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Revised Costs of Large Truck- and Bus-Involved Crashes

Final Report for

Federal Motor Carrier Safety Administration

Federal Highway Administration

400 Seventh Street, SW, Washington, DC

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by

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16. Abstract

This study provides the latest estimates of the costs of highway crashes involving large trucks and buses by severity. Based on the latest data available, the estimated cost of police-reported crashes involving trucks with a gross weight rating of more than 10,000 pounds averaged $59,153 (in 2000 dollars). The average cost of police-reported crashes involving transit or inter-city buses was $32,548 per crash. These costs represent the present value, computed at a 4% discount rate, of all costs over the victim's expected life span that result from a crash. They include medically related costs, emergency services costs, property damage costs, lost productivity, and the monetized value of the pain, suffering, and quality of life that the family loses because of a death or injury.

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Executive Summary

This study provides the latest comprehensive, economically sophisticated estimates of the costs of highway crashes involving large trucks and buses by severity. Based on the latest data available, the estimated cost of police-reported crashes involving trucks with a gross weight rating of more than 10,000 pounds averaged $59,153 (in 2000 dollars). The average cost of police-reported crashes involving transit or inter-city buses was $32,548 per crash. These costs represent the present value, computed at a 4% discount rate, of all costs over the victims' expected life span that result from a crash. They include medically related costs, emergency services costs, property damage costs, lost productivity, and the monetized value of the pain, suffering, and quality of life that the family loses because of a death or injury. Other notable findings include:

- The cost of crashes in which truck-tractors with two or three trailers were involved was the highest among all crashes – $88,483 per crash.
- Among crashes with all configuration information available, bus-involved crashes had the lowest cost – $32,548 per crash.
- The costs per crash with injuries averaged $164,730 for large truck crashes and $77,043 for bus crashes.
- As expected, fatal crashes cost more than any other crash. The average cost of fatal crashes involving bobtails was the highest among all fatal crashes – $4.2 million per crash.
- The crash costs per 1,000 truck miles are $157 for single unit trucks, $131 for single combination trucks, and $63 for multiple combinations.
- The average annual cost of large truck crashes in 1997-99 exceeded $19.6 billion. That total included $6.6 billion in productivity losses, $3.4 billion in resource costs, and quality of life losses valued at $9.6 billion.
- Bus crashes were a much smaller factor than truck crashes, costing $0.7 billion annually in 1997-99.
- The cost estimates exclude mental health care costs for crash victims, roadside furniture repair costs, cargo delays, earnings lost by family and friends caring for the injured, and the value of schoolwork lost.

Introduction

Trucks and buses with a gross weight rating of over 10,000 pounds constitute the majority of interstate commercial vehicles. They are the primary focus of Federal Motor Carrier Safety Regulations. Crashes involving such vehicles impose a variety of costs on the vehicle and its driver, other drivers either directly or indirectly involved in the crash, and society as a whole. In addition to costs such as property damage, emergency services, and travel delays, injuries and fatalities impose significant costs. This report provides unit costs of large (medium and heavy) vehicle crashes, stated in 2000 dollars.

Safety analysts use crash cost data for a variety of purposes, from analyzing the effectiveness of a particular roadway enhancement to measuring the impact of seatbelt use. Crash costs are used to compare the relative efficacy of various crash countermeasures, which are expected to have a differential impact on crashes of different severity. These figures are also used to calculate and compare the cost-effectiveness of proposed safety regulations. Efficient allocation of research, enforcement, and analysis resources requires reliable data on crash costs.

Miller, Viner et al. (1991) made a first attempt to estimate truck and bus crash costs. They first computed costs by threat-to-life severity measured by Maximum Abbreviated Injury Score (MAIS; AAAM, 1985). The AIS scheme is a detailed medical classification developed by physicians as a basis for rating the survival threat injuries pose. It assigns a numeric rating ranging from 0 (uninjured) to 6 (maximum, generally unsurvivable). National Highway Traffic Safety Administration (NHTSA) data sets that are AIS coded add codes for "injured, severity unknown" and "unknown if injured". MAIS is simply the maximum AIS among the multiple injuries a victim suffers. The purpose of the AIS scale is to differentiate injuries by survival threat, not the cost, functional losses, or course of recovery they involve. For example, loss of teeth is an AIS-1 injury that can involve substantial costs and lifetime pain and suffering. Conversely, timely surgery often allows complete and rapid recovery from ruptured spleens and other AIS 3-5 internal injuries. Nevertheless, average costs per case within a body region almost always rise with MAIS (Miller 1993).

By multiplying average costs per highway crash victim by MAIS times the MAIS distribution of victims in crashes sorted by the heaviest vehicle involved, Miller, Viner et al. (1991) estimated costs by vehicle type. Those estimates implicitly assumed that the distribution of injuries by body region within an AIS severity level did not vary with vehicle type. Only property damage and crash-related travel delay costs were tailored to truck and bus crashes.

Miller, Levy et al. (1998) and Miller, Spicer et al. (1999) improved on Miller, Viner et al. (1991) by computing medium/heavy vehicle crash costs by vehicle type from 1982-1992 data on victim MAIS and body region in medium/heavy vehicle crashes. Zaloshnja, Miller, and Spicer (2000) paralleled their methods. It updated their estimates and substantially increased the number of cases used to estimate the injury distribution for occupants of light passenger vehicles involved in medium/heavy vehicle crashes. With the larger sample, it was able to more finely differentiate costs among heavy vehicle types. That study was the first to differentiate costs of single versus multiple trailer crashes.

The present study updates the results of Zaloshnja, Miller, and Spicer (2000) using methods described in Blincoe, Seay, et al (2002) and Zaloshnja, Miller, et al (2002). Notably, costs per non-fatally-injured victim of a highway crash were estimated by maximum AIS (MAIS), body part, and whether the victim suffered a fracture/dislocation. In addition to the more detailed diagnoses used in estimation, the accuracy of our estimates was increased by using current medical cost, wage, and income data. Property damage costs were updated using the latest insurance data on commercial vehicles. In estimating the productivity loss due to travel delays, we now assume that only police reported crashes delay traffic. This was based on the premise that any substantial impact on traffic would attract the attention of police. Within the constraints of available data, this study provides economically sophisticated, reliable estimates of the average costs of medium/heavy vehicle crashes with different levels of severity.

Methods

Estimating crash costs requires estimates of the number of people and vehicles involved in a crash, the severity of each person's injuries, and the costs of those injuries and associated vehicle damage and travel delay. The following section describes the methodology used to estimate the incidence and severity of large truck and bus crashes. The succeeding section explains how the costs of crashes were estimated.

Incidence and Severity Estimation. To Incidence and Severity Estimation. To estimate injury incidence and severity, we followed procedures developed by Miller and Blincoe (1994) and Miller, Galbraith et al. (1995) and also applied in Zaloshnja, Miller, and Spicer (2000), and Blincoe, Seay, et al (2002). Our estimates of the average number of people and vehicles involved in a medium/heavy vehicle crash by vehicle type, restraint use, crash severity, and police-reported injury severity come from NHTSA's Fatality Analysis Reporting System (FARS) and General Estimates System (GES).

Crash databases do not accurately describe the severity of large truck and bus crashes. Accordingly, we made several adjustments to more accurately reflect the severity of crashes. These adjustments are described below.

FARS is a census of U.S. fatal crashes but it does not describe injuries to survivors in these crashes. GES provides a sample of U.S. crashes by police-reported severity for all crash types. GES records injury severity by crash victim on the KABCO scale (National Safety Council, 1990) from police crash reports. Police reports in almost every state use KABCO to classify crash victims as K-killed, A-disabling injury, B-evident injury, C-possible injury, or O-no apparent injury. KABCO ratings are coarse and inconsistently coded between states and over time. The codes are selected by police officers without medical training, typically without benefit of a hands-on examination. Some victims are transported from the scene before the police officer who completes the crash report even arrives. Miller, Viner et al. (1991) and Blincoe and Faigin (1992) documented the great diversity in KABCO coding across cases.

O'Day (1993) more carefully quantified the great variability in use of the A-injury code between states. Viner and Conley (1994) explained the contribution to this variability of differing state definitions of A-injury. Miller, Whiting et al. (1987) found police-reported injury counts by KABCO severity systematically varied between states because of differing state crash reporting thresholds (the rules governing which crashes should be reported to the police). Miller and Blincoe (1994) found that state reporting thresholds often changed over time.

Thus, police-reporting does not accurately describe injuries medically. To minimize the effects of variability in severity definitions between states, reporting thresholds, and police perception of injury severity, we turned to NHTSA data sets that included both police-reported KABCO and medical descriptions of injury in the Occupant Injury Coding system (OIC; AAAM 1990, AAAM 1985). OIC codes include AIS score and body region, plus more detailed type injury descriptors that changed from the 1985 to the 1990 edition. We used both 1993-99 Crashworthiness Data System (CDS; NHTSA 2000) and 1982-86 National Accident Sampling System (NASS; NHTSA 1987) data. CDS describes injuries to passenger vehicle occupants involved in towaway crashes. The 1982-86 NASS data provide the most recent medical description available of injuries to medium/heavy truck and bus occupants, non-occupants, and other non-CDS crash victims. The NASS data were coded with the 1980 version of AIS, which differs slightly from the 1985 version; but NHTSA made most AIS-85 changes well before their formal adoption. CDS data were coded in AIS-85 through 1992, then in AIS-90.

