Cost-Benefit Analysis of Safety Belts in Texas School Buses

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Ms. Mary Lauderdale and Ms. Cindy Knox of the Texas Department of Public Safety provided the accident data for this study.

Synopsis

Although safety belts have been shown to reduce the risk of serious injury or death in automobile crashes, evidence of their effectiveness in school buses is uncertain. In this paper, the potential costs and benefits of mandatory safety belts in Texas school buses are estimated, based on the assumption that their effectiveness is less than or equal to rear seatbelt effectiveness in autos. Costs are based on both retrofitting old buses with belts and installing them in new buses. Benefits include the direct and indirect (forgone earnings) cost-savings from preventable injuries and fatalities. Results indicate that a law mandating safety belts in Texas school buses would not be cost-beneficial. Annual benefits would exceed the annual costs of installing belts in new school buses. However, the benefits would not be large enough to compensate for the first-year costs associated with retrofitting old buses.

IN TEXAS, more children and adults were injured in school bus accidents in 1985—a total of 635—than in any of the previous 8 years (*1*). Of the injured children, only 11 (1.7 percent) were wearing safety belts at the time of the accident because few Texas school buses are equipped with belts. A summary of the accidents, injuries, and fatalities since 1978 among school bus occupants in Texas is provided in table 1. The table indicates that although fatalities are down, the number of injuries remains high.

The potential reduction in injury and death to school children from the installation of safety belts in school buses has become a major issue in Texas, as it has in many other States around the country. The National Highway Traffic Safety Administration (NHTSA) does not require safety belts in 24-passenger and larger buses. However, the number of school districts, now about 70 nationwide, that require safety belts in their school buses is increasing (*2*). Currently, they are mandatory for 15- and 19-passenger buses in Texas and are available as optional equipment for larger buses.

Unfortunately, at present the protective effect of safety belts in school buses cannot be demonstrated conclusively, despite the fact that their effectiveness in reducing fatalities and injuries in automobile crashes is well known (*3*). Most simulation studies suggest that belts would improve safety, particularly in side impact and rollover collisions (*4*). There is some evidence, however, that belts might do more harm than good in head-on collisions (*5*). Actual accident data are insufficient to resolve the debate because the total number nationwide of deaths and serious injuries among belted and unbelted school bus occupants is so low.

This paper does not address the effectiveness debate, however. Its focus is the hypothetical question of whether the installation of safety belts in school buses would be cost-beneficial from the perspective of the entire State, assuming a certain effectiveness rate could be achieved. It is intended to contribute to the policy debate that is underway in several States concerning the adoption of laws mandating the installation of safety belts for school buses.

Method

The study compares the present value of the annual economic costs and benefits that Texas would derive from the installation of safety belts in school buses, based on the assumption that the effectiveness of safety belts in school buses in preventing injuries and fatalities would be less than or equal to the effectiveness of safety belts for rear seat auto passengers. This assumption is based on

Table 1. Accidents, fatalities, and injuries among school bus occupants in Texas, 1978–85

Category	1978	1979	1980	1981	1982	1983	1984	1985
Noninjury accidents	811	942	904	910	897	943	900	898
Injury accidents[1]	259	260	273	284	308	297	316	323
Fatal accidents[1]	8	4	7	9	9	5	5	7
Total	1,078	1,206	1,184	1,203	1,214	1,245	1,221	1,228
Fatalities, drivers	0	1	0	0	0	0	0	0
Fatalities, passengers	6	2	1	4	2	1	0	0
Total	6	3	1	4	2	1	0	0
Injuries, drivers	56	48	57	65	84	72	84	78
Injuries, passengers	511	271	484	338	523	538	487	557
Total	567	319	541	403	607	610	571	635

[1]Does not include pedestrian accidents.

SOURCE: Reference *1*.

the similarities between school bus and auto rear seat configurations. Rear seat auto occupants are generally restrained only by lap belts (a few cars now provide outboard lap and shoulder harness combinations), and they have the back of a seat immediately in front of them. This is the same configuration that would be experienced by the majority of school bus occupants; only those riding in the front seat of each side would not have a seat back in front of them, and they would still be restrained with only a lap belt. Furthermore, it is reasonable to assume that the additional safety provided to school bus occupants by lap belts would not be any greater than that provided rear seat auto occupants, given the overall construction and pattern of use of school buses compared with autos (communication from Kathleen Weber, MA, and John Melvin, PhD, University of Michigan, Department of Mechanical Engineering and Applied Mechanics, January 23, 1986).

