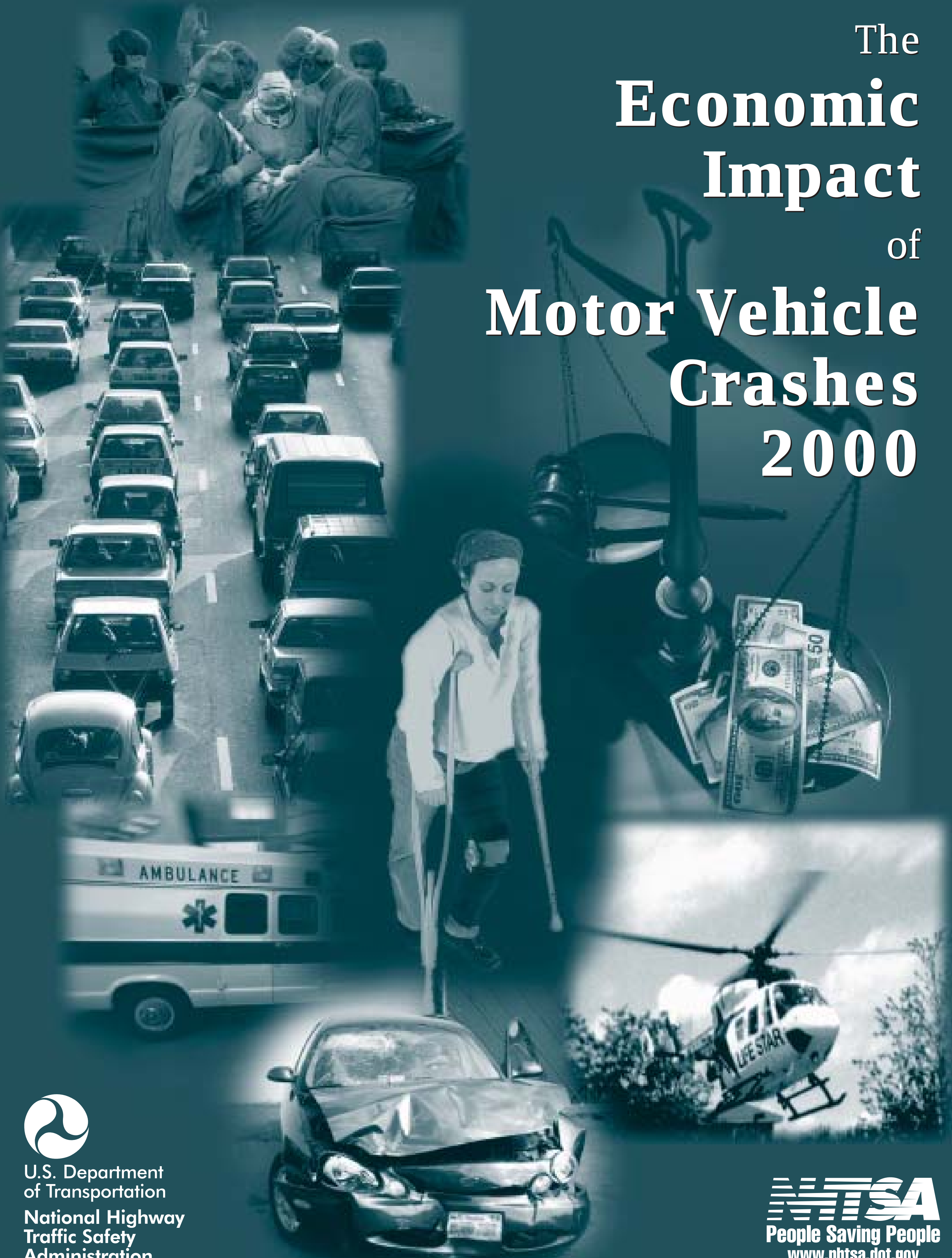
The Economic Impact of Motor Vehicle Crashes 2000



U.S. Department
of Transportation
National Highway
Traffic Safety
Administration

NHTSA
People Saving People
www.nhtsa.dot.gov

Technical Report Documentation Page

1. Report No. DOT HS 809 446	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle The Economic Impact of Motor Vehicle Crashes, 2000		5. Report Date May, 2002 6. Performing Organization Code
7. Author(s) L. Blincoe, A. Seay, E. Zaloshnja, T..Miller, E. Romano, S.Luchter, R.Spicer		8. Performing Organization Report No.
9. Performing Organization Name and Address Plans and Policy National Highway Traffic safety Administration Washington, D.C. 20590		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		13. Type of Report and Period Covered NHTSA Technical Report 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This report presents the results of an analysis of motor vehicle crash costs in the United States in the year 2000. The total economic cost of motor vehicle crashes in 2000 was $230.6 billion. This represents the present value of lifetime costs for 41, 821 fatalities, 5.3 million non-fatal injuries, and 28 million damaged vehicles, in both police-reported and unreported crashes. Lost market productivity accounted for $61 billion of this total, while property damage accounted for nearly as much - $59 billion. Medical expenses totaled $32.6 billion and travel delay accounted for $25.6 billion. Each fatality resulted in an average discounted lifetime cost of $977,000. Public revenues paid for roughly 9 percent of all motor vehicle crash costs, costing tax payers $21 billion in 2000, the equivalent of over $200 in added taxes for every household in the U.S. Alcohol-involved crashes accounted for $51.1 billion or 22 percent of all economic costs, and 75 percent of these costs occurred in crashes where a driver or non-occupant had a BAC of .10 or greater. In roughly 80 percent of these cases, alcohol was the cause of the crash. Crashes in which police indicate that at least one driver was exceeding the legal speed limit or driving too fast for conditions cost $40.4 billion in 2000. Safety belt use prevented 11,900 fatalities, 325,000 serious injuries, and $50 billion in injury related costs in 2000, but the failure of a substantial portion of the driving population to buckle up caused 9,200 unnecessary fatalities, 143,000 serious injuries, and cost society $26 billion in easily preventable injury related costs.

17. Key Words economic - costs - motor vehicle - crashes – alcohol – speed – safety belts – seat belts - source of payment – accidents – highway – safety – fatalities – injuries – functional capacity – fci - highways - roads		18. Distribution Statement This document is available to the public from the National Technical Information Service, Springfield, VA 22161 http//:www.ntis.gov	
19. Security Classif. (of this report) None	20. Security Classif. (of this page) None	21. No. of Pages	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

The Economic Impact of Motor Vehicle Crashes 2000

Lawrence J. Blincoe
Angela G. Seay, M.Sc.
Eduard Zaloshnja, Ph.D.
Ted R. Miller, Ph.D.
Eduardo O. Romano, Ph.D.
Stephen Luchter
Rebecca S. Spicer, Ph.D.

May 2002

U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA
People Saving People
www.nhtsa.dot.gov

Table of Contents

Summary

In the year 2000, the total economic cost of motor vehicle crashes in the United States was $230.6 billion. This represents the present value of lifetime economic costs for 41,821 fatalities, 5.3 million non-fatal injuries, and 28 million damaged vehicles. These figures include both police-reported and unreported crashes.

All costs in this report are expressed in year 2000 economics using a 4 percent discount rate. Nonfatal injury costs are stratified by severity level based on the Abbreviated Injury Scale. The cost components include productivity losses, property damage, medical costs, rehabilitation costs, travel delay, legal and court costs, emergency services (such as medical, police, and fire services), insurance administration costs, and the costs to employers. Values for more intangible consequences such as physical pain or lost quality of life are not included in this estimate, but are discussed separately in Appendix A of this report.

Economic Impact of Crashes

- The cost of motor vehicle crashes that occurred in 2000 totaled $230.6 billion. This is equal to approximately $820 for every person living in the United States and 2.3 percent of the U.S. Gross Domestic Product.
- The lifetime economic cost to society for each fatality is over $977,000. Over 80 percent of this amount is attributable to lost workplace and household productivity.
- Each critically injured survivor cost an average of $1.1 million. Medical costs and lost productivity accounted for 84 percent of the cost for this most serious level of non-fatal injury.
- Lost workplace productivity costs totaled $61 billion, which equaled 26 percent of the total costs. Lost household productivity totaled $20.2 billion, representing 9 percent of the total costs.
- Total property damage costs for **all crash types** (fatal, injury, and property damage only) totaled $59 billion and accounted for 26 percent of all costs.
- **Property damage only crashes** (in which vehicles were damaged but nobody was injured) were the most costly type of crash, due to their very high rate of occurrence. Their costs totaled $59.8 billion and accounted for 26 percent of total motor vehicle crash costs.
- Present and future medical costs due to injuries occurring in 2000 were $32.6 billion, representing 14 percent of the total costs. Medical costs accounted for 26 percent of costs from non-fatal injuries.
- Travel delay cost $25.6 billion or 11 percent of total crash costs.

- Approximately 9 percent of all motor vehicle crash costs are paid from public revenues. Federal revenues accounted for 6 percent and states and localities paid for approximately 3 percent. Private insurers pay approximately 50 percent of all costs. Individual crash victims pay approximately 26 percent while third parties such as uninvolved motorists delayed in traffic, charities, and health care providers pay about 14 percent. Overall, those not directly involved in crashes pay for nearly three-quarters of all crash costs, primarily through insurance premiums, taxes and travel delay. In 2000 these costs, borne by society rather than by crash victims, totaled over $170 billion.

Incidence of Crashes

- 5.3 million persons were injured in 16.4 million motor vehicle crashes in 2000, including 41,821 fatalities. Twenty-one percent of these injuries occurred in crashes that were not reported to police.
- 27.6 million vehicles were damaged in motor vehicle crashes in 2000; 23.6 million or 86 percent of these vehicles were damaged in incidents that incurred property damage only. The remaining 14 percent involved injuries to occupants of the vehicle, or to non-occupants such as pedestrians or bicyclists.
- Approximately half of property damage only crashes and a fifth of all injury crashes are not reported to the police

Alcohol Involvement in Crashes

- Alcohol-involved crashes resulted in 16,792 fatalities, 513,000 nonfatal injuries, and $50.9 billion in economic costs in 2000, accounting for 22 percent of all crash costs.
- Costs for crashes involving a driver or non-occupant with a blood alcohol content of .10 percent or greater (the legal definition in most states), accounted for 75 percent of the total of all alcohol-involved crash costs.
- The impact of alcohol involvement increases with injury severity. Alcohol-involved crashes accounted for 10 percent of property damage only (PDO) crash costs, 21 percent of nonfatal injury crash costs; and 46 percent of fatal injury crash costs.
- Although drinking drivers may experience impaired judgment, perceptions and reaction times, not all crashes in which alcohol was present were caused by alcohol. Crashes in which alcohol was the cause resulted in 13,570 fatalities, over 360,000 nonfatal injuries, and nearly $40 billion in economic costs. This is approximately 80 percent of the alcohol-related fatalities and 78 percent of costs. It represents 32 percent of **all** fatalities and 17 percent of all costs from motor vehicle crashes.

