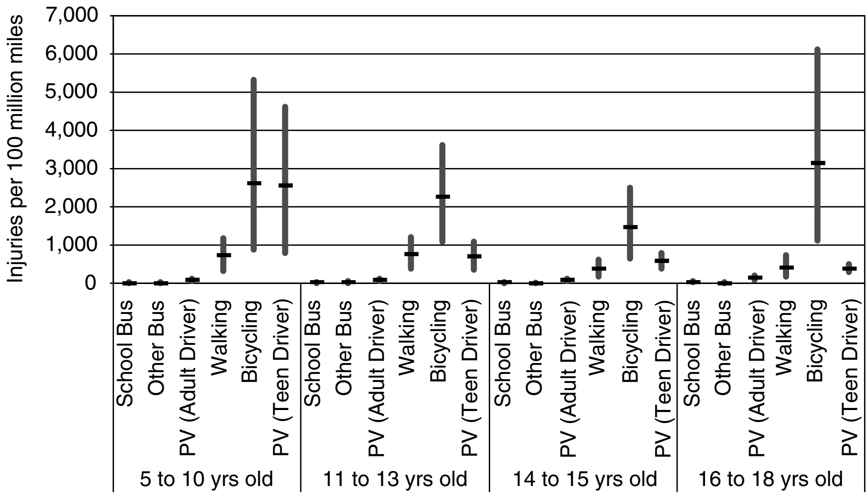


FIGURE 3-8 Injuries per 100 million student-miles shown by age group and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

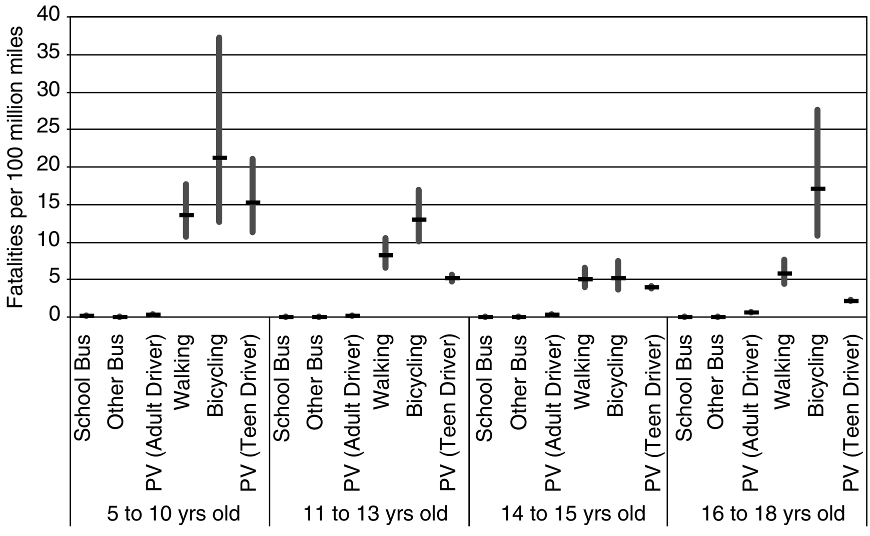


FIGURE 3-9 Fatalities per 100 million student-miles shown by age group and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

TABLE 3-5 Fatalities per 100 Million Student-Miles: Confidence Bounds on Average Estimates by Age Group and Transportation Mode

Age Group and Transportation Mode	5th	Mean	95th
Ages 5–10			
School bus	0.10	0.10	0.10
Other bus	0.01	0.01	0.01
Passenger vehicle (adult driver)	0.27	0.27	0.27
Walking	10.66	13.61	17.64
Bicycling	12.63	21.16	37.33
Passenger vehicle (teen driver)	11.26	15.22	20.99
Ages 11–13			
School bus	0.04	0.04	0.04
Other bus	0.03	0.03	0.03
Passenger vehicle (adult driver)	0.21	0.21	0.22
Walking	6.60	8.30	10.58
Bicycling	10.03	12.95	16.97
Passenger vehicle (teen driver)	4.75	5.20	5.71
Ages 14–15			
School bus	0.04	0.04	0.04
Other bus	0.01	0.01	0.01
Passenger vehicle (adult driver)	0.23	0.24	0.24
Walking	3.95	5.03	6.50
Bicycling	3.65	5.15	7.47
Passenger vehicle (teen driver)	3.85	3.97	4.10
Ages 16–18			
School bus	0.02	0.02	0.02
Other bus	0.02	0.02	0.02
Passenger vehicle (adult driver)	0.58	0.59	0.59
Walking	4.49	5.80	7.63
Bicycling	10.78	17.03	27.64
Passenger vehicle (teen driver)	2.16	2.19	2.22

Note: Data shown are for normal school travel hours as defined in Chapter 1.

through 3-7 (and Figures 3-8 through 3-11) are not significantly different with 95 percent confidence. Taking, for example, the values in Table 3-4 (injuries/100 million student-miles) for children aged 5–10 using school buses or other buses, the 90 percent confidence range for school bus (5–21 injuries/100 million student-miles) overlaps with the 90 percent confidence range for other bus (0–24 injuries/

TABLE 3-6 Injuries per 100 Million Student Trips: Confidence Bounds on Average Estimates by Age Group and Transportation Mode

Age Group and Transportation Mode	5th	Mean	95th
Ages 5–10			
School bus	24	65	106
Other bus	0	119	255
Passenger vehicle (adult driver)	257	400	543
Walking	143	304	468
Bicycling	521	1,311	2,248
Passenger vehicle (teen driver)	1,224	4,586	10,044
Ages 11–13			
School bus	48	103	158
Other bus	49	276	527
Passenger vehicle (adult driver)	262	419	581
Walking	187	368	555
Bicycling	1,014	2,057	3,281
Passenger vehicle (teen driver)	1,240	2,779	4,696
Ages 14–15			
School bus	63	138	214
Other bus	1	56	115
Passenger vehicle (adult driver)	335	526	723
Walking	130	277	435
Bicycling	596	1,299	2,186
Passenger vehicle (teen driver)	2,651	4,252	6,124
Ages 16–18			
School bus	125	295	470
Other bus	0	68	143
Passenger vehicle (adult driver)	718	1,147	1,588
Walking	108	274	451
Bicycling	1,328	4,623	9,525
Passenger vehicle (teen driver)	1,599	2,131	2,678

Note: Data shown are for normal school travel hours as defined in Chapter 1.

100 million student-miles). Therefore, even though the average hazard rate for the other bus mode is smaller (12 versus 13), this difference is not statistically significant, and one cannot say that this mode has less risk. For the different hazard rate measures and many of the younger age groupings, the school bus and other bus modes are not significantly different.

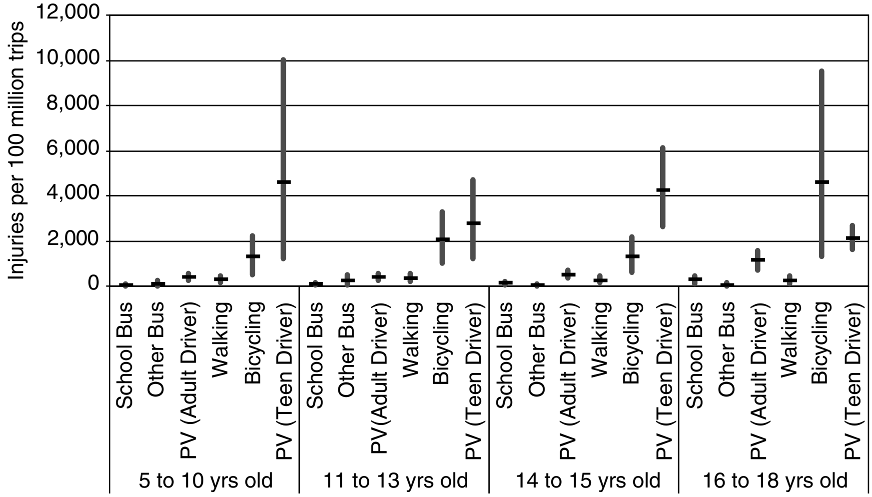


FIGURE 3-10 Injuries per 100 million student trips shown by age group and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

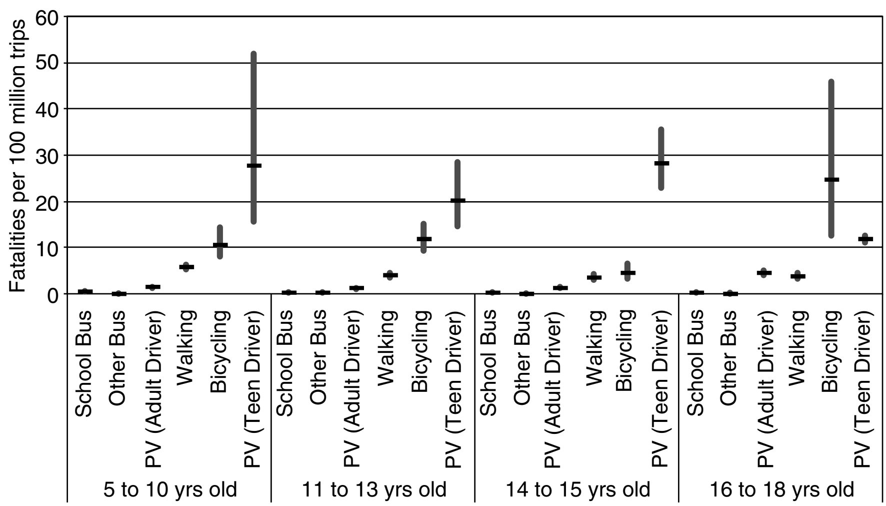


FIGURE 3-11 Fatalities per 100 million student trips shown by age group and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

TABLE 3-7 Fatalities per 100 Million Student Trips: Confidence Bounds on Average Estimates by Age Group and Transportation Mode

Age Group and Transportation Mode	5th	Mean	95th
Ages 5–10			
School bus	0.47	0.50	0.53
Other bus	0.07	0.09	0.12
Passenger vehicle (adult driver)	1.32	1.39	1.48
Walking	5.18	5.70	6.30
Bicycling	8.04	10.62	14.30
Passenger vehicle (teen driver)	15.61	27.61	51.93
Ages 11–13			
School bus	0.18	0.19	0.21
Other bus	0.18	0.24	0.31
Passenger vehicle (adult driver)	1.09	1.17	1.27
Walking	3.60	4.02	4.51
Bicycling	9.21	11.74	15.20
Passenger vehicle (teen driver)	14.57	20.17	28.60
Ages 14–15			
School bus	0.22	0.25	0.27
Other bus	0.07	0.08	0.11
Passenger vehicle (adult driver)	1.20	1.32	1.44
Walking	3.01	3.61	4.36
Bicycling	3.32	4.59	6.51
Passenger vehicle (teen driver)	22.83	28.32	35.56
Ages 16–18			
School bus	0.16	0.18	0.21
Other bus	0.08	0.10	0.13
Passenger vehicle (adult driver)	3.96	4.43	4.98
Walking	3.15	3.73	4.45
Bicycling	12.58	24.79	45.82
Passenger vehicle (teen driver)	10.97	11.76	12.63

Note: Data shown are for normal school travel hours as defined in Chapter 1.

INTERPRETATION OF DATA

The above data show some clear trends for the nation. Travel by bus (whether school bus or other bus) appears safer than the other modes. Drivers aged 19 and older apparently provide safer transportation than teen drivers. On a per-mile basis, walking and bicycling to and from school appear riskier than most

TABLE 3-8 Injuries per 100 Million Student Trips: Confidence Bounds on Average Estimates by Gender and Transportation Mode

Gender and Transportation Mode	5th	Mean	95th
Male			
School bus	65	104	142
Other bus	54	148	247
Passenger vehicle (adult driver)	305	405	504
Walking	212	321	435
Bicycling	1,199	1,839	2,551
Passenger vehicle (teen driver)	1,495	1,922	2,353
Female			
School bus	66	106	149
Other bus	35	103	187
Passenger vehicle (adult driver)	436	566	703
Walking	186	302	434
Bicycling	541	1,414	2,625
Passenger vehicle (teen driver)	2,079	2,696	3,375

Note: Data shown are for normal school travel hours as defined in Chapter 1.

TABLE 3-9 Injuries per 100 Million Student Trips: Confidence Bounds on Average Estimates by Time of Day and Transportation Mode

Time of Day and Transportation Mode	5th	Mean	95th
6–8:59 a.m.			
School bus	70	111	153
Other bus	23	79	139
Passenger vehicle (adult driver)	267	363	460
Walking	176	288	404
Bicycling	928	1,872	3,110
Passenger vehicle (teen driver)	1,330	1,775	2,231
2–4:59 p.m.			
School bus	60	98	135
Other bus	63	154	252
Passenger vehicle (adult driver)	445	572	701
Walking	216	322	431
Bicycling	1,050	1,613	2,273
Passenger vehicle (teen driver)	2,077	2,635	3,225

Note: Data shown are for normal school travel hours as defined in Chapter 1.

TABLE 3-10 Fatalities per 100 Million Student Trips: Confidence Bounds on Average Estimates by Gender and Transportation Mode

Gender and Transportation Mode	5th	Mean	95th
Male			
School bus	0.35	0.37	0.39
Other bus	0.20	0.23	0.28
Passenger vehicle (adult driver)	1.56	1.61	1.67
Walking	4.82	5.24	5.70
Bicycling	9.51	11.44	13.88
Passenger vehicle (teen driver)	13.71	14.44	15.21
Female			
School bus	0.28	0.32	0.36
Other bus	0.03	0.04	0.06
Passenger vehicle (adult driver)	1.49	1.60	1.71
Walking	3.23	3.94	4.85
Bicycling	3.44	6.64	11.74
Passenger vehicle (teen driver)	10.20	11.48	12.98

Note: Data shown are for normal school travel hours as defined in Chapter 1.

TABLE 3-11 Fatalities per 100 Million Student Trips: Confidence Bounds on Average Estimates by Time of Day and Transportation Mode

Time of Day and Transportation Mode	5th	Mean	95th
6–8:59 a.m.			
School bus	0.21	0.22	0.23
Other bus	0.09	0.11	0.13
Passenger vehicle (adult driver)	1.47	1.55	1.63
Walking	4.46	4.98	5.58
Bicycling	6.94	9.77	14.12
Passenger vehicle (teen driver)	11.92	13.02	14.24
2–4:59 p.m.			
School bus	0.44	0.46	0.50
Other bus	0.11	0.13	0.16
Passenger vehicle (adult driver)	1.55	1.65	1.75
Walking	4.05	4.44	4.87
Bicycling	8.13	9.84	12.03
Passenger vehicle (teen driver)	12.14	13.30	14.60

Note: Data shown are for normal school travel hours as defined in Chapter 1.

TABLE 3-12 Fatalities per 100 Million Student Trips: Confidence Bounds on Average Estimates by Geographic Region and Transportation Mode

Geographic Region and Transportation Mode	5th	Mean	95th
Urban			
School bus	0.34	0.36	0.39
Other bus	0.03	0.03	0.03
Passenger vehicle (adult driver)	0.73	0.77	0.81
Walking	3.43	3.71	4.02
Bicycling	7.56	9.14	11.14
Passenger vehicle (teen driver)	5.79	6.35	6.98
Rural			
School bus	0.30	0.32	0.34
Other bus	0.42	0.56	0.77
Passenger vehicle (adult driver)	2.86	3.05	3.25
Walking	7.46	8.72	10.25
Bicycling	8.05	11.12	15.73
Passenger vehicle (teen driver)	19.61	21.50	23.64

Note: Data shown are for normal school travel hours as defined in Chapter 1.

TABLE 3-13 Injuries per 100 Million Student-Miles: Confidence Bounds on Average Estimates by Gender and Transportation Mode

Gender and Transportation Mode	5th	Mean	95th
Male			
School bus	12	19	27
Other bus	11	28	46
Passenger vehicle (adult driver)	57	75	94
Walking	429	661	910
Bicycling	1,632	2,594	3,727
Passenger vehicle (teen driver)	262	335	408
Female			
School bus	12	19	26
Other bus	3	9	15
Passenger vehicle (adult driver)	77	99	122
Walking	305	542	848
Bicycling	552	1,312	2,658
Passenger vehicle (teen driver)	437	553	671

Note: Data shown are for normal school travel hours as defined in Chapter 1.

TABLE 3-14 Injuries per 100 Million Student-Miles: Confidence Bounds on Average Estimates by Time of Day and Transportation Mode

Time of Day and Transportation Mode	5th	Mean	95th
6–8:59 a.m.			
School bus	13	20	28
Other bus	2	8	13
Passenger vehicle (adult driver)	63	86	108
Walking	340	582	852
Bicycling	903	1,786	2,900
Passenger vehicle (teen driver)	251	330	409
2–4:59 p.m.			
School bus	11	18	25
Other bus	9	23	36
Passenger vehicle (adult driver)	70	89	108
Walking	394	600	827
Bicycling	1,391	2,209	3,186
Passenger vehicle (teen driver)	389	485	581

Note: Data shown are for normal school travel hours as defined in Chapter 1.

TABLE 3-15 Fatalities per 100 Million Student-Miles: Confidence Bounds on Average Estimates by Gender and Transportation Mode

Gender and Transportation Mode	5th	Mean	95th
Male			
School bus	0.07	0.07	0.07
Other bus	0.04	0.04	0.05
Passenger vehicle (adult driver)	0.30	0.30	0.30
Walking	9.39	10.79	12.46
Bicycling	12.74	16.13	20.71
Passenger vehicle (teen driver)	2.49	2.52	2.54
Female			
School bus	0.06	0.06	0.06
Other bus	0.00	0.00	0.00
Passenger vehicle (adult driver)	0.28	0.28	0.28
Walking	5.04	7.06	10.14
Bicycling	3.52	6.31	11.74
Passenger vehicle (teen driver)	2.30	2.36	2.41

Note: Data shown are for normal school travel hours as defined in Chapter 1.

TABLE 3-16 Fatalities per 100 Million Student-Miles: Confidence Bounds on Average Estimates by Time of Day and Transportation Mode

Time of Day and Transportation Mode	5th	Mean	95th
6–8:59 a.m.			
School bus	0.04	0.04	0.04
Other bus	0.01	0.01	0.01
Passenger vehicle (adult driver)	0.36	0.37	0.37
Walking	8.14	10.06	12.56
Bicycling	6.82	9.34	13.08
Passenger vehicle (teen driver)	2.39	2.42	2.45
2–4:59 p.m.			
School bus	0.09	0.09	0.09
Other bus	0.02	0.02	0.02
Passenger vehicle (adult driver)	0.25	0.26	0.26
Walking	7.04	8.26	9.76
Bicycling	10.51	13.48	17.54
Passenger vehicle (teen driver)	2.41	2.45	2.49

Note: Data shown are for normal school travel hours as defined in Chapter 1.

TABLE 3-17 Fatalities per 100 Million Student-Miles: Confidence Bounds on Average Estimates by Geographic Region and Transportation Mode

Geographic Region and Transportation Mode	5th	Mean	95th
Urban			
School bus	0.09	0.09	0.09
Other bus	0.00	0.00	0.00
Passenger vehicle (adult driver)	0.16	0.17	0.17
Walking	6.19	7.15	8.32
Bicycling	8.58	10.58	13.20
Passenger vehicle (teen driver)	1.34	1.36	1.39
Rural			
School bus	0.05	0.05	0.05
Other bus	0.04	0.04	0.04
Passenger vehicle (adult driver)	0.43	0.43	0.43
Walking	12.26	16.09	21.50
Bicycling	10.99	18.00	30.22
Passenger vehicle (teen driver)	3.40	3.44	3.49

Note: Data shown are for normal school travel hours as defined in Chapter 1.