The potential costs of installation are the value to society of resources (labor and materials) that would be required for safety belt installation. These costs would accrue in (*a*) equipping all new buses with belts, and (*b*) retrofitting all old buses with safety belts. In this study, these costs are estimated for the 10-year period 1985–94 for the Texas school bus fleet.

The potential benefits of installation are the medical care, transportation, legal services, and forgone earnings costs that could be avoided if school bus injuries and fatalities were reduced. These benefits are estimated based on the assumption regarding the effectiveness of safety belts in preventing school bus injuries and fatalities.

The effectiveness estimates were derived from a relative risk analysis performed on the motor vehicle injury data for children ages 5–18 years over the 3-year period 1983–85 (*6*). (The source of the data was the Texas Department of Public Safety.) The analysis was limited to those children who were rear seat auto passengers at the time of an accident. The relative risk of nonuse of safety belts was estimated by comparing the probability of injury or death in persons not wearing safety belts with that of persons wearing safety belts (*7,8*). The example presented subsequently for rear seat passengers in autos illustrates this method.

Variables	*Belted*	*Unbelted*
All occupants ages 5–14 in crashes	4,424	25,591
Critical injuries (MAIS) 5	99	763
Proportion of critical injuries among all occupants	.02	.03

Calculation: estimated belt effectiveness in reducing severe injuries $= \frac{.03 - .02}{.03} = .33$

These data indicate that safety belts are 33 percent effective in reducing critical injuries to back seat auto passengers ages 5–14, based on all occupants. In our effectiveness analysis, the .33 figure represents the estimated proportion (prevented fraction) of critical injuries to school bus passengers that could have been prevented. It is derived for six different categories of injury severity classified by the Multiple Abbreviated Injury Scale (MAIS)—a trauma severity scale consisting of seven numerical codes and associated injury levels (*9*) (see box on opposite page). The prevented fraction for each MAIS category was applied to school bus injury data for the same 3-year period, 1983–85, also categorized by MAIS, to estimate the potential reduction in injuries and fatalities from using safety belts.

To translate the estimated number of preventable injuries into dollar benefits, the per capita costs of motor vehicle injuries and deaths estimated by

Representative Nonfatal Motor Vehicle Injuries, by Abbreviated Injury Scale (AIS) Level

AIS Code	*Injury severity level*	*Representative injuries*
0	No injury	
1	Minor injury	Superficial abrasion or laceration of skin; digit sprain; first-degree burn; head trauma with headache or dizziness (no other neurological signs).
2	Moderate injury	Major abrasion or laceration of skin; cerebral concussion (unconscious less than 15 minutes); finger or toe crush, amputation; closed pelvic fracture with or without dislocation.
3	Serious injury	Major nerve laceration; multi-rib fracture (but without flail chest); abdominal organ contusion; hand, foot, or arm crush, amputation.
4	Severe injury	Spleen rupture; leg crush; chest-wall perforation; cerebral concussion with other neurological signs (unconscious less than 24 hours).
5	Critical injury	Spinal cord injury (with cord transection); extensive or deep laceration of kidney or liver; extensive second- or third-degree burns; cerebral concussion with severe neurological signs (unconscious more than 24 hours).
6	Maximum (currently untreatable, immediately fatal)	Decapitation; torso transection; massively crushed chest.
7	Injured, unknown severity	

SOURCE: Reference 9.

Hartunian and coworkers are used (*10*). Their estimates, which are also available by MAIS category, were adjusted to 1985 prices and income with the use of the medical care component of the Consumer Price Index and the annual growth in personal income. The costs and benefits were then compared over 5-year and 10-year periods to find present values. Sensitivity analysis was performed to assess the implications of alternative discount rates, seatbelt effectiveness rates, and installation costs.

Results

Costs of installation. The estimated annual costs of installing safety belts on all school buses in the State follow:

Item	*Amount*
Assumptions:	
Number of new type 1[1] public school buses	2,000
Number of old type 1 public school buses	20,000
Total	22,000
Cost per bus for installing lap belts	$1,100
Cost for installing belts in new type 1 buses	$2.2 million
Cost for retrofitting old type 1 buses	$22.0 million
Estimated annual costs:	
Total cost for installing belts, year 1	$24.2 million
Total cost for installing belts, year 2 to year ?	$2.2 million

[1]17-passenger or larger.
SOURCES: Texas Education Agency, Transportation Division; Blue Bird Body Company, Engineering Services; and Wayne Bus Company, Austin, TX, distributor.