We used 1990-1999 GES data to weight the CDS and NASS data so they represent the annual estimated GES injury victim counts in medium/heavy vehicle crashes by CDS and NASS sample strata. In applying these weights we controlled for crash type (as defined by the truck/bus type involved) police-reported injury severity, restraint use, and vehicle occupied (or non-occupant). Weighting the NASS data to GES restraint use levels updates the NASS injury profile to a profile reflecting contemporary belt use levels. Again, sample size considerations drove the decision to pool all available data. At the completion of the weighting process (Figure 1), we had a hybrid CDS/NASS file with weights that summed to the estimated annual GES incidence by police-reported injury severity and other relevant factors.

Trucks and buses with a gross weight rating of over 10,000 pounds were grouped into the following categories:

1. Straight truck, no trailer;
2. Straight truck with trailer;
3. Straight truck, unknown if with trailer
4. Truck tractor with no trailer (bobtail);
5. Truck tractor with one trailer;
6. Truck tractor with two or three trailers;
7. Truck tractor with unknown number of trailers;

8. Medium/heavy truck, unknown if with trailer;

9. All large trucks; and

10. Transit/inter-city bus

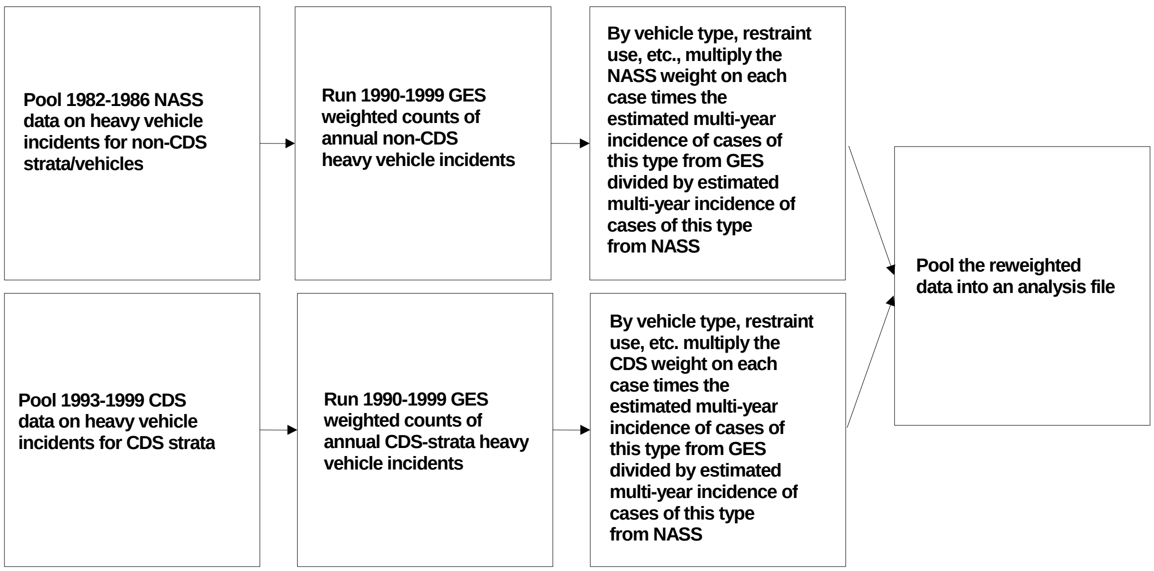

Figure 1. The merger of NASS, CDS, and GES files

In order to create reasonable sample sizes, two assumptions were made in the categorization of trucks/buses. Trucks that were reported in the GES and FARS data as medium/heavy trucks and had no trailing units were assumed to be straight trucks with no trailer. Trucks that were reported as unknown medium/heavy trucks and had more than one trailing unit were assumed to be truck tractors with two or three trailers. Following Zaloshnja, Miller, and Spicer (2000), straight trucks with trailer and medium/heavy trucks with one trailer were grouped together.

Cost Estimation. The second step required to estimate average crash costs is to generate estimates of crash costs by severity. This section describes the process used to develop these estimates. In order to estimate the average costs per crash by medium/heavy vehicle type and crash severity, costs per injury by maximum AIS (MAIS), body part, and whether the victim suffered a fracture/dislocation were adapted from the costs in Zaloshnja, Miller et al. (2002) These costs were merged onto the GES-weighted NASS/CDS file. The costs represent the present value, computed at a 4% discount rate, of all costs over the victim's expected life span that result from a crash. We included the following major categories of costs:

- Medically related costs

- Emergency services

- Property damage
- Lost productivity
- Monetized Quality-Adjusted Life Years (QALYs)

Medically Related Costs include ambulance, emergency medical, physician, hospital, rehabilitation, prescription, and related treatment costs, as well as ancillary costs for crutches, physical therapy, etc. To estimate medical costs, we started from nationally representative samples that use International Classification of Diseases - 9th Revision - Clinical Modification (ICD9-CM) diagnosis codes to describe the injuries of US crash victims, namely, the 1996-1997 National Hospital Discharge Survey (NHDS) for hospital-admitted victims and 1990-1996 National Health Interview Survey (NHIS) for non-hospitalized victims. The analysis included the following steps, some of which are explained in further detail below: (1) assign a cause or probabilistic cause distribution for each NHDS and NHIS case; (2) estimate the costs associated with each crash case in NHDS and NHIS; (3) use ICDmap-85 (Johns Hopkins University & Tri-Analytics, 1997) to assign 1985 Occupant Injury Codes (OIC) or code groups to each NHDS and NHIS case; (4) collapse the code groups to achieve adequate case counts per cell by MAIS, body part, and whether fracture/dislocation was involved; (5) tabulate ICD-based costs by MAIS, diagnosis code grouping, and whether hospital admitted; (6) estimate the percentage of hospital admitted cases by diagnosis group from 1996-99 CDS and apply it to collapse the cost estimates to eliminate hospital admission status as a stratifier (necessary because current admission rates are unknown for crash victims in non-CDS strata); and (7) infer costs for diagnosis groups that appear in CDS crash data but not in the ICD-based file.

Cause Assignment - NHIS explicitly identifies victims of road crashes. NHDS has seven data fields where hospitals code injury diagnoses or causes. When all seven fields are used, a cause code is rarely included. Typically, diagnosis codes (which drive reimbursement) are given priority over cause codes. More than 70% of 1996-1997 NHDS cases with less than six diagnoses are cause-coded. We assumed causes by age group, sex, and diagnosis for these cases were representative of all injury admissions with less than six diagnoses. For NHDS cases with six or seven diagnoses, we inferred causation probabilities by age group, sex, and diagnosis using data for cases with at least six diagnoses in cause-coded state hospital discharge censuses that we previously had pooled from California, Maryland, Missouri, New York, and Vermont (Lawrence et al., 2000). As a partial check, we compared the resulting firearm injury estimate with a published national surveillance estimate (Annest et al., 1995). The two estimates were less than 5% apart.

Estimation of Medical Costs Associated with Each Crash Case in NHDS and NHIS - Except for added tailoring to differentiate the costs of child from adult injury and estimating fatality costs, we used the methods employed in building the U.S. Consumer Product Safety Commission's (CPSC) injury cost model. These methods are summarized below and documented in detail in Miller et al. (1998), Miller, Romano, & Spicer (2000), Lawrence et al. (2000), and Zaloshnja, Miller, et al (2002).

Although the methods for estimating the costs and consequences associated with each case differed for fatally injured persons, survivors admitted to the hospital, and survivors treated elsewhere, in each case we extracted costs of initial treatment from nationally representative or statewide data sets. For survivors, by diagnosis, we added aggregate medical follow-up, rehabilitation, and long-term costs computed from national data on the percentage of medical costs associated with initial treatment. Due to data unavailability, these percentages were less current than the costs for initial treatment.

For hospitalized survivors, we computed medical costs in stages. Maryland and New York were the only states that regulated and tracked the detailed relationships between charges, payments, and actual costs of hospital care in recent years. (Because US health care payers negotiate widely varying, sometimes large discounts from providers, hospital charges bear little relationship to actual hospital costs.) Computations were by diagnosis group. Using average cost per day of hospital stay by state as an adjuster (Bureau of the Census, 1999, Table 189), we price-adjusted diagnosis-specific hospital costs per day from Maryland in 1994-95 and New York in 1994 (the last year of that state's cost control) to national estimates. We multiplied the costs per day by diagnosis times corresponding NHDS lengths of hospital stay. To the hospital costs, we added physician costs estimated from Civilian Health and Medical Program of the Uniformed Services (CHAMPUS) data for 1992-1994. Costs after hospital discharge were computed from the most recent nationally representative sources available, the 1987 National Medical Expenditure Survey (NMES) and National Council on Compensation Insurance (NCCI) data for 1979-1987. Both CHAMPUS and NCCI data report only primary diagnoses at the 3-digit ICD level or broader, so mapping was imperfect, especially for brain injury. The NCCI data describe occupational injury; however, following Rice et al (1989), Miller (1993), and Miller et al. (1995), we assumed the time track of medical care by diagnosis is independent of injury cause. Where the victim was discharged to a nursing home, following Lawrence et al. (2000), nursing home lengths of stay were estimated at two years for burn victims, and ten years for other catastrophic injuries, at a cost double the cost of an intermediate care facility (from Bureau of the Census, 1997). Costs per visit for other nonfatal injuries came from CHAMPUS.