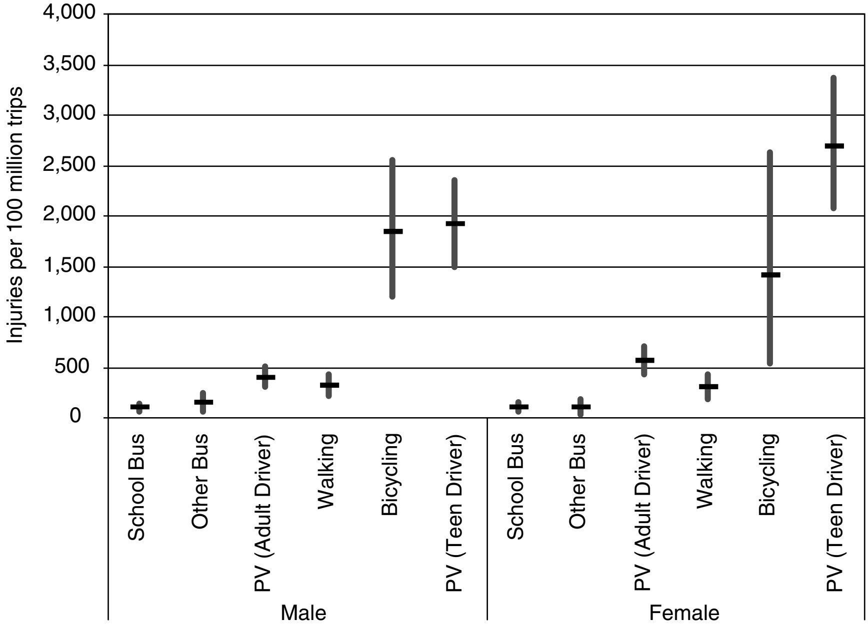


FIGURE 3-12 Injuries per 100 million student trips shown by gender and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

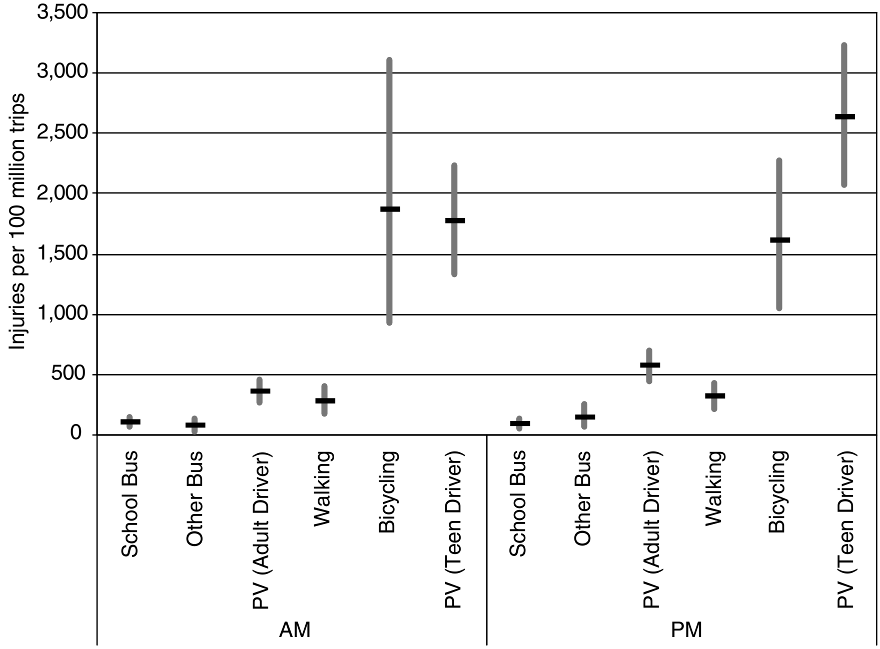


FIGURE 3-13 Injuries per 100 million student trips shown by time of day and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

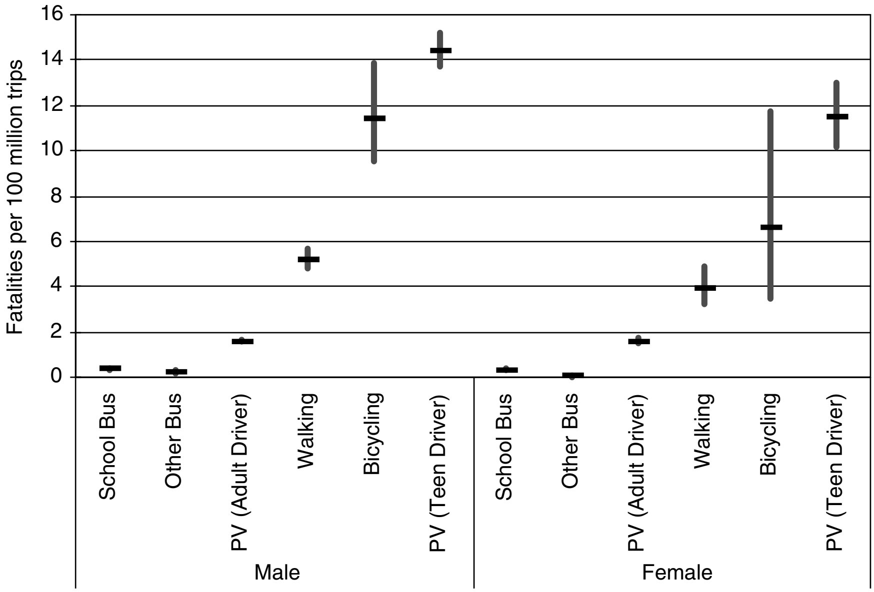


FIGURE 3-14 Fatalities per 100 million student trips shown by gender and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

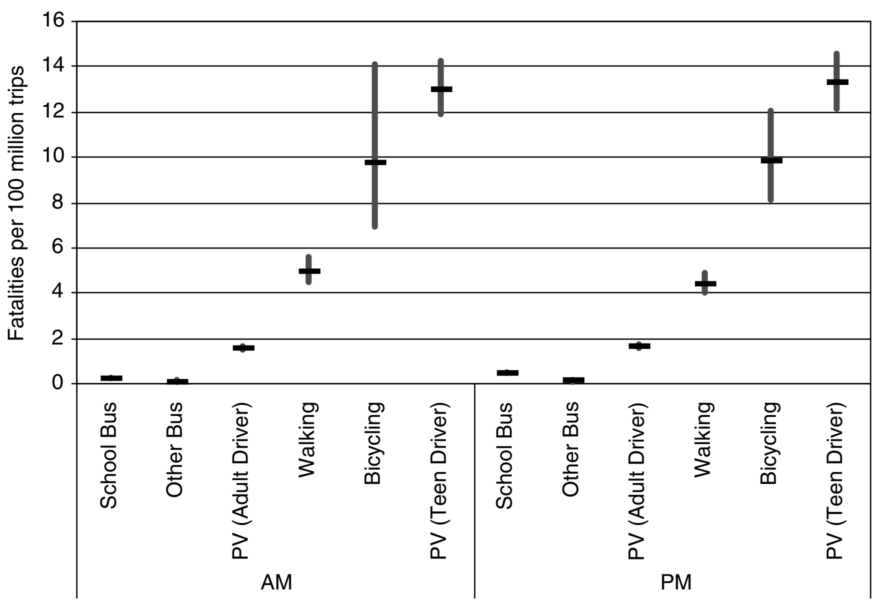


FIGURE 3-15 Fatalities per 100 million student trips shown by time of day and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

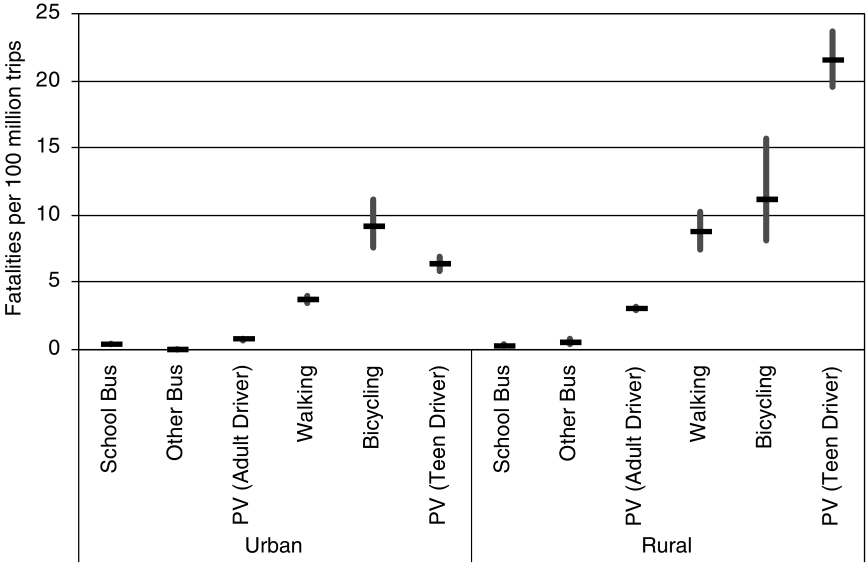


FIGURE 3-16 Fatalities per 100 million student trips shown by geographic region and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

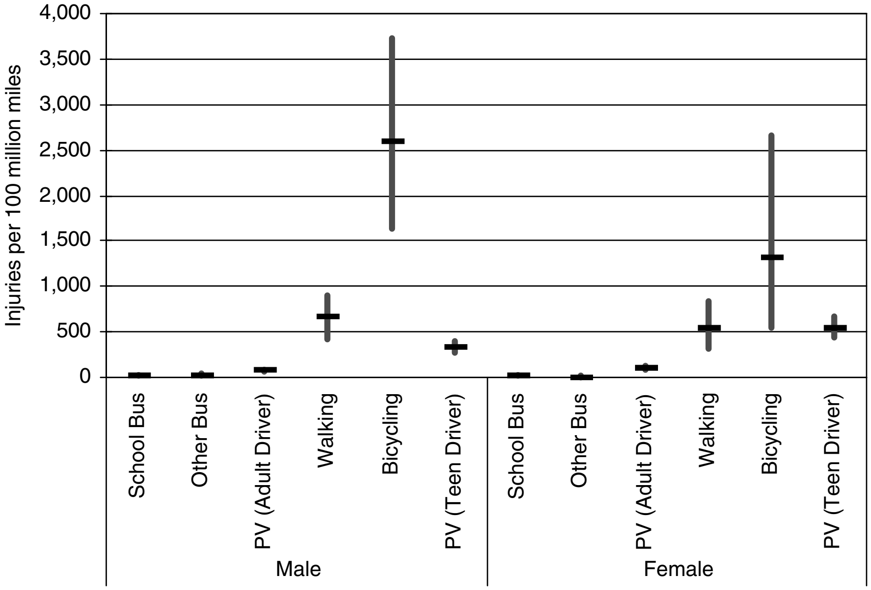


FIGURE 3-17 Injuries per 100 million student-miles shown by gender and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

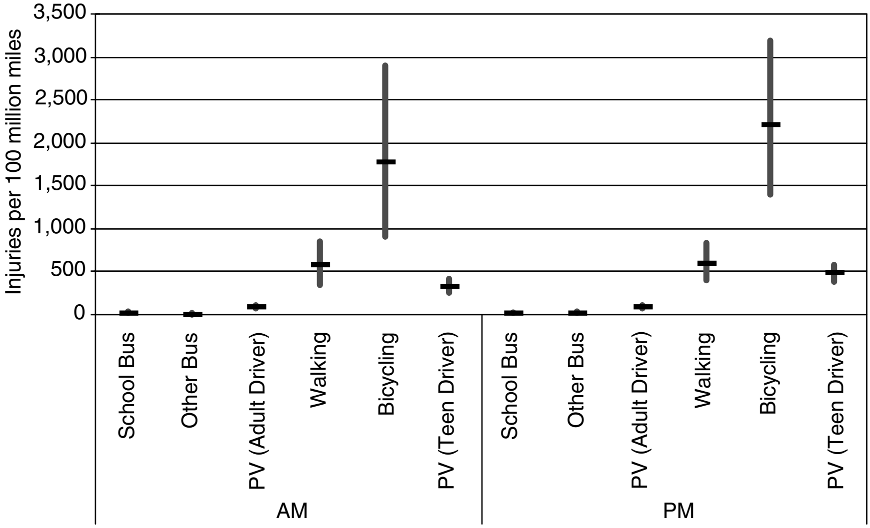


FIGURE 3-18 Injuries per 100 million student-miles shown by time of day and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

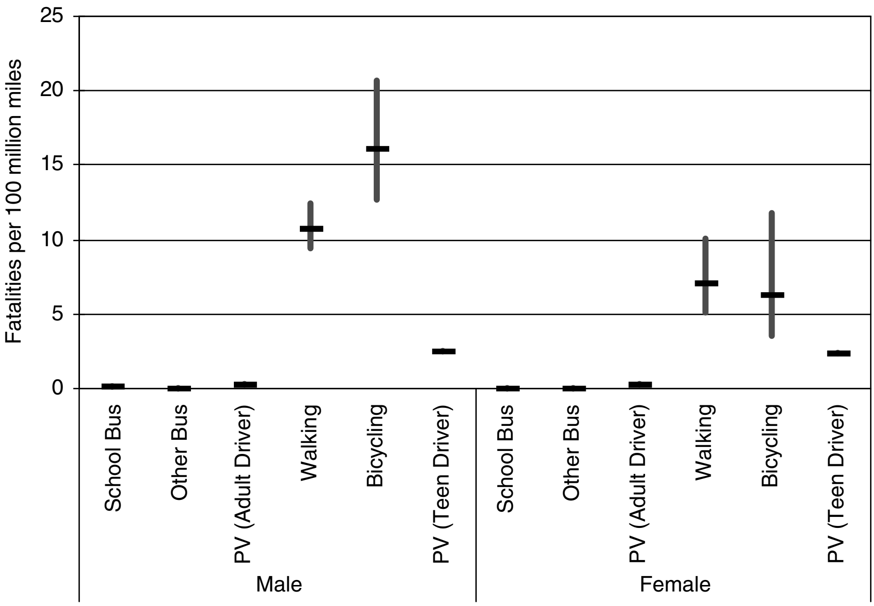


FIGURE 3-19 Fatalities per 100 million student-miles shown by gender and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

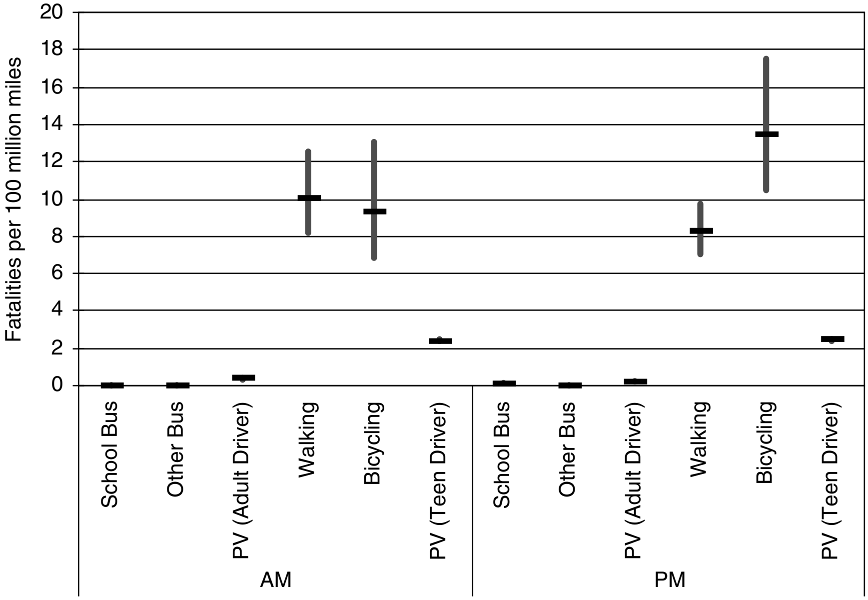


FIGURE 3-20 Fatalities per 100 million student-miles shown by time of day and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

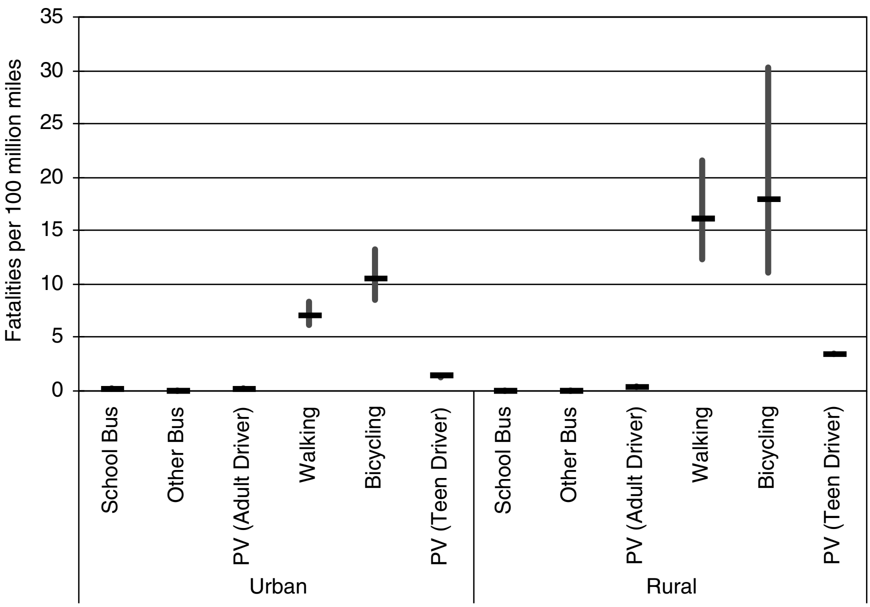


FIGURE 3-21 Fatalities per 100 million student-miles shown by geographic region and travel mode (PV = passenger vehicle). (Horizontal bars are the average, and vertical bars represent 90 percent confidence intervals of the average values.)

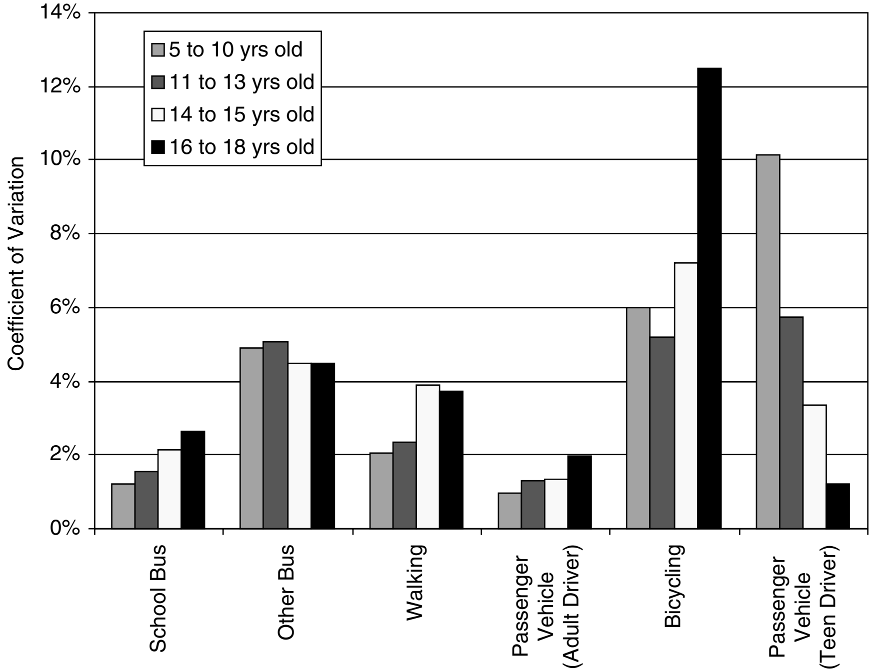


FIGURE 3-22 Coefficient of variation for fatalities per 100 million student trips shown by travel mode.