The first-year cost, $24.2 million, includes the cost of installing belts in 2,000 new type 1 buses and

Table 2. Injuries among belted versus unbelted occupants of school buses in Texas, 1983–85 annual average, by age and Multiple Abbreviated Injury Scale (MAIS) category

Age and injury category	*Belted*	*Not belted*
MAIS 0	4	354
5–14 years	3	297
15–18 years	1	57
MAIS 1	3	253
5–14 years	2	212
15–18 years	1	41
MAIS 2	1	150
5–14 years	1	126
15–18 years	0	24
MAIS 3	0	91
5–14 years	0	76
15–18 years	0	15
MAIS 4	0	37
5–14 years	0	31
15–18 years	0	6
MAIS 5	0	22
5–14	0	18
15–18	0	4

NOTE: There were no injuries in the MAIS 6 category.

Table 3. Prevented fraction and number of cases of school bus injuries and fatalities averted, by age and MAIS category

Age and injury category	*Prevented fraction*	*Number*
MAIS 1:		
5–14 years	.00	0
15–18 years	.00	0
MAIS 2:		
5–14 years	.01	1
15–18 years	.23	6
MAIS 3:		
5–14 years	.07	5
15–18 years	.39	6
MAIS 4:		
5–14 years	.20	6
15–18 years	.64	4
MAIS 5:		
5–14 years	.25	5
15–18 years	.71	3
MAIS 6:		
5–14	.52	0
15–18	.88	0

retrofitting approximately 20,000 old type 1 buses with belts. After the first year, the annual cost would decline to $2.2 million, which is the cost of installing belts in 2,000 new buses each year.

In deriving these costs, several assumptions are made in addition to the ones listed. First, it is assumed that retrofitting old buses (pre- or post-1977 construction) with safety belts could be done successfully. At present, retrofitting is not recommended by school bus manufacturers without examining and possibly reinforcing the bus seat frames and floor. Second, it is assumed that the cost of maintenance and replacement of belts over time would be zero. Third, the cost of enforcement of wearing belts is assumed to be zero. Enforcement costs may include the indirect effects on driver morale, turnover, sick leave, and so forth, as well as the direct cost of monitors if required to achieve high seatbelt usage. Although these costs may be substantial, they are not measurable without a far more sophisticated and costly study. Finally, it is assumed that all private school buses and type 2 public school buses (fewer than 17 passengers) already have belts installed and in use. Thus, the cost of installing belts on the entire school bus fleet is reflected in the costs for type 1 public school buses.

Benefits of installation. The average number of injuries annually among belted versus unbelted school bus occupants, by injury category, is provided in table 2. The table shows that the majority of passengers involved in school bus accidents are not injured or receive only minor injuries. (Note: Before 1985, police officers were requested, but not required, to record information concerning seatbelt usage among persons who were not injured (MAIS 0) in accidents. In 1985, when the reporting became a requirement, the number of reports having information on seatbelt usage among noninjured school bus and automobile passengers rose significantly. The effect of this reporting change on our analysis is discussed in the last section.) The data for MAIS 1 to MAIS 5 in table 2 do not equal the total number of injuries in table 1 because they represent a 3-year average and because the process of deriving the injury severity breakdown by MAIS category changes the sum of annual injuries slightly.

Table 3 indicates the potential reductions in the proportion and number of annual school bus injuries and fatalities, by injury severity level, based on the risk analyses described. To calculate the estimated number of preventable injuries and fatalities, the prevented fraction that was derived for rear seat auto passengers involved in accidents in 1983-85 was applied to the average number of safety belt nonusers who were injured in school bus accidents. The table indicates a range of safety belt prevention rates from 0 to 88 percent and the number of cases prevented from zero to six.

The effectiveness rates for rear-seat belts shown in table 3 are somewhat less than those reported elsewhere. Summaries of studies comparing death rates of safety belt users versus nonusers have yielded reduction rates ranging from 8 to 85 percent (*11*). Some of the studies have controlled for seating position and others have not. Most of the studies have not been age-specific. A review and synthesis by NHTSA estimates that the manual lap and shoulder belt combination has an effectiveness (that is, percentage reduction in fatalities or injuries for restrained occupants as compared to unrestrained occupants) of 40-50 percent for fatalities, 45-55 percent for moderate to critical injuries, and approximately 10 percent for minor injuries (*12*). Subsequently, Evans (*13*) reported a 41 percent effectiveness figure for fatalities after applying a double-pair comparison method that controls for confounding effects.