Past studies (e.g., Rice et al., 1989; Miller, 1993; and Miller et al., 1995) estimated lifetime medical spending due to a child's injury from the all-age average acute care spending shortly after the injury and the longer term recovery pattern of adults or victims of all ages. Instead, our hospitalization cost estimates are age-group specific. We also accounted for differences in resiliency between children and adults; using longitudinal 1987-1989 health care claims data from Medstat Systems, we developed diagnosis-specific factors to adjust all-age and adult estimates of follow-up and longer-term care to child-specific treatment patterns. The percentage of medical costs in the first six months that resulted from the initial medical visit or hospitalization did not vary with age. After that, children were more resilient; the percentage of their total treatment costs incurred in the first six months often was higher, especially for brain injuries. These conclusions come from analysis of a random sample of 15,526 episodes of childhood injury and 40,624 episodes of non-occupational adult injury to victims covered by private health insurance. For each episode, the claims data covered a range of 13-36 months and an average of 24 months after injury. Because we decided to maximize the diagnostic detail preserved, sample size considerations dictated bringing costs forward onto CDS files that represented averages across victims of all ages.

For spinal cord injuries (SCI) and burns, medical costs were not estimated from NHDS and NHIS files because of the limited number of these cases in the files. In addition, long-term SCI costs are not captured in the NHDS and NHIS data. Information from a special study (Berkowitz et al., 1998) was used to estimate first year and annual medical costs for SCI. Costs were estimated by applying the age and gender distribution of SCI victims in the CDS 1993-99 to a lifetime estimating model with 1997 life expectancy tables adjusted for spinal cord injury mortality rates from Berkowitz et al. (1998). Highway crash-specific costs for burns were adapted from Miller, Brigham, & Cohen et al. (1993), using its regression equations.

Mapping ICD Codes into OIC Codes - To make the ICD-based injury descriptors compatible with CDS and NASS descriptors we mapped ICD to AIS85, and to body part. AIS85 was mapped using the ICDmap-85. This map lists AIS by each ICD code up to the 5 digit level of detail. For NHIS, which uses almost exclusively 3-digit ICDs (85.5% of the data set), the lowest AIS within that 3-digit group was selected.

Body part was mapped to AIS from previously collapsed ICD groupings (Miller et al., 1995) and fracture or dislocation was identified with the ICD codes. The ICD/AIS mapping was developed by consensus and contains many assumptions related to the assignment of AIS codes to ICD rubrics (Miller et al. 1995). For multiple-injury NHDS cases, we assigned the body part of the maximum AIS injury. In case of a tie in AIS, we used the body part defined by the principal diagnosis in discharge records. NHIS reports only principal diagnoses.

Inferring Costs for Categories that Appear in CDS Data, but not in the ICD-Based File – Six percent of AIS/body part/fracture diagnosis categories that appear in CDS crash data did not appear in the ICD-based files. Costs for these categories were assigned as follows: (1) mean costs were estimated for each AIS: (2) based on these averages, incremental cost ratios from one preferably lower AIS to another were estimated. Lower AIS was preferred because it offered larger case counts: (3) costs for empty ICD-based cells were assigned by multiplying costs from adjacent cells by this ratio. For instance, if the mean medical costs for AIS-2 and AIS-3 were $500 and $1,000, respectively, then the incremental ratio for AIS-2 to AIS-3 was set to: 1,000/500 = 2. Then the cost for an empty AIS-3 cell was estimated by multiplying the body part/fracture-specific cost for AIS-2 times the ratio. For body parts with no cost estimates available for any AIS, a general average cost for the appropriate AIS was assigned.

<u>Emergency Services Costs</u> include police and fire services. Fire and police costs were computed from assumed response patterns by crash severity and vehicle involvement, constrained by data on total responses. For fatal, injury, and PDO crashes, time spent per police cruiser responding came from ten jurisdictions with automated police time-tracking systems. A single officer was assumed to have responded to a PDO crash and one officer per injury to other crashes. Time spent per fire truck responding came from nine large fire departments. It was assumed that the fire personnel would respond to:

- 90 percent of fatal and severe injury crashes and 95 percent of critical injury crashes.
- 40 percent of heavy truck crashes involving injury.

- 25 percent of police-reported heavy truck crashes involving only property damage.

Property Damage is the cost to repair or replace damaged vehicles, cargo, and other property including the costs of damage compensation. To estimate property damage in heavy vehicle crashes, we first purchased aggregated Insurance Services Office (ISO) data detailing coverage and claims experience with 28.9% of all motor vehicle insurance premiums collected for commercial vehicles. We assumed the percentage covered does not vary by vehicle type. The insurance data included payments per insurance claim and aggregate payments for damage to the insured vehicle and separately, for damage it inflicted on other vehicles in at-fault crashes. We used GES data to estimate the vehicles involved per crash, which let us estimate costs per crash. The data distinguished buses and medium trucks, but imperfectly differentiated tractor-trailers from other heavy trucks. Separate property damage costs for trailers insured separately allowed us to compute cost differentials for multi-trailer vehicles. (We assumed that 10% were triples and the remainder doubles.) Net of the insurance deductible of an estimated $1,000 per crash, costs per crash-involved vehicle averaged $2,510 in bus crashes, $4,341 in medium/heavy straight truck crashes, $6,872 in single-trailer combination truck crashes, and $18,132 in multi-trailer truck crashes.

Appendix A contains three tables summarizing the measures derived from the ISO data. These tables parallel the tables for private passenger vehicles in Miller and Lawrence (2002). They also include some parallel summary data on private passenger vehicle coverage drawn from that report. That report defines the column headings and explains how the measures presented were computed. Table A-1 summarizes the ISO data by type of coverage and vehicle type. Table A-2 summarizes coverage comprehensiveness. It shows that commercial vehicles are slightly more likely to be self-insured than private passenger vehicles, especially for collision coverage. Table A-3 provides comparative performance statistics. It shows that premiums are quite similar for commercial and private passenger auto policies. Commercial policyholders file far fewer claims per 1,000 policies than other policyholders, but their average claim is much larger. Consequently, commercial policies involve much larger losses per policy.

Lost Productivity includes wages, fringe benefits, and household work lost by the injured, as well as the costs of processing productivity loss compensation claims. It also includes productivity loss by those stuck in crash-related traffic jams and by co-workers and supervisors investigating crashes, recruiting and training replacements for disabled workers, and repairing damaged company vehicles. Excluded are earnings lost by family and friends caring for the injured and the value of schoolwork lost. The productivity loss resulting from traffic delay is given separately and as part of total productivity lost.

Future work loss costs were estimated using methods that parallel the Consumer Product Safety Council (CPSC) Injury Cost Model. These methods are summarized below and documented in detail in Miller et al. (1998), Lawrence et al. (2000), Miller, Romano, & Spicer (2000), Blincoe, Seay, et al (2002), and Zaloshnja, Miller, et al. (2002). For nonfatal injuries, the work loss cost is the sum of the lifetime loss due to permanent disability (averaged across permanently disabling and non-disabling cases) plus the loss due to temporary disability. We first computed lifetime wage and household work losses due to a death or permanent total disability and discounted them to present value with the standard age-earnings model described in Rice et al. (1989) and in Miller et al. (1998). The inputs to this model were for 1997-2000. They include, by age group and sex, survival probabilities from National Vital Statistics Reports (1999); weighted estimates of annual earnings tabulated from the 2001 Current Population Survey, a nationally representative sample; and the value of household work performed from Expectancy Data (1999).

For survivors, we applied National Council on Compensation Insurance (NCCI) probabilities that an occupational injury will result in permanent partial or total disability and the NCCI percentage of earning power lost to partial disability to compute both the number of permanently disabled victims and the percentage of lifetime work lost. These data are by diagnosis group and whether hospital-admitted. We used the ICD maps to assign 1985 and 1990 OIC injury codes or code groups to each category.

Diagnosis-specific probabilities of injuries to employed people causing wage work loss came from CDS 1993-99. The days of work loss per person losing work were estimated from the 1999 Survey of Occupational Injury and Illness of the U.S. Bureau of Labor Statistics; this survey contains employer reports of work losses for more than 600,000 workplace injuries coded in a system akin to the OIC but with less diagnostic detail. According to a survey of 10,000 households, injured people lose housework on 90% of the days they lose wage work (S. Marquis, The RAND Corporation, personal communication, 1992). Thus, we were able to compute the days of household work lost from the days of wage work lost. Household work was valued based on the cost of hiring people to perform household tasks (e.g., cooking, cleaning, yard work) and the hours typically devoted to each task from Expectancy Data (1999). Lost productivity for repairing vehicles involved in crashes was updated from Miller et al. (1991) and included in the lost household productivity.

For temporary disability, we assumed that an adult caregiver would lose the same number of days of wage work or housework because of a child's temporarily disabling injury as an adult would lose when suffering the same injury. Since the adult with the lowest salary often stays home as the caregiver, we estimated caregiver wages as the mean hourly earnings for non-supervisory employees in private non-agricultural industries. These assumptions may overestimate slightly because the caregiver may be able to do some work at home. Conversely we may underestimate the losses because we ignored (1) the work loss of other individuals who visit a hospitalized child or rush to the child's bedside shortly after an injury and (2) any temporary wage work or household work loss by adolescents.