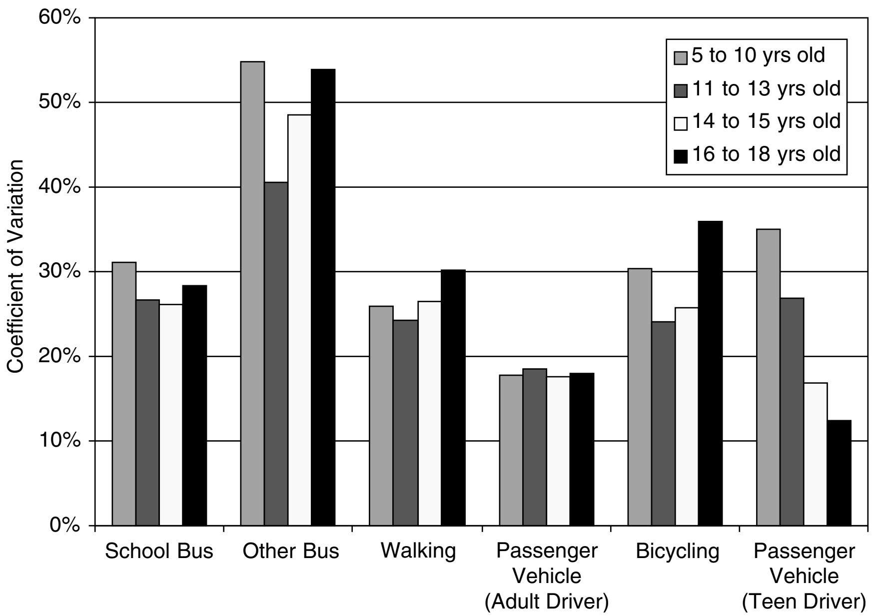


FIGURE 3-23 Coefficient of variation for injuries per 100 million student-miles shown by travel mode.

TABLE 3-18 Not Significant Differences in Average Hazard Rates by Travel Mode and Age Category (All Other Comparisons Are Significantly Different with 90 percent Confidence)

	Age Group (years)			
	5–10	11–13	14–15	16–18
Figure 3-8, injuries per 100 million student-miles				
School bus and other bus[a]	NS	NS		
Walking and passenger vehicle (adult driver)		NS	NS	NS
Bicycling and passenger vehicle (teen driver)	NS			
Figure 3-9, fatalities per 100 million student-miles				
Walking and bicycling			NS	
Walking and passenger vehicle (adult driver)	NS			
Bicycling and passenger vehicle (teen driver)	NS			
Figure 3-10, injuries per 100 million student trips				
School bus and other bus	NS	NS		
School bus and walking				NS
Other bus and walking				
Walking and passenger vehicle (adult driver)		NS		
Bicycling and passenger vehicle (teen driver)	NS	NS		

Note: Data shown are for normal school travel hours as defined in Chapter 1. "NS" indicates not significantly different with 95 percent confidence.
[a] As noted previously, the school bus category includes school-age children who are injured or killed as pedestrians (e.g., when boarding or alighting from the bus and crossing the street) as well as those who are passengers on the school bus. However, the other bus category only includes those school-age children who are passengers; the datasets do not capture injuries or fatalities for those students as pedestrians.

of the other modes, whereas these two modes appear less risky when viewed on a per-trip basis.

When comparing morning and afternoon trips, there is little difference in the risks for each travel mode. Though there are some significant gender differences, they do not tell a consistent story. Males have a higher fatality risk per trip for modes in which they are responsible for their actions (i.e., walking, bicycling, and teen driving) when the risk is measured per trip. Yet the difference disappears for teen driving when the risk is measured per mile, possibly because male drivers are driving greater distances than females. Regarding urban versus rural risks, students in rural areas have a significantly greater fatality risk for all modes other than bus for both risk measures (per trip and per mile). No urban versus rural comparison for injuries is possible because no usable urban/rural measure exists in the GES database. The difference between rural and urban teen drivers is quite large. The hazard rates for drivers aged 19 and older are also different.

Despite this report's focus on accidents during normal school travel hours, the committee thought it important to report for comparison the risks faced by school-age children during non–school travel hours. Figures 3-24 and 3-25 present the fatality risk measures (per trip and per mile, respectively) for normal school travel hours and all non–school travel hours. On a per-trip basis and across the four age groupings, travel risks during non–school travel hours are approximately twice what they are during normal school travel hours. On a per-mile basis, the risks are approximately 20 percent higher during non–school travel hours, but vary slightly with the age groups. While trips by school bus make up 25 percent of the trips during normal school travel hours, the risk per school bus trip is only 7.5 percent that of all the other modes combined (0.34 fatalities per 100 million trips versus 4.78 fatalities per 100 million trips). During non–school travel hours, children are exposed to less-safe modes of travel (with the possible exception of transit and light rail).

It would be valuable to know whether these risks change over time (e.g., whether school buses are becoming safer as compared with teen driving). Unfortunately, it is difficult to draw rigorous conclusions in this regard without replicating a large portion of this study for a different time period (e.g., using the 1990 and forthcoming 2002 NPTS data). In fact, studying trends only in the exposure measures (miles or trips) or only in the outcome measures (injuries or fatalities) without considering their ratios could yield misleading conclusions. A dramatic decrease in the number of children killed on bicycles during the past 10 years, for example, does not necessarily mean that bicycles are now much safer. In addition, when comparing the risk results presented in this report with those in other studies, careful attention must be paid to the definitions of the risk measures. Fatalities per "vehicle-mile" is not the same as fatalities per "student-mile," and indeed will usually be higher. Annex 3-1 addresses these

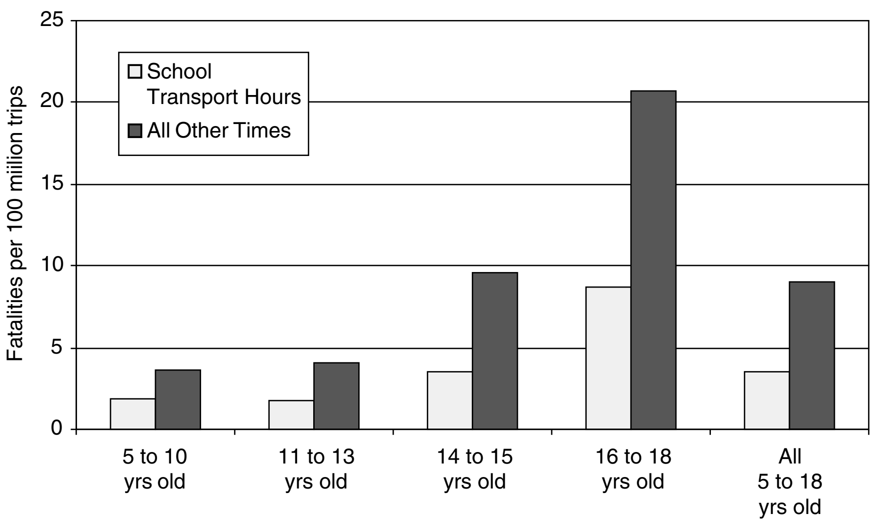


FIGURE 3-24 Comparison of fatality rates per 100 million student trips during school travel hours and all other times by age group.

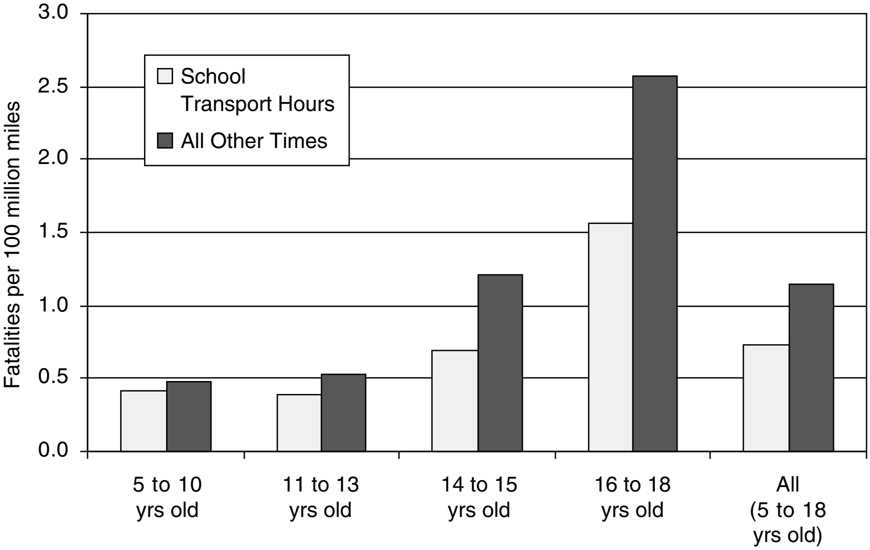


FIGURE 3-25 Comparison of fatality rates per 100 million student-miles during school travel hours and all other times by age group.

points, presents trends for several different measures, and shows how these trends can be misinterpreted.

Finally, when considering these results, it must be remembered that they are based on national averages. Results for specific school districts may vary significantly in accordance with local conditions. How these results can be used to inform policy decisions is demonstrated in Chapter 5.

Annex 3-1

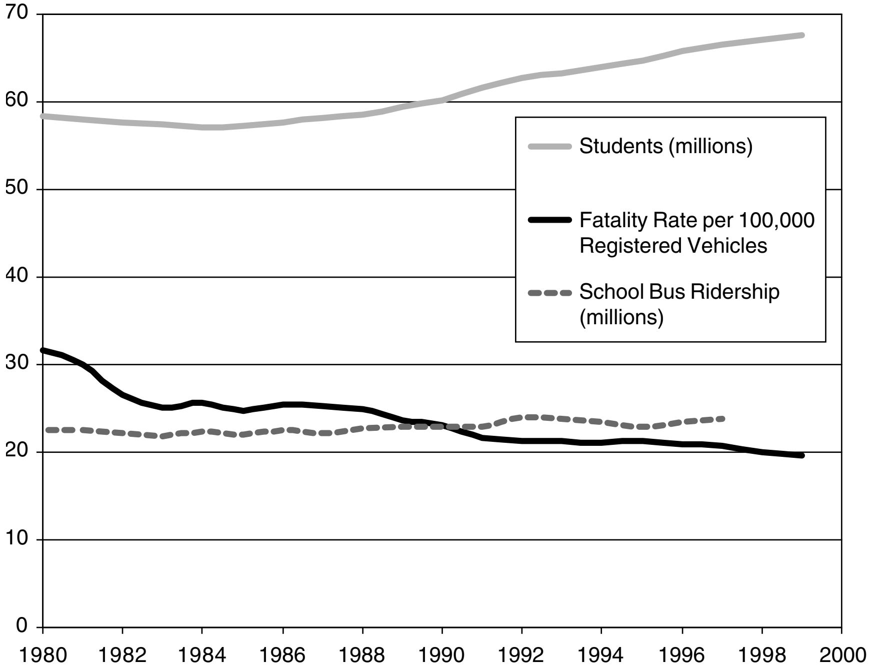
Between 1980 and 1998, national fatality rates for all drivers/all times (fatalities/100,000 vehicles) decreased from 31.6 to 20.0 (as reported in FARS); the number of students attending school increased from 58.3 million to 67.0 million (as reported in the U.S. Census); and the number of children riding school buses increased from 22.6 million to 23.8 million (as reported in the ridership database of the National Association of State Directors for Pupil Transportation Services) (see Annex 3-1 Figure 1). Unfortunately, it is difficult to extrapolate from these data any trends regarding the risks students face traveling to and from school.

If the above school bus ridership data are accepted as being accurate (something the committee did not believe appropriate for data quality reasons), the percentage of children taking school buses can be calculated (see Annex 3-1 Figure 2). From 1992 to 1998, there appears to have been a decrease in ridership of approximately 2.5 percent, implying that 1.5 million children who may previously have ridden school buses ceased doing so. If these children selected less safe modes (e.g., teenagers driving themselves), then the risk for all children as a group may have increased. However, this conclusion is dependent on the answers to several questions: What is the significance of the improvement in overall motor vehicle risk as compared with the change in risk caused by modal shift? Did other children switch from riskier modes to less risky modes? Were school buses even an option for these children? If the children switched to transit buses, the risks may not have increased.

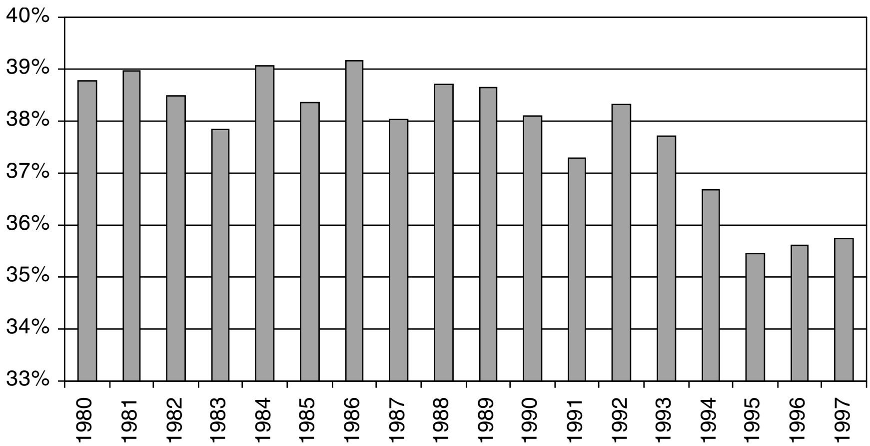
Shown in Annex 3-1 Figure 3 are pedestrian fatality rates for those under age 20 (deaths per 100,000). The apparent sharp decline in the rate says absolutely nothing about what is happening to the risk of children walking to school; the decline could be caused by a significant decrease in the number of children walking. A far more valuable graph would show the fatality rate per trip (as is done in this report), but these data are not available for multiple years.

Shown in Annex 3-1 Figure 4 are the numbers of fatalities resulting from bicycle accidents for children age 16 or younger. Again, the sharp decline shown in this figure says nothing about what is happening to the risk of children bicycling to and from school. If the number of children bicycling were decreasing more rapidly than the number of fatalities, the actual risk could be increasing. Exposure data that would make it possible to draw any conclusions are not readily available.

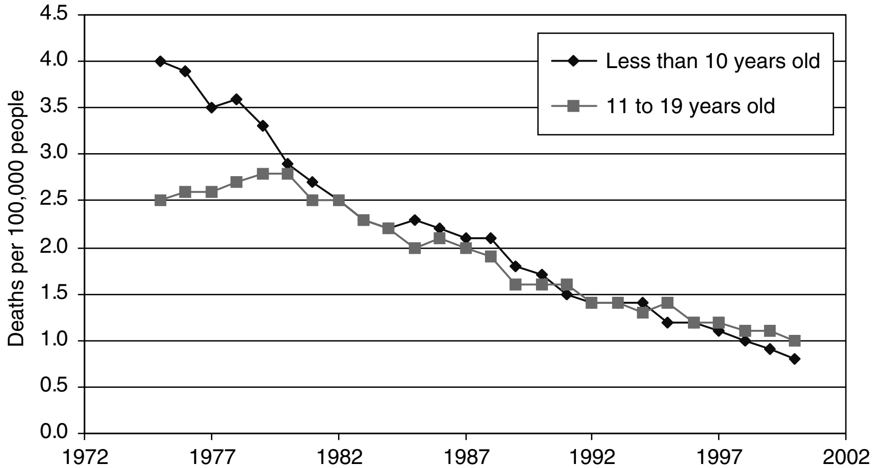
Finally, without repeating the present study using multiple historical datasets (which are not available), it is not possible to draw any concrete conclusions about the trend in overall risk. Relying on data whose pedigree can be questioned (e.g., Annex 3-1 Figures 1 and 2) or whose exposure measures are irrelevant or missing (e.g., Annex 3-1 Figures 3 and 4) can be misleading and confusing.



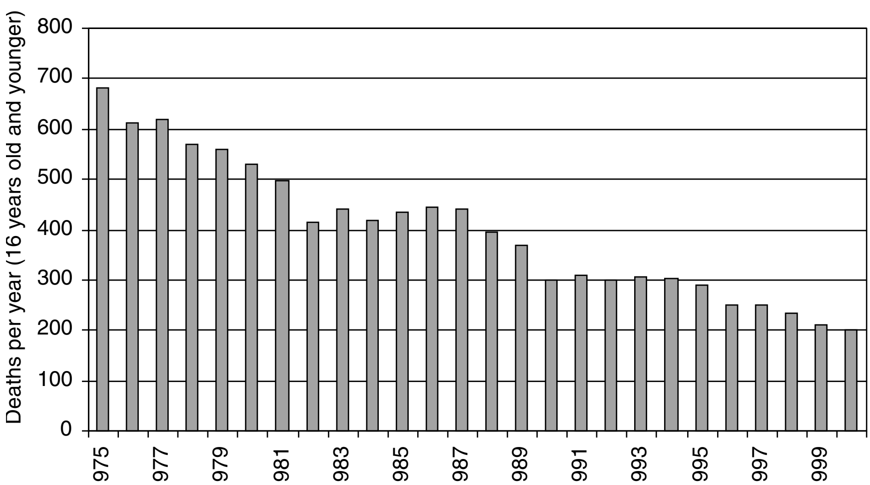
ANNEX 3-1 FIGURE 1 Trend data.



ANNEX 3-1 FIGURE 2 Percent of school children riding school buses.



ANNEX 3-1 FIGURE 3 Pedestrian fatality rate over time.



ANNEX 3-1 FIGURE 4 Fatality rate for bicyclists age 16 or younger over time.

4 Identifying and Managing Risks Associated with School Transportation

The school travel problem is explored in Chapters 2 and 3 from a national perspective using injury and fatality risk measures. As noted earlier, however, decisions about school travel alternatives are made at the regional, school, household, and individual levels. Although these decisions reflect considerations other than safety—such as cost, flexibility, and convenience—an understanding of the risk factors that determine school travel safety can provide essential input for the decision-making process. This understanding can also make it possible to evaluate alternatives designed to reduce the risks associated with each mode, and enable a school district to provide a range of choices for school travel that meet a variety of needs, including safety. Accordingly, the risk factors associated with school travel, as well as potential interventions to reduce the risks most salient for each school travel mode, are reviewed in this chapter.

To examine the risks involved in school travel, the committee grouped the risk factors into five categories that cut across the various school travel modes: (*a*) human, (*b*) vehicular, (*c*) operational, (*d*) infrastructure/environmental, and (*e*) societal. It should be noted that much of the information presented here on these factors is descriptive or nonquantitative in nature. Moreover, the list of factors reviewed is not intended to be exhaustive, but includes those factors the committee considers most important. It should be noted as well that the risk factors vary not only across travel modes, but also across school districts, students, and days of the year. Following the discussion of the five risk categories, a checklist is provided for each mode that can be used by decision makers in a given community (whether policy makers, local administrators, or parents) to enhance the safety of school travel.

HUMAN RISK FACTORS

For this study, human risk factors are defined as those factors that can be attributed to the people in the system (school-age pedestrians, school-age passengers, and school-age and adult drivers). This category includes both factors that cannot be directly changed (e.g., age, gender, personality, information processing, cognitive ability) and those that can (e.g., experience levels; training, education, and qualifications; substance use; compliance; peer pressure).

It should be noted that, although fatalities to school-age children who ride school buses are low, the majority of those fatalities occur outside the vehicle. In contrast, injuries occur much more frequently to school bus riders when they are on the bus than during the pedestrian segment of their trip. The human risk factors for the pedestrian segment of the trip will be different from those for the passenger segment.