Impact of Speed-related Crashes

- Crashes in which at least one driver was exceeding the legal speed limit or driving too fast for conditions cost $40.4 billion in 2000.
- Speed-related crashes are associated with 12,350 fatalities, 690,000 nonfatal injuries and damage to 2.3 million vehicles in property damage only crashes. This represents 30 percent of all fatalities; 13 percent of all nonfatal injuries, and 10 percent of all property damage only crashes.
- Speed-related crashes cost an average of $144 for every person in the United States.

Safety Belt Use

- In the year 2000, safety belts prevented 11,900 fatalities and 325,000 serious injuries, saving $50 billion in medical care, lost productivity, and other injury related costs.
- Safety belt non-use represents an enormous lost opportunity for injury prevention. In the year 2000 alone, over 9,200 persons were killed and 143,000 were injured unnecessarily because they failed to wear their safety belts, costing society $26 billion.
- Over the last 26 years, safety belts have prevented 135,000 fatalities and 3.8 million injuries. This saved society $585 billion in medical care, lost productivity, and other injury related economic costs. During the same time period, nearly 315,000 additional fatalities and 5.2 million serious injuries could have been prevented by safety belts if all occupants had used them. This represents an economic loss of $913 billion in unnecessary expenses and lost productivity.

Introduction

In the year 2000, 41,821 persons were killed, 5.3 million were injured, and 27.6 million vehicles were damaged in motor vehicle crashes in the United States. The economic costs of these crashes totaled $230.6 billion. Included in these losses are lost productivity, medical costs, legal and court costs, emergency service costs, insurance administration costs, travel delay, property damage, and workplace losses. The $230.6 billion cost of motor vehicle crashes represents the equivalent of nearly $820 for each of the 281.4 million persons living in the United States, and 2.3 percent of the $9,872 billion U.S. Gross Domestic Product for 2000.

Society, individual crash victims and their families, friends and employers are affected by motor vehicle crashes in many ways. For example, the cost of medical care is borne by the individual in the form of payments for insurance, deductibles, uncovered costs, and uninsured expenses. It is borne by society through higher insurance premiums and through the diversion of medical resources away from other medical needs, such as medical research, disease prevention and control, and basic public health needs. There are also significant costs associated with the lost productivity experienced by an individual and others when the victim dies prematurely or experiences a short or long-term disability. The victim's dependents suffer immediate economic hardship in the loss of the victim's income and other contributions; society also suffers by the necessity to support the victim or their dependents, and through foregone contributions to the nation's productivity.

This report examines these and other costs resulting from motor vehicle crashes. The purpose of presenting these costs is to place in perspective the economic losses that result from these crashes, and to provide information to government and private sector officials for use in structuring programs to reduce or prevent these losses.

Total economic costs are summarized in Table 1. The total economic cost of motor vehicle crashes in 2000 is estimated to have been $230.6 billion. Of this total, medical costs were responsible for $32.6 billion, property damage losses for $59 billion, lost productivity (both market and household) $81 billion, and other related costs $58 billion.

The most significant costs were lost market productivity and property damage, each of which separately accounted for 26 percent of the total economic costs in 2000. For lost productivity, these high costs are a function of the level of disability that has been documented for crashes involving injury and death. For property damage, costs are primarily a function of the very high incidence of minor crashes in which injury does not occur or is negligible. The value of household productivity accounts for 9 percent of total costs. Medical care costs and emergency services (which includes police and fire services) are responsible for about 15 percent of the total. Travel delay caused by congestion at the crash site accounts for 11 percent.

Legal and court costs account for 5 percent and insurance administration costs for about 7 percent of the total. These costs are summarized in Tables 1 and 2, and Figures 1-3. The incidence of injuries and crashes that produced these costs is summarized in Table 3.

Alcohol consumption remains a major cause of motor vehicle crashes; 2000 data show that alcohol-involved crashes declined slightly in incidence. Historically, approximately half of all motor vehicle fatalities have occurred in crashes where the driver or non-occupant had been drinking, but this number has gradually declined in recent years. Alcohol is involved in crashes that account for 22 percent of all economic costs, with 75 percent of these costs involving crashes where a driver or non-occupant was legally intoxicated, defined as a Blood Alcohol Content (BAC) of >.10.

NHTSA last examined the cost of motor vehicle crashes in 1996. At that time the report was based on 1994 data. The current report indicates a total cost from traffic crashes in 2000 of $230.6 billion, approximately 50 percent higher than our previous estimate of $150.5 billion. The higher estimate is attributable to a number of factors. Inflation accounts for a rise of approximately 20 percent, but most of the increase is due to higher estimates of certain cost categories. These, in turn, are partly due to improved data sources, to changes in estimates of the incidence of some nonfatal injury categories, and to real cost increases in excess of inflation.

One category that increased noticeably was lost productivity for serious nonfatal injuries. Unit costs for these injuries increased due to new studies that revealed higher levels of long-term impairment than previously estimated. Medical care costs also increased substantially. This reflects both an increase in treatment costs and an increase in the prevalence of injury in the most costly medical care categories. This increase may be partially due to an uncharacteristically low occurrence of these injuries during 1994 as corresponding injury levels have been fairly stable since that time. By far the largest contribution to this increase is higher estimates of travel delay costs. Recent studies indicate that travel delay is far more costly than previously estimated. Again, this is partially due to better data, but it also reflects the growing problem of congestion on our nation's roadways.

The report indicates that while alcohol-involved crashes are more costly than in 1994, they account for a smaller portion of the overall crash cost. This reflects the impact of efforts at federal, state, and local levels to reduce the incidence of drunk driving. The report also estimates the portion of alcohol-involved crash costs that were actually caused by impaired driving. Although drinking drivers may experience impaired judgment, perceptions and reaction times, not all crashes in which alcohol was present were caused by alcohol. Alcohol was the cause in crashes that produced 78 percent of crash costs where at least one driver or non-occupant had been drinking.

The report also analyzes the impact of safety belt use as well as the cost the nation incurs from failure to wear safety belts. Over the last quarter century, safety belts have prevented over 135,000 fatalities and 3.8 million nonfatal injuries, which saved $585 billion in costs (in 2000 dollars). During this same period, the failure of a substantial portion of the driving population to wear belts caused 315,000 unnecessary deaths and 5.2 million nonfatal injuries, costing the nation $913 billion in preventable medical costs, lost productivity, and other injury related expenditures.

The Abbreviated Injury Scale (AIS) used in this report provides the basis for stratifying societal costs by injury severity. Significant sources of economic loss, such as medical costs and lost productivity, are highly dependent on injury outcome. AIS codes are primarily oriented toward the immediate threat to life resulting from the injury, and are estimated soon after a crash occurs. Although the more serious injuries tend to have more serious outcomes, AIS codes are not always accurate predictors of long-term injury outcomes. Some injuries with low AIS codes, such as lower extremity injuries, can actually result in serious and expensive long-term outcomes. There is currently no incidence database organized by injury outcome. The development and use of such a database could improve the accuracy of economic cost estimates, and might result in a significant shift in the relative number of injuries regarded as serious.

This report will focus on "average" costs for injuries of different severity. While this approach is valid for computing combined costs at a nationwide level, the costs of individual cases at different injury levels can vary quite dramatically. The average costs outlined in this report are significant; however, in individual cases they can be exceeded by a factor of three or more. There is considerable evidence to indicate that the most serious injuries are not adequately covered by insurance. Depending on the financial ability and insurance coverage of the individual crash victims, the medical and rehabilitation costs, as well as the loss in wages resulting from serious injury, can be catastrophic to the victim's economic well being in addition to their physical and emotional condition.

When using this report for the analysis of crash impact and injury countermeasures, it is important to include only those cost elements that are applicable to the specific programs addressed. For example, programs that encourage safety belt use may reduce costs associated with injuries, but would not have an effect on property-damage crashes. Therefore, careful consideration should be given to the nature of the benefits from any proposal before incorporating the results of this report into analyses or recommendations.

Economic costs represent only one aspect of the consequences of motor vehicle crashes. Persons injured in these crashes often suffer physical pain and emotional anguish that is beyond any economic recompense. The permanent disability of spinal cord damage, loss of mobility, loss of eyesight, and serious brain injury can profoundly limit a person's life, and can result in dependence on others for routine physical care. More common, but less serious injuries, can cause physical pain and limit a victim's physical activities for years after the crash. Serious burns or lacerations can lead to long-term discomfort and the emotional trauma associated with permanent disfigurement. For an individual, these non-monetary outcomes can be the most devastating aspect of a motor vehicle crash.

The family and friends of the victim feel the psychic repercussions of the victim's injury acutely as well. Caring for an injured family member can be very demanding for others in the family, resulting in economic loss and emotional burdens for all parties concerned. It can change the very nature of their family life; the emotional difficulties of the victim can affect other family members and the cohesiveness of the family unit. When a crash leads to death, the emotional damage is even more intense, affecting family and friends for years afterward and sometimes leading to the breakup of previously stable family units.

Action taken by society to alleviate the individual suffering of its members can be justified in and of itself; in order to increase the overall quality of life for individual citizens. In this context, economic benefits from such actions are useful to determine the net cost to society of programs that are primarily based on humane considerations. If the focus of policy decisions was purely on the economic consequences of motor vehicle crashes, the most tragic, and, in both individual and societal terms, possibly the most costly aspect of such crashes would be overlooked.

The focus of the costs presented in this report is on the economic impact of motor vehicle crashes. These costs do not represent the more intangible consequences of these events and should not, therefore, be used alone to produce cost-benefit ratios. Measurement of the dollar value of intangible consequences such as pain and suffering has been undertaken in numerous studies. These studies have estimated values based on wages for high-risk occupations and prices paid in the market place for safety products, among other measurement techniques. These "willingness to pay" costs can be an order of magnitude higher than the economic costs of injuries. Most researchers agree that the value of fatal risk reduction falls in the range of $2-5 million per life saved. Appendix A discusses these estimates.