Legal and insurance administration costs per crash victim were derived from the medical and work loss costs, using models developed by Miller (1997). Legal costs include the legal fees and court costs associated with civil litigation resulting from motor vehicle crashes. In estimating these costs, the probability of losing work, the percentage of victims who claimed, the percentage of claimers who hired an attorney, estimated plaintiff's attorney fees, and the ratio of legal costs over plaintiff's attorney fees were taken into consideration. Insurance administration costs include the administrative costs associated with processing insurance claims resulting from motor vehicle crashes and defense attorney fees. In estimating these costs, medical expense claims, liability claims, disability insurance, Worker's Compensation, welfare payments, sick leave, property damage, and life insurance were estimated.

Following Blincoe, Seay, et al (2002) and Zaloshnja, Miller et al. (2002), travel delay was computed similarly to Zaloshnja, Miller et al. (2000), but with three refinements. First, using a newer and broader survey of five police departments, the hours-of-delay ratio was updated to 49:86:233 for the delays due to PDO, injury, and fatal crashes, respectively. Second, to extract delay per person from delay per crash we used data on the average number of people killed or injured in a heavy vehicle crash. And finally, we conservatively assumed that only police-reported crashes delay traffic. This is based on the premise that any substantial impact on traffic would attract the attention of the police.

<u>Monetized Quality-Adjusted Life Years (QALYs)</u> Monetary losses associated with medical care, other resources used, and lost work do not fully capture the burden of injuries. Injuries also cost victims and families by reducing their quality of life. The good health lost when someone suffers a health problem or dies can be accounted for by estimating quality-adjusted life years (QALYs) lost. A QALY is a health outcome measure that assigns a value of 1 to a year of perfect health and 0 to death (Gold et al., 1996). QALY loss is determined by the duration and severity of the health problem. To compute it, following Miller (1993), we used diagnosis and age-group specific estimates from Miller et al. (1995) of the fraction of perfect health lost during each year that a victim is recovering from a health problem or living with a residual disability. Such an impairment fraction was estimated by body part, AIS85, and fracture/dislocation. The resulting estimates in AIS85 were applied to NHDS and NHIS cases. The monetary value of a QALY ($98,527) was derived by dividing the value of statistical life (VSL) by the number of years in the person's life span. Differently from Zaloshnja, Miller, and Spicer (2000), in this analysis, we followed the guidance of the Office of the Secretary of Transportation on the VSL (OST, 2002). For comparison purposes, monetized QALYs per crash based on the VSL found in a systematic review in Miller (1990) and used in Zaloshnja, Miller, and Spicer (2000) are presented in the Appendix. As with the other components of cost, QALY losses in future years were discounted to present value at a 4% discount rate (Gold et al., 1996; Cropper et al, 1991; Viscusi & Moore, 1989).

Results

Table 1 summarizes estimated victims per highway crash, by truck/bus type and police-reported injury severity. For example, the table indicates that in crashes in which trucks with no trailers are involved, an average of 2.085 people had no injury, 0.207 had possible injury, and so on. An average of 2.531 people is involved in these types of crashes. Some caution is warranted in interpreting these numbers because police-reported injury severity is often inaccurate. Many victims who the police code as not injured are actually injured; conversely, the majority of injuries reported by police as disabling do not result in hospital admission (Miller et al. 1991). These shortcomings are one of the reasons why we developed our injury costs based on body part, MAIS, and whether the victim suffered a fracture/dislocation.

Another problem with police-reported counts of people in crashes, which is evident in Table 1, is the undercount of uninjured people involved in transit/intercity bus crashes. Specifically, Table 1 suggests that no more than 3 people were involved in an average transit/intercity bus crash. This obviously incorrect number results from the widespread police practice of not recording uninjured bus passengers involved in a crash.

Table 2 presents estimated victims per highway crash, by crash type, crash severity, and police-reported injury severity. As mentioned earlier, estimates for fatal crashes came from FARS. Truck-tractors without trailers (bobtails) involved in a fatal crash caused more deaths than any other truck configuration – an average of 1.527 people had fatal injuries in a typical crash. The unweighted and weighted GES counts of people involved in truck/bus crashes by vehicle type and police-reported severity are presented in Tables 3 through 6. The number of people killed in fatal truck/bus crashes is presented in Table 7. The GES tables reveal adequate cell sizes (a minimum of 10 and preferably 30 cases per cell) except when trailer information is unknown. Given the cell sizes, when information about trailers is unknown, it is advisable to use the average cost per large truck crash rather than a configuration-specific cost.

Table 8 presents the annual number of truck/bus crashes, by crash severity. Compared to the period 1988-97 (the analyzed period in Zaloshnja, Miller, and Spicer, 2000), there were less severe crashes in the period 1990-99. During this period only 5.8% of crashes caused incapacitating or fatal injuries, as compared with 6.1% during 1988-97. On the other side, 69% of the crashes in 1990-99 did not cause any injury, as compared with 65% in 1988-97.

Table 9 presents the average estimated costs per victim injured by vehicle type and injury severity. Given the adequate sample size for most of the truck configurations, these unit costs can be reliably used in analyses of crash costs when information on the number of victims per crash is available. The unit costs reported here represent a major improvement compared to those found in Zaloshnja, Miller, and Spicer (2000), because they are based on costs per injury by maximum AIS (MAIS), body part, and whether the victim suffered a fracture/dislocation. Previously, costs per injury were estimated only by MAIS and body region. As a result of the changes in methodology and the use of newer sources of cost data, there are noticeable differences between the unit costs presented in this report and those in Zaloshnja, Miller, and Spicer (2000).

The most evident difference can be found in monetized QALYs, which are now based on the VSL recommended by the Office of the Secretary of Transportation. On average, the current monetized QALYs are 20% lower than the same monetized QALYs estimated based on Miller (1990). Moreover, QALYs themselves are now more accurately estimated because they are diagnosis, age, and sex specific. Previously, they were group-diagnosis, group-age and sex specific.

Another cost category that has been dramatically revised downward is the lost productivity from travel delays. The major contributors to this downward shift are the change in the hours-of-delay ratio, which was updated to 49:86:233 from 40:130:385 for the delays due to PDO, injury, and fatal crashes, respectively, and the exclusion of crashes not reported to the police.

Table 10 provides detailed cost per crash estimates for different truck/bus configurations and crash severity. These estimates are calculated based on the incidence figures presented in Table 2 and costs per injury by truck configuration, injury severity, and crash severity. The differences between estimates in Table 10 and their counterparts in Zaloshnja, Miller, and Spicer (2000) are mainly due to the changes in unit costs discussed above.

Table 11 presents the estimated costs per crash for all crashes and Table 12 presents the estimated costs per crash for injury crashes only. The $88,483 average cost per crash for vehicles with two or three trailers far exceeds the $72,459 for a tractor-trailer crash. Bus crashes and crashes where trailer presence was unknown have the lowest average costs. Crashes involving bobtails have higher average costs than straight truck crashes. The reason for this finding is unclear. These vehicles could have stability problems. Alternatively, since their engines are far more powerful than their trailer-less weight demands, they may be driven aggressively. Also, since bobtail drivers are not generating revenue and are often not paid, they may face financial incentives to speed.

In average, the total cost per large truck crash reported here is 22% lower than that reported in Zaloshnja, Miller, and Spicer. In addition to the changes in unit costs discussed above, a shift towards less severe crashes has contributed to this sharp decrease.

Table 13 shows the average annual cost of police-reported heavy vehicle crashes captured in 1997-99 GES data. The annual costs of large truck crashes during that period exceeded $19.6 billion. That total included $6.6 billion in productivity losses, $3.4 billion in resource costs, and quality of life losses valued at $9.6 billion. The largest share of this total was the $12.6 billion in costs of single-trailer combination trucks. Bobtail crashes cost about one sixty-seventh this much, meaning that bobtails would be over- (or under-) represented in crashes if they comprise less (or more) than about 1.5% of combination truck traffic. Similarly, combination trucks with multiple trailers accounted for about 4.2% of combination truck crash costs. Single straight trucks accounted for about $5 billion of the truck crash costs, about one fourth. Bus crashes were a much smaller factor than truck crashes, costing $0.7 billion annually in 1997-99.

Computed with 1997 Vehicle Inventory and Use Survey (VIUS) data on truck mileage (Bureau of the Census, 1999), the crash costs per 1,000 truck miles are $157 for single unit trucks, $131 for single combination trucks, and $63 for multiple combinations.