Pedestrian behavior is complex. Children must acquire many skills and learn many tasks to become safe pedestrians, and they do not reliably demonstrate these skills (Sandels 1975; Vinje 1981). Moreover, because children walking may encounter and interact with other modes during their travel, they must have the skills needed to interpret the dangers represented by these other modes. Thus, children need to develop schema for critical behaviors such as street crossing, which may require the ability to judge vehicle speed and distance, as well as safe gaps. While evidence of the effectiveness of generic pedestrian safety education in reducing injuries and fatalities and in preventing accidents is lacking (Duperrex et al. 2002; TRB 2001), implementation of school bus passenger safety education has been linked to a reduction in the risk of fatality for school bus passengers during the pedestrian segment of their trip in New York and Kansas (New York State Education Department 2002; unpublished data from Kansas Department of Education for 1971–2001). Effective training programs for other modes, as well as environmental change and adult supervision, are needed to provide for the safety of children who walk to and from school, bus stops, and the like.

It is well known that children's motor, cognitive, and behavioral skills develop chronologically and sequentially. Between the ages of 6 and 8 years, children begin to develop the ability to plan ahead, understand rules, consider consequences of actions, follow a logical sequence of thought, and understand the difference between right and wrong (Flavell 1963; Tyson 2002). Thus, even with training of various programmatic levels and quality, young elementary school-age children cannot be relied upon to make consistent, safe traveling decisions, regardless of the modes they use. Accordingly, age is regarded as a major risk factor in school travel, particularly for those younger than age 10, who are not considered to have internalized the principles of safe travel and thus may not exhibit those principles in their travel behaviors (Sandels 1975; Dewar 2002b). Indeed, the pedestrian road accident rate has been shown to be a function of age (Oxley et al. 1997; NHTSA 1999). Sandels (1975), who has studied the behavior and cognition of children, suggests that the degree of maturity necessary for safe behavior is reached between the ages of 9 and 12.

To educate children about traffic safety and implement a successful school transportation safety education program, then, it is important to understand the abilities and limitations of school-age children as they relate to behavior in the roadway and in the school site environment (Dewar 2002b). A program must be developed at a level that corresponds to the cognitive abilities of the children who will be receiving the training. Parents, as well as schools and law enforcement personnel, can assist in this effort. At the same time, it must be noted that the committee was unable to locate sufficient data demonstrating the effectiveness of such safety training programs in decreasing the number and severity of injuries to school-age children. Therefore, attention must also be paid to the environment and infrastructure to safeguard the child pedestrian. (For a thorough review of children's social and cognitive development and the implications for a traffic environment, see Collins and Gunnar 1990; Dewar 2002b; and Vinje 1981.)

A number of personality-related traits (e.g., hostility, alienation) that cannot easily be changed have been shown to be strongly linked to a number of human risk factors, such as risk taking and sensation seeking (behavior that appears to peak between 16 and 19 years of age, then decreases with age; see Dewar 2002b, 124). These personality traits and associated risk factors have been shown to be related to crash involvement (Donovan et al. 1983; Pelz and Schuman 1973). In addition, a relationship has been established between sensation seeking and risky driving (defined as excessive speed, increased frequency of speeding, less seat belt usage, and increased frequency of drinking and driving; see Burns and Wilde 1995; Jonah 1997).

Higher risks of involvement in crashes or incidents are associated with age (for both the young and the elderly); driving experience; training received; and temperament and physical condition, including visual acuity, reaction time, information processing ability, stamina, and alcohol impairment levels (Dewar and Olson 2001; Evans and Schwing 1985; Mareck and Sten 1977). Driver risk has been found to be higher for younger than for older drivers and higher for less experienced than for more experienced drivers, other conditions being equal (Chen et al. 2000; Levy 1990; Mayhew and Simpson 1990).

The *Driver Performance Data Book* (Henderson 1987) contains source materials applicable to driving that address such human factors as response times, anthropometrics, visual and auditory performance, and information processing. This information is used by those who design vehicles, roadways, and traffic control devices. There is an extensive base of empirical data to support these materials, and it continues to be broadened (Dewar and Olson 2001).

Research in other, less traditional areas also continues to expand the knowledge base on human factors related to driving and to shed light on the effects of experience and situational conditions on driving behavior and accepted risk. Young drivers have been found to be less perceptive than older drivers of risk in the driving environment. One study revealed that young drivers (aged 18–24) detected the presence of children in only 51 percent of the total number of encounters (Egberink et al. 1986); another showed that young drivers were less likely to recognize potential hazards (Brown 1982; Quimby and Watts 1981). The results of these and other studies suggest that careful consideration should be given to the school site, including ingress and egress areas, where young drivers, as well as adult drivers, are likely to encounter pedestrians and bicyclists.

Peer pressure, and at times just the presence of peers, is another important factor that influences children's behavior. There is evidence that the presence of peers in a vehicle is associated with accidents among young drivers (Dewar 2002a). Another study of young drivers (Williams et al. 1997) revealed that if the driver was wearing a safety belt, the passenger was more likely to do so as well. Chen et al. (2000) examined the influence of 16- and 17-year-old drivers having passengers in their vehicles on the likelihood of crashes. They determined that the risk of death rose significantly for young drivers with an increase in the number of passengers, regardless of time of day and gender of the driver.

Human risk factors such as those reviewed above must be considered not only when making decisions about mode choice, but also when considering procedures and other operational factors (discussed more fully later) that affect the overall safety of a mode. For example, depending on the state or local school district, students traveling by school bus are required to receive safety training at least biannually (NHTSA 2000). This passenger training—a safety feature unique to this mode—includes appropriate behaviors and activities while waiting for and riding on the school bus (e.g., remaining in one's seat, not distracting the driver, proper boarding and alighting procedures, proper street crossing, emergency evacuation). Students who ride other buses typically do not receive such training, or if they do, it is provided either by parents or through observation of other passengers.

Depending on the school system, students who ride as passengers in passenger vehicles may also receive verbal instruction from school administrators on appropriate locations for being dropped off and picked up from school, and on safe procedures for crossing parking lots or streets as required to get to and from the vehicle and the school building. Again, however, such instruction of school-age children is not always successful, durable, or reliable.

Unlike drivers of passenger vehicles, bus drivers are generally required to possess a commercial driver's license (CDL) or similar license, and receive considerable training. Moreover, federal regulations require drug and alcohol testing of bus drivers (initial, random, on-suspicion, and postcrash). All CDL drivers are required to have a biennial physical, and school bus drivers in many states must have an annual physical. All states, however, do not have parallel requirements, including criminal history checks and other screening procedures.

Certain elements of training differ for drivers of school buses and other buses. For example, school bus drivers generally receive specialized training in passenger management, loading and unloading procedures, and vehicle evacuation, as well as additional training in transporting, assisting, and monitoring special-education children. In contrast, the committee's review of training for drivers of other buses revealed considerable variability across states in training requirements. Relatively few transit agencies provide specific training for bus drivers with regard to transporting school children. At the same time, some transit agencies providing significant levels of transportation for school children instruct bus drivers in a variety of safety-related issues, including security and crossing. Some transit agencies and bus companies have developed administrative relationships with schools and school districts regarding not only discounted fares, but also disciplinary actions for students not complying with safe or appropriate ridership practices. Agencies responsible for transporting school children would benefit from guidelines regarding appropriate and effective training for bus drivers.

Beyond the minimum qualifications established by state laws or federal regulations for drivers of school buses and public transit vehicles, then, there is extreme variation with respect to recruitment, selection, and training practices, as well as rates of pay. While the committee believes such a range in practices is likely to be associated with variations in driver safety performance, it was not possible to determine the extent of such variation in practices, let alone the effect of the various practices on student travel safety. A review of factors associated with school bus crashes (about 26,000 per year) would provide information on driver factors, vehicle factors, and contributing causes that would be helpful for districts making decisions about the various modes and measures to improve their safety. As an example, a report on a study by the California Department of Education addressing training requirements for school bus drivers, prepared for the California Highway Patrol (Chapter 1509, California Statutes of 1982), revealed a decrease in frequency of school bus accidents and a decline in accidents caused by school bus drivers after mandatory training requirements were adopted for school bus drivers in 1974. The report validated the need to maintain at least 20 hours of classroom instruction and 20 hours of behind-the-wheel training for school bus drivers.

VEHICULAR RISK FACTORS

While safety is an important consideration in vehicle design, it is important to recognize that many other criteria are also factored into the design process, including the design and placement of controls and displays, performance, comfort, durability (including life-cycle costing factors), versatility, directional stability, maintainability, packaging (i.e., the arrangement of subsystems and components), air quality, fuel efficiency, cost, and marketability (see Peacock and Karwowski 1993). A number of design elements based on these criteria—including capacity, mass, structure and suspension systems, occupant restraints, and handling and braking—affect driver and passenger safety directly or indirectly.

Some vehicles are subject to many standards; others, such as bicycles, are subject to few; and still others, such as skateboards and scooters, are subject to virtually none. Motorized vehicles are regulated by the Federal Motor Vehicle Safety Standards (FMVSSs). The standards that apply to motor vehicles used to transport school-age children are listed in Table 4-1. It is important to note that vehicle safety standards are performance standards, not design standards. What they accomplish is subject to regulation; how it is accomplished is not.

The safety record of school and other buses is due in part to both their mass and design, which in general provide an advantage in most crashes. Standards for school buses have emanated from congressional actions including the National Traffic and Motor Vehicle Safety Act of 1966 and the School Bus Safety Amendments of 1974. There are 36 FMVSSs that apply to school buses, 6 of which specify unique requirements for school buses; 4 standards are applicable only to school buses, 21 apply to transit buses and motorcoaches (see Table 4-1), and fewer apply to the various types of passenger vehicles.

Apart from obvious features such as vehicle mass, the safety record of school bus service has also been attributed to several unique factors of school buses: they are clearly distinguishable—painted a special color universally recognized by most motorists—and enhanced by other vehicle features, such as flashing red lights; stop arms; and, in at least 20 states and many more school districts, cross-

TABLE 4-1 Federal Motor Vehicle Safety Standards

FMVSS Number	Standard Subject	School Bus	Other Bus	Passenger Vehicle
Crash Avoidance				
101	Control Location, Identification and Illumination	X	X	X
102	Transmission Shift Lever Sequence, Starter Interlocks and Transmission Braking Effect	X	X	X
103	Windshield Defrosting and Defogging Systems	X	X	X
104	Windshield Wiping and Washing Systems	X	X	X
105	Hydraulic Brake Systems	X[a]	X	X
106	Brake Hoses	X	X	X
108	Lamps, Reflective Devices and Associated Equipment	X[a]	X	X
109	New Pneumatic Tires			X[b]
110	Tire Selection and Rims			X[b]
111	Rearview Mirrors	X[a]	X	X
113	Hood Latches	X	X	X
114	Theft Protection			X[c]
116	Motor Vehicle Brake Fluids	X	X	X
117	Retreaded Pneumatic Tires			X[b]
118	Power-Operated Window, Partition and Roof Panel Systems			X[c]
119	New Pneumatic Tires for Motor Vehicles Other Than Passenger Cars	X	X	X
120	Tire Selection and Rim for Motor Vehicles Other Than Passenger Cars	X	X	X
121	Air Brake Systems	X	X	X[d]

(*continued*)

TABLE 4-1 (continued) **Federal Motor Vehicle Safety Standards**

FMVSS Number	Standard Subject	School Bus	Other Bus	Passenger Vehicle
122	Motorcycle Brake Systems			
123	Motorcycle Control Systems			
124	Accelerator Control Systems	X	X	X
125	Warning Devices			
129	New Non-Pneumatic Tires for Passenger Cars			X[b]
131	School Bus Pedestrian Safety Devices	X		
135	Passenger Car Brake Systems			X[b]
Crashworthiness During Crash				
201	Occupant Protection in Interior Impact	X[e]	X[e]	X[b,c]
202	Head Restraints	X[e]	X[e]	X[b,c]
203	Impact Protection for the Driver	X[e]	X[e]	X[b,c]
204	Steering Control Rearward Displacement	X[e]	X[e]	X[b,c]
205	Glazing Materials	X	X	X
206	Door Locks and Door Retention Components			X
207	Seating Systems	X[f]	X[f]	X
208	Occupant Crash Protection	X[f,g]	X[f]	X
209	Seat Belt Assemblies	X[f,g]	X[f]	X
210	Seat Belt Assembly Anchorage	X[f,g]	X[f]	X
212	Windshield Mounting	X[e]	X[e]	X[b,c]

213	Child Restraint Systems	X[h]	X[h]	X[h]
214	Side Impact Protection	X[e]	X[e]	X[b,c]
217	Bus Emergency Exits and Window Retention and Release	X[a]	X	
218	Motorcycle Helmets			
219	Windshield Zone Intrusion	X[e]	X[e]	X[b,c]
220	School Bus Rollover Protection	X		
221	School Bus Body Joint Strength	X		
222	School Bus Passenger Seating and Crash Protection	X		
225	Child Restraint Anchorage Systems	X[i]	X[i]	X[b,i]
Postcrash				
301	Fuel System Integrity	X[a]	X[c]	X[b,c]
302	Flammability of Interior Materials	X	X	X
303	Fuel System Integrity of Compressed NG Vehicles	X[a]	X[c]	X
304	Compressed Natural Gas Fuel Container Integrity			
305	Electric-Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection	X[e]	X[e]	X[b,c]
401	Interior Trunk Release			X[b,c]
500	Low Speed Vehicles			

[a] Denotes additional unique requirements.
[b] Applies to passenger cars.
[c] Applies to vehicles with gross vehicle weight rating of 10,000 pounds or less.
[d] Applies to trucks.
[e] Applies to school buses, other buses with gross vehicle weight rating of 10,000 pounds or less.
[f] Applies to driver's seat only.
[g] FMVSSs 209 and 210 apply to driver's seats on all school buses. FMVSSs 209 and 210 apply to passenger seats on school buses of 10,000 pounds or less.
[h] Applies to vehicles with an integral child safety seat.
[i] Applies to vehicles with gross vehicle weight rating of 8,500 pounds or less.

ing control arms. There are also routinely enforced laws and regulations affording school bus passengers special treatment during their boarding and alighting, as well as street crossings.

The fact that public transit buses have two sets of doors—and in some cases three—may be a source of increased risk. Rear doors are activated by the bus operator upon an action of the passenger (e.g., stop chime request) or when a stop is reached. Rear door interlocks are designed to stop the bus from moving when a passenger is holding a rear door open while exiting, since exiting through a rear door takes place outside the direct view of the bus driver. In addition, passengers alighting from rear doors are likely to have a wider gap separating the bus and the curb than those alighting from the front because of the way the driver positions the bus in the loading zone. School buses provide better screening of blind-spot areas than other buses. Transit vehicles have larger blind spots than school buses, and their mirror systems do not help with blind spots in the front of the vehicle caused by such things as the designed location of the farebox.

Motorcoaches are designed for travel involving longer distances, with few stops and virtually no street crossings. They contain padded, high-backed, forward-facing seats. Many also have lateral supports and comfort features such as reclining seats and adjustable spacing, and some contain occupant restraint systems. Motorcoaches have emergency windows, including roof hatches and large, well-marked, push-out windows. However, their large passenger windows do not possess the window retention characteristics of school buses, and in rollovers can result in passenger ejection. At the same time, motorcoaches have considerable mass, and many have monocoque construction, pneumatic suspension systems, and antilock braking systems. However, they are not required to pass rollover and side-impact tests mandated for school buses.

Unlike school buses, passenger vehicles used for school travel are not required to be a distinctive color or have special lighting, nor must they meet the same safety standards for occupant protection, joint strength of body panels, roof rollover protection, and so on. In addition, passenger vehicles do not have the capacity to transport as many students as school and other buses, nor do they have the same or comparable mass, crashworthiness, conspicuity, maintenance/inspection requirements, and the like.

Finally, bicycles lack mass, stability, speed, and conspicuity (except for the bright-colored clothing worn by some bicycle operators). They have minimal crashworthiness characteristics, no restraints, and no maintenance/inspection requirements.

OPERATIONAL RISK FACTORS

In terms of operational characteristics, state and local school districts have established extensive policies and programs to ensure the safety of school travelers. Much of the guidance for these actions comes from Highway Safety Program Guideline 17, Pupil Transportation Safety, issued by the National Highway Traffic Safety Administration (NHTSA). This guideline, which was originally a standard, "establishes minimum recommendations for a state highway safety program for pupil transportation safety including the identification, operation, and maintenance of buses used for carrying students; training passengers, pedestrians, and bicycle riders; and administration" (NHTSA 2000, xx).

School buses serve all types of areas (urban, suburban, and rural), all ages of children (prekindergarten through high school), and children with disabilities and special needs. They usually operate according to fixed routes with designated stops or, for some categories of passengers (e.g., children with special needs), may provide door-to-door service according to a fixed schedule.

School bus drivers are responsible for the safety and well-being of their passengers, including discipline. Unlike drivers of other forms of public transportation, however, school bus drivers cannot order an unruly student passenger off the bus (the driver can ask system officials to suspend the student, pending correction of the misbehavior). School bus drivers also have more responsibility for the safety of students while they are pedestrians, particularly as the drivers must provide student riders regular safety instruction and participate proactively in the students' crossing in front of the bus. (On undivided roadways, drivers are not to discharge students until other vehicles traveling in both the same and opposing directions have stopped in response to the driver's engagement of flashing lights and stop arms.) Some states also require riders to wait for the bus driver's signal to cross the roadway. All school bus passengers ride seated. In fact, typical transit practices whereby students begin to walk toward the door as the vehicle approaches their stop are prohibited.

Although other bus drivers certainly have responsibilities for monitoring and assisting school children and others in crossing, these responsibilities are limited. This is the case largely because passengers cross behind the bus, except when it is stopped at the near side of a signalized intersection and the signal instructs pedestrians to cross. The legal responsibility for such activities varies significantly from state to state. In the state of Missouri, for example, a safe stop includes (*a*) the place where the passenger steps off the bus, (*b*) the area around the bus, (*c*) the intersection where the bus has pulled over, and (*d*) a safe path to the likely primary origins and destinations of most passengers. In contrast, Pennsylvania law restricts the responsibility for a bus's operation to such time as it is in motion, effectively defining liability for loading and unloading out of existence. Driver responsibilities reflect these state-to-state differences and must be taken into consideration in an evaluation of comparative safety and relative risk.

The design goals and operating objectives of school and other buses reflect different needs. Other buses must accommodate a broader range of passengers (including school children), different destinations (including schools), different duty cycles and operating environments (some similar to those of pupil transportation), and special user groups (elderly and disabled individuals). However, the peak-hour nature of the majority of transit trips and the uneven distribution of passengers within these peaks lead to overcrowding and other operational issues. These issues, in turn, must be addressed by vehicle and operating characteristics—such as room for standees; vertical and horizontal stanchions;

flat, unpadded, and side-facing seats; irregular positioning of modesty panels; and other amenities not optimized specifically for student riders. And because passengers board and alight at the same stops—an occurrence virtually nonexistent in school bus service—passenger movement, boarding, alighting, crossing, fare collection, wheelchair securement, lift usage, and so on are considerably different than with school bus usage. Most important, because passengers do not cross in front of the bus, driver attention is diverted to many places it would not be during school bus loading, unloading, or crossing.

Most bus operating agencies are involved in planning, education, monitoring, and inspection. They receive input from a variety of regulatory agencies and local (school district or transit agency) staff and their contractors. In addition to drivers, operators often employ managers, supervisors, planners, system designers, schedulers, reservation personnel, dispatchers, training instructors, mechanics, marketing and outreach personnel, and other technical and administrative support personnel. Each of these disciplines has its own set of standards, procedures, policies, training programs, and oversight, and each plays an important role in the safety of bus transportation.