Table 1
Summary of Total Costs, 2000
2000 Dollars (Millions)

	PDO	MAIS 0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal	Total	% Total
INJURY COMPONENTS										
Medical	$0	$3	$11,088	$6,813	$5,854	$4,794	$3,146	$924	$32,622	14.15%
Emergency Services	$733	$56	$452	$92	$46	$30	$8	$35	$1,453	0.63%
Market Productivity	$0	$0	$8,151	$10,908	$8,996	$3,886	$4,151	$24,898	$60,991	26.45%
Household Productivity	$1,111	$84	$2,664	$3,193	$2,653	$1,023	$1,413	$8,010	$20,151	8.74%
Insurance Admin.	$2,741	$204	$3,453	$3,012	$2,379	$1,181	$645	$1,552	$15,167	6.58%
Workplace Cost	$1,208	$87	$1,175	$852	$537	$172	$78	$364	$4,472	1.94%
Legal Costs	$0	$0	$699	$2,172	$1,990	$1,230	$756	$4,272	$11,118	4.82%
Subtotal	**$5,793**	**$433**	**$27,682**	**$27,041**	**$22,456**	**$12,315**	**$10,197**	**$40,056**	**$145,973**	**63.31%**
NON-INJURY COMPONENTS										
Travel Delay	$18,976	$1,970	$3,620	$369	$118	$36	$87	$383	$25,560	11.09%
Property Damage	$35,069	$2,597	$17,911	$1,724	$856	$359	$89	$430	$59,036	25.60%
Subtotal	**$54,046**	**$4,567**	**$21,532**	**$2,093**	**$974**	**$395**	**$176**	**$812**	**$84,595**	**36.69%**
Total	**$59,838**	**$5,000**	**$49,214**	**$29,134**	**$23,430**	**$12,710**	**$10,373**	**$40,868**	**$230,568**	**100.00%**
% Total	25.95%	2.17%	21.34%	12.64%	10.16%	5.51%	4.50%	17.72%	100.00%	

Note: MAIS is the maximum injury severity level experienced by the victim. PDO is property damage only.
Totals may not add due to rounding.

Table 2
Summary of Unit Costs, 2000
2000 Dollars

	PDO	MAIS 0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
INJURY COMPONENTS								
Medical	$0	$1	$2,380	$15,625	$46,495	$131,306	$332,457	$22,095
Emergency Services	$31	$22	$97	$212	$368	$830	$852	$833
Market Productivity	$0	$0	$1,749	$25,017	$71,454	$106,439	$438,705	$595,358
HH Productivity	$47	$33	$572	$7,322	$21,075	$28,009	$149,308	$191,541
Insurance Admin.	$116	$80	$741	$6,909	$18,893	$32,335	$68,197	$37,120
Workplace Cost	$51	$34	$252	$1,953	$4,266	$4,698	$8,191	$8,702
Legal Costs	$0	$0	$150	$4,981	$15,808	$33,685	$79,856	$102,138
Subtotal	**$245**	**$170**	**$5,941**	**$62,020**	**$178,358**	**$337,301**	**$1,077,567**	**$957,787**
NON-INJURY COMPONENTS								
Travel Delay	$803	$773	$777	$846	$940	$999	$9,148	$9,148
Prop Damage	$1,484	$1,019	$3,844	$3,954	$6,799	$9,833	$9,446	$10,273
Subtotal	**$2,287**	**$1,792**	**$4,621**	**$4,800**	**$7,739**	**$10,832**	**$18,594**	**$19,421**
Total	**$2,532**	**$1,962**	**$10,562**	**$66,820**	**$186,097**	**$348,133**	**$1,096,161**	**$977,208**

Note: Unit costs are on a per-person basis for all injury levels. PDO costs are on a per damaged vehicle basis.

Table 3
Incidence Summary – 2000 Total Reported and Unreported Injuries

	Police-Reported	Unreported	Total	Percent Unreported
VEHICLES				
Injury Vehicles	3,080,321	839,486	3,919,807	21.42%
PDO Vehicles*	12,288,482	11,343,214	23,631,696	48.00%
Total Vehicles	**15,368,803**	**12,182,700**	**27,551,503**	**44.22%**
PEOPLE IN INJURY CRASHES				
MAIS 0	2002667	545791	2,548,458	21.42%
MAIS 1	3599995	1059590	4,659,585	22.74%
MAIS 2	366987	69020	436,007	15.83%
MAIS 3	117694	8209	125,903	6.52%
MAIS 4	36264	245	36,509	0.67%
MAIS 5	9463	0	9,463	0.00%
MAIS 1-5 Non-Fatal Injuries	4,130,403	1,137,064	5,267,467	21.59%
Fatal	41821	0	41,821	0.00%
Total Injured Persons	**4,172,224**	**1,137,064**	**5,309,288**	**21.42%**
CRASHES				
PDO	7,013,424	6,473,930	13,487,355	48.00%
Injury	2,221,773	605,504	2,827,277	21.42%
Fatal	37,409	0	37,409	0.00%
Total Crashes	**9,272,607**	**7,079,434**	**16,352,041**	**43.29%**

** PDO vehicles are crash involved vehicles in which nobody was injured. All PDO vehicles, including those involved in injury crashes, are included under PDO vehicles.*

Figure 1
Components of Total Costs

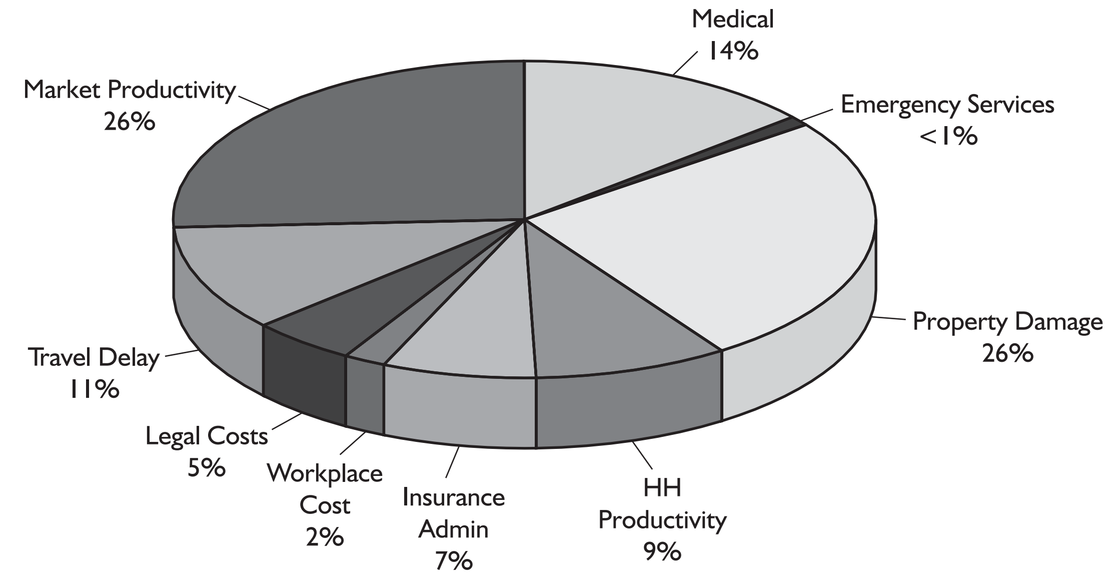


Figure 2
Components of Total Costs, Fatalities

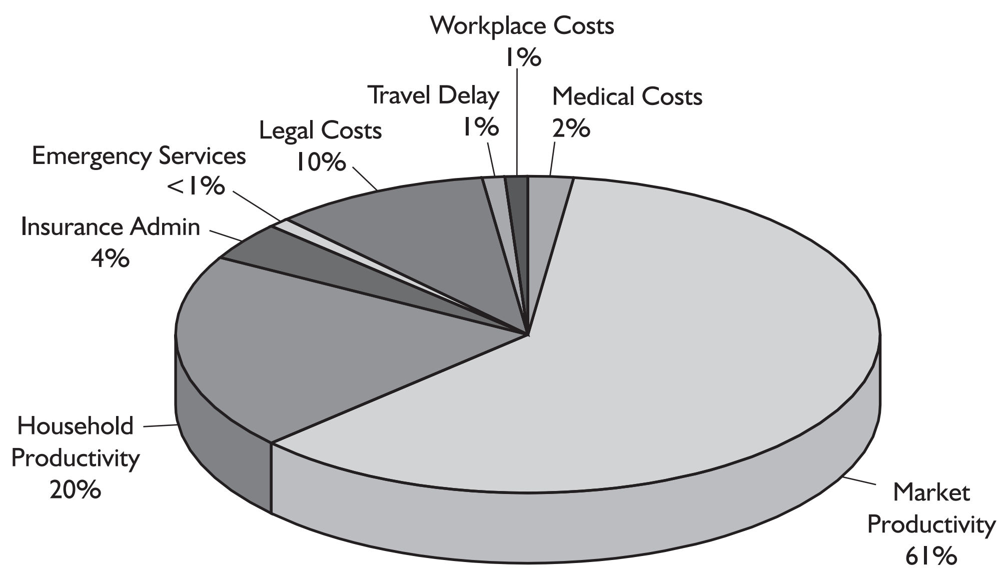
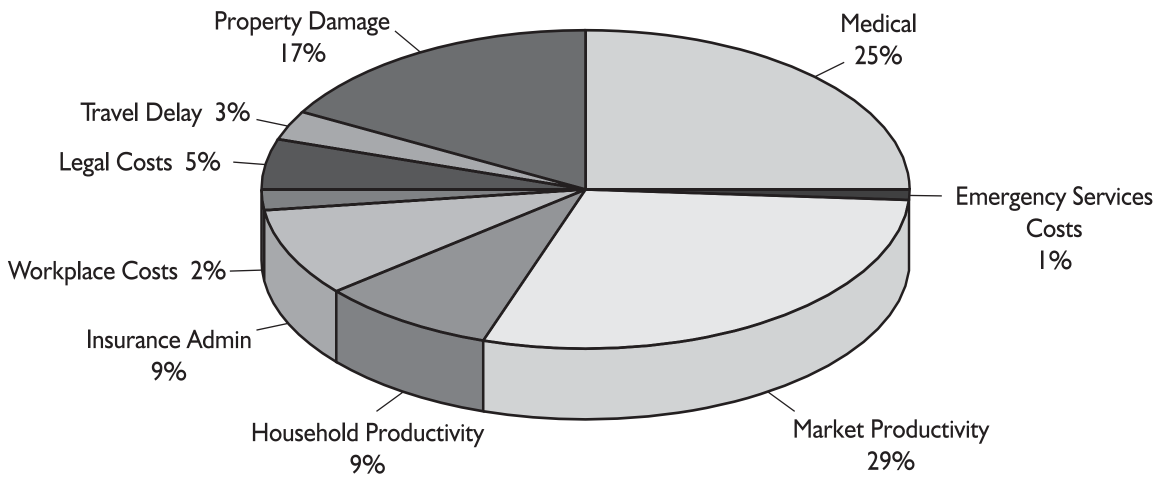


Figure 3
Components of Total Costs, Non-Fatal Injuries



Human Capital Costs

The costs documented in this report are the economic or "human capital" cost components for motor vehicle injuries and crashes. The conceptual framework of human capital costs encompasses direct and indirect costs to individuals and to society as a whole from the decline in the general health status of those injured in motor vehicle crashes. During their lifetime, individuals function as producers and consumers of economic output. Injured individuals are considered a fundamental part of total societal impact; the value of their decreased production and their decreased consumption is included in the total cost. The resources consumed as a result of any injury or crash that might otherwise be used for increasing the societal well-being are also counted in the total cost.