TABLE 1. The Average Number of People Involved in a Truck/Bus Crash, by Crash Type and Police-Reported Injury Severity (1990-1999)

Truck/bus crash type	No injury	Possible injury	Non-incapacitating	Incapacitating	Fatal injury	Unknown severity	Unknown if injured
Straight truck, no trailer	2.085	0.207	0.103	0.057	0.007	0.005	0.066
Straight truck with trailer	2.109	0.165	0.102	0.090	0.014	0.005	0.112
Straight truck, unknown if with trailer	1.558	0.018	0.041	0.018	0.000	0.000	0.771
Bobtail	2.186	0.194	0.093	0.059	0.007	0.005	0.074
Truck-tractor, 1 trailer	1.904	0.161	0.102	0.067	0.015	0.003	0.077
Truck-tractor, 2 or 3 trailers	1.701	0.174	0.088	0.066	0.017	0.000	0.070
Truck-tractor, with unknown # of trailers	2.021	0.044	0.016	0.030	0.004	0.000	0.251
Medium/heavy truck, unknown if with trailer	1.638	0.139	0.051	0.036	0.002	0.003	0.435
All large trucks	1.982	0.179	0.101	0.063	0.011	0.004	0.080
Bus, transit/intercity	2.146	0.427	0.100	0.044	0.003	0.021	0.130

Source: GES

TABLE 2. The Average Number of People Involved in a Truck/Bus Crash by Crash Type, Crash Severity, and Police-Reported Injury Severity (1990-1999)

Truck/bus crash type	Maximum severity in crash: No injury	Maximum severity in crash: Possible injury			
		No injury	Possible injury	Unknown severity	Unknown if injured
Straight truck, no trailer	2.408	1.542	1.394	0.002	0.038
Straight truck with trailer	2.426	1.680	1.296	0.000	0.101
Straight truck, unknown if with trailer	2.003	1.248	1.000	0.000	0.413
Bobtail	2.508	1.707	1.333	0.001	0.011
Truck-tractor, 1 trailer	2.193	1.390	1.298	0.003	0.046
Truck-tractor, 2 or 3 trailers	1.923	1.637	1.237	0.000	0.066
Truck-tractor, with unknown # of trailers	2.372	1.266	1.000	0.000	0.221
Medium/heavy truck, unknown if with trailer	1.948	0.937	1.481	0.000	0.442
All large trucks	2.287	1.473	1.340	0.002	0.048
Bus, transit/intercity	2.476	1.627	1.867	0.005	0.065

	Maximum severity in crash: Nonincapacitating				
	No injury	Possible injury	Nonincapacitating	Unknown severity	Unknown if injured
Straight truck, no trailer	1.208	0.299	1.248	0.005	0.038
Straight truck with trailer	1.339	0.208	1.196	0.002	0.053
Straight truck, unknown if with trailer	1.320	0.122	1.213	0.000	0.478
Bobtail	1.538	0.297	1.266	0.001	0.008
Truck-tractor, 1 trailer	1.182	0.210	1.200	0.003	0.042
Truck-tractor, 2 or 3 trailers	1.182	0.274	1.049	0.002	0.034
Truck-tractor, with unknown # of trailers	1.356	0.424	1.197	0.000	0.215
Medium/heavy truck, unknown if with trailer	1.056	0.181	1.082	0.000	0.193
All large trucks	1.207	0.247	1.217	0.003	0.041
Bus, transit/intercity	1.304	1.059	1.315	0.044	0.122

	Maximum severity in crash: Incapacitating					
	No injury	Possible injury	Non-incapacitating	Incapacitating	Unknown severity	Unknown if injured
Straight truck, no trailer	1.201	0.204	0.220	1.292	0.008	0.020
Straight truck with trailer	1.709	0.238	0.287	1.747	0.070	0.034
Straight truck, unknown if with trailer	0.375	0.291	0.291	1.000	0.000	0.625
Bobtail	1.268	0.309	0.146	1.335	0.000	0.022
Truck-tractor, 1 trailer	1.055	0.146	0.166	1.224	0.004	0.026
Truck-tractor, 2 or 3 trailers	0.833	0.073	0.128	1.214	0.000	0.009
Truck-tractor, with unknown # of trailers	2.146	0.220	0.073	1.010	0.000	0.000
Medium/heavy truck, unknown if with trailer	0.388	0.096	0.572	2.536	0.000	0.032
All large trucks	1.132	0.173	0.190	1.275	0.008	0.024
Bus, transit/intercity	1.377	1.042	0.274	1.417	0.000	0.030

	Maximum severity in crash: Fatal						
	No injury	Possible injury	Non-incapac-itating	Incapacitating	Fatal	Unknown severity	Unknown if injured
Straight truck, no trailer	0.844	0.340	0.278	0.382	1.134	0.002	0.021
Straight truck with trailer	1.086	0.488	0.194	0.395	1.302	0.000	0.000
Straight truck, unknown if with trailer	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Bobtail	0.582	0.175	0.050	0.482	1.527	0.000	0.012
Truck-tractor, 1 trailer	0.869	0.182	0.254	0.474	1.213	0.000	0.012
Truck-tractor, 2 or 3 trailers	0.535	0.487	0.521	0.252	1.200	0.000	0.000
Truck-tractor, with unknown # of trailers	1.000	0.000	0.000	0.000	1.000	0.000	0.000
Medium/heavy truck, unknown if with trailer	0.486	0.079	0.000	0.000	1.000	0.000	0.000
All large trucks	0.859	0.241	0.260	0.441	1.200	0.001	0.013
Bus, transit/intercity	6.755	0.809	0.026	0.274	1.020	0.000	0.013

	Maximum severity in crash: Unknown severity			**Maximum severity in crash: Unknown if injured**	
	No injury	**Unknown severity**	**Unknown if injured**	**No injury**	**Unknown if injured**
Straight truck, no trailer	1.377	1.246	0.111	1.199	1.120
Straight truck with trailer	3.390	1.061	0.049	1.163	1.065
Straight truck, unknown if with trailer	0.000	0.000	0.000	0.105	3.685
Bobtail	1.009	1.047	0.000	1.163	1.058
Truck-tractor, 1 trailer	1.085	1.114	0.046	1.368	1.042
Truck-tractor, 2 or 3 trailers	1.000	1.000	0.000	1.104	1.000
Truck-tractor, with unknown # of trailers	0.000	0.000	0.000	1.171	1.000
Medium/heavy truck, unknown if with trailer	3.374	2.780	0.593	1.464	1.160
All large trucks	1.281	1.184	0.078	1.298	1.074
Bus, transit/intercity	1.554	2.612	0.046	1.601	1.257

Source: GES and FARS

TABLE 3. The Unweighted Count of Truck/Bus Occupants Involved in Crashes,by Crash Type and Police-Reported Injury Severity (1990-1999)

Truck/bus crash type	No injury	Possible injury	Non-incapacitating	Incapacitating	Fatal injury	Unknown severity	Unknown if injured
Straight truck, no trailer	25,559	2,607	1,492	683	45	62	660
Straight truck with trailer	2,866	227	114	87	6	5	103
Straight truck, unknown if with trailer	21	1	2	0	0	0	12
Bobtail	2,407	195	138	62	9	4	78
Truck-tractor, 1 trailer	46,833	3,106	2,022	952	134	60	1,910
Truck-tractor, 2 or 3 trailers	1,608	127	61	37	2	0	39
Truck-tractor, with unknown # of trailers	124	4	3	5	0	0	31
Medium/heavy truck, unknown if with trailer	480	45	8	10	1	0	159
All large trucks	79,898	6,312	3,840	1,836	197	131	2,992
Bus, transit/intercity	2,482	1,326	265	137	3	120	153

Source: GES

TABLE 4. The Unweighted Count of Non-Truck/Bus Occupants Involved in Truck/Bus Crashes, by Crash Type and Police-Reported Injury Severity (1990-1999)

Truck/bus crash type	No injury	Possible injury	Non-incapacitating	Incapacitating	Fatal injury	Unknown severity	Unknown if injured
Straight truck, no trailer	18,027	7,300	4,201	2,405	352	210	594
Straight truck with trailer	2,002	784	451	301	48	8	82
Straight truck, unknown if with trailer	21	4	8	3	0	0	4
Bobtail	1,993	762	452	236	23	10	77
Truck-tractor, 1 trailer	34,927	13,754	8,238	4,683	797	264	1,415
Truck-tractor, 2 or 3 trailers	1,205	473	290	158	28	2	50
Truck-tractor, with unknown # of trailers	134	34	20	6	1	0	5
Medium/heavy truck, unknown if with trailer	479	168	105	40	4	7	24
All large trucks	58,788	23,279	13,765	7,832	1,253	501	2,251
Bus, transit/intercity	1,870	564	444	212	19	16	100

Source: GES

TABLE 5. The Weighted Count of Truck Occupants Involved in Crashes, by Crash Type and Police-Reported Injury Severity (1990-1999)

Truck/bus crash type	No injury	Possible injury	Non-incapacitating	Incapacitating	Fatal injury	Unknown severity	Unknown if injured
Straight truck, no trailer	1,460,573	66,435	38,465	17,703	1,451	1,619	56,133
Straight truck with trailer	141,170	3,882	2,644	2,272	89	229	11,314
Straight truck, unknown if with trailer	1,352	6	16	0	0	0	364
Bobtail	108,613	3,574	2,219	1,279	257	53	5,317
Truck-tractor, 1 trailer	1,770,786	59,348	46,144	26,655	3,472	1,377	97,248
Truck-tractor, 2 or 3 trailers	48,196	2,228	1,060	979	62	0	2,479
Truck-tractor, with unknown # of trailers	11,059	36	16	168	0	0	2,019
Medium/heavy truck, unknown if with trailer	28,821	951	150	989	55	0	17,383
All large trucks	3,570,570	136,460	90,713	50,045	5,386	3,277	192,257
Bus, transit/intercity	285,492	69,173	8,890	3,881	298	4,130	15,481

Source: GES

TABLE 6. The Weighted Count of Non Truck Occupants Involved in Truck/Bus Crashes by Crash Type and Police-Reported Injury Severity (1990-1999)