Students riding in transit or other buses to and from school face a number of operational factors that differ from those they encounter on a school bus. First, they are subject to commingling with the general population. Second, as noted above, they must generally cross the street behind the bus rather than in front of it, except when the bus is stopped at the near side of a signalized intersection and the signal instructs pedestrians to cross. They must cross with no help from equipment and limited, if any, help from the driver of the bus and fellow motorists. And these buses do not have identifying marks and flashing lights to indicate that they are carrying student passengers or that students are boarding or alighting, nor are motorists required to stop for transit buses loading and unloading passengers. Third, these students also often spend more time than school bus riders as pedestrians walking to and from and waiting at the bus stop.

A considerable statutory and regulatory structure exists for passenger vehicles (e.g., mandatory child safety seat laws in all states and seat belt laws in many states), including distinctions that reflect driver age, such as graduated licensing programs (for a review, see Foss and Evenson 1999). In contrast, the framework for travel by bicycle and walking is generally personal; provided by parents, relatives, and friends; and often learned through observation and experience, occasionally with a contribution by the school.

Students traveling to and from school in a passenger vehicle often leave directly from their home (or origin of trip) and thus do not make another trip, using a different mode, to an indirect transfer point (i.e., a bus stop). As a consequence, the total trip length and trip time are generally shorter and the routing more direct than is the case for bus trips (unless multiple students are being transported in the same vehicle from different origins to different destinations). Passenger vehicles also have the ability to pick up and drop off passengers directly at their originating point and destination, without the need to cross roadways or walk to bus stops. Like other non–school bus modes, however, passenger vehicles have no means of controlling other traffic (e.g., stop signal arms, red flashing lights).

Bicyclists, although using a nonmotorized vehicle, are considered vehicle operators according to traffic laws. Research indicates that the wearing of helmets could significantly reduce bicycle-related injuries and fatalities. Currently, 20 states and 84 localities have bicycle helmet laws (Bicycle Helmet Safety Institute 2002). There is little if any enforcement of these laws, however, apart from parents and guardians [see Dinh-Zarr et al. (2001) for a review of the research literature]. Largely because of its travel speed, the attractiveness of bicycling diminishes with increasing trip distance. As a consequence, bicycle trips are generally shorter in distance than school bus and other bus trips, and may be shorter than passenger vehicle trips.

Trip distances for walking are significantly shorter than for any of the other modes. Like bicycle trips, moreover, walking trips are generally more direct. The relative risks of walking encompass a broad spectrum of considerations, including trip length, roadway and infrastructure conditions, supervision, intersections and signalization, traffic volumes, and laws and law enforcement.

INFRASTRUCTURE AND ENVIRONMENTAL RISK FACTORS

Infrastructure and environmental risk factors are those characteristics of the route along which school-age children travel to and from school and of the areas around the school location. These factors, which affect every travel mode, can be organized into four categories: roadway characteristics and traffic control devices, traffic characteristics, adjacent land use characteristics, and school zone safety and site location characteristics. Roadway characteristics include road type (e.g., lanes, width, shoulders), surface (e.g., composition), condition (e.g., quality, irregularities), topography (e.g., degree of slope, straightness), and road hazards (e.g., detours). Traffic control devices include signs, signals, and pavement markings. Traffic characteristics include traffic volume, speed, and density, as well as traffic mix competing for the same space. Adjacent land use characteristics include lighting and light conditions, presence of sidewalks and bike paths, and weather and atmospheric conditions. School zone safety and school site location factors include competing modes in and around the school zone, school-related traffic impacts to local roadway traffic, ingress/egress at the school, traffic flow pattern at the school, and school site location and impact on modal choice.

As noted by Dewar (2002c), much research has been conducted on highway design engineering from a traffic safety perspective (e.g., Lamm et al. 1999), but relatively little has been done from a driver or pedestrian behavior perspective. The *Manual on Uniform Traffic Control Devices* (FHWA 2001), which is updated regularly, sets forth national standards for the installation and maintenance of traffic control devices on all roadways built with federal funds. States have their own manuals, which in many cases duplicate the federal standards, but may also include sections that address state-unique situations (Dewar 2002c). Part 7 of the FHWA manual, entitled "Traffic Controls for School Areas," is dedicated to school areas. The standards in many other parts of the manual apply to most roadways, but are applicable to school areas as well (e.g., Sections 1A.02 and 1A.07, which contain information on the application of standards; Section 2A.17, which contains information regarding the mounting height of signs; and Sections 2B.34, 2B.35, and 2B.36, which address the signs that govern parking regulations in school zone areas).

The Institute of Transportation Engineers (ITE) also deals with various aspects of transportation planning, traffic operations, and traffic control. *Traffic Circulation and Safety at School Sites* (ITE 1998) presents a sampling of traffic engineering techniques that can be used to address these concerns, such as school speed zones, traffic control devices, routing and layout, flashing beacons, and crossing guards, particularly at elementary and middle schools. ITE also provides information on traffic calming techniques that are applicable to school areas.

Reduced speeds (and traffic volumes) have been shown to result in increased pedestrian safety (Dewar 2002c; Ragland and Hundenski 1992). School speed zones are usually instituted where pedestrians must cross roadways to get to and from the school. In most instances, these reduced speed limits remain in effect for specific time periods on particular days. School zone speed limits are set in relation to the regular speed limit on the roadway, and are generally 10 mph below the road's posted speed limit. Various types of signs are used to inform drivers of the limits. ITE's *School Zone Speed Limits* study (ITE 1999), which "examined the effect of different types of school-zone speed-limit signs and the effect of different speed limits on the roads approaching the schools," revealed that about half of the motor vehicles in the school zone were in compliance with the posted speed restrictions, and flashing-light school zone signs were effective in slowing vehicles. The use of well-trained crossing guards has also been found to be one of the most effective measures for promoting the safety of children walking to and from school (see www.walkinginfo.org).

Bicycles generally share the roadways with other vehicles (except when operated on exclusive bike paths and on sidewalks or other terrain). For bicycles, infrastructure and environmental features, especially if they are substandard or hazardous, will likely have a more direct impact on the likelihood of crashes than is the case for other vehicles. However, numerous interventions have been shown to increase bicyclist safety, including traffic calming devices and raised crossings. Infrastructure-related interventions, such as walking paths, can also increase safety for pedestrians, as well as those using skateboards, rollerblades, and the like (OECD 1998).

Depending upon local conditions, numerous infrastructure features may contribute to or mitigate school travel risks. Such features include the presence or absence and condition of sidewalks, the number of street crossings students must negotiate to reach the school, the presence or absence of marked crosswalks and crossing guards, signalization, pedestrian-exclusive walkways and overpasses, and the volume density and speed of vehicular traffic (Ragland and Hundenski 1992). Such factors should be considered when selecting a particular mode if alternative modes are available, as well as when selecting potential school sites. Schools should work with communities and traffic engineers to provide an environment that enhances the safety of school travel by all modes. Planning for the transportation needs of children should be an integral part of the planning of new school sites. According to NCST (2000, 90), "school officials should provide:

1. Separate and adequate space for school bus loading zones;
2. Clearly marked and controlled walkways through school bus zones;
3. Traffic flow and parking patterns for the public and non-bused students separate from the school bus loading zone;
4. A designated loading area for disabled passengers with special needs, if required;
5. An organized schedule of loading areas with stops clearly marked;
6. A loading and unloading site to eliminate the backing of transportation equipment;
7. Procedure for evaluating each school site plan annually."

SOCIETAL RISK FACTORS

Societal factors are not directly related to the transportation process, but have significant impacts on school travel. These factors reflect values of the community and its institutions and thus influence decisions and choices, including those related to travel. With respect to school travel, some of the more salient factors are related to health and fitness, security, quality of life, public spending and investment, politics, freedom of choice, and liability.

One example of how such concerns affect school travel decisions is the value placed on health improvement as a result of increased physical fitness (see, for example, HHS 1996). A variety of programs have been implemented to promote walking for children, including "Walk Your Child to School Day" and "Walkable Communities." Some of these programs support changes in infrastructure (e.g., implementation of traffic restraint devices, traffic calming and speed reduction, widening of sidewalks, well-marked crosswalks, lighting improvements, and landscaping). Others encourage adult supervision and groups walking together (e.g., the "Walking School Bus") to increase personal safety and security while meeting other objectives, such as reducing travel and health care costs, reducing congestion and improving air quality, and promoting fitness and health benefits.

Other factors in this category, such as perceptions about security and safety, influence modal choices and may not be consistent with other factors related to the relative safety of the various modes. For example, many believe that children are more secure in a passenger vehicle than on a bus. Likewise, a child who is beaten up on a bus may be statistically less likely than users of other modes to be killed in a vehicular crash, but the child's personal feeling of safety has been violated. In other cases, mode choices may be based purely on lifestyle factors, such as teenagers' preference for driving or riding in their peers' cars over traveling by transit or school bus.

In every modern society, the notion of safety—the protection of human life and property—exists alongside the concept of holding individuals and organizations accountable for providing and ensuring safety. This latter notion is termed *liability*. But safety and liability are not merely related; they are inextricably intertwined. While laws, regulations, and practices establish criteria presumably related to safety, verdicts and settlements often set standards that can diverge significantly from those criteria.

Under the American legal system, an attempt is made to define the elements and degrees of responsibility for safety (through statutes, regulations, and standards), nuances specific to each exercise of responsibility, the parties responsible, and the parties entitled to relief when responsibilities are not met. When a party violates prohibitions or fails to meet prescribed or generally accepted standards of care, that party is said to be *negligent*. Negligence consists of either things done wrong (errors of commission) or things not done that should have been (errors of omission). The U.S. legal system empowers the courts to assess monetary damages against parties who have violated various safety standards and practices. While designed to compensate victims and deter both types of errors, these assessments have increasingly raised transportation costs, consumed human resources, and often complicated the provision of goods and services. On the positive side, the notion of liability has provided an additional incentive for parties to improve safety in an effort to avoid burdensome judgments or damage awards.

Another societal factor—funding of school transportation—has become a major concern in recent years. Budgetary reductions in some school districts have resulted in competition for funding between transportation and classroom activities. These and other dynamics have led some states to consider alternatives for transporting students to and from school. For example, some smaller cities and rural areas have integrated a variety of student and social service transportation services with public transit services (thus mixing the school bus and other bus modes discussed in this study). However, federal law prohibits public transit agencies from providing exclusive school bus service (either separately or as part of their contracted provision of transit service) unless private operators are not available for the purpose. This prohibition was designed to ensure that transit agencies subsidized by public funds would not compete with private school bus operators. Public transit can, however, accommodate school children through regular transit service, including routes designed primarily for school travel (i.e., "tripper service"), as long as that service is open to the general public as well.

STRATEGIES FOR MANAGING RISK

The safety of a school travel mode is affected by a combination of factors from each of the above five risk categories, and the net impact of these factors (the relative risk) will differ across modes, locations, and students. Because of the complexity of the risk problem, it is likely that every community could take steps to improve the safety of every mode. However, limited resources, multiple objectives, and conflicting priorities may prevent a district from taking a safety-only perspective; communities must balance safety with other goals. To aid in this task, it would be ideal if precise calculations of the costs and benefits for different risk mitigation measures could be made. Unfortunately, this is not possible. Many of the salient studies that have been completed give only general estimates of risk reductions for specific situations, and the actual cost of implementing a measure could vary significantly among school districts. Moreover, some risk mitigation options have no real supporting empirical research, but are widely accepted as being "best practice."

Despite these limitations, the committee developed a set of checklists that it believes can provide decision makers with a rough (but useful) road map of the types of actions that could be considered to reduce the risks associated with each school travel mode. Many states and school districts may already have addressed most of the items on these checklists. For these districts, additional risk reduction could be expensive and difficult to attain. For others, however, the checklists, when combined with the national statistics highlighted in previous chapters, can serve as a valuable starting point for discussing and prioritizing risk mitigation options.

Before proceeding to the checklists, the committee wishes to emphasize a point made in Chapter 1: the importance of considering the entire transportation system. Any risk reduction measures must be undertaken with the understanding that a change in a risk factor associated with one mode can shift students from/to other modes and affect a school's overall risk in unexpected ways.

Finally, it should be noted that the range of topics covered in the checklists is quite large, and the committee has not conducted a comprehensive review of the issues involved; rather, issues judged to be important by the committee are highlighted as examples. Moreover, the cost-effectiveness of the various safety measures is unknown.

Checklist for School Bus

Questions	*Yes*	*No*
1. Do all school buses meet current required FMVSSs, including FMVSS 111, 131, and 222?		
2. Have all drivers been properly trained?		
3. Do school-age passengers receive training in loading, alighting, proper behavior while on board, and emergency procedures?		
4. Do the passengers on the bus behave properly to minimize driver distraction?		
5. Are school bus passengers under 60 pounds transported in child safety seats?		
6. Are children with special medical needs properly restrained and secured in school buses? Are wheelchairs, when needed, properly secured?		
7. Are students on small buses required to wear seat belts?		
8. Is after-hours/late bus service provided?		
9. Are pupil passengers kept separate from the general public?		

		Yes	No
10.	Are routes and pick-up/drop-off locations selected, designed, and checked periodically for safety?		
11.	Are school-age children required to cross roads with less than average traffic volume only to get to and from the bus stop?		
12.	Do driver training programs meet the recommendations of NHTSA's Guideline 17?		
13.	Do all drivers comply with FMCSA hours-of-service requirements?		
14.	Are onboard monitors required for the transportation of special-needs pupils?		
15.	Are all passengers provided a safe seat?		
16.	Are crossing guards employed to assist school-age children who need to cross the street?		
17.	Are roadways around the school adequate, safely designed, and in good repair?		
18.	Are passenger loading/unloading zones adequate and safely designed?		
19.	Are traffic flow patterns designed to avoid or minimize people–vehicle and vehicle–vehicle (e.g., bus and passenger vehicle) interactions/conflicts?		
20.	Are speed limits in school zones obeyed?		
21.	Are traffic control devices properly installed and maintained?		
22.	Are video cameras installed on the buses?		

Checklist for Other Bus

	Questions	*Yes*	*No*
1.	Do all buses meet current required FMVSSs?		
2.	Have all drivers been properly trained?		
3.	Do school-age passengers receive training in loading, alighting, proper behavior while on board, and emergency procedures?		
4.	Are school bus passengers under 60 pounds transported in child safety seats?		
5.	Do the passengers on the bus behave properly to minimize driver distraction?		
6.	Do all drivers comply with FMCSA hours-of-service requirements?		
7.	Are all school-age passengers provided a safe seat?		
8.	Is after-hours/late bus service provided?		
9.	Are routes and pick-up/drop-off locations checked for safety periodically?		
10.	Are pupil passengers kept separate from the general public?		

11. Are school-age children required to cross roads with less than average traffic volume only to get to and from the bus stop?	*Yes*	*No*
12. Are crossing guards employed to assist school-age children who need to cross the street?		
13. Are roadways around the school adequate and in good repair?		
14. Are passenger loading/unloading zones adequate and safely designed?		
15. Are traffic flow patterns designed to avoid or minimize people–vehicle and vehicle–vehicle (e.g., bus and passenger vehicle) interactions/ conflicts?		
16. Are speed limits obeyed?		
17. Are traffic control devices properly installed and maintained?		
18. Are video cameras installed on the buses?		

As mentioned previously, all motorized vehicles are subject to FMVSSs. In 1977, NHTSA issued three new FMVSSs and modified four others to enhance the safety of school bus transportation. However, some school buses that were built prior to 1977 and thus do not incorporate these more recent safety features are still used to transport school-age children. This use of older buses puts their passengers at greater risk.

The committee did not specifically address the issue of lap belts on school buses, given the previous TRB report (TRB 1989) and recent National Transportation Safety Board (NTSB) reports (NTSB 1999; NTSB 2000) addressing this issue. The NTSB (2000) report indicates that compartmentalization is an incomplete measure for lateral impact with vehicles of large mass and in rollover collisions. A more recent NHTSA report (NHTSA 2002), prepared since this committee completed its deliberations, shows that a lap/shoulder belt restraint system is superior to compartmentalization and to lap belts used in conjunction with compartmentalization. As school buses are replaced, they should have the newest and safest occupant protection system. California is the only state at present to have adopted lap/shoulder restraints for all school buses beginning in the 2004–2005 school year (California Vehicle Code Section 27316, Chapter 581, Statutes of 2001). NHTSA's ongoing research program is also addressing side-impact protection.

As discussed earlier, drivers of buses must possess a current CDL or other appropriate license or certification, and many operators provide periodic retraining and refresher training. Retraining occurs when a driver has had a given number of crashes and is required to undergo retraining in a particular area (this training does not involve all drivers in the system). Refresher training is given over a period of time for all drivers to keep their skills honed. It generally includes defensive driver training, passenger safety, fatigue awareness, and environmental and site-specific issues (e.g., snow, fog, security). Many believe this refresher training should occur at least annually, but the committee found insufficient evaluative documentation identifying the best time interval between refresher courses or the specific components that should be included in the training. It is also important for students to receive training on proper school travel behavior and safety, as discussed earlier, but once again, no evaluation studies could be found that indicated how often this training should be given for best retention or how the training should be carried out.

In the general roadway environment, it has been shown that heterogeneous traffic results in increased traffic fatalities (Fazio et al. 1999). Thus to further increase safety, modes should be separated in time (through dedicated movement times; e.g., no vehicles may be in an occupied crosswalk) or space (e.g., through pedestrian overpasses or tunnels). Special signage may also be used (see, e.g., Retting et al. 1996). If there are traffic signals at the ingress/egress points of the school, right-turn-on-red should probably not be permitted (see Preusser et al. 1984).[1]

Criteria for effective traffic control devices include conspicuity, legibility, glance legibility, comprehension, and response time. Various methods for evaluation of traffic control devices are available (see, e.g., Dewar and Ells 1974; Dewar and Ells 1984). Detailed analysis of the design and use of painted road markings has also been undertaken (see Commission internationale de l'eclairage 1988).

Checklist for Passenger Vehicle with Driver Younger Than 19

Questions	*Yes*	*No*
1. Is seat belt compliance high?		
2. Is a graduated driver licensing program being used?		
3. Are drivers alcohol and drug free?		
4. Is driver education conducted?		
5. Are the students required to remain on school grounds during school session hours unless they are enrolled in a work–study program or have special circumstances (e.g., doctor appointment, sickness)?		
6. Are roadways around the school adequate and in good repair?		
7. Are traffic flow patterns designed to avoid or minimize people–vehicle and vehicle–vehicle (e.g., bus and passenger vehicle) interactions/conflicts?		
8. Are speed limits obeyed?		
9. Do drivers show caution toward pedestrians on school grounds?		
10. Are traffic control devices properly installed and maintained?		

[1] For more information on street design and traffic calming, the reader is referred to the websites of ITE (www.ite.org) and the Surface Transportation Policy Project (www.transact.org).

Because of the rates of injuries and fatalities for passenger vehicles with teen drivers (see Chapter 3), the committee discourages the use of this mode. However, a number of risk factors could be addressed to help decrease the risk associated with this mode. For example, it has been estimated that the adoption and enforcement of primary safety belt use laws in all states could reduce the risk of nonfatal injuries by 2 percent and fatalities by 9 percent for individuals in passenger vehicles (Dinh-Zarr et al. 2001). Graduated driver licensing (GDL) programs (especially those with passenger limitations) may also reduce the risks associated with this mode. Such programs have proven effective in some states. In Michigan and North Carolina, for example, implementation of GDL provisions has led to marked reductions in crashes. According to Foss et al. (2001), Shope et al. (2001), and McKnight and Peck (2002), a carefully designed GDL system that introduces young drivers to driving in stages and provides practical experience for extended periods of time before unrestricted driving is permitted has been found to reduce crashes by 20 to 25 percent in the first years of driving. [See Foss and Evenson (1999) for a detailed review and analysis of evaluations of existing GDL systems.] Having a closed campus where unwarranted transportation during school hours is controlled can also reduce the possibility of crashes, and hence resulting fatalities and injuries.