Emergency treatment, initial medical costs, rehabilitation costs, long-term care and treatment, insurance administration expenses, legal costs, and employer/workplace costs are all considered to be direct costs. Indirect costs are productivity costs in the workplace due to temporary and permanent disability and decreases in household productivity emanating from these disabilities. Property damage and travel delay, crash costs other than those directly attributable to an injury, are estimated for injury and non-injury crashes. A description of each of these cost categories is included in Appendix D.

The human capital method used to calculate the injury and crash costs does not include the costs associated with loss of emotional well being unless medical attention is required. Values for "pain and suffering" or permanent losses in functional capacity, unless they result in permanent earnings loss, are also not quantified by human capital measures. However, this report does include an appendix (B) that discusses the psychosocial costs of injury. This chapter will address these impacts in an effort to put the quantified economic impacts into perspective with the emotional impact that affects the lives of crash victims and their families. In Appendix A, estimates of Comprehensive costs, which include a value for lost quality of life, are also discussed

Human capital costs can be used in the following ways:

- To calculate the economic cost savings from reducing a given number of injuries or crashes
- To demonstrate the economic magnitude of the crash problem in the United States or in any given location
- To evaluate the impact of injury on a specific sub-sector of the economy such as medical costs or employer costs

Unit costs in this report were developed by Ted Miller and associates. There were significant changes made in the development of these unit costs as compared to earlier reports, Miller et al (1995); Miller (1995), Miller et al (1991), Blincoe and Faigin (1992), Miller (1993) and Blincoe (1996). The following modifications were made:

Market Productivity

Unit costs for market productivity costs are now more carefully targeted than they were in previous studies. First of all, injuries were categorized using MAIS-90 definitions rather than MAIS-85. A 4 percent discount rate was used in calculating costs. More importantly, an AIS-specific calculation is used for disabled and partially disabled, rather than a flat 17 percent rate across each MAIS category. This allowed for the costs to be fine-tuned, reflected most obviously in the MAIS-5 category where the unit cost dramatically increased. This is intuitive, as one would expect to see a much higher rate of disability in an MAIS-5 injury.

In addition, comprehensive earnings data from the Bureau of Labor Statistics were used to calculate the final market productivity figures. The data were divided by gender and by employment status and included ages above 75 in the fatality lost productivity calculations.

The methods used to derive future work loss costs parallel the CPSC Injury Cost Model and details can be found in its documentation. 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. The lifetime wage and household work losses due to a death or permanent total disability were computed first and then discounted 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. They include, by age group and sex, survival probabilities from National Vital Statistics Reports (1999), plus average annual earnings and the value of household work performed from Expectancy Data (1999). The distribution of crash cases by body part, MAIS, fracture/dislocation, age group, and sex, was estimated from CDS files (1988-91 for AIS-85 and 1993-99 for AIS-90).

For survivors, NCCI probabilities that an injury will result in permanent partial or total disability and on the percentage of earning power lost to partial disability were applied to compute both the number of permanently disabled victims and the percentage of lifetime work lost. These probabilities are by diagnosis and whether the victim was admitted to the hospital. ICDmap85 and ICDmap90 (Johns Hopkins University, 1997) were used to assign 1985 and 1990 Occupational Injury Codes (OIC) injury codes or code groups to each category. The permanent disability estimates in the injury cost model account for children's longer life span but are not child-specific in other respects.

Diagnosis-specific probabilities of injuries to employed people causing wage loss came from CDS 1988-91 (for AIS-85) and CDS 1993-99 (for AIS-90). The days of work loss per person losing work were estimated from the 1993 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.

Household Work Loss

Since the parent with the lowest salary often stays home as the caregiver, caregiver wages are estimated as the mean hourly earnings for non-supervisory employees in private non-agricultural industries. Injured people lose housework on 90 percent of the days they lose wage work (S. Marquis, The RAND Corporation, Personal Communication, 1992). Thus, the days of household work lost were computed 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, Viner, et al., (1991) and was included in the lost household productivity.

For temporary disability, it was 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. This assumption may cause a slight overestimate because the caregiver may be able to do some work at home. Conversely the work loss of other individuals that visit a hospitalized child or rush to the child's bedside shortly after an injury, was not estimated, nor was any temporary wage work or household work loss by adolescents.

Travel Delay

Travel delay was computed similarly to methods outlined in Miller, Viner et al. (1991), with four refinements. First, the prior work differentiated delay by crash severity in proportion to police time at the crash scene using data from 3 police departments. Data from two additional departments were added to this study. This resulted in an hours-of-delay ratio of 49 to 85.6 to 232.8 for the delays due to PDO, injury, and fatal crashes respectively. Second, the hours of delay per urban interstate crash were increased in proportion to the major increase documented by Lan and Hu (2000) in Minneapolis-St Paul. Their study found an average of 5,057 hours of delay per heavy truck crash in Minneapolis-St Paul (and 2,405 hours per crash without heavy vehicles involved). The study collected data on 289 heavy truck crashes (and 3,762 other crashes).

Third, the previous analysis arbitrarily assumed no travel delay on some classes of roadways and arbitrarily stepped down the delay estimates for other classes. Instead, starting from the hours of delay per crash on urban interstates (the most complete and data-driven estimates available). Delay for other roadway classes by rural-urban location was computed in proportion to traffic density (vehicle-miles per lane mile) for each roadway class relative to urban interstate. Traffic density was computed from Federal statistical data (FHWA, 1998). The costs per hour of delay from the prior analysis (60 percent of the wage rate for non-commercial drivers and 100 percent for commercial drivers) were used since they fell in the range prescribed by current guidance from the Office of the Secretary of Transportation (U.S. DOT, 1997). Table 1 of that report details the delay estimates per heavy vehicle crash by roadway class and location.

Finally, it was assumed that only police-reported crashes delayed traffic. This was based on the premise that any substantial impact on traffic would attract the attention of police. It is recognized that this may be a conservative assumption since a portion of these unreported crashes would have some limited impact on traffic flow.

The resulting estimate of travel delay is considerably higher than previously estimated. This reflects both improved data and the growing problem of congestion on our nation's roadways. A recent study conducted by the Oak Ridge National Laboratory also examined travel delay from motor vehicle crashes, but limited its study to highways and principal arterials. That study (Chin et al, 2002) used a modeling technique to predict losses and estimated delay in vehicle hours rather than person hours. When the vehicle occupancy rate used in this study was applied to the Chin et al study, the average person hours lost per freeway and principal arterial crash was 466, compared to 428 in this study – a difference of only 9 percent.

Medical Care

Injury Incidence and Severity Estimation

To estimate injury incidence and severity, procedures developed by Miller and Blincoe (1994) and Miller, Galbraith et al. (1995) were used and also applied in Blincoe (1996), Miller, Levy et al. (1998), Miller, Lestina, and Spicer (1998), and Miller, Spicer et al. (1999).

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 motor vehicle crashes. The succeeding section explains how the costs of injuries and associated vehicle damage and travel delay were estimated.

Crash databases do not accurately describe the severity of motor vehicle crashes. Accordingly, several adjustments were made to more accurately reflect the severity of crashes. These adjustments are described below.

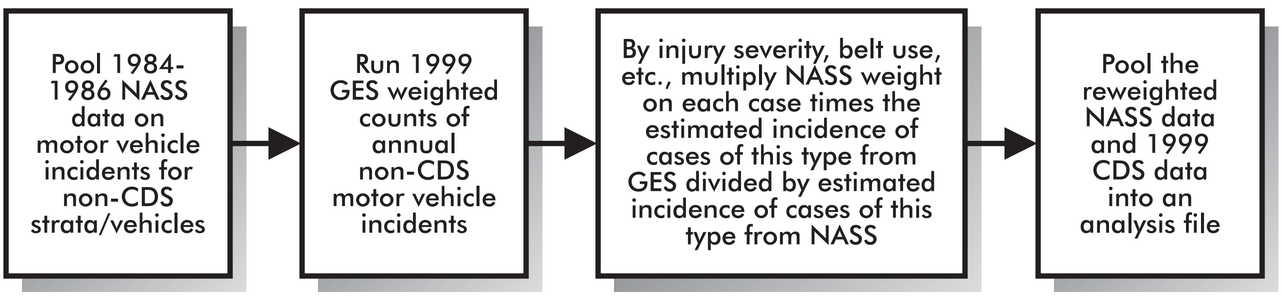
NHTSA's General Estimates System (GES) provides a sample of U.S. crashes by police-reported severity for all crash types. GES records injury severity by crash victim on the KABCO scale (National Safety Council, 1990) from police crash reports. Police reports in almost every state use KABCO to classify crash victims as K-killed, A-incapacitating injury, B-non-incapacitating injury, C-possible injury, or O-no apparent injury.

KABCO ratings are imprecise 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 the use of the A-injury code between states. Viner and Conley (1994) explained the contribution to the variability in the state definitions of A-injury. Miller, Whiting et al. (1987) found that police-reported injury counts by KABCO severity varied by state 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 variance in severity definitions between states, reporting thresholds, and police perception of injury severity, 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) were utilized. OIC codes include AIS score and body region, plus more detailed injury descriptors. The 1999 Crashworthiness Data System (CDS; NHTSA 2000) and 1984-86 National Accident Sampling System (NASS; NHTSA 1987) data were utilized. The CDS describes injuries to passenger vehicle occupants involved in tow-away crashes. The 1984-86 NASS data provide the most recent medical description available for 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-90. The analysis of two versions of AIS were differentiated because AIS-90 scores and OIC codes differ greatly from codes and scores in AIS-85, especially for brain and severe lower limb injury. Garthe et al. (1996) found that AIS scores shifted for approximately 25 percent of all OICs between AIS-85 and AIS-90.

The 2000 CDS and GES non-CDS weights were used to weight the CDS and NASS data respectively, so they represent the estimated injury victim counts in motor vehicle crashes during 2000. In applying the GES weights to old NASS data, the analysis was controlled for police-reported injury severity, restraint use, alcohol involvement, and occupant type (CDS occupant, non-CDS occupant, and non-occupant). Weighting the NASS data to GES restraint use and alcohol involvement levels updates the NASS injury profile to a profile reflecting contemporary belt use and alcohol involvement levels, although it remains imperfect in terms of its representation of airbag use in non tow-away crashes. At the completion of the weighting process (Figure 4), the result was a hybrid CDS/NASS injury-level file. Weights from the 2000 CDS file were used for CDS sample strata.

Figure 4
The Merger of NASS, CDS, and GES Files Cost Estimation



The second step required for estimating average crash costs was the generation of estimates of per-crash-victim costs by maximum AIS (MAIS), body part, and whether the victim suffered a fracture/dislocation. A forty-one level body part descriptor was created based on information provided by the NASS/CDS variables describing the body region, system/organ, lesion, and aspect of each injury. Burns were classified as a separate category due to the lack of location information for such injuries.