Estimates of the per capita costs of school bus injuries are presented in table 4, by MAIS categories 1-5 (MAIS 6 is not included because the average number of school bus fatalities 1983-85 was zero). The estimates include the direct costs of medical care (emergency services, inpatient and outpatient services, insurance administration, rehabilitation services, institutional or attendant home care, medical equipment and appliances, drugs and medical supplies) and legal services (court costs and legal fees), and the indirect costs (forgone earnings due to restricted activity). As indicated in the table, direct costs are the most significant costs on a per capita basis for all MAIS categories and age groups except MAIS 5 injuries to children ages 15-18. This exception is reasonable because forgone earnings calculations (indirect costs) increase with age and injury severity. That is, the more serious the injury, the greater the loss in productivity, and, the older the child, the sooner a loss in productivity is likely to reduce income.

Table 5 indicates the potential annual benefits of installing safety belts in school buses in terms of the cost-savings associated with avoided fatalities and injuries. The benefits were derived by multiplying the per capita cost of injuries (table 4) by the number of preventable injuries, based on the effectiveness assumption (table 3). Table 5 indicates potential direct and indirect injury cost-savings of $2.3 million per year, assuming that seatbelts are as effective for school bus occupants as they are for rear seat auto passengers.

Comparison of costs and benefits. The costs and benefits were compared over 5-year and 10-year periods. A social discount rate of 6 percent was used to convert future benefits and costs into current values. It was assumed that inflation would have a uniform effect on both benefits and costs. Table 6 shows the present value of costs and benefits, the net present value (NPV), and the benefit-cost ratio for each period. As noted earlier, the benefit-cost perspective represented by the figures is that of the whole State.

Table 6 indicates that the net present value is negative for 5 years and 10 years, and the potential benefit-cost ratio is less than 1. Thus, this analysis argues that the safety belts should not be implemented if their usage is limited to a 10-year period. That is, if the State implemented a program requiring safety belt usage and abandoned it after 10 years, the program could not be defended on

Table 4. 1985 per capita costs of injuries (in dollars), by MAIS category and age

Cost and age group	*MAIS 1*	*MAIS 2*	*MAIS 3*	*MAIS 4*	*MAIS 5*
Direct costs, medical care:					
Ages 0–14....	$484	$2,454	$5,365	$17,641	$123,344
Ages 15–18...	484	2,454	5,365	17,525	118,341
Direct costs, legal services:					
Ages 0–14....	231	252	1,154	2,224	3,398
Ages 15–18...	231	252	1,154	2,224	3,398
Indirect costs:					
Ages 0–14....	0	0	0	0	83,488
Ages 15–18...	61	406	1,378	3,470	174,981
Total costs:					
Ages 0–14....	715	2,706	6,519	19,865	210,230
Ages 15–18...	776	3,112	7,897	23,219	296,720

SOURCE: Reference *10*.

Table 5. Potential annual cost-savings from installing safety belts in school buses (in thousands of dollars)

Injury category	*Age 5–14 years*	*Age 15–18 years*	*Total*
MAIS 1................	0	0	0
MAIS 2................	$3	$19	$22
MAIS 3................	33	47	80
MAIS 4................	119	93	212
MAIS 5................	1,051	890	1,941
MAIS 6................	0	0	0
Total	$1,206	$1,049	$2,255

Table 6. Present value of costs and benefits occurring over 5 and 10 years (in millions of dollars)

Cost-benefit	*5 years*	*10 years*
Present value of costs	$31.8	$39.1
Present value of benefits...............	9.5	16.6
Net present value	−22.3	−22.5
Benefits ÷ costs........................	.30	.42

'Another deficiency is that this analysis does not consider the possible carryover effects of the students' belt-wearing to their use of belts in private vehicles. If children learn to use safety belts on all vehicles by using them on buses, the safety belts have an enormous life-saving potential.'

economic grounds. As indicated in the table, the economic evidence against the program, as measured by the NPV, is about the same for the two periods. This result reflects the fact that the annual benefits from safety belts slightly exceed the annual costs ($2.3 million versus $2.2 million) after the first year. Thus, if the program is perceived as one that will likely remain in place in perpetuity, it may be justified in the sense that annual benefits cover annual costs. However, the present value of the annual benefits is not great enough to compensate for the high first-year costs associated with outfitting the entire school bus fleet with belts.