Truck/bus crash type	No injury	Possible injury	Non-incapacitating	Incapacitating	Fatal injury	Unknown severity	Unknown if injured
Straight truck, no trailer	1,209,560	199,063	93,189	55,024	7,660	5,024	28,928
Straight truck with trailer	117,016	16,307	9,824	8,704	1,615	387	2,449
Straight truck, unknown if with trailer	1,308	24	54	30	0	0	952
Bobtail	103,955	15,291	6,835	4,477	441	478	1,899
Truck-tractor, 1 trailer	1,553,143	221,104	132,079	90,888	22,103	4,082	37,354
Truck-tractor, 2 or 3 trailers	38,981	6,694	3,445	2,379	823	11	1,133
Truck-tractor, with unknown # of trailers	11,984	463	169	169	46	0	843
Medium/heavy truck, unknown if with trailer	43,390	5,197	2,107	606	31	140	1,808
All large trucks	3,079,337	464,144	247,701	162,277	32,720	10,120	75,364
Bus, transit/intercity	263,611	40,081	16,799	7,330	441	1,350	17,751

Source: GES

TABLE 7. The Number of People Killed in Truck/Bus Crashes by Truck/Bus Type (1990-1999)

Truck/bus crash type	Number of fatal crashes	Truck occupants killed in crashes	Non-truck occupants killed in crashes	Total number of people killed in crashes
Straight truck, no trailer	7,629	1,216	7,784	9,000
Straight truck with trailer	1,160	193	1,184	1,377
Straight truck, unknown if with trailer	26	5	22	27
Bobtail	1,935	342	1,927	2,269
Truck-tractor, 1 trailer	26,980	3,996	27,839	31,835
Truck-tractor, 2 or 3 trailers	1,600	260	1,563	1,823
Truck-tractor, with unknown # of trailers	348	42	351	393
Medium/heavy truck, unknown if with trailer	65	4	63	67
All large trucks	39,743	6,058	40,733	46,791
Bus, transit/intercity	1,347	118	1,416	1,534

Source: FARS

TABLE 8. The Annual Number of Truck/Bus Crashes, by Crash Severity (1990-99)

Truck/bus crash type	Maximum severity in crash							Total
	No injury	Possible injury	Non-incapacitating	Incapacitating	Fatal injury	Unknown severity	Unknown if injured	
Straight truck, no trailer	89,388	16,046	9,418	5,392	763	435	6,586	128,028
Straight truck with trailer	8,253	1,258	877	599	116	17	1,110	12,229
Straight truck, unknown if with trailer	126	2	5	4	3	0	34	173
Bobtail	6,730	1,164	666	415	194	49	655	9,873
Truck-tractor, 1 trailer	120,640	18,187	13,186	8,790	2,698	376	11,323	175,200
Truck-tractor, 2 or 3 trailers	3,450	597	361	261	160	0	382	5,212
Truck-tractor, with unknown # of trailers	775	39	13	33	35	0	275	1,170
Medium/heavy truck, unknown if with trailer	2,295	389	175	63	7	5	1,473	4,406
All large trucks	231,656	37,683	24,702	15,556	3,974	883	21,837	336,292
Bus, transit/intercity	16,189	4,371	1,790	777	135	171	2,218	25,652

Source: GES and FARS

TABLE 9. Costs per Victim Injured, by Crash Type and Police-Reported Injury Severity (in 2000 dollars)

Truck/bus crash type	Injury severity	Medical costs	Emergency services	Property damage	Lost productivity from delays	Total lost productivity	Monetized QALYs based on VSL from DOT	Total
Straight truck, no trailer	No injury	74	39	1,384	1,584	2,179	208	3,884
	Possible injury	4,236	152	2,678	3,585	9,993	9,663	26,722
	Nonincapacitating	4,477	258	4,131	4,191	10,046	6,370	25,281
	Incapacitating	10,922	477	5,394	4,140	28,336	27,275	72,403
	Fatal injury	22,195	833	13,154	5,176	869,877	1,742,086	2,648,145
	Unknown severity	3,088	181	3,127	3,481	8,626	6,274	21,295
	Unknown if injured	742	109	2,151	3,220	5,217	1,724	9,943
Straight truck with trailer	No injury	363	40	1,946	1,654	2,256	344	4,949
	Possible injury	6,510	198	5,235	3,782	11,820	16,990	40,754
	Nonincapacitating	8,107	272	6,133	3,797	14,078	20,356	48,946
	Incapacitating	17,328	439	7,474	4,017	33,348	50,388	108,977
	Fatal injury	19,985	833	18,744	5,176	896,679	1,796,656	2,732,897
	Unknown severity	2,749	174	5,446	2,669	13,970	10,041	32,380
	Unknown if injured	675	77	2,805	1,750	3,352	1,972	8,881
Straight truck, unknown if with trailer	No injury	433	40	1,550	1,675	2,313	401	4,737
	Possible injury	6,991	200	4,295	3,728	11,703	19,441	42,629
	Nonincapacitating	8,671	276	5,060	3,847	14,581	22,547	51,135
	Incapacitating	38,311	470	6,330	3,835	36,049	120,532	201,691
	Unknown if injured	1,241	71	2,232	1,761	3,333	2,918	10,524
Bobtail	No injury	299	39	1,875	2,058	2,875	554	5,642
	Possible injury	3,894	138	3,623	4,248	10,831	7,773	26,260
	Nonincapacitating	2,644	269	5,645	4,248	10,411	5,592	24,560
	Incapacitating	3,182	434	7,397	4,248	15,054	7,166	33,233
	Fatal injury	23,250	833	17,990	5,176	894,832	1,792,895	2,729,800
	Unknown severity	291	152	4,209	1,813	2,537	605	7,794
	Unknown if injured	820	70	2,964	1,800	3,395	1,979	9,228
Truck-tractor, 1 trailer	No injury	363	40	2,146	1,652	2,254	339	5,141
	Possible injury	6,429	199	5,779	3,737	11,545	17,248	41,199
	Nonincapacitating	7,380	275	6,796	3,772	13,888	20,467	48,807
	Incapacitating	14,220	443	8,212	3,994	29,944	38,304	91,123
	Fatal injury	24,542	833	20,728	5,176	886,772	1,776,485	2,709,360
	Unknown severity	3,310	79	4,242	2,765	5,770	2,026	15,427
	Unknown if injured	688	78	3,132	1,737	3,196	1,812	8,905
Truck-tractor, 2 or 3 trailers	No injury	387	40	6,114	1,661	2,283	362	9,187
	Possible injury	6,085	198	16,316	3,702	11,293	16,866	50,758
	Nonincapacitating	6,733	275	19,145	3,750	13,330	19,226	58,709
	Incapacitating	14,364	448	23,184	4,003	30,421	37,199	105,615
	Fatal injury	20,198	833	58,490	5,176	845,481	1,692,415	2,617,417
	Unknown severity	0	27	9,075	1,476	1,746	0	10,848
	Unknown if injured	597	88	6,229	1,704	2,929	1,441	11,284
Truck-tractor, with unknown # of trailers	No injury	358	39	2,665	1,652	2,235	342	5,640
	Possible injury	6,692	196	7,181	3,857	12,192	16,965	43,226
	Nonincapacitating	2,827	280	8,522	3,706	10,241	12,839	34,709
	Incapacitating	14,216	410	10,054	4,133	35,036	39,268	98,984
	Fatal injury	19,842	833	25,785	5,176	822,827	1,646,292	2,515,579

Truck/bus crash type	Injury severity	Medical costs	Emergency services	Property damage	Lost productivity from delays	Total lost productivity	Monetized QALYs based on VSL from DOT	Total
	Unknown if injured	710	71	3,661	1,749	3,159	1,716	9,317
Medium/heavy truck, unknown if with trailer	No injury	2	37	1,959	1,481	1,755	4	3,757
	Possible injury	3,419	203	5,423	3,249	8,672	8,931	26,648
	Nonincapacitating	3,739	266	6,291	4,133	11,240	8,420	29,955
	Incapacitating	26,187	463	7,632	4,221	20,273	76,185	130,740
	Fatal injury	21,032	833	19,381	5,176	786,188	1,571,695	2,399,129
	Unknown severity	4,171	229	2,877	4,248	10,861	18,879	37,016
	Unknown if injured	809	72	2,605	1,829	3,426	1,961	8,873
All large trucks	No injury	241	39	1,875	1,636	2,239	290	4,685
	Possible injury	5,347	176	4,476	3,682	10,813	13,498	34,310
	Nonincapacitating	6,116	268	5,866	3,951	12,280	14,480	39,010
	Incapacitating	13,047	454	7,422	4,054	29,109	34,587	84,620
	Fatal injury	22,095	833	19,658	5,176	882,060	1,766,891	2,691,537
	Unknown severity	3,061	138	3,733	3,092	7,484	4,618	19,034
	Unknown if injured	718	87	2,804	2,217	3,865	1,807	9,281
Bus, transit/intercity	No injury	7	36	549	1,513	1,801	17	2,411
	Possible injury	2,149	144	1,797	3,241	7,025	2,697	13,812
	Nonincapacitating	2,640	256	2,051	4,034	9,401	6,734	21,081
	Incapacitating	35,401	315	2,248	4,248	38,906	128,795	205,665
	Fatal injury	21,198	833	6,051	5,176	827,803	1,656,421	2,512,305
	Unknown severity	2,705	213	1,799	3,852	8,833	11,454	25,004
	Unknown if injured	1,068	116	977	2,985	5,525	2,778	10,465