The present value of future costs (computed at 3 percent, 4 percent, and 7 percent discount rates) has been calculated, and a societal perspective that includes all costs – costs to victims, families, government, insurers, and taxpayers has been adopted.[1] The societal perspective captures the full scope of injury costs. More constrained perspectives like government's or health care payers' include only a subset of the costs. Cost estimates are in 2000 dollars. They include:

- Medically related costs
- Police and fire (emergency) services
- Property damage
- Lost wage work
- Lost household work

[1]When costs will occur in future years, their present value, defined as the amount one would have to invest today in order to pay these costs when they come due, is computed. A present value is computed by applying an inflation-free discount rate (the reverse of an interest rate).

- Legal costs
- Insurance administration costs
- Travel delay
- Monetized Quality-Adjusted Life Years (QALYs)

In addition to these cost categories, the probability of partial and total permanent disability, the percent of permanent disability for those partially disabled, short-term days lost, and non-monetized QALYs lost were estimated.

Medically Related Costs

Medical costs include ambulance, emergency medical, physician, hospital, rehabilitation, prescription, and related treatment costs, as well as ancillary costs (for crutches, physical therapy, etc.), and the administrative costs of processing medical payments to providers.

Medical costs were estimated from nationally representative samples that use International Classification of Diseases, 9th Edition, Clinical Modification (ICD) diagnosis codes to describe the injuries of U.S. crash victims, namely, the National Hospital Discharge Survey (NHDS) for hospital-admitted victims and the National Health Interview Survey (NHIS) for non-hospitalized victims. The analysis included the following steps; the more complex of which are explained in further detail below:

1. Assign a cause or probable cause distribution for each NHDS and NHIS case.
2. Estimate the costs associated with each crash case in NHDS and NHIS.
3. Use ICDmap85 and ICDmap90 (Johns Hopkins University, 1997) to assign 1985 and 1990 OIC injury codes 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 CDS 1996-1999 and apply it to collapse the cost estimates to eliminate admission status as a stratifier (necessary because current admission rates are unknown for crash victims in non-CDS strata).
7. Infer costs for diagnostic groups that appear in NASS or CDS crash data but not in the ICD-based file.

Cause Assignment

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, diagnostic codes (which drive reimbursement) are given priority over E-codes. More than 70 percent of NHDS cases with less than six diagnoses are E-coded. It was assumed that causes by age group, sex, and diagnoses for these cases were representative of all injury admissions with less than six diagnoses. For NHDS cases with six or seven diagnoses, causation probabilities were inferred by age group, sex, and diagnosis using data for cases with at least six diagnoses in E-coded state hospital discharge censuses that were previously pooled from California, Maryland, Missouri, New York, and Vermont (Miller, Cohen, and Weirsema 1996).

For non-hospitalized injury survivors, motor vehicle crash victims were identified based on information provided by NHIS variables identifying the record as an injury (allinj), which is not chronic (cdonset), took place on a street (locacc), was vehicle-related (mtrveh), and occurred with the involved vehicle in movement (movingmv).

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, the methods used were those 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). Peer-reviewed summaries of them appear in the childhood injury costs in Miller, Romano, and Spicer (2000) and Lawrence et al. (1999).

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

In the case of fatalities, the distribution of place of injury death by broad cause grouping was obtained from 1994 vital statistics data. All fatalities were assigned the difference in present value of burial costs in 2000 versus the value at the end of the victim's expected life span (from Miller, Pindus et al., 1995), as well as coroner or medical examiner costs from National Highway Traffic Safety Administration (1983). Except for deaths at the scene, we added costs for emergency transport from 1987 National Medical Expenditure Survey (NMES) data (the most recent available when these computations were done). For deaths on arrival or in the emergency department, we also added average charges for injury fatalities in the emergency department by external cause grouping and age group (child vs. adult) from 1997 South Carolina emergency department discharge data.

For deaths in a hospital or nursing home, as well as hospitalized survivors, medical costs were computed 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 health care payers negotiate widely varying, sometimes large discounts from providers, hospital charges bear little relationship to actual hospital costs.) Non-fatal computations were by diagnostic group; fatal computations were by cause group. Using average cost per day of hospital stay by state as an adjuster (Bureau of the Census. US Statistical Abstract 1997, Table 189, p. 129), diagnosis-specific or cause-specific hospital costs per day were price-adjusted from Maryland in 1994-95 and New York in 1994 (the last year of that state's cost control) to national estimates. (The costs per day for survivors by age were not differentiated because the cost per day by diagnosis almost never varied significantly between children and adults, at the 95 percent confidence level.) The costs per day by diagnosis or cause were multiplied by corresponding age-group-specific NHDS lengths of hospital stay by survival.

Table 4
Length of Stay Comparisons

MAIS-90	17 Pooled State HDSs	Length of Stay			Unweighted Cases		
		NHDS	CDS	Sd	17 HDSs	NHDS	CDS
HEAD							
1	2.6	2.2	6	10.27	2598	1651	2265
2	2.8	2.8	6.1	11.84	11932	5509	1575
3	8.3	6.8	10.2	16.46	4391	3257	1374
4	11.4	8.8	11.6	18.5	7249	6712	769
5	17.8	15.7	10.4	27.2	3180	2031	546
FACE							
1	1.8	4.2	6.3	1.74	4466	2753	8108
2	3.2	3	8.6	3.43	3086	2180	945
3	6	5.3	9.6	8.88	777	519	146
4	7.9	8.2	8	8.03	195	161	1
NECK							
1	2.4	1	5.3	3.34	56	10	837
2	4.9	5	8.2	5.29	45	2	341
3	9.7	2	9.7	10.96	36	1	185
4	60		12.6		1		18
5	1	1	20.1		1	1	20
THORAX							
1	2	1.9	6.2	1.96	2326	588	2522
2	3.3	2.9	7.5	4.79	2065	459	500
3	5.9	5.2	9.4	7.15	5179	2783	1037
4	12	12	11.7	12.97	1321	580	393
5	16.2	3.6	10.9	22.28	135	37	94
ABDOMEN & PELVIS							
1	1.9	2	7.1	2.11	990	626	1205
2	5.8	5.1	10.3	7.24	3360	1168	905
3	10.4	9	11.3	12.42	1574	742	237
4	11.6	12.6	10.7	15.1	936	611	142
5	11.6	9.7	13.6	15.61	914	479	65
SPINE							
1	2.2	2.7	5.8	2.38	1565	1233	593
2	4.9	5.4	9.8	6.42	5251	7925	567
3	12.6	13.2	11.2	15.76	1322	842	100
4	17	12.9	20.8	19.43	706	277	13
5	25.6	31.3	16	32.02	306	126	18

MAIS-90	17 Pooled State HDSs	Length of Stay NHDS	CDS	Sd	Unweighted Cases 17 HDSs	NHDS	CDS
UPPER EXTREMITIES							
1	2.2	2.4	6.2	3.48	1765	1930	4663
2	3.2	3.2	8.9	4.03	6901	10750	1168
3	6.6	4.5	8.4	6.98	2324	2162	557
LOWER EXTREMITIES							
1	2.9	3.1	6.8	3.99	1673	2036	5613
2	5.5	4.8	9	6.63	17780	27617	2730
3	8.9	8.3	10.5	10.19	13154	53413	1506
4	14.7	10.7	12	15.69	766	704	3
5	21.4	32.1		30.43	127	129	
EXTERNAL BURNS							
1	3	4.7	5	4.2	6347	14800	181
2	5.6	5.9	14	10.83	3933	15909	2
3	7.7	6.6	11.2	13.51	2745	7531	5
4	11.9	8.7		17.07	562	1348	
5	22.4	19.1	19.9	29.78	108	145	5

The lengths of stay from recent CDS files were not used because of data scarcity and lack of representation. The latter concern arose from comparing lengths of stay for highway crash victims by MAIS and body region in NHDS, CDS, and pooled cause coded hospital discharge data from 17 states. As Table 1 shows, possibly because CDS samples relatively few hospital-admitted cases, its lengths of stay are quite different than national averages.

Physician costs estimated from the Civilian Health and Medical Program of the Uniformed Services (CHAMPUS) data for 1992-1994 were added to hospital costs. Costs after hospital discharge were computed from the most recent nationally representative sources available: the 1987 NMES and National Council on Compensation Insurance (NCCI) data for 1979-1987. A concern about past cost studies is the reliance on adult data in estimating childhood injury costs. Past studies 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. The hospitalization cost estimates in this report are, instead, age-group specific. This report also accounts for differences in resiliency between children and adults; using longitudinal 1987-1989 health care claims data from Medstat Systems, diagnosis-specific factors were developed 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 the initial six months, children proved more resilient; the percentage of their total treatment costs incurred in the first six months was often higher, especially for brain injuries. These conclusions come from an analysis 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 post injury. Where the victim was discharged to a nursing home, Miller et al.(1998), nursing home lengths of stay were estimated at one month for fatalities, 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. Medstat-adjusted NMES and NCCI data were used to estimate costs per adult or child victim from costs per visit. The diagnostic detail preserved was maximized; therefore, sample size considerations dictated bringing costs forward onto NHTSA files that represented averages across victims of all ages.

For two categories of injuries – spinal cords and burns – medical costs were not estimated from NHDS and NHIS files because of the limited number of SCI cases and burn center admissions in the files. In addition, for spinal cord injuries, long-term 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 spinal cord injuries. Costs were estimated by applying the age and gender distribution of spinal cord injury 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). Costs for burns were adapted from Miller et al. (1993), using their regression equations.

Mapping ICD Codes Into OIC Codes

To make the ICD-based injury descriptors compatible with CDS and NASS descriptors, ICD was mapped to body part and AIS-85 and AIS-90. AIS-85 was mapped using the ICDmap85. 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 percent of the data set), the lowest AIS within that 3-digit group was selected.

AIS90 was mapped using the ICDmap90. The ICDmap90 uses artificial intelligence and input from injury coding experts to translate ICD-9CM codes into AIS-90 injury codes and severity scores. This map is more complex than ICDmap-85 and considers up to 6 ICD codes plus age of the victim. It also assigns AIS body region codes (which accurately classify AIS-85 body region as well).

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. Since the NHIS uses almost exclusively 3-digit ICDs, it often is not possible to know the body part for its non-fracture ICDs since non-fracture body part tends to be coded in the fourth or fifth digit. For NHIS non-fracture cases, a body region was assigned rather than a body part category using the ICDmap-90 software.

Inferring Costs for Categories That Appear in NASS or CDS Data But Not In the ICD-Based File

Costs for AIS/body part/fracture diagnosis categories that appear in NASS or CDS crash data but not in the ICD based files 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 then assigned by multiplying costs from adjacent cells by this ratio.

For instance, if the mean medical cost for AIS-2 and AIS-3 are 5 and 10, respectively, then the incremental ratio for AIS-2 to AIS-3 was set to: 10/5 = 2. Then an empty AIS-3 cell was estimated by multiplying the cost for AIS-2 times the incremental AIS-2 to AIS-3 ratio.