Discussion

The negative results found in the analysis are somewhat surprising, given the overwhelming evidence that society would benefit more than it would lose from the use of safety belts in automobiles (*14*). The results may be explained by the following factors: first, the economic benefits of safety belts in school buses may not be as significant as they are in autos because school bus injuries are not as serious, and the value of increased safety at the margin may not be so great. The inherent safety of school buses is indicated by a low vehicle accident rate per miles driven and a low rate of serious injuries among those involved in accidents. Thus, the potential cost-savings from installing safety belts, or introducing any other safety measure for that matter, is not great.

Second, in placing an economic value on injuries or death, a person's expected lifetime earnings, discounted back to the year of the onset of the accident, is used. This approach generates benefits that are less for the very young who ride school buses than, say, middle-aged persons whose income loss occurs immediately. Obviously, discounted future earnings and avoided medical costs do not provide a complete picture of the benefits of health and safety programs. There are psychic and social costs of injury and death that also must be considered. Indeed, to many people these costs are the most important reason for considering safety belts. The political decision maker should take these costs into account when deciding whether, on balance, the program is a "good" investment for society.

In interpreting our results, a number of methodological weaknesses should also be considered. Probably the most serious problem is the uncertainty concerning the protective effect of safety belts in school buses. An attempt was made to skirt this problem by basing the calculations on an assumption thought to be generous. The fact that net benefits were negative under these generous assumptions, however, indicates the importance of this issue. There is an obvious need for some sort of experimental trial to compare the injury and fatality rates of safety belt users and nonusers. This may be possible as more belt-equipped buses come into use.

Another deficiency is that this analysis does not consider the possible carryover effects of the students' belt-wearing to their use of belts in private vehicles. If children learn to use safety belts on all vehicles by using them on buses, the safety belts have an enormous life-saving potential. Unfortunately, at present, there is no definitive information on this issue to consider. Certainly, the effect that belts on school buses have on habit and behavior reinforcement also deserves further study.

Finally, in considering the likely error in our analysis resulting from data deficiencies, we performed sensitivity analysis with respect to three important variables: the discount rate, cost estimates, and seatbelt effectiveness rates. Changing the discount rate has no significant effect on the overall results. Future benefits and costs are approximately the same, so their discounted values remain relatively similar using different discount rates.

Raising the cost estimates from $1,100 per bus to $2,000 per bus, which is reasonable if structural reinforcements are required when retrofitting old buses, would obviously strengthen the support for not installing seatbelts on type 1 school buses. We did not consider the option of installing seatbelts only in new buses or buses of a certain age. Eliminating the cost of retrofitting old buses that may soon be replaced would reduce costs considerably. However, it would also reduce benefits, which are calculated on the basis that the entire fleet be outfitted with belts. There is no way to estimate the proportion of total benefits that would be realized if a proportion of the fleet were outfitted.

The use of different data sets for deriving effectiveness rates also had no effect on the overall results. Besides the rates reported in table 3 that were based on 3 years (1983-85) of auto accident data, effectiveness rates and the number of potential school bus injuries prevented were also calculated using 1983-84 data and 1985 data. The differences were small, and for each injury category the estimate of the number of cases prevented was higher using the 1983-85 data than it would have been using the other data sets.

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Discrepancies in Racial Designations of School Children in Minneapolis

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This research was supported by the National Heart, Lung, and Blood Institute, Public Health Service, under grant R01-HL-19877.

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Synopsis

To determine the frequency of inaccuracies in racial designations of school children in a health survey, racial designations were examined for a sample of 1,509 children in Minneapolis public schools who participated in the first home interview of the Minneapolis Children's Blood Pressure Study. The data were obtained from three sources: the school enrollment data based on parentally supplied information and teachers' visual judgments, school survey interviewers participating in a research project, and the parents themselves, at home interviews. Assuming the correctness of the information obtained from the parent in the home interview, cross tabulation comparisons were made of the accuracy of the information obtained from the other sources, and within sources.

Results show a high degree of agreement between the parents' or teachers' designations at enrollment, and survey interviewers' sight judgments. Furthermore, sight judgments of interviewers show high repeatability. There was a significant degree of disagreement between the designations by teachers' and screeners' visual judgments, obtained in school, and the interviews with the parents. Misidentification occurred for up to 20 percent of Native American children, a rate which, if prevalent, may significantly affect public health studies