Given the age of the driver (below age 19) for this mode, the human risk factors described earlier in this chapter need to be taken into consideration. For example, as noted above, previous studies of the driving behavior of young drivers have provided much useful information about the relationship between crashes and such behaviors as alcohol and substance use, risk taking, and sensation seeking. If compliance with speed limits, traffic signals, and the like is low, the risk associated with these factors is higher.

Finally, the previous discussion of the importance of traffic flow patterns and separation of different modes (especially at the school location), proper installation of traffic control devices, and adequate repair of roadways around the school applies equally to this mode.

Checklist for Passenger Vehicle with Driver 19 and Older

Questions	*Yes*	*No*
1. Is seat belt compliance high?		
2. Are drivers alcohol and drug free?		
3. Are roadways around the school adequate and in good repair?		
4. Are traffic flow patterns designed to avoid or minimize people–vehicle and vehicle–vehicle (e.g., bus and passenger vehicle) interactions/conflicts?		
5. Are speed limits obeyed?		
6. Do drivers show caution toward pedestrians on school grounds?		
7. Are traffic control devices properly installed and maintained?		

With the exception of GDL and driver education programs, the items on this checklist are the same as those for passenger vehicles with driver younger than 19. Most of the issues are the same as well, except those related specifically to younger drivers, and the reader is referred to the preceding discussion. It should be noted, however, that driver education programs have not been shown to be effective.

Checklist for Bicycling and Walking

Questions	*Yes*	*No*
1. Is appropriate crossing protection provided at intersections (e.g., crossing guards, signals, special signage)?		
2. Are students trained in safe bicycling and walking behaviors and practices?		
3. Are young bicyclists and walkers supervised or accompanied en route?		
4. Are bicycle helmets required and used? Is compliance enforced?		
5. Are safe and secure bicycling and walking routes designated?		
6. Are bicycle paths and sidewalks available and in good repair?		
7. Are traffic flow patterns designed to avoid or minimize people–vehicle and vehicle–vehicle (e.g., bus and passenger vehicle) interactions/ conflicts?		
8. Are students on bicycles required to dismount and walk their bicycles on school property?		
9. Are minimum walking distances realistic, given the associated risks?		
10. Are traffic control devices properly installed and maintained?		

Many interventions or countermeasures can be implemented to mitigate the risks to school-age children associated with these two modes. In particular, the risk of fatality and injury to a child bicyclist could be significantly reduced if bicycle helmets were worn universally. A meta-analysis of data from several countries indicates that bicycle helmets reduce the likelihood of bicyclist fatalities by 73 percent, of head injury by 60 percent, and of brain injury by 58 percent in crashes (Attewell et al. 2001).

The committee was unable to find objective evaluations of bicycling safety programs and walking programs for children; however, numerous such programs exist, and they are part of the overall education of many school-age children. As discussed earlier, age-appropriate educational programs, properly designed and evaluated, should be a component of the strategies used to enhance the safety of children traveling to and from school by these modes. In addition, operational improvements have been achieved through the installation of bicycle paths; to date, however, their safety impact has not been demonstrated (Harkey et al. 1998; Harkey and Stewart 1997). FHWA has published a *Good Practices Guide for Bicycle Safety Education* (2002); NHTSA, FHWA, and the Centers for Disease Control and Prevention (CDC) have published *National Strategies for Advancing Bicycle Safety* (2001); CDC and NHTSA have published *National Strategies for Advancing Child Pedestrian Safety* (2001); and the Pedestrian and Bicycle Information Center (PBIC) has published a *Walkability Checklist*. These resources identify goals communities should strive to attain and provide much information on actions that can be taken to achieve those goals. These actions can in turn mitigate the risks identified in this chapter that are of concern for school-age children.[2]

Finally, the risk of injuries and fatalities from bicycling and walking could be reduced if the interaction of different/mixed modes were minimized by reducing the number of times they must come together. For example, an infrastructure that included sidewalks, bicycle paths, and dedicated school-site access/egress for passenger vehicles in one area and bicyclists in another might be considered to increase safety for bicyclists and pedestrians. In addition, once on campus, bicycles should be walked.

SUMMARY

In assessing the comparative safety of the various school travel modes, their relative risks, and measures that can be taken to enhance their safety, one must consider a broad range of factors, as set forth in this chapter. It is also important to keep in mind that the risks associated with each mode are partly generic (e.g., buses have a greater mass than automobiles or bicycles) and partly with respect to conditions at the local level (e.g., a bicycle path may be safer than a road). Also to be taken into account are the community's resources and values.

The risk level of each mode can be affected positively or negatively by a variety of factors involved in its operations, as well as in the local infrastructure and environment. In many cases, engineering, education, and enforcement interventions whose effectiveness has already been proven by research can have a highly beneficial impact.

[2] There are many websites that address bicycle and walking safety. See, for example, the websites of PBIC (www.pedbikeinfo.org and www.walkinginfo.org.), the National Center for Bicycling and Walking (www.bikefed.org), U.S. Access Board (www.access-board.gov), NHTSA Traffic Safety Programs (www.nhtsa.dot.gov/people/injury/pedbimot/), the National SAFE KIDS Campaign (www.safekids.org), America Walks (www.americawalks.org), the Partnership for a Walkable America of the National Safety Council (www.nsc.org/walkable.htm), and Street Design and Traffic Calming for Pedestrian and Bicycling Safety (www.fhwa.dot.gov/environment/bikeped/index.htm).

The difficulty of evaluating the risks and making decisions accordingly is compounded by the fact that school trips often involve the use of more than one mode. Changes involving one mode used in the trip may affect the risks associated with the other, and in some cases may compound them. In addition, though students often go directly to school in the morning, they may take very different trips returning home in the afternoon, greatly complicating the analysis in this study and making it more difficult to define a school trip.

The integration or coordination of different modes, such as school bus and transit service, raises new challenges and opportunities that must be addressed at the operating level (e.g., both drivers and students may need different training), at the vehicle level (e.g., the features such vehicles should have to accommodate crossing), at the societal level (e.g., concerns for security and liability), at the human level (e.g., whether such hybrid services may be less safe for school children of certain ages), and at the environmental level (e.g., changes in roads, signage, and other infrastructure to accommodate the services). Such changes are often complex, reflecting decades of development and refinement aimed at optimizing safety and other aspects of these modes as traditionally operated. As NTSB has pointed out with respect to the comparative safety of school bus and motorcoach vehicles, a vehicle's safety is largely reflective of the type of service for which it is designed and in which it is operated.

Finally, it must be reiterated that while data presented in this report and elsewhere provide valuable insights regarding the safety of the various school travel modes and often the vehicles they deploy, such data are likely to be misleading if used to make policy changes at the local level without considering the factors that affect the safety of school travel for that community. While modes indeed have certain generic characteristics, it is also true that many of their characteristics differ markedly from place to place. Local conditions affecting these characteristics must be considered in such analyses and evaluations.

Some factors in each of the five categories can be controlled by policies at the local, state, and federal levels. Other factors, such as age and gender, cannot be changed but must be considered when making policy decisions. Still others, such as safety education, bicycle helmet laws, and availability of crosswalks, can be changed through direct policy choices made by decision makers. Infrastructure must be designed and constructed to accommodate the needs of children. The information provided in this chapter can be used to understand how the national risk estimates for each mode presented in Chapter 3 can be adjusted for local conditions and programs.

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Abbreviations

CDC	Centers for Disease Control and Prevention
FHWA	Federal Highway Administration
FTA	Federal Transit Administration

HHS	U.S. Department of Health and Human Services
ITE	Institute of Transportation Engineers
NCST	National Conference on School Transportation
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
OECD	Organization for Economic Cooperation and Development
TRB	Transportation Research Board

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5 Application of Risk Estimates: Illustrative Scenarios

In this chapter, three simple scenarios are used to illustrate how the results presented in Chapter 3 can be used in a quantitative risk assessment to analyze alternative policies and procedures regarding the transportation of children to and from school. The committee wishes to reiterate that the results of the risk analyses are based on national statistics and that care must be exercised in using those results to draw specific conclusions about local problems. It is important to keep in mind that the results of similar scenarios for any particular school district could be different from those presented here. However, the general insights gained from these types of analyses are applicable to many school districts and can serve as a starting point for discussion and for the application of the safety checklists presented in the previous chapter.

The three scenarios presented here illustrate the application of all four risk measures presented in Chapter 3: injuries and fatalities per 100 million student-miles and per 100 million student trips. The first scenario examines the effects of changing the minimum school bus pickup distances for a suburban elementary school and employs the *per student-mile* risk measures. The second scenario shows the benefits of adding a later after-school bus service to the pupil transportation services provided for a suburban middle school. The final scenario explores the impacts of doubling the size of a suburban/urban high school parking lot. These last two scenarios use the *per student trip* risk measures.

Though the risk estimates are based on national statistics, the three scenarios are set in well-defined but hypothetical school districts. In every case, realistic values for the schools were selected. The transportation mode distributions under different busing conditions were based on discussions with several school districts. It must be emphasized that an actual school would have to estimate these types of changes in travel mode usage through expert opinion or a survey sent to parents.

SCENARIOS

Scenario 1: Changing the School Bus Pickup Policy for a Suburban Elementary School

To examine how different school bus pickup policies would affect the risk to students, a hypothetical elementary school was created in a rural/suburban area. There are 250 students attending school. All students live within 10 miles of the school, although most live closer (20 percent within 1 mile, 50 percent within 3 miles). The students currently travel to school using a variety of modes. Table 5-1 shows the distribution of mode choices for students who live various distances from the school based on two minimum school bus pickup

TABLE 5-1 Scenario 1: Distribution of Travel Modes (percent) for 1-Mile and 2-Mile Minimum School Pickup Distances and No School Bus Service

Miles from School	Walk	Bike	School Bus	Adult Driver	Teen Driver	Other Bus
(a) 1-Mile Pickup Distance						
Less than 1	60	30	–	10	–	–
1–1.5	30	20	35	15	–	–
1.5–2	8	8	49	35	1	–
2–3	3	8	49	40	1	–
3–4	–	–	54	45	1	–
4–5	–	–	59	40	1	–
5–6	–	–	59	40	1	–
6–7	–	–	59	40	1	–
7–8	–	–	59	40	1	–
8–9	–	–	59	40	1	–
9–10	–	–	59	40	1	–
(b) 2-Mile Pickup Distance						
Less than 1	60	30	–	10	–	–
1–1.5	50	35	–	15	–	–
1.5–2	36	26	–	37	1	–
2–3	3	8	49	40	1	–
3–4	–	–	54	45	1	–
4–5	–	–	59	40	1	–
5–6	–	–	59	40	1	–
6–7	–	–	59	40	1	–
7–8	–	–	59	40	1	–
8–9	–	–	59	40	1	–
9–10	–	–	59	40	1	–
(c) No School Bus Service						
Less than 1	60	30	–	10	–	–
1–1.5	50	35	–	15	–	–
1.5–2	36	25	–	37	2	–
2–3	22	16	–	60	2	–
3–4	5	10	–	82	3	–
4–5	–	5	–	92	3	–
5–6	–	–	–	97	3	–
6–7	–	–	–	97	3	–
7–8	–	–	–	97	3	–
8–9	–	–	–	97	3	–
9–10	–	–	–	97	3	–

distances—1 mile and 2 miles—and the case of no school bus service. In all cases, students who live close to school predominantly walk. As the living distance from school increases, more students take a school bus or are driven by someone else. As the minimum school bus pickup distance increases, more students have to rely on other, non–school bus modes. For example, it was assumed that 49 percent of the students living between 1.5 and 2 miles from school would take a school bus if it were available. However, if bus service were eliminated for these students, a sizable number would shift to walking or bicycling, and a few more would be driven by their parents.

Tables 5-2 through 5-4 convert these distributions of children by travel mode into average numbers of children/day and total student-miles traveled/year by mode for the three school bus pickup policies. Fractional numbers are permitted because students may use different modes on different days. To compute total distance traveled by students living at the various distances and taking the different modes, an average trip-length multiplier was used. It was assumed that a student walking to school would take a fairly direct path and would travel a distance closest to the direct distance; the multiplier for a walking student was estimated to be 1.25 times the direct distance. School buses, with their more complex routing, had the largest multiplier (1.75 times the direct distance). Bicycling and the other motor vehicle categories had multipliers of 1.30 and 1.50, respectively. For an actual school, these numbers would most likely have to be approximated.

Using these multipliers and the number of children using each transportation mode at each distance from school, the total annual miles for each mode can be calculated. These results are shown in the Tables 5-2(b), 5-3(b), and 5-4(b) for the three different policies. The number of total miles may, at first glance, appear to be surprisingly large. For the 1-mile minimum school bus pickup distance [Table 5-2(b)], the students log more than 285,000 miles riding school buses, nearly 175,000 miles in parents' cars (drivers age 19 and older), more than 12,000 miles walking, nearly 11,000 miles bicycling, and more than 4,000 miles in cars with drivers younger than 19. The overall total is just under 0.5 million student-miles per year for this relatively small elementary school.

Using the hazard rates from Chapter 3 (Tables 3-4 and 3-5, using mean values for ages 5–10) and these annual student-miles by travel mode, risk estimates for the school can be calculated [Tables 5-2(c), 5-3(c), and 5-4(c)]. For example, from Table 3-4, the average injury rate per 100 million student-miles for a child aged 5–10 bicycling is 2,625. In this hypothetical school, the students bicycle 10,962 miles per year under the 1-mile minimum school bus pickup distance [Table 5-2(b)]. Thus, the expected number of injuries per year for children who bicycle is

$$\text{Expected bicycle injuries/year} = \frac{2{,}625 \times 10{,}962}{100{,}000{,}000} = 0.29$$

This number appears in Table 5-2(c) under the bicycle column. Similar calculations are done for the other modes, for fatalities, and for the different pickup distances. These values can be summed across all modes to obtain an overall injury and fatality risk for the school.

TABLE 5-2 Scenario 1: Travel and Risk Measures for 1-Mile Minimum School Bus Pickup Distance

	Walking	Bicycling	School Bus	Adult Driver	Teen Driver
(a) Number of Students by Transportation Mode					
Miles from school					
Less than 1	28.5	14.3	–	4.8	–
1–1.5	7.1	4.8	8.3	3.6	–
1.5–2	1.4	1.4	9.2	6.6	0.2
2–3	0.9	2.8	18.4	15.0	0.4
3–4	–	–	17.6	14.6	0.3
4–5	–	–	16.2	11.0	0.3
5–6	–	–	13.3	9.0	0.2
6–7	–	–	10.3	7.0	0.2
7–8	–	–	7.4	5.0	0.1
8–9	–	–	4.4	3.0	0.1
9–10	–	–	1.5	1.0	0.0
Total students	**38**	**23**	**107**	**81**	**2**
% of students	**15**	**9**	**43**	**32**	**1**
(b) Student Miles per Year by Transportation Mode					
Miles from school					
Less than 1	6,413	3,463	–	1,283	–

1–1.5	4,008	2,886	6,546	2,405	–
1.5–2	1,107	1,196	10,129	6,202	177
2–3	1,055	3,417	28,941	20,250	506
3–4	–	–	38,698	27,641	614
4–5	–	–	45,998	26,730	668
5–6	–	–	45,998	26,730	668
6–7	–	–	42,281	24,570	614
7–8	–	–	34,847	20,250	506
8–9	–	–	23,696	13,770	344
9–10	–	–	8,828	5,130	128
Total miles/year	**12,582**	**10,962**	**285,961**	**174,960**	**4,227**
% miles	**3**	**2**	**59**	**36**	**1**
(c) Risk Measures					
Injuries/year	0.09	0.29	0.04	0.13	0.11
% of injuries	14	44	6	20	16
Fatalities/year	0.0017	0.0023	0.0003	0.0005	0.0006
% of fatalities	32	43	5	9	12
Total injuries per year	**0.659**				
Total fatalities per year	**0.0054**				

TABLE 5-3 Scenario 1: Travel and Risk Measures with 2-Mile Minimum School Bus Pickup Distance

	Walking	Bicycling	School Bus	Adult Driver	Teen Driver
(a) Number of Students by Transportation Mode					
Miles from school					
Less than 1	28.5	14.3	–	4.8	–
1–1.5	11.9	8.3	–	3.6	–
1.5–2	6.8	4.9	–	6.9	0.2
2–3	0.9	2.8	18.4	15.0	0.4
3–4	–	–	17.6	14.6	0.3
4–5	–	–	16.2	11.0	0.3
5–6	–	–	13.3	9.0	0.2
6–7	–	–	10.3	7.0	0.2
7–8	–	–	7.4	5.0	0.1
8–9	–	–	4.4	3.0	0.1
9–10	–	–	1.5	1.0	0.0
Total students	**48**	**30**	**89**	**81**	**2**
% of students	**19**	**12**	**36**	**32**	**1**
(b) Student Miles per Year by Transportation Mode					
Miles from school					
Less than 1	6,413	3,463	–	1,283	–

1–1.5	6,680	5,050	–	2,405	–
1.5–2	5,316	4,146	–	6,556	177
2–3	1,055	3,417	28,941	20,250	506
3–4	–	–	38,698	27,641	614
4–5	–	–	45,998	26,730	668
5–6	–	–	45,998	26,730	668
6–7	–	–	42,281	24,570	614
7–8	–	–	34,847	20,250	506
8–9	–	–	23,696	13,770	344
9–10	–	–	8,828	5,130	128
Total miles/year	**19,463**	**16,076**	**269,286**	**175,314**	**4,227**
% miles	**4**	**3**	**56**	**37**	**1**
(c) Risk Measures					
Injuries/year	0.14	0.42	0.04	0.13	0.11
% of injuries	17	50	4	16	13
Fatalities/year	0.0026	0.0034	0.0003	0.0005	0.0006
% of fatalities	36	46	4	6	9
Total injuries per year	**0.842**				
Total fatalities per year	**0.007**				

TABLE 5-4 Scenario 1: Travel and Risk Measures for No School Bus Service

	Walk	Bike	School Bus	Adult Driver	Teen Driver
(a) Number of Students by Transportation Mode					
Miles from school					
Less than 1	28.5	14.3	–	4.8	–
1–1.5	11.9	8.3	–	3.6	–
1.5–2	6.8	4.7	–	6.9	0.4
2–3	8.3	6.0	–	22.5	0.8
3–4	1.6	3.3	–	26.7	1.0
4–5	–	1.4	–	25.3	0.8
5–6	–	–	–	21.8	0.7
6–7	–	–	–	17.0	0.5
7–8	–	–	–	12.1	0.4
8–9	–	–	–	7.3	0.2
9–10	–	–	–	2.4	0.1
Total students	**57**	**38**	**-**	**150**	**5**
% of students	**23**	**15**	**-**	**60**	**2**
(b) Student Miles per Year by Transportation Mode					
Miles from school					
Less than 1	6,413	3,463	–	1,283	–
1–1.5	6,680	5,050	–	2,405	–
1.5–2	5,316	3,987	–	6,556	354
2–3	9,281	7,290	–	30,375	1,013
3–4	2,559	5,528	–	50,369	1,843
4–5	–	3,007	–	61,479	2,005
5–6	–	–	–	64,820	2,005
6–7	–	–	–	59,582	1,843
7–8	–	–	–	49,106	1,519
8–9	–	–	–	33,392	1,033
9–10	–	–	–	12,440	385
Total miles/ year	**30,248**	**28,325**	**-**	**371,807**	**11,998**
% miles	**7**	**7**	**-**	**86**	**3**
(c) Risk Measures					
Injuries/year	0.22	0.74	–	0.29	0.31
% of injuries	14	48	0	18	20
Fatalities/year	0.0041	0.0060	–	0.0010	0.0018
% of fatalities	32	46	0	8	14
Total injuries per year	**1.555**				
Total fatalities per year	**0.013**				

For the 1-mile school bus pickup distance, the total injury rate is approximately 1 injury every 1.5 years[1] and 1 fatality every 185 years.[2] The majority of these risks (more than 70 percent) involve students who walk and ride bicycles, even though these students account for just 25 percent of the trips and log only 5 percent of the student-miles traveled. If the minimum school bus pickup distance is increased to 2 miles (Table 5-3) or if school bus service is eliminated altogether (Table 5-4), more students will depend on transportation modes that are disproportionately riskier, and injuries and fatalities per year will increase.