For body parts with no cost estimates available for any AIS, a general average cost for the appropriate AIS was assigned.

Merging ICD-Based Costs Onto the Re-Weighted NASS/CDS Injury-Level File

Typically, motor vehicle crash patients suffer multiple injuries. In the ICD-based data, when a victim had two injuries of maximum AIS, the body part of the more costly injury was assigned. In merging costs onto the re-weighted NASS/CDS injury level file (NASS/CDS lists up to six injuries per injury victim) the medical, work loss, and quality of life costs were merged separately. In each case, the cost for the injury with the highest cost in the cost category was assigned. Thus, if a victim's ruptured spleen had the highest medical cost and her broken leg had the highest work loss cost, this hybrid set of costs was assigned to the case.

Costs Derived from Medical and Work Loss Costs

Legal and insurance administration costs per crash victim were derived from the medical and work loss costs merged in the NASS/CDS file as described above, using models developed by Miller (1997). The methods used to derive theses costs are shown in detail in Appendix F.

Incidence

Fatalities

The Fatality Analysis Reporting System (FARS) is a complete census of all the fatal crashes on United States' public roads that result in death within 30 days of the crash. In the year 2000, FARS recorded a total of 41,821 deaths in motor vehicle crashes. This total represents 1,105 more individuals than in 1994, the last year for which NHTSA examined economic costs. This represents a 2.7 percent increase over six years. However, during this same period, the resident population increased 8.1 percent, the number of licensed drivers increased by 8.7 percent, and vehicle miles traveled (VMT) increased 16.6 percent. With this increase in exposure, the overall fatality rate actually declined from 1.7 deaths per million VMT in 1994 to 1.5 per million in 2000. Table 5 shows the historical trend in fatalities, exposure measures, and fatality rates from 1975 to 2000.

Nonfatal Injuries

Though the FARS census provides an accurate count of fatalities, there is no equivalent data source for nonfatal injuries. These injuries must be estimated from several data sources. These sources include the Crashworthiness Data System (CDS), the General Estimates System (GES), the National Automotive Sampling System (NASS), the National Health Interview Survey (NHIS), and injury estimates provided to the Federal Highway Administration (FHWA) by individual states. A detailed discussion of these databases is available in NHTSA's 1990 report (Blincoe and Faigin, 1992); however, the methods used for combining these data in this report are somewhat different.

The CDS contains detailed information on police-reported injuries incurred by passengers of towed passenger vehicles. These represent about 54 percent of all police-reported injuries and typically involve the most serious injuries to vehicle occupants. Estimates of these cases for each survivor injury severity category (MAIS) were derived directly from the 2000 CDS. These estimates were then increased by the ratio of CDS equivalent injury cases from the GES, to the CDS total. This was done because the GES sample is significantly larger than the CDS, and it has a smaller standard error. It is therefore likely to be a better predictor of total injuries. However, the level of detail available in the CDS makes that system a more reliable predictor of injury severity.

Injuries that occur in non-tow-away crashes, to occupants of large trucks, buses, motorcycles, bicyclists or to pedestrians, are not included in the CDS data and, therefore, must be derived from other sources. The GES provides estimates based on all crash and vehicle types. However, detailed information regarding injury severity (MAIS) is not provided. Instead, GES provides information based on vague police-reported injury designations such as "incapacitated," and "non-incapacitated," and "possible injury." These are frequently referred to as "KABCO" designations.* In order to estimate GES injuries based on the MAIS coding structure, a translator derived from 1982-1986 NASS data was applied to the GES police-reported injury profile. NASS data are used because they were the last available data that provided both MAIS and KABCO designations for non-CDS cases.

Table 5
Persons Killed with Fatality Rates by Population, Licensed Drivers, Registered Vehicles, and Vehicle Miles Traveled, 1975-2000

Year	Fatalities	Resident Population	Fatality Rate per 100,000	Licensed Drivers	Fatality Rate per 100,000	Registered Motor Vehicles	Fatality Rate per Registered	Vehicle Miles Traveled	Fatality Rate per 100m VMT
1975	44525	215973	20.62	129791	34.31	126153	35.29	1328	3.4
1976	45523	218035	20.88	134036	33.96	130793	34.81	1402	3.2
1977	47878	220239	21.74	138121	34.66	134514	35.59	1467	3.3
1978	50331	222585	22.61	140844	35.74	140374	35.85	1545	3.3
1979	51093	225055	22.70	143284	35.66	144317	35.40	1529	3.3
1980	51091	227225	22.48	145295	35.16	146845	34.79	1527	3.3
1981	49301	229466	21.49	147075	33.52	149330	33.01	1555	3.2
1982	43945	231664	18.97	150234	29.25	151148	29.07	1595	2.8
1983	42589	233792	18.22	154389	27.59	153830	27.69	1653	2.6
1984	44257	235825	18.77	155424	28.48	158900	27.85	1720	2.6
1985	43825	237924	18.42	156868	27.94	166047	26.39	1775	2.5
1986	46087	240133	19.19	159486	28.90	168545	27.34	1835	2.5
1987	46390	242289	19.15	161816	28.67	172750	26.85	1921	2.4
1988	47087	244499	19.26	162854	28.91	177455	26.53	2026	2.3
1989	45582	246819	18.47	165554	27.53	181165	25.16	2096	2.2
1990	44599	249464	17.88	167015	26.70	184275	24.20	2144	2.1
1991	41508	252153	16.46	168995	24.56	186370	22.27	2172	1.9
1992	39250	255030	15.39	173125	22.67	184938	21.22	2247	1.7
1993	40150	257783	15.58	173149	23.19	188350	21.32	2296	1.7
1994	40716	260327	15.64	175403	23.21	192497	21.15	2358	1.7
1995	41817	262803	15.91	176628	23.68	197065	21.22	2423	1.7
1996	42065	265229	15.86	179539	23.43	201631	20.86	2486	1.7
1997	42013	267784	15.69	182709	22.99	203568	20.64	2562	1.6
1998	41501	270248	15.36	184980	22.44	208076	19.95	2632	1.6
1999	41717	272691	15.30	187170	22.29	212685	19.61	2691	1.6
2000	41821	281422	14.86	190625	21.94	217028	19.27	2750	1.5

**K=killed; A=incapacitating injury; B=non-incapacitating injury; C=possible injury; O=no injury.*

Table 5a
Persons Injured with Injury Rates by Population, Licensed Drivers, Registered Vehicles, and Vehicle Miles Traveled, 1990-2000

Year	Police Reported Injuries	Resident Population	Injury Rate per 100,000	Licensed Drivers	Injury Rate per 100,000	Registered Motor Vehicles	Injury Rate per Registered	Vehicle Miles Traveled	Injury Rate per 100m VMT
1990	3231000	249464	1295	167015	1935	184275	1753	2144	151
1991	3097000	252153	1228	168995	1833	186370	1662	2172	143
1992	3070000	255030	1204	173125	1773	184938	1660	2247	137
1993	3149000	257783	1222	173149	1819	188350	1672	2296	137
1994	3266000	260327	1255	175403	1862	192497	1697	2358	139
1995	3465000	262803	1318	176628	1962	197065	1758	2423	143
1996	3483000	265229	1313	179539	1940	201631	1727	2486	140
1997	3348000	267784	1250	182709	1832	203568	1645	2562	131
1998	3192000	270248	1181	184980	1726	208076	1534	2632	121
1999	3236000	272691	1187	187170	1729	212685	1521	2691	120
2000	3189000	281422	1133	190625	1673	217028	1469	2750	116

Non-CDS equivalent cases were isolated from the 1982-86 NASS files and split according to their safety belt status. Belt status was examined separately because belts have a significant impact on injury profiles, and belt use has increased significantly since the 1982-86 period. The examined categories were: belted occupants, unbelted occupants, unknown belt status occupants, and non-occupants including motorcyclists. A separate translator was derived for each of these categories. These translators were applied to their corresponding non-CDS equivalent cases from the 2000 GES file to estimate total non-CDS equivalent injuries by MAIS level for 2000.

The sum of the CDS and non-CDS cases represents police-reported injuries as estimated in these systems. However, previous analysis comparing state police reports to GES counts have found that actual police-reported injuries exceed those accounted for in the GES by 10-15 percent (Blincoe and Faigin, 1992). This issue was reexamined by comparing 1996-1999 state police-reported injury counts to the 1996-1999 GES and it was found that the ratio of police reports to GES counts was still in that same range. The average ratio over these 4 years was 1.13. Therefore, for the current analysis, a 13 percent adjustment was applied to the 2000 injury total.

The above methods resulted in an estimate of 4.1 million nonfatal police-reported injuries, 87 percent of which are minor (MAIS1). These estimates are summarized in Table 3 of the Introduction.

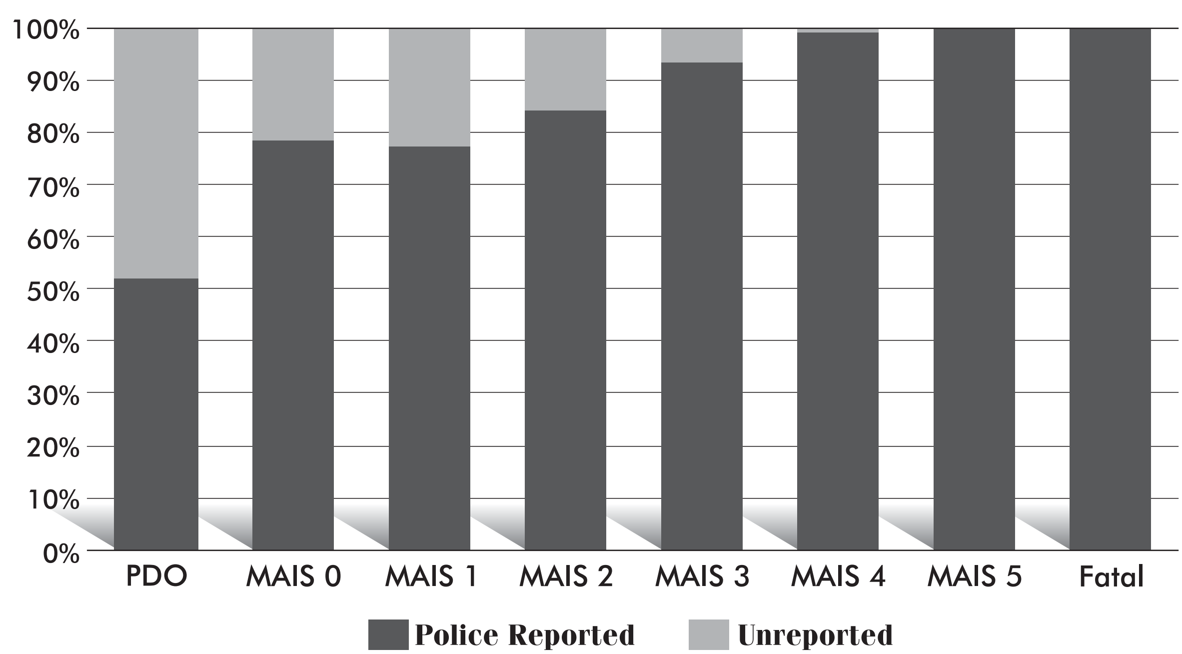
Property Damage Crashes

Crashes that do not result in injury, Property Damage Only crashes (PDOs), are by far the most common type of crash. Unfortunately, information on PDOs is unreliable because of the wide variety of damage reporting thresholds in the states. For this report, the ratio of PDO involved vehicles to injuries (Blincoe and Faigin, 1992) was applied to the 2000 injury total. Unreported crashes, which account for 48 percent of all PDOs, were also estimated from the ratio developed in that report. A total of 12.3 million vehicles were estimated to be damaged in police-reported PDO crashes. Another 11.3 million were estimated to be damaged in non-police reported crashes, for a total of 23.6 million PDO involved vehicles.