TABLE 10. Costs per Crash, by Crash Type and Crash Severity (in 2000 dollars)

Truck/bus crash type	Injury severity	Medical costs	Emergency services	Property damage	Lost productivity from delays	Total lost productivity	Monetized QALYs based on VSL from DOT	Total
Straight truck, no trailer	No injury	176	91	3,282	3,759	5,156	486	9,191
	Possible injury	5,883	279	5,888	7,467	17,288	13,556	42,894
	Nonincapacitating	6,816	406	7,419	7,993	17,672	10,814	43,128
	Incapacitating	15,847	744	9,974	8,837	42,400	37,990	106,955
	Fatal injury	31,633	1,270	19,811	10,893	987,286	1,951,498	2,991,498
	Unknown severity	3,746	261	5,712	6,303	13,048	7,543	30,310
	Unknown if injured	901	164	3,946	5,420	8,258	2,101	15,371
Straight truck with trailer	No injury	883	97	4,677	3,998	5,461	835	11,953
	Possible injury	9,312	323	10,109	7,748	19,109	22,786	61,640
	Nonincapacitating	10,370	429	11,126	7,567	21,670	27,085	70,680
	Incapacitating	35,434	961	19,580	11,935	70,049	99,483	225,507
	Fatal injury	38,642	1,479	33,667	12,981	1,197,243	2,374,243	3,645,273
	Unknown severity	1,547	260	12,509	7,981	13,425	3,944	31,685
	Unknown if injured	1,398	126	5,188	3,856	6,411	2,722	15,846
Straight truck, unknown if with trailer	No injury	883	81	3,104	3,362	4,652	813	9,533
	Possible injury	8,319	295	6,868	7,097	16,330	17,967	49,779
	Nonincapacitating	9,450	436	9,774	7,997	21,131	24,423	65,214
	Incapacitating	37,963	586	9,746	6,680	43,357	114,811	206,464
	Unknown if injured	4,684	265	8,389	6,662	12,539	10,991	36,867
Bobtail	No injury	717	96	4,618	5,026	7,000	1,354	13,785
	Possible injury	5,561	252	7,951	9,191	19,275	10,963	44,002
	Nonincapacitating	4,986	434	10,945	9,769	20,874	10,256	47,495
	Incapacitating	5,288	611	12,325	9,024	24,396	11,547	54,166
	Fatal injury	35,721	1,483	33,081	12,047	1,374,180	2,741,658	4,186,122
	Unknown severity	1,031	203	6,438	4,572	6,854	1,992	16,518
	Unknown if injured	1,101	110	5,193	4,104	6,524	2,474	15,401
Truck-tractor, 1 trailer	No injury	816	88	4,735	3,664	5,008	763	11,409
	Possible injury	9,027	319	10,693	7,290	18,450	23,285	61,775
	Nonincapacitating	10,595	433	12,237	7,516	22,178	28,643	74,086
	Incapacitating	19,651	672	14,561	7,922	43,228	52,533	130,645
	Fatal injury	37,779	1,371	33,839	11,272	1,105,903	2,193,252	3,372,143
	Unknown severity	3,957	142	7,533	5,136	9,479	2,950	24,060
	Unknown if injured	1,479	136	6,243	4,218	6,720	2,578	17,156
Truck-tractor, 2 or 3 trailers	No injury	772	81	11,924	3,332	4,580	718	18,074
	Possible injury	8,470	322	30,744	7,613	18,318	22,007	79,862
	Nonincapacitating	10,495	412	32,494	7,256	21,518	28,611	93,529
	Incapacitating	18,912	654	37,449	7,201	41,407	47,909	146,331
	Fatal injury	36,129	1,383	97,381	11,817	1,044,962	2,067,979	3,247,834
	Unknown severity	47	68	15,189	3,016	3,765	84	19,153
	Unknown if injured	1,166	132	12,412	3,618	5,630	1,967	21,308

Truck/bus crash type	Injury severity	Medical costs	Emergency services	Property damage	Lost productivity from delays	Total lost productivity	Monetized QALYs based on VSL from DOT	Total
Truck-tractor, with unknown # of trailers	No injury	768	93	6,322	3,890	5,230	753	13,166
	Possible injury	8,107	293	13,075	7,304	18,181	21,033	60,688
	Nonincapacitating	7,104	532	18,496	9,438	22,641	25,871	74,645
	Incapacitating	20,147	658	20,007	9,837	51,880	54,247	146,939
	Fatal injury	22,122	861	28,450	6,662	824,626	1,646,346	2,522,405
	Unknown if injured	1,413	118	6,781	3,789	6,046	2,331	16,688
Medium/heavy truck, unknown if with trailer	No injury	12	77	3,990	3,047	3,627	22	7,728
	Possible injury	5,523	371	11,116	7,061	15,813	14,160	46,984
	Nonincapacitating	5,482	373	10,386	7,032	17,817	12,646	46,704
	Incapacitating	67,664	1,383	24,447	14,100	57,867	196,346	347,707
	Fatal injury	22,543	865	20,760	6,230	788,368	1,572,577	2,405,112
	Unknown severity	12,071	811	16,153	17,850	38,074	53,636	120,745
	Unknown if injured	945	141	5,969	4,375	6,675	2,298	16,028
All large trucks	No injury	524	90	4,086	3,746	5,083	627	10,411
	Possible injury	7,162	303	8,402	7,560	17,749	17,238	50,853
	Nonincapacitating	8,806	434	10,284	8,041	20,712	20,671	60,906
	Incapacitating	20,460	711	13,212	8,663	44,786	55,520	134,689
	Fatal injury	35,916	1,349	31,278	11,446	1,076,607	2,133,038	3,278,188
	Unknown severity	4,298	278	6,548	6,919	13,750	9,387	34,261
	Unknown if injured	1,260	148	5,249	4,694	7,369	2,516	16,542
Bus, transit/intercity	No injury	21	93	1,417	3,813	4,554	52	6,137
	Possible injury	3,860	319	4,391	8,580	15,816	5,258	29,644
	Nonincapacitating	6,741	595	5,756	12,000	25,485	13,669	52,245
	Incapacitating	54,804	756	6,649	13,148	70,171	191,499	323,880
	Fatal injury	26,674	1,318	12,664	20,033	892,003	1,739,182	2,671,841
	Unknown severity	7,443	626	5,658	12,653	26,226	29,568	69,520
	Unknown if injured	1,347	196	2,139	6,044	9,611	3,467	16,760

TABLE 11. Costs per Crash, by Crash Type (in 2000 dollars)

Truck/bus crash type	Medical costs	Emergency services	Property damage	Lost productivity from delays	Total lost productivity	Monetized QALYs based on VSL from DOT	Total
Straight truck, no trailer	2,286	177	4,341	4,887	15,514	18,690	41,008
Straight truck with trailer	4,569	204	6,793	5,116	24,018	39,220	74,804
Straight truck, unknown if with trailer	2,775	142	4,548	4,279	7,685	6,047	21,196
Bobtail	1,976	168	5,961	5,988	16,554	18,508	43,167
Truck-tractor, 1 trailer	3,854	186	6,872	4,677	23,039	38,509	72,459
Truck-tractor, 2 or 3 trailers	3,816	184	18,132	4,447	24,302	42,048	88,483
Truck-tractor, with unknown # of trailers	1,901	130	7,296	4,232	10,778	11,399	31,505
Medium/heavy truck, unknown if with trailer	2,051	157	5,873	4,184	8,624	8,835	25,540
All large trucks	3,195	182	6,035	4,800	19,794	29,945	59,153
Bus, transit/intercity	3,050	203	2,510	5,782	13,031	13,754	32,548

TABLE 12. Costs per Injury Crash, by Crash Type (in 2000 dollars)

Truck/bus crash type	Medical costs	Emergency services	Property damage	Lost productivity from delays	Total lost productivity	Monetized QALYs based on VSL from DOT	Total
Straight truck, no trailer	7,162	376	6,787	7,495	39,450	59,169	112,943
Straight truck with trailer	12,191	425	11,167	7,426	62,384	115,469	201,635
Straight truck, unknown if with trailer	8,045	310	8,566	6,832	16,129	20,117	53,166
Bobtail	4,806	329	8,978	8,151	38,026	55,603	107,741
Truck-tractor, 1 trailer	10,645	406	11,648	6,944	63,343	119,657	205,699
Truck-tractor, 2 or 3 trailers	10,086	397	30,920	6,745	64,921	123,824	230,147
Truck-tractor, with unknown # of trailers	4,309	210	9,365	4,959	22,564	33,146	69,594
Medium/heavy truck, unknown if with trailer	4,264	244	7,917	5,419	14,049	17,916	44,390
All large trucks	9,076	389	9,968	7,162	52,534	92,764	164,730
Bus, transit/intercity	8,268	392	4,393	9,173	27,629	36,361	77,043

TABLE 13. Average Annual Crash Costs, by Crash Type: 1997-99 (in millions of 2000 dollars)