To perform this analysis, it was assumed that students who no longer took a school bus would adopt new transportation modes in rough proportion to those already using the various modes. This impact can be seen in Figure 5-1: increasing the minimum pickup distance from 1 to 2 miles would increase the student risk by more than 27 percent, while eliminating school bus service would more than double the student risk as compared with a 1-mile pickup policy.

Scenario 2: Adding School Bus Service for Students Attending After-School Activities

A hypothetical suburban middle school with 750 students was used to demonstrate how additional after-school bus service might affect total transportation

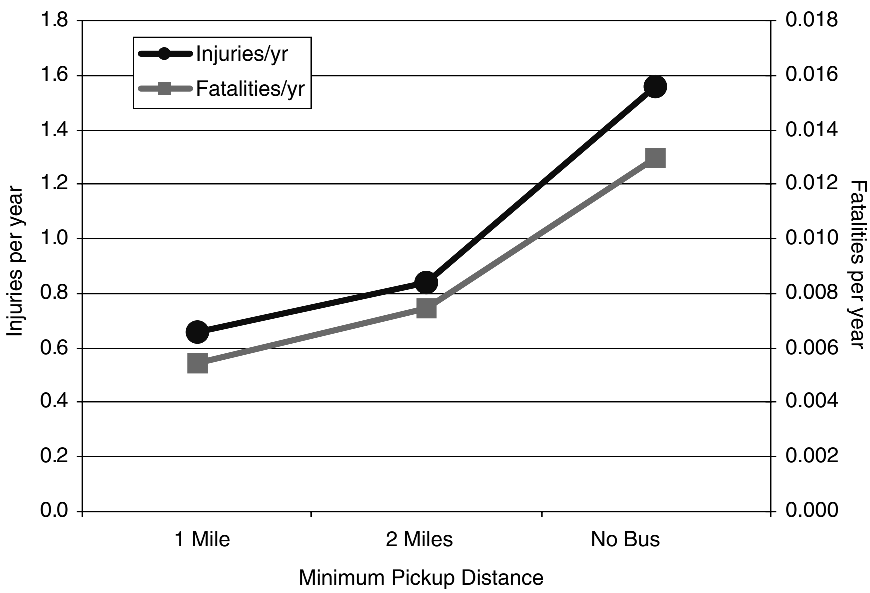

FIGURE 5-1 Scenario 1: effects of minimum school bus pickup distances on student injuries and fatalities per year.

[1] This injury rate includes all severities of nonfatal injury (Types A, B, and C). Most injuries are Type C and do not require significant medical treatment.

[2] Looking at the risk from another perspective, given 100 schools of this size, two-thirds of the schools will have one injury every year, and only 0.9 schools will have a fatality every year.

risk. The distribution of the transportation modes for the base case with no after-school bus service is shown in Table 5-5(a). This distribution includes all students for the afternoon trip from school. Most students either take the bus (35 percent) or are driven by a parent (35 percent); nearly 20 percent walk, and 10 percent bicycle. Because of its suburban location, no public transit service was assumed for this school.

Using the per student trip risk measures derived in Chapter 3 (Tables 3-6 and 3-7, using mean values for children aged 11–13) and the expected number of trips per day by mode from Table 5-5(a), and assuming 180 days per school year, annual risks were calculated. For bicycle trips, for example, there are 2,057 injuries per 100,000,000 trips for those aged 11–13 (Table 3-6), and 75 students ride bicycles every day [Table 5-5(a)]. Therefore, the calculation for bicycle injuries is

TABLE 5-5 Scenario 2: Effects of Adding Bus Service for Students Participating in After-School Activities, Showing Afternoon Trips for All Students (Students 11–13 Years Old)

	% of Mode	No. of Students	Injuries per Year	Fatalities per Year
(a) No After-School-Activity Bus Service				
School bus	35	263	0.05	0.0001
Other bus	0	–	–	–
Passenger vehicle (adult driver)	35	263	0.20	0.0006
Walking	19	143	0.09	0.0010
Bicycling	10	75	0.28	0.0016
Passenger vehicle (teen driver)	1	8	0.04	0.0003
Total	**100**	**750**	**0.66**	**0.0035**
Years between events			**1.52**	**283**
(b) After-School-Hours-Activity Bus Service Added				
School bus	48	360	0.07	0.0001
Other bus	0	–	–	–
Passenger vehicle (adult driver)	30	225	0.17	0.0005
Walking	15	113	0.07	0.0008
Bicycling	7	53	0.19	0.0011
Passenger vehicle (teen driver)	0	–	–	–
Total	**100**	**750**	**0.51**	**0.0025**
Years between fatalities			**1.98**	**396**
(c) Net Effect of New Policy				
Change in risk (%)			–23	–29

$$\text{Expected bicycle injuries/year} = \frac{2{,}057 \times 75 \times 180}{100{,}000{,}000} = 0.28$$

As in the previous scenario, this calculation is repeated for all modes and the fatality risk measures. The results are then summed to determine the injury and fatality rates for the entire school over 1 year. To put these small decimal values in perspective, the number of years between injuries and fatalities (the reciprocal of the annual rates) is also shown. For this hypothetical school, a student injury can be expected to occur slightly more than once every 1.5 years and a fatality to occur on average once every 280 years.

In this hypothetical example, it was assumed that 120 students (approximately 15 percent of the student population) participate in some type of after-school activity (e.g., sports, clubs, band). With the addition of a new bus service in the late afternoon, some of the students who would previously have walked, bicycled, or received a ride from a parent now take the bus. The new distribution of transportation modes is shown in Table 5-5(b). With the shift away from the riskier transportation modes to the relatively safer school bus category, the students' overall risk is reduced. In this hypothetical case, the risk of injuries decreases 23 percent per year and the risk of fatalities decreases 29 percent per year with the new bus service.

Scenario 3: Increasing Student Parking at a High School

The third scenario involves a hypothetical suburban/urban high school with 2,400 students. Mass transit is available for some of the students (7.5 percent), but most commute by school bus (30 percent) or by passenger vehicle with adult driver (22.5 percent) or teen driver (22.5 percent). It is assumed that the neighborhood around the school has been affected by student parking on local streets and that a permit-parking program is now strictly enforced to prevent unauthorized student parking. More students would drive if they could find legal parking. Because the risk measures in Chapter 3 vary with the age of the students, two separate calculations are necessary: one for those aged 14–15 and one for those aged 16–18. Table 5-6(a) shows the initial distribution of transportation modes for these two age categories.

As in the second scenario, the per student trip risk measures are used to calculate annual injury and fatality rates and times between injuries and fatalities. Once again the risk measures from Chapter 3 (Tables 3-6 and 3-7 for those aged 14–15 and 16–18, respectively) are used in conjunction with specific information about the school and the students' travel modes. Following the same process as in the previous scenario, risks per trip and trips per year are used to calculate an estimate of the total risk for the school. These values are shown at the bottom right of Table 5-6(a). In this case, the student population will average nearly eight injuries per year and have a fatality once every 20 years.

Of all the scenarios, this one has the greatest negative effect on school travel safety. If the school encourages student driving by doubling the number of student parking spaces, the risks faced by the student population increase considerably. Travel shifts from the relatively safer school bus and other bus modes

TABLE 5-6 Scenario 3: Effects on Travel Risk of Increasing Student Parking

	% of Mode	No. of Students	Injuries per Year	Fatalities per Year
(a) No After-School-Activity Bus Service				
14–15 Years Old				
School bus	35	420	0.21	0.0004
Other bus	10	120	0.02	0.0000
Passenger vehicle (adult driver)	20	240	0.45	0.0011
Walking	15	180	0.18	0.0023
Bicycling	5	60	0.28	0.0010
Passenger vehicle (teen driver)	15	180	2.76	0.0184
Total for age group	**100**	**1,200**	**3.90**	**0.023**
Years between events			**0.3**	**43.1**
16–18 Years Old				
School bus	25	300	0.45	0.0002
Other bus	5	60	0.03	0.0000
Passenger vehicle (adult driver)	25	300	0.99	0.0048
Walking	12	144	0.18	0.0019
Bicycling	3	36	1.00	0.0032
Passenger vehicle (teen driver)	30	360	1.38	0.0152
Total for age group	**100**	**1,200**	**4.02**	**0.025**
Years between events			**0.2**	**39.4**
School total			**7.92**	**0.05**
Years between events for school			**0.13**	**50.56**
(b) 600 Student Parking Spaces				
14–15 Years Old				
School bus	25	300	0.15	0.0003
Other bus	5	60	0.01	0.0000
Passenger vehicle (adult driver)	20	240	0.45	0.0011
Walking	12	144	0.14	0.0019
Bicycling	3	36	0.17	0.0006
Passenger vehicle (teen driver)	35	420	6.43	0.0428
Total for age group	**100**	**1,200**	**7.36**	**0.047**
Years between events			**0.1**	**21.4**
16–18 Years Old				
School bus	15	180	0.32	0.0001

(*continued*)

TABLE 5-6 (continued) **Scenario 3: Effects on Travel Risk of Increasing Student Parking**

	% of Mode	No. of Students	Injuries per Year	Fatalities per Year
Other bus	5	60	0.01	0.0000
Passenger vehicle (adult driver)	20	240	1.24	0.0038
Walking	7	84	0.14	0.0011
Bicycling	3	36	0.60	0.0032
Passenger vehicle (teen driver)	50	600	2.76	0.0254
Total for age group	**100**	**1,200**	**5.07**	**0.034**
Years between events			**0.2**	**29.7**
School total			**12.43**	**0.08**
Years between events for school			**0.08**	**12.43**
(c) Net Effect of New Policy				
Change in risk (%)			+57	+65

to the less safe passenger vehicle with a teen driver. Moreover, interaction among the modes at the school, though not modeled in this scenario, will increase the risk to school-age pedestrians and bicyclists, who will now have to deal with increased traffic density as a result of the greater availability of parking. To complete the analysis, it was necessary to make assumptions about how these shifts would occur; the results are shown in Table 5-6(b). Injuries per year increase 57 percent to more than 12 per year, and fatalities per year increase nearly 65 percent to 1 every 13 years. As expected, the results are highly sensitive to the assumptions made about travel mode shifts. For this school, any policy resulting in an increase in teens driving to school is not advocated.

CONCLUSIONS

The scenarios presented in this chapter illustrate how the risk measures from Chapter 3 can be used with local school information to complete an assessment of the risks associated with different school travel policies. In these examples, adding after-school bus service or changing the minimum school bus pickup distance can easily increase or decrease injury and fatality risks by 20 to 50 percent or more. Though these cases are hypothetical, they are realistic. The use of risk estimates based on national averages does limit the accuracy of results for specific applications, but these types of analyses nonetheless provide policy makers with important insights into the risks associated with the different modes.

As noted in earlier chapters, local conditions can change the magnitude of and relationships among these risks. Schools that have in place many of the risk reduction options suggested by the safety checklists presented in Chapter 4 can have risk rates below those used in these scenarios. For example, a well-designed network of bicycle paths separated from motor vehicle traffic would likely reduce the risks of bicycling below those shown in Chapter 3 and used in this chapter. Similarly, improvements in sidewalks, speed limit enforcement, and deployment of crossing guards would likely reduce the risks associated with walking to school to levels below those used in the scenarios. Unfortunately, the data available to the committee were not sufficient to determine the extent of risk reduction associated with these and other risk mitigation options. Nevertheless, before adopting policies that shift the distribution of travel among modes, policy makers would be well advised to consider the trade-offs involved. Budgetary and other criteria must be considered in conjunction with the injury and fatality risks derived in this study and illustrated in the above scenarios. School transportation solutions to districtwide equity or school-choice problems can have safety implications. Increases in risk might be justified if the monetary savings were applied to other, more pressing problems; however, large increases in risk in exchange for modest savings could prove difficult to defend.

6 Conclusions and Recommendations

Students use many modes to travel to and from school and school-related activities. As the scenarios in Chapter 5 demonstrate, the risk factors associated with these modes are complex and highly interrelated. Changes in any one characteristic of school travel can lead to dramatic changes in the overall risk to the student population. Thus, it is important for school transportation decisions to reflect input from those representing a spectrum of disciplines and perspectives, including policy makers, transportation planners, traffic engineers, school administrators, drivers, parents and students, and possibly others who may have knowledge or expertise regarding the use and safety of the various modes used for school travel.

For this study, the committee grouped the modes used for school travel into six broad categories for analysis: (*a*) school buses, (*b*) all other buses, (*c*) passenger vehicles with adult drivers, (*d*) passenger vehicles with teen drivers, (*e*) bicycles, and (*f*) walking. Estimates of relative risk among these modes were developed using available information collected at the national level. Because data on trip purpose are not included in the available datasets, the data analyzed were deaths, injuries, number of trips, and student miles traveled during normal school travel hours.

It must be recognized, of course, that school districts, parents, and school-age children choose travel modes for many reasons other than safety. The approach suggested by the committee is to balance safety- and non-safety-related factors. The committee believes this reconciliation can best be achieved when a broad range of factors and perspectives is considered, and when choices are supported with accurate data and perceptive, experienced observations.

QUANTITATIVE ANALYSES

The Nationwide Personal Transportation Survey (NPTS) was used to obtain data on the number of trips made and miles traveled by school-age children during normal school travel hours. The Fatality Analysis Reporting System (FARS) and the General Estimates System (GES) datasets were used to obtain outcome data (number of fatalities and number of injuries) for school-age children during these same time periods. The data were then grouped into age groupings and combined across multiple years to reduce the effects of anomalies in the data and allow the development of more robust estimates.

Using the NPTS dataset, it was determined that school bus service accounts for approximately 25 percent of trips and 28 percent of student-miles traveled during normal school travel hours and other buses for about 2 to 3 percent of trips and student-miles traveled. Passenger vehicles (with adult and teen drivers) represent 60 percent of trips and 66 percent of student-miles traveled. Student pedestrian travel accounts for 12 percent of trips, but only 1 percent of student-miles. (See Tables 2-2 and 2-3 in Chapter 2, as well as the tables in Annexes 2-1 and 2-2, for a breakdown of the data.)

Approximately 75 percent of the deaths and 84 percent of the injuries resulting from crashes during normal school travel hours occurred in the two passenger vehicle categories, while only 2 percent of deaths and 4 percent of injuries occurred on school buses. Fatalities and injuries to student bicyclists and pedestrians involved in crashes represent the next-largest share—22 percent and 11 percent, respectively. (See Tables 2-6 through 2-11 in Chapter 2 for a breakdown of the fatality and injury data.)

Three modes (school buses, other buses, and passenger vehicles with adult drivers) have injury estimates and fatality counts below those expected on the basis of the exposure to risk implied by the number of trips taken and student-miles traveled. Conversely, the other three modal classifications (passenger vehicles with teen drivers, bicycling, and walking) have estimated injury rates and fatality counts disproportionately greater than expected on the basis of exposure data. For example, passenger vehicles with teen drivers account for more than half of the injuries and fatalities, a much greater proportion than the 14–16 percent that would be expected (see Table 3-3 in Chapter 3).

IDENTIFYING AND MANAGING RISK

The committee developed a risk assessment process in which quantitative estimates of travel mode risk derived from national statistics (or other sources) can be combined with local student demographics and travel mode distributions to calculate risk estimates for a school or region. Using this process, school officials and families can better understand, prioritize, and manage the risks of school travel. Moreover, the effects of changing the relative safety of a mode or shifting students among modes can be appreciated. In particular, the committee's approach can highlight when policy changes intended to improve one aspect of safety inadvertently increase risks in other areas.

Because the committee's findings are based on national averages, exact risk reductions that would occur for a local school district using various risk mitigation measures cannot be determined. Each district has unique environmental and operational characteristics that result in different levels of risk associated with each mode. Shifts from those modes that are overrepresented in crashes (bicycling, walking, and passenger vehicles with teen drivers) to those that are underrepresented (school buses, other buses, and passenger vehicles with adult drivers) represent one way of lowering risks that should be considered. This is not, however, the only way to manage the risk associated with school travel; measures designed to enhance the safety of particular modes—e.g., changing school bus pickup and drop-off locations, changing passenger vehicle pickup and drop-off locations, enforcing bicycle helmet laws, and implementing and enforcing graduated driver licensing programs—can also be employed. To help inform the risk mitigation evaluation process, the committee has also created for each school travel mode safety checklists that delineate opportunities that have been shown to reduce risk or are accepted as best practice. Combining quantitative risk assessment measures with these safety checklists creates a risk management framework that can be used to provide guidance to those who must make many types of safety-related school travel decisions.

The risk management framework can help inform local decisions on such matters as school siting, student parking policies, and changes in the minimum walking distance (the distance from school below which school bus service is not provided). The framework reveals, for example, that absent the provision of adequate infrastructure for pedestrians and bicyclists, other policy decisions (e.g., a simple change in the minimum walking distance from 1 to 2 miles) could increase the overall risk. As another example, a decision to accommodate more teen driving by increasing the number of parking spaces at a suburban high school could increase injury and fatality risks significantly. Alternatively, a policy of closing the school campus during school hours would improve safety by eliminating student motor vehicle and pedestrian trips for lunches off campus, running of errands, and similar purposes. Altering the environment and infrastructure to improve the safety of a mode is another approach to be considered.

Risk estimates developed in Chapter 3 can also be helpful to local and state transportation agencies in making more informed decisions regarding the allocation of available funds for infrastructure improvements designed to reduce situations in which motor vehicles, pedestrians, and bicyclists conflict with one another. These estimates can assist as well in determining the advisability of policies to address bicycling safety (such as helmet laws); strategies to improve occupant safety (such as laws mandating use of safety belts); strategies to reduce the risks of teen driving (such as graduated licensing programs already enacted in many states); and modifications to the environment to avoid conflict at school sites among pedestrians, bicyclists, and motor vehicles. More evaluation and research are needed to assist state and local decision makers in reducing student risk in the most cost-effective manner.

To increase the likelihood of implementing effective policies, it is important to have input and support from all stakeholders. To this end, there must be open communication in sharing information on policies, procedures, and guidelines that enhance safety. If the participants in such a process understand the risks associated with the various modes and the means by which those risks can be reduced, they can work cooperatively to achieve safety improvements. Knowledge of the relative risks of the various modes can be used by communities to focus resources on those modal improvements for which the expenditure of resources can effect the greatest safety improvements. A well-thought-out risk management program that measures the risks and benefits of the various modes and identifies a set of reasonable risk mitigation alternatives for each mode would facilitate relevant discussions among the stakeholders.

Recommendation 1: School transportation planners and policy makers at all levels should analyze transportation risks comprehensively in their decision making related to school travel.