Unreported Crashes and Injuries

Although most crashes are reported to police, a significant number go unreported. This underreporting is most likely to occur in crashes where the injured party is at fault, and does not want to involve police due to concerns about insurance or legal repercussions; or in which minor bicycle or pedestrian injuries occur. In addition, a variety of administrative, clerical, or procedural errors may result in the injury going unrecorded. For example, in some cases, helicopters or ambulance transport may occur prior to police arrival, or information on the injured parties may not be provided to police. Estimates of unreported injuries vary by injury severity with nearly one quarter of all minor injuries and almost half of all PDO crashes remaining unreported. By contrast, it is believed that all critical or fatal injuries are reported. For this report, estimates of the portions of injuries that were not reported to police are taken from Blincoe (1996). Unreported PDOs were derived from Blincoe and Faigin (1992) and Blincoe (1996). The relative incidence of unreported crashes is illustrated in Figure 5.

Figure 5
Distribution of Reported/Unreported Injuries



Uninjured Occupants in Injury Crashes

Although uninjured occupants in injury crashes (MAIS 0 injuries) incur no long-term medical care costs, they can incur substantial costs for lost productivity, insurance administration, travel delay, property damage, emergency services and workplace costs. To determine the incidence rate for these occupants, an estimate was made using the 2000 GES, taking the ratio of uninjured occupants to injured occupants in crashes where at least one person was injured. This ratio was then applied to the total number of injured occupants to estimate a total of 2.5 million uninjured occupants. It is likely that police records do not capture all of the uninjured that are involved in injury crashes. If this is the case, then this method will produce a conservative estimate of uninjured occupants in injury crashes.

Crashes

Estimates of the number of crashes that occurred in 2000 were derived based on the ratio of injuries and vehicles to crashes from the 2000 GES. Separate ratios were derived for injury crashes (based on injured persons) and property damage crashes (based on vehicles involved). These ratios were applied to total injuries and total vehicles in PDOs to estimate crashes. Fatal crashes were taken directly from the 2000 FARS file.

The incidence analysis provided above is summarized in Table 3, located in the introduction of this report.

Alcohol Costs

Alcohol consumption is a major cause of motor vehicle crashes and injury. Historically, about half of all motor vehicle fatalities occur in crashes in which a driver or non-occupant has consumed a measurable level of alcohol prior to the crash, and of these cases, nearly 80 percent involved a level of consumption which met the typical legal definition for intoxication or impairment - 0.10 percent Blood Alcohol Content (BAC) or greater. In the last decade, there has been an increased awareness of the problems caused by impaired driving. Many groups, from NHTSA to Mothers Against Drunk Driving (MADD), Students Against Destructive Decisions (SADD) and state and local agencies, have promoted the enactment of laws and implemented public awareness campaigns to assist in combating this problem. Legal measures such as administrative license revocation/suspension have been enacted in numerous states. As a result, there has been a marked decrease in the number of fatalities resulting from alcohol-involved crashes. Table 6 displays the share of fatalities associated with alcohol involvement (>0.01 BAC) and legal intoxication (.0.10 BAC) since 1982. Alcohol involvement in fatal crashes has declined from 60 percent of all fatalities in 1982 to 40 percent in 2000, while legal intoxication (defined as .10 BAC or greater) has declined from 49 percent to 32 percent over the same period. While these declines are encouraging, alcohol still remains a significant causative factor in motor vehicle crashes.

As of February 2002, 29 states, the District of Columbia, and Puerto Rico define legal intoxication, the level at which DWI convictions can be made, as having a blood alcohol content of 0.08 percent or higher. Since complete data on the effects of 0.08 percent on fatality and injury rates are not yet available, this report will use the definition of legal intoxication of 0.10 BAC or higher. This definition remains consistent with the categories of BAC used in NHTSA publications. FARS data indicate that fatalities involving legally intoxicated drivers or nonoccupants account for 79 percent of the fatalities arising from all levels of alcohol involvement.

Fatalities

The Fatality Analysis Reporting System (FARS) provides detailed information about all traffic fatalities that occur within 30 days of a crash on a public road. Each case is investigated and documentation regarding alcohol involvement is included. Alcohol involvement can be indicated either by the judgment of the investigating police officers or by the results of administered BAC tests. Cases where either of these factors is positive are taken as alcohol-involved and any fatalities that result from these crashes are considered to be alcohol-involved fatalities. In addition, there are a large number of cases where alcohol involvement is unknown. In 1986, NHTSA's National Center for Statistics and Analysis (NCSA) developed an algorithm based on discriminant analysis of crash characteristics that estimates the BAC level for these cases (Klein, 1986). More recently, NHTSA has developed a more sophisticated technique to accomplish these estimates using multiple imputation (Rubin et al, 1998), and will substitute this method beginning with the 2001 FARS file. However, NHTSA has already recomputed previous FARS files using this method and alcohol involvement rates based on the new method are used in this report. The total number of alcohol-involved fatalities by BAC level is shown in Table 6 from 1982 through 2000. The alcohol involvement rates in this table were derived using the newer multiple imputation method.

Table 6
Alcohol-Involved and Intoxicated Traffic Fatalities, 1982-2000

Year	Total Fatalities	Alcohol-Involved (=>.01 BAC) Fatalities	Percent of Total	Legally Intoxicated (=>.10 BAC) Fatalities	Percent of Total
1982	43945	26173	60%	21702	49%
1983	42589	24635	58%	20651	48%
1984	44257	24762	56%	20232	46%
1985	43825	23167	53%	18682	43%
1986	46087	25017	54%	19927	43%
1987	46390	24094	52%	19219	41%
1988	47087	23833	51%	19243	41%
1989	45582	22424	49%	18247	40%
1990	44599	22587	51%	18363	41%
1991	41508	20159	49%	16462	40%
1992	39250	18290	47%	14741	38%
1993	40150	17908	45%	14502	36%
1994	40716	17308	43%	13968	34%
1995	41817	17732	42%	14162	34%
1996	42065	17749	42%	14183	34%
1997	42013	16711	40%	13421	32%
1998	41501	16284	39%	12839	31%
1999	41717	16192	39%	12833	31%
2000	41821	16792	40%	13277	32%

Nonfatal Injuries

NHTSA collects crash data though a two-tiered system, a system that was redesigned in 1988 to replace the former National Accident Sampling System (NASS); the NASS Crashworthiness Data System (CDS) and the General Estimates System (GES) comprise this new method.

The CDS is a probability sample of a subset of police reported crashes in the U.S. It offers detailed data on a representative, random sample of thousands of minor, serious, and fatal crashes. The crash in question must be police-reported and must involve property damage and/or personal injury resulting from the crash in order to qualify as a CDS case. It must also include a towed passenger car or light truck or van in transport on a public road or highway. Injuries in vehicles meeting these criteria are analyzed at a level of detail not found in the broader GES.

In contrast, the GES collects data on a sample of all police-reported crashes, without a specific set of vehicle and severity criteria. Although GES collects data on a broader array of crashes, it collects less information on each crash, limiting possible analysis of alcohol involvement. Cases are restricted to a simple "yes," "no," or "unknown" alcohol indication on the police crash report, as observed by the reporting police office. Actual BAC test results are not available through the GES sample.

Due to these limitations in the GES file, alcohol involvement rates were taken from CDS cases stratified by injury severity level. Although there has been a steady decline in alcohol involvement for fatal crashes (as measured in FARS), the relative scarcity of data on alcohol involvement in nonfatal injury crashes produces data spikes that do not reflect this trend. For the more severe injury categories only a few hundred cases, and sometimes less than a hundred cases, are sampled for alcohol involvement. It is probable that these occasional spikes reflect normal sample variation at specific injury severity levels rather than actual jumps in alcohol rates. Therefore, in order to estimate the alcohol involvement in nonfatal injuries, CDS alcohol distributions were taken from a multi-year CDS file that represents the average alcohol involvement rates from 1997-2000. Note that the basic rates used in this analysis represent police reported rates only. Some cases in CDS files contain additional alcohol information obtained by the accident investigator that were not in the police report. These data were removed from the CDS files in order to provide a basis for estimating underreported alcohol involvement, which is derived from studies that are based on police reported alcohol rates. This adjustment is addressed in a following section.

Since CDS samples only tow away crashes involving passenger vehicles, there is some uncertainty as to whether the alcohol involvement rates in CDS crashes are representative of crashes that do not fit the CDS profile. To address this issue, data from the GES were divided into CDS equivalent crashes and non-CDS crashes and examined for comparability of their alcohol involvement profiles. Data were examined from 1996 through 2000. It was found that the rates of alcohol involvement for the 3 KABCO injury categories were fairly stable over this time period. The average rates of alcohol involvement from 1996-2000 were as follows:

	CDS	Non- CDS	Ratio
Possible Injury (C)	6.9%	3.5%	2.0
Non-Incapacitating Injury (B)	12.5%	6.4%	1.95
Incapacitating Injury (A)	16.1%	9.8%	1.64

The rates of alcohol involvement in non-CDS cases are significantly lower than in CDS equivalent cases from the same GES files. The rate of alcohol involvement is twice as high in C (Possible) and B (Non-Incapacitating) CDS equivalent injuries as in non-CDS injuries. For A (Incapacitating) injuries, the rate is 64 percent higher. In order to adjust for these differences, 2000 GES non-CDS cases were converted to MAIS equivalents using KABCO/MAIS translators. These translators were derived from 1982-1986 NASS data. These NASS files were used because they are the only files available that contain non-CDS cases with both MAIS and KABCO ratings. The resulting injury matrix was then used to produce a weighted average ratio of alcohol involvement in non-CDS cases to CDS cases for each MAIS injury severity level. The results are summarized in the upper part of Table 7. They show a gradual increase in the relative rate of alcohol involvement for non-CDS cases as injury severity rises. Rates for minor injuries (MAIS1) are approximately half of their CDS equivalent counterparts, while those for critical injuries (MAIS5) are 60 percent of their CDS counterparts.