Truck/bus crash type	Medical costs	Emergency services	Property damage	Lost productivity from delays	Total lost productivity	Monetized QALYs based on VSL from DOT	Total
Straight truck, no trailer	300	24	608	692	1,946	2,089	4,966
Straight truck with trailer	92	3	107	78	397	659	1,259
Straight truck, unknown if with trailer	0	0	0	0	0	0	0
Bobtail	13	1	49	51	91	47	201
Truck-tractor, 1 trailer	697	35	1,289	884	4,015	6,529	12,564
Truck-tractor, 2 or 3 trailers	24	1	109	26	155	268	557
Truck-tractor, with unknown # of trailers	2	0	6	3	6	3	16
Medium/heavy truck, unknown if with trailer	5	1	23	17	26	12	66
All large trucks	1,133	65	2,190	1,752	6,636	9,606	19,630
Bus, transit/intercity	76	5	63	143	291	283	719

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Appendix

Table A1. Commercial Auto Insurance Statistics by Vehicle Type, Selected Companies, 1999

		Claims Per 1000 Covers	Claim Severity	Average Loss Cost	% of Total Losses	Loss Ratio	Premiums per Cover
Bodily Injury Liability	Bus	14.0	$25,608	$349	58.4%	86.7%	$532
	Light Truck	13.0	$25,323	$324	52.3%	85.1%	$539
	Medium Truck	11.0	$31,120	$355	56.4%	86.0%	$590
	Heavy Truck	12.0	$34,037	$407	54.1%	79.9%	$756
	Extra Heavy Truck	16.0	$41,994	$678	54.4%	78.8%	$1,240
	Heavy Truck-Tractor	15.0	$49,369	$748	61.5%	106.3%	$941
	Extra Heavy Truck-Tractor	24.0	$54,002	$1,283	63.2%	103.2%	$1,635
	Trailer	1.0	$36,439	$41	36.6%	61.4%	$99
	Pvt Passenger Vehicle	11.0	$26,074	$291	43.6%	75.1%	$529
	Other Public Livery	82.0	$16,117	$1,317	52.8%	80.3%	$2,141
	Total	12.0	$28,573	$335	52.0%	84.0%	$557
Property Damage Liability	Bus	53.0	$2,122	$112	18.7%	Folded into Bodily Injury	Folded into Bodily Injury
	Light Truck	52.0	$2,597	$135	21.7%		
	Medium Truck	58.0	$2,644	$153	24.3%		
	Heavy Truck	68.0	$2,911	$197	26.1%		
	Extra Heavy Truck	106.0	$2,812	$299	24.0%		
	Heavy Truck-Tractor	72.0	$3,496	$253	20.8%		
	Extra Heavy Truck-Tractor	95.0	$4,262	$405	20.0%		
	Trailer	6.0	$3,136	$20	18.3%		
	Pvt Passenger Vehicle	41.0	$2,576	$106	16.0%		
	Other Public Livery	148.0	$2,724	$403	16.1%		
	Total	49.0	$2,735	$133	20.6%		
Personal Injury Protection	Bus	12.0	$3,413	$40	2.0%	87.6%	$46
	Light Truck	4.0	$6,251	$26	1.5%	94.2%	$28
	Medium Truck	2.0	$6,805	$17	1.0%	58.5%	$29
	Heavy Truck	1.0	$6,458	$9	0.4%	31.7%	$28
	Extra Heavy Truck	2.0	$4,129	$7	0.2%	28.3%	$26
	Heavy Truck-Tractor	1.0	$14,863	$15	0.4%	49.1%	$31
	Extra Heavy Truck-Tractor	2.0	$8,418	$16	0.2%	40.8%	$39
	Trailer	0.0	$5,693	$1	0.2%	10.4%	$9
	Pvt Passenger Vehicle	7.0	$5,543	$38	2.2%	74.5%	$51
	Other Public Livery	185.0	$3,156	$584	13.8%	162.8%	$359
	Total	6.0	$5,091	$29	1.6%	84.0%	$35
Collision	Bus	14.0	$2,823	$40	14.2%	106.4%	$38
	Light Truck	43.0	$3,331	$143	16.5%	87.9%	$162
	Medium Truck	27.0	$4,745	$130	12.5%	75.0%	$173
	Heavy Truck	25.0	$6,675	$167	14.4%	78.0%	$214
	Extra Heavy Truck	29.0	$11,036	$323	17.1%	78.0%	$414
	Heavy Truck-Tractor	29.0	$8,601	$252	13.8%	63.7%	$395
	Extra Heavy Truck-Tractor	38.0	$12,207	$466	13.7%	74.3%	$627
	Trailer	8.0	$7,057	$58	31.4%	85.3%	$68
	Pvt Passenger Vehicle	62.0	$3,442	$214	28.1%	81.2%	$264
	Other Public Livery	13.0	$3,470	$44	12.6%	102.0%	$44
	Total	38.0	$3,898	$150	18.4%	83.0%	$180

		Claims Per 1000 Covers	Claim Severity	Average Loss Cost	% of Total Losses	Loss Ratio	Premiums per Cover
Compre-hensive	Bus	20.0	$879	$18	6.7%	88.2%	$20
	Light Truck	55.0	$1,133	$63	7.9%	76.5%	$82
	Medium Truck	31.0	$1,714	$53	5.7%	68.4%	$77
	Heavy Truck	21.0	$2,413	$52	5.0%	61.3%	$84
	Extra Heavy Truck	17.0	$4,081	$70	4.3%	51.8%	$135
	Heavy Truck-Tractor	19.0	$2,944	$57	3.6%	49.7%	$115
	Extra Heavy Truck-Tractor	17.0	$5,161	$87	0.0%	47.2%	$185
	Trailer	6.0	$3,829	$21	13.5%	75.4%	$28
	Pvt Passenger Vehicle	55.0	$1,436	$78	10.1%	56.5%	$139
	Other Public Livery	9.0	$1,875	$17	4.7%	72.9%	$23
	Total	41.0	$1,374	$56	7.4%	66.3%	$84
Total	Bus	26.0	$4,108	$105	100.0%	89.2%	$118
	Light Truck	36.0	$4,421	$160	100.0%	85.0%	$189
	Medium Truck	29.0	$5,833	$172	100.0%	82.8%	$208
	Heavy Truck	30.0	$6,731	$201	100.0%	77.9%	$258
	Extra Heavy Truck	41.0	$8,007	$327	100.0%	76.7%	$427
	Heavy Truck-Tractor	33.0	$9,976	$325	100.0%	93.5%	$348
	Extra Heavy Truck-Tractor	43.0	$13,205	$569	0.0%	94.6%	$601
	Trailer	5.0	$6,735	$31	100.0%	68.3%	$45
	Pvt Passenger Vehicle	38.0	$4,258	$162	100.0%	74.2%	$218
	Other Public Livery	29.0	$5,072	$149	100.0%	88.4%	$169
	Total	32.0	$5,057	$162	100.0%	82.2%	$197

Table A-2. Percentage of Policyholders with Different Coverage, by Policy Type, Selected Companies, 1999

Coverage	Commercial	Motorcycle	Other Private Passenger
Bodily Injury Liability	93.9%	87.1%	99.6%
Property Damage Liability	93.9%	85.4%	96.0%
Personal Injury Protection	33.6%	3.8%	37.9%
Collision	74.5%	52.3%	86.1%
Comprehensive	80.0%	56.8%	90.8%

Table A3. Statistics About Auto Insurance Policies by Vehicle Type, Commercial versus Private Passenger, Selected Companies, 1999

	Policies @	Covers per Policy	Premium per Actual Policy	Premium per All-Cover Policy	Claims per 1000 Policies	Losses per Policy
Buses	433,443	2.5	$298	$636	64.7	$266
Light Trucks	3,057,914	3.9	$730	$811	140.2	$620
Medium Trucks	454,860	3.7	$758	$869	107.7	$628
Heavy Trucks	392,134	3.8	$966	$1,082	111.9	$753
Extra Heavy Trucks	108,135	3.8	$1,628	$1,815	155.9	$1,248
Heavy Truck-Tractors	73,273	3.7	$1,301	$1,482	121.9	$1,216
Extra Heavy Truck-Tractors	191,919	3.6	$2,148	$2,486	153.8	$2,031
Trailers	785,533	3.6	$162	$204	16.4	$111
Private Passenger	1,346,992	4.1	$899	$983	156.6	$667
Other Public Liveries	247,732	2.4	$399	$2,567	69.5	$353
Total	7,091,935	3.7	$734	$856	119.3	$603
Private Passenger Auto *	43,732,804	5.7 **	$718	$808	252.5	$481

* = excludes motorcycle
** = includes uninsured motorist and own medical coverage not collected for commercial.
@ = represents 28.9% of all commercial premiums and presumably of all commercial policies.

Table A4. Monetized QALYs based on Miller (1990)

Truck/bus type	Average per crash	Per injury crash only
Straight truck, no trailer	23,363	73,961
Straight truck with trailer	49,026	144,336
Straight truck, unknown if with trailer	7,558	25,146
Bobtail	23,135	69,504
Truck-tractor, 1 trailer	48,136	149,571
Truck-tractor, 2 or 3 trailers	52,560	154,780
Truck-tractor, with unknown # of trailers	14,249	41,432
Medium/heavy truck, unknown if with trailer	11,044	22,395
All large trucks	37,431	115,955
Bus, transit/intercity	17,192	45,451

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