Application of the results of risk analyses—a major component of the committee's risk management framework that is illustrated in Chapter 5—reveals how decisions affecting one mode of school travel influence the risks faced by users of other modes. Decisions about such issues as increasing or decreasing student parking, changing the minimum walking distance, and providing bus services can significantly affect overall risk in ways that may not appear obvious. The risk management framework can highlight the importance of such choices and allow a full appreciation of their implications. It does not, however, stand alone. School transportation planners and policy makers must also take into account budget constraints, local conditions and values, local data, and judgments about the relative safety and cost-effectiveness of alternative policies.

Recommendation 2: Using a systematic risk management framework, school districts should identify the risk factors most salient for the modes of school travel used by children in their community and identify approaches that can be used to manage and reduce those risks, including shifts to safer modes and safety improvements within each mode.

Each school district, and even schools within a district, will have different conditions and requirements that will affect school travel risks and the choices of officials and parents for reducing those risks. When resources permit, districts should support strategies that promote safety, such as reducing the number of teen drivers, designing bus services to better meet needs (e.g., offering early and late bus services, and providing bus services to different morning and afternoon locations), as deemed appropriate for that school or district. Districts can also adopt policies designed to support walking and bicycling to school in order to promote healthy lifestyles after carefully assessing the adequacy of sidewalks, bicycling paths, crosswalks, and other supporting infrastructure and safety measures, and making improvements where needed.

Recommendation 3: The U.S. Department of Transportation (USDOT) should disseminate information presented in this study on the relative risks of using various modes of travel for school and school-related activities and on possible ways to mitigate the risks. USDOT should also use this information to assess what role, if any, federal policy makers should have in efforts to improve the transportation safety of school children and the cost-effectiveness of specific safety measures.

State and local legislators, school boards, parent–teacher associations, private and church schools, parents, students, and the media all play a role in decisions about school transportation. The national-level data presented in this report provide a starting point for such decision making by highlighting the considerable differences in risk across modes of travel. Local risk estimates will differ from these national estimates, however. School officials, as well as state and local officials responsible for transportation facilities and operations, parents, and others, need information on how to assess the adequacy of their school transportation systems. They also need information on the relative risks and cost-effectiveness of various safety measures, and on how to promote safety across and within modes in the most cost-effective ways. Such information is currently lacking.

DATA

Numerous databases contain information related to transportation safety. Most of these databases, however, were not useful for this study because they do not allow comparison across modes so that exposure to risk can be analyzed in a consistent manner. One of the primary responsibilities and contributions of the agencies whose mission encompasses issues related to school transportation is to collect good, accurate, reliable data. Current data are illuminating, but not complete. Yet obtaining more thorough and complete data is not without cost. Given the large number of fatalities and injuries that occur on highways in the United States and the relatively small proportion that involve students during normal school travel hours, the benefits of additional data collection efforts focused solely on school travel should be carefully considered before such efforts are recommended or implemented.

At present, the lack of uniformity in local- and state-level data collection requirements and methodology, together with the lack of consistency in definitions and interpretations across and within datasets, makes it difficult and often impossible to address student as well as other transportation issues of interest. An integrated data system (one in which different databases would use many of the same variables, definitions, and data collection procedures) is needed to enable a better understanding of the risks associated with the various modes of travel, not just for school transportation safety, but for highway safety in general. If performed correctly, a consistent, comprehensive data collection effort could benefit school transportation as well.

Recommendation 4: The compatibility and completeness of existing databases should be examined and improved by USDOT and other agencies to allow development of better risk estimates. To the extent possible, critical data elements (e.g., vehicle classifications, roadway classifications) should be included and defined consistently in all the datasets.

The three data sources relied upon in this report—NPTS, FARS, and GES—are the best available but are not fully compatible because of different variables, definitions, and classifications. A first step would be for USDOT and other appropriate agencies to explore the possibility of changing definitions and classifications to make them more consistent. Doing so would enable the development of more precise risk estimates than could be accomplished in this study. Similarly, it may be possible to adjust for weaknesses in one or more of these datasets by examining other datasets. For example, GES excludes nontraffic injuries, such as a fall from a bicycle when no motor vehicle is involved, thus introducing a bias in the estimates. Sample data from hospital records on bicycling injuries might allow for adjustments to correct for such bias.

Recommendation 5: USDOT and appropriate agencies, in consultation with outside experts, should analyze the advisability and cost-effectiveness of establishing and maintaining any new school transportation–related database.

The committee encountered many difficulties in developing estimates of risk by mode for school travel and could develop only national-level estimates. Moreover, it was not possible to estimate the risk of travel for school-related activities because of a lack of relevant data. However, the magnitude of the school transportation safety problem does not appear to warrant major expenditures for new data collection efforts. Rather, cost-effective means of collecting new data using existing structures, both governmental and nongovernmental, should be explored and identified. The national school bus loading zone fatality survey conducted annually by the Kansas Department of Education, for example, is a volunteer data collection structure that has provided valuable information for more than 30 years at minimal cost.

It is also important to know the purpose for which data are to be used before they are collected. It may be that estimates of cost-effectiveness and better estimates of risk can be derived by carrying out Recommendations 3 and 4 without the need for extensive new data collection; if not, it may be prudent to collect more and better data. Such choices, however, should be based on the policy decisions the data are expected to inform.

SUMMARY

Without doubt, travel of children to and from school is a complex and sensitive issue. Each travel mode has its attendant risks, which vary from community to community and school to school, and any shifts from one mode to another can have a marked effect on the overall safety of school travel for a particular community or school. A risk management framework can be used to identify, analyze, and prioritize the risks associated with student travel, and in turn to formulate interventions that can be used to manage these risks. Risk measures can be applied to analyze alternative policies at the state and local levels (as is demonstrated in the scenarios in Chapter 5), and various existing countermeasures can be implemented to reduce the risks to students who use the various modes (as discussed in Chapter 4). Each state, school district, and private school must assess its own situation and circumstances and apply the information presented in this report to make sound, informed decisions. The goal is to improve safety for all children traveling to and from school and school-related activities and to provide communities with the information needed to make informed choices that balance their needs and resources.

APPENDIX

Transportation Equity Act for the 21st Century

Section 4030, School Transportation Safety

(a) Study.—Not later than 3 months after the date of enactment of this Act, the Secretary shall offer to enter into an agreement with the Transportation Research Board of the National Academy of Sciences to conduct, subject to the availability of appropriations, a study of the safety issues attendant to the transportation of school children to and from school and school-related activities by various transportation modes.

(b) Terms of Agreement.—The agreement under subsection (a) shall provide that—
- (1) the Transportation Research Board, in conducting the study, shall consider—
  - (A) in consultation with the National Transportation Safety Board, the Bureau of Transportation Statistics, and other relevant entities, available crash injury data;
  - (B) vehicle design and driver training requirements, routing, and operational factors that affect safety; and
  - (C) other factors that the Secretary considers to be appropriate;
- (2) if the data referred to in paragraph (1) (A) is unavailable or insufficient, the Transportation Research Board shall recommend a new data collection regimen and implementation guidelines; and
- (3) a panel shall conduct the study and shall include—
  - (A) representatives of—
    - (i) highway safety organizations;
    - (ii) school transportation;
    - (iii) mass transportation operators;
    - (iv) employee organizations; and
    - (v) bicycling organizations;
  - (B) academic and policy analysts; and
  - (C) other interested parties.

(c) Report.—Not later than 12 months after the Secretary enters into an agreement under subsection (a), the Secretary shall transmit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Transportation and Infrastructure of the House of Representatives a report that contains the results of the study.

(d) Authorization.—There are authorized to be appropriated to the Department of Transportation to carry out this section $200,000 for fiscal year 2000 and $200,000 for fiscal year 2001. Such sums shall remain available until expended.

Study Committee Biographical Information

H. Douglas Robertson, *Chair,* Director of the Highway Safety Research Center, University of North Carolina at Chapel Hill, has extensive experience in transportation safety, engineering, and education. He has worked in the public and private sectors as well as academia, and has a broad perspective of past, present, and potential future transportation safety needs and services. He is former Vice President and Regional Operations Manager for Science Applications International Corporation's Transportation Consulting Group; previous positions also include ITS America, the University of North Carolina at Charlotte, the National Highway Traffic Safety Administration (NHTSA), the Federal Highway Administration (FHWA), BioTechnology, Inc., and the U.S. Army. Professional affiliations include the Transportation Research Board (TRB) (e.g., chaired the TRB Group Council on Operation, Safety, and Maintenance of Transportation Facilities), Institute of Transportation Engineers, Intelligent Transportation Society of America, Reserve Officers' Association, and Association of the U.S. Army. He was promoted to major general in the U.S. Army Reserve and was selected to command one of the Army's seven training divisions. Dr. Robertson was senior editor and a principal author of the Manual of Transportation Engineering Studies for IITE and has published more than 60 journal articles and reports. He has a Ph.D. in civil engineering from the University of Maryland (1983), an M.S. in transportation engineering from the University of South Carolina (1971), and a B.S. in civil engineering from Clemson University (1966).

Phyllis F. Agran, M.D., M.P.H, is Professor of Pediatrics and Director, Pediatric Injury Prevention Research Group, Health Policy and Research, University of California, Irvine. She is a Fellow of the American Board of Pediatrics, American Academy of Pediatrics (AAP) and a fellow and past president of the Association for the Advancement of Automotive Medicine. Her current professional activities include the AAP Committee on Injury, Violence, and Poison Prevention; Executive Committee of the AAP Section on Injury Control and Poison Prevention; and Chair of AAP Chapter 4 Injury Control and Poison Prevention Committee. She was Chair of the Injury Research Grant Review Committee, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention. She served on the Blue Ribbon Panel II, Protecting Older Children in Motor Vehicles. Dr. Agran is the Co-Executive Director of the Injury Prevention Program of the California Chapter 4 American Academy of Pediatrics. She is a reviewer for a number of scientific journals including *Pediatrics, Accident Analysis and Prevention, American Journal of Public Health, Injury Prevention,* and

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Richard D. Blomberg is President of Dunlap and Associates, Inc. His experience in school bus safety includes developing and evaluating a pedestrian safety program for elementary school bus riders, serving as a consultant in the area of school bus operations and pedestrian safety to several large school districts, and developing a school bus safety plan and a pupil transportation policy manual. He has co-authored a study on School Bus Driver Age and Safety for NHTSA. Other pedestrian safety studies he has been involved in include pedestrian safety zones for elderly pedestrians, pedestrian alcohol countermeasures, pedestrians and alcohol, and pedestrian safety messages. He has completed two pedestrian safety films titled *Willy Whistle* and *Keep on Looking.* He is a former member of the Committee for a Strategic Transportation Research Study: Highway Safety of TRB; and he chaired the Aerospace Safety Advisory Panel of the National Aeronautics and Space Administration. Mr. Blomberg received B.S. and M.S. degrees in industrial and management engineering from Columbia University.

Ann M. Dellinger is an epidemiologist for the National Center for Injury Prevention and Control of the Centers for Disease Control and Prevention. She is a former instructor of epidemiology at Morehouse College and Clark Atlanta University and reviews articles for many scientific publications including the *American Journal of Preventive Medicine,* the *American Journal of Health Behavior,* and the *Journal of the Canadian Medical Association.* In 1999, she was awarded the National Center for Injury Prevention and Control Research Award for development of new hypotheses about older drivers' risks for motor vehicle crashes. Dr. Dellinger received a B.A. in biology from the University of San Diego, an M.P.H. from the San Diego State University, and a Ph.D. from the School of Public Health at the University of California, Los Angeles.

Rodney G. Dobey chairs the Department of Health, Physical Education, Recreation and Sport Science at St. Cloud State University in St. Cloud, Minnesota. He is also the former chair of the university's Department of Health and Safety. He has authored more than 20 reports on school bus transportation safety issues and has participated in more than 30 conferences. His professional affiliations include the Minnesota Association for Pupil Transportation, National Committee for Motor Fleet Supervisor Training, School Bus Operators Association, the National Association for Pupil Transportation (NAPT), and the American School Health Association. Dr. Dobey received a B.S. in physical education and M.S. and Ph.D. degrees in education (health and safety) from Southern Illinois University.

Ned B. Einstein is the President of Transportation Alternatives, a New York–based transportation and automotive consultancy and forensic accident analysis firm engaged in the transit, paratransit, pupil transportation, and motor coach fields. Mr. Einstein also served as the Chairman and General Manager of

PTS Transportation, a California-based paratransit operating company, and Chairman and President of TAM-USA, the U.S. joint venture partner of European bus and truck manufacturer TAM (Slovenia). During more than 25 years in the industry, Mr. Einstein has published more than 45 technical documents and articles, and writes regularly for *National Bus Trader* and *School Transportation News*. He is a member of the American Public Transportation Association (APTA), NAPT, ABA, UMA, AIST, and the ongoing National School Transportation Conference's Non–School Bus Use Committee. Mr. Einstein also served as Director of the U.S. Business Council for Slovenia during that nation's first 5 years of independence, and as a member of the Board of Directors of the U.S. Business Council for Southeastern Europe. He holds a B.A. from Rutgers University and a master's of urban and regional planning from George Washington University.

John S. Fabian is Chief of the Motor Carrier Accident Investigation Section of the New York State Department of Transportation (NYSDOT) and New York State Public Transportation Safety Board in Albany. He is responsible for supervision of the day-to-day operations and performance of the oversight and reconstruction/investigation and analysis into cause and result of mass transit accidents. Before assuming the position of Supervisor, Mr. Fabian served as a Safety Specialist/Investigator in the Bus Safety Section of NYSDOT. He serves as a lecturer and an instructor for various institutions including the U.S. Department of Transportation, the Bureau of Municipal Police, and the University of North Florida at Jacksonville. He has authored two articles: Gray Line Tours Bus Crash, Schroon Lake N.Y., which appeared in the July/August 1994 issue of *Accident Reconstruction Journal,* and How to Make System Safety Work in Transit. He is a member of several organizations including APTA and the New York State Association of Transportation Engineers. Mr. Fabian holds a B.A. in criminology from the State University of New York.

James C. Fell is Director of Traffic Safety and Enforcement Programs at Pacific Institute for Research and Evaluation. His duties include designing and conducting research in the relationship between alcohol and violent crime, impaired driving, and underage drinking programs. Earlier, he worked at NHTSA for 30 years, including more than 7 years as program manager of the Fatality Analysis Reporting System in the National Center for Statistics and Analysis. He currently serves on the Board of Directors for Mothers Against Drunk Driving and the National Commission Against Drunk Driving. He is the recipient of numerous awards including the Secretary of Transportation's Silver Medal for Meritorious Achievement, and the A. J. Lauer Award for outstanding contributions to human factors aspects of highway traffic safety from the Human Factors and Ergonomics Society. He has been listed in the Marquis *Who's Who in America in Science and Engineering*. Mr. Fell received a B.S. in industrial engineering and an M.S. in human factors engineering from the State University of New York at Buffalo.

Ted Finlayson-Schueler is the Executive Director of the Pupil Transportation Safety Institute, where he is responsible for program development, creation and publication of materials, research, organizational support, and financial management. Some of his major projects include school bus crash data analysis for the Governors Traffic Safety Committee at FHWA, transit bus driver instructor train-the-trainer curriculum development, and the New York State School Bus Definition Grant. Prior to this he was a supervisor of the Cayuga-Onondaga Board of Cooperative Education Services School Transportation Safety Program in Auburn, New York. From 1980 to 1985, he was a bus driver for Leon Franklin, Inc., in Syracuse, New York, driving for severely physically and emotionally challenged children. He has co-authored numerous articles and manuals including *Seat Belts on School Buses; Bus Safely, Safe Routes—Safe Stops;* and *School Safety Planning for Vehicles and Pedestrian Traffic.* He is the editor of *Around the State,* a newsletter that provides school transportation safety information to superintendents, transportation directors, driver trainers, and school boards. Mr. Finlayson-Schueler has a B.A. in religion and an M.S. from the School of Education at Syracuse University.

Paul S. Fischbeck is an Associate Professor in the Department of Engineering and Public Policy and the Department of Social and Decision Sciences at Carnegie Mellon University, Pittsburgh, Pennsylvania. His general research involves normative and descriptive risk analysis. Past and current research includes the development of a risk index to prioritize inspections of offshore oil production platforms, an engineering and economic policy analysis of air pollution from international shipping, a large-scale probabilistic risk assessment of the space shuttle's tile protection system, and a geographic information system designed to evaluate the environmental risk, economic potential, and political factors of abandoned industrial sites. Dr. Fischbeck was a member of the National Research Council (NRC) Marine Board Committee on Risk Assessment and Management of Marine Systems and was a technical advisor to the NRC Ship Structure Committee. Dr. Fischbeck received a B.S. in architecture from the University of Virginia, an M.S. in operations research and systems analysis from the Naval Postgraduate School, and a Ph.D. in industrial engineering and engineering management from Stanford University. He has written extensively on various applications of decision and risk analysis methods and has won several awards from the Institute of Operations Research and Management Sciences. He is a retired Navy Captain.

Lindsay I. Griffin III is a Senior Research Scientist for the Texas Transportation Institute at Texas A&M University System. Before this he served as a Research Psychologist/Scientist at the Institute and headed its Safety Division. His committee appointments include serving as chairman of the Subcommittee for the National Accident Reporting Form, 11th National Conference on School Transportation; and serving as a member of TRB's Committee for a Study of Consumer Automotive Safety Information (1995) and the Committee on Motorcycles and Mopeds (1979). He has written more than 80 transportation safety–related articles and reports. Dr. Griffin has a B.A. in psychology and a Ph.D. in experimental psychology from the University of North Carolina.

Ronald J. Hundenski is a senior statistician at the San Francisco Municipal Railway, where he is currently responsible for research, analysis, and performance monitoring for the public transit agency serving the City and County of San Francisco. Among his duties, he conducts research and analyses of passenger and traffic accident data. He has authored a number of papers related to public transit safety and security published in TRB's *Transportation Research Record* and elsewhere and served on the panel of a TRB synthesis study dealing with violence on public transit. He has also presented several papers at TRB's annual meetings and currently serves on TRB's Bus Transit Systems Committee. His involvement with school transportation safety first occurred when he served as lieutenant of the safety patrol of Holy Trinity Elementary School in Moon Run, Pennsylvania, and later as a VISTA volunteer when he drove the van transporting developmentally disabled adults to and from a sheltered workshop. Dr. Hundenski received a B.A. from Ohio University and an M.A. and Ph.D. in social sciences from Brown University.

Ronald L. Kinney is the Director of Marketing for Business and Government Relations at Laidlaw Education Services. He is a former manager in the Office of School Transportation at the California Department of Education and served as State Director of School Transportation for California from 1983 to 1997. His professional affiliations include serving as president of the National Association of State Directors of Pupil Transportation Services, California Association for School Transportation Officials, member of NAPT, and chair of the 13th National Conference on School Transportation for 2000. He has taken numerous extension and specialized courses at Boise State College, the University of California at Berkeley, and the University of California at Davis.

Jeffrey C. Tsai directs the Pupil Transportation Group (PTG) and manages the Operation Research/Education Laboratory of the Institute for Transportation Research and Education at North Carolina State University, whose mission is to apply technological and scientific principles to the operation and management of multimodal school transportation systems in order to provide for the safe and efficient transportation of school children. As director of PTG, he coordinates project activities with school systems and other pupil transportation–related projects. In his position as manager of the Operation Research/Education Laboratory, he oversees the use of mathematical models for improving decision making in educational institutions and state and local governmental agencies. Mr. Tsai is a member of NAPT and the North Carolina Pupil Transportation Association and sits on committees for the NAPT Professional Development Committee and the North Carolina School Safety Conference. He holds a B.Sc. and an M.S. in geophysics from North Carolina State University.