Using these ratios, an estimate was derived of alcohol involvement rates for non-CDS cases. This estimate results from the product of the CDS police-reported rates and the MAIS specific ratio. This estimate is shown in the lower part of Table 7. The CDS and non-CDS alcohol involvement rates were then weighted together based on the relative frequency of injury in each category for each MAIS level. These average frequencies are shown in the upper part of Table 8.

Underreported Alcohol

Although police accident reports typically include an indication of whether alcohol was involved, the nature of accident investigations often precludes an accurate assessment of alcohol involvement at the crash site. Police underreporting of alcohol involvement has been well documented in numerous studies. Typically, studies on underreporting compare the results of BAC tests administered in a medical care facility to police reports of alcohol involvement. In a 1982 study of injured drivers, Terhune found that police correctly identified 42 percent of drivers who had been drinking. These rates of identification improved at higher BAC levels, ranging from only 18.5 percent of those with a BAC of .01-.09, to 48.9 percent for those with BACs of .10 or greater. In a 1990 study, Soderstrom et al. found that police correctly identified alcohol use in 71 percent of legally intoxicated, injured drivers. Earlier studies by Maull et al. in 1984 and Dischinger and Cowley in 1989, found that police correctly identified 57.1 percent and 51.7 percent of intoxicated drivers, respectively. The Dischinger and Cowley study also found a lower identification rate for “involved but not intoxicated” drivers of 28.6 percent. In a 1991 study of injured motorcycle drivers, Soderstrom et al, found that police correctly identified only half the drivers with positive alcohol readings later identified by the hospital.

Table 7
Estimated Ratio of Non-CDS to CDS Equivalent Alcohol Involvement Rates in GES, Stratified by Translated MAIS Severity Levels

	A	B	C		Non-CDS/CDS Ratio	All Yes	Implied GES Non-CDS
0	1.86%	8.00%	90.15%	100.00%	0.503877	6.22%	3.13%
1	5.85%	21.78%	72.36%	100.00%	0.509660	6.40%	3.26%
2	33.52%	25.68%	40.80%	100.00%	0.539859	15.90%	8.58%
3	41.87%	16.36%	41.77%	100.00%	0.547845	21.64%	11.86%
4	72.75%	15.48%	11.77%	100.00%	0.580993	16.35%	9.50%
5	91.12%	3.32%	5.55%	100.00%	0.599462	27.08%	16.23%
6	100.00%	0.00%	0.00%	100.00%	0.608659	40.15%	24.44%
Fatal	84.02%	11.36%	4.62%	100.00%	0.592685		
Total	**7.61%**	**18.97%**	**73.42%**	**100.00%**	**0.511252**	**7.23%**	

These early studies demonstrate that during the late 1980s and early 1990s, the police were identifying approximately half of all legally intoxicated drivers, and about one quarter of all drivers who were alcohol involved, but not legally intoxicated. It is clear from the studies that police are more accurate in identifying alcohol involvement as the BAC rate increases. This may reflect the more obvious nature of impaired behavior on the part of drivers who have higher BAC levels, as well as a tendency to investigate more thoroughly the more serious crashes that result from higher BACs.

In previous versions of this report (Blincoe and Faigin,1992 and Blincoe, 1996) the studies cited above were used to estimate the impact of police underreporting of alcohol involvement. However, those studies are over a decade old, and when applied to current data, they produced results that imply a higher rate of alcohol involvement in less severe injuries than in fatalities and more severe injuries. This is both counter-intuitive and at odds with historical alcohol involvement patterns. Moreover, over the last decade there has been a concerted effort on the part of federal, state and local governments to reduce alcohol related crashes, and this has likely improved the rate of alcohol reporting during accident investigations. More recent data was therefore needed to make this adjustment for 2000 data.

The Crash Outcome Data Evaluation System (CODES) is a system that links existing crash and injury data so that specific person, vehicle, and event characteristics can be matched to their medical and financial outcomes. Currently there are 25 states participating in this program and 17 of these states are part of a data network supporting NHTSA highway safety programs. An effort was made to contact all states participating in NHTSA's CODES project to determine whether data was available that could be used to estimate current alcohol reporting rates. For a variety of reasons, only one state, Maryland, had data that was properly linked to allow a comparison between alcohol assessments in police reports and actual measured BACs. The Maryland data represent 2,070 cases admitted to the R Adams Cowley Shock Trauma Center between 1997 and 1999. The basis for this data is thus similar to most of the studies cited above from the late 80s and early 90s.

An analysis of these data indicated that police were correctly identifying 74 percent of all alcohol involved cases where BACs equaled or exceeded 0.10, and 46 percent of all cases where BACs were positive, but less than 0.10. This represents a significant improvement from the corresponding rates of only 55 percent and 27 percent that were found in the earlier studies. This is consistent with the expectation that reporting rates have improved, and, when applied to police reported rates in the NHTSA data bases, the more recent factors produce overall estimates that are consistent with FARS rates of involvement for fatal crashes. However, although these data produce logical results, they were gathered from only one state and there are no data to confirm whether the Maryland experience is typical of the nation. These estimates are thus subject to the caveat that these results have not been verified by broader studies from more diverse regions. One of the previous studies (Soderstrom, 1990) was conducted at this same facility and found a higher rate of alcohol recognition than the other studies previously discussed. A second caveat is that, because these data were collected at a Trauma unit, they may reflect the more serious cases rather than a sample of all injury levels. There are two different, somewhat offsetting biases that could result from this. Trauma unit cases are more likely to involve emergency transport and treatment which may occur before police are able to gain access to drivers to determine alcohol involvement. This could result in police missing a larger portion of Trauma unit cases. On the other hand, the severity of the crash may prompt a more thorough investigation by the police, resulting in a higher rate of correct alcohol identification. It is not clear what the net effect of these biases would be.

Given these caveats, reporting rates from the Maryland data were applied to the average police reported rates for the combined CDS and non-CDS incidence. This was done by computing an average rate weighted by the relative portion of alcohol-involved cases that were above or below 0.10 BAC. The resulting rates, stratified by injury severity are shown in Table 8. Overall, they show an increase in alcohol involvement as injury severity rises. Minor injuries (MAIS1) are unlikely to involve alcohol – only 8 percent of such crashes are alcohol-involved. At the other extreme, critical injuries (MAIS 5) occur in alcohol-involved crashes at almost the same high rate as for fatalities – 40 percent. This is not unexpected since the factors that correlate with alcohol involvement such as time of day, sex and age of drivers, belt use, etc., are similar for both critical and fatal injuries. Table 9 lists the factors used to estimate unknown BAC levels in FARS that are available in both FARS and CDS. The factors listed are those that increase the probability of alcohol involvement in NHTSA's multiple imputation BAC estimation procedure. The table indicates similar experience for MAIS 5 injuries and fatalities for most of these risk factors. Moreover, both fatalities and MAIS 5 injuries experience rates of occurrence for most risk factors that are higher than those of the overall sample.

Table 8
Average Total Alcohol Rates CDS and GES Cases, WTD by Incidence, and Adjusted for Underreported Alcohol

	BAC =0	BAC=<.10	BAC=>.10	All Yes, PR
0	96.20%	11.07%	88.93%	3.80%
1	94.78%	29.92%	70.08%	5.22%
2	85.49%	16.89%	83.11%	14.51%
3	80.90%	26.41%	73.59%	19.10%
4	84.01%	20.32%	79.68%	15.99%
5	73.95%	30.04%	69.96%	26.05%
Fatal	59.85%	20.93%	79.07%	40.15%
Total	**100.00%**	**19.58%**	**80.42%**	
Weight		0.462	0.736	

	BAC =0	BAC=<.10	BAC=>.10	All Yes, Adjusted
0	89.68%	38.45%	61.55%	10.32%
1	92.01%	40.48%	59.52%	7.99%
2	78.97%	24.45%	75.55%	21.03%
3	71.21%	36.38%	63.62%	28.79%
4	76.50%	28.89%	71.11%	23.50%
5	60.15%	20.93%	79.07%	39.85%
Fatal	59.85%	20.93%	79.07%	40.15%
Total	**100.00%**	**27.89%**	**72.11%**	

BAC Levels

The breakdown between those alcohol-involved cases that were above or below .10 BAC was essentially computed using the same techniques as noted above regarding unreported cases. However, it was not possible to make adjustments for the non-CDS cases because there is no BAC data available in GES files. This analysis assumes that within each injury severity category, the incidence of higher or lower BAC levels is similar for both non-CDS and CDS cases. The BAC breakouts produce results that are less satisfying than the overall alcohol involvement rates. There is no apparent trend towards higher BAC involvement as injury severity increases. Rather, the portion of alcohol cases that were above .10 appears to drift somewhat randomly between 60 and 80 percent (see Table 8). This is basically true in the original police reported data as well as in the adjusted data, but the adjustment process seems to exacerbate the problem because a disproportionate part of MAIS 5 injuries are below .10 in police accident reports, and the adjustment factors boost this category by much more than the higher BAC category, leaving a 20 point difference between the portion of alcohol cases that are above .10 in fatalities and MAIS 5 injuries. The problem here appears to be a scarcity of data. About 60-70 cases (unweighted) of MAIS 5 injuries with known BACs occur annually in the CDS. The portion that is above .10 varies noticeably from year to year. For example, in the year 2000, 95 percent of the weighted MAIS 5 cases with known BACs were above .10, while in 1999 it was only 56 percent. With such dramatic swings it appears likely that the sample is not adequate to measure the split in alcohol levels for MAIS 5 injuries, despite the use of a multi-year file. Given the similarities in factors that involve alcohol use between MAIS 5 injuries and fatalities, it is likely that their alcohol split would be similar. This report will therefore use the BAC split found in FARS for MAIS 5 injuries as well.

Table 9
Relative Frequency for MAIS 5 Injuries and Fatalities in Factors that Influence FARS BAC Estimates which are Also Available in CDS Files

	1998-2000 CDS			
Risk Factor	MAIS 5	CDS Fatal	All Cases	1998-2000 FARS
WEIGHTED				
PAR Alc Involvement Yes	25.7%	20.8%	6.9%	18.7%
Age <21	23.4%	12.8%	21.8%	14.3%
Sex = Male	71.8%	68.8%	54.6%	73.2%
Restraint Not Used	52.7%	56.4%	13.8%	54.4%
Weekend	27.4%	32.9%	27.1%	33.2%
After Midnight	17.8%	21.7%	12.0%	20.5%
%LTV	40.3%	31.4%	29.6%	32.8%
UNWEIGHTED				
PAR Alc Involvement Yes	24.9%	21.5%	11.4%	
Age <21	21.0%	12.6%	17.2%	
Sex = Male	70.7%	70.0%	58.5%	
Restraint Not Used	49.8%	52.2%	22.2%	
Weekend	33.7%	33.2%	28.8%	
After Midnight	22.0%	27.4%	13.5%	
%LTV	33.2%	29.9%	31.2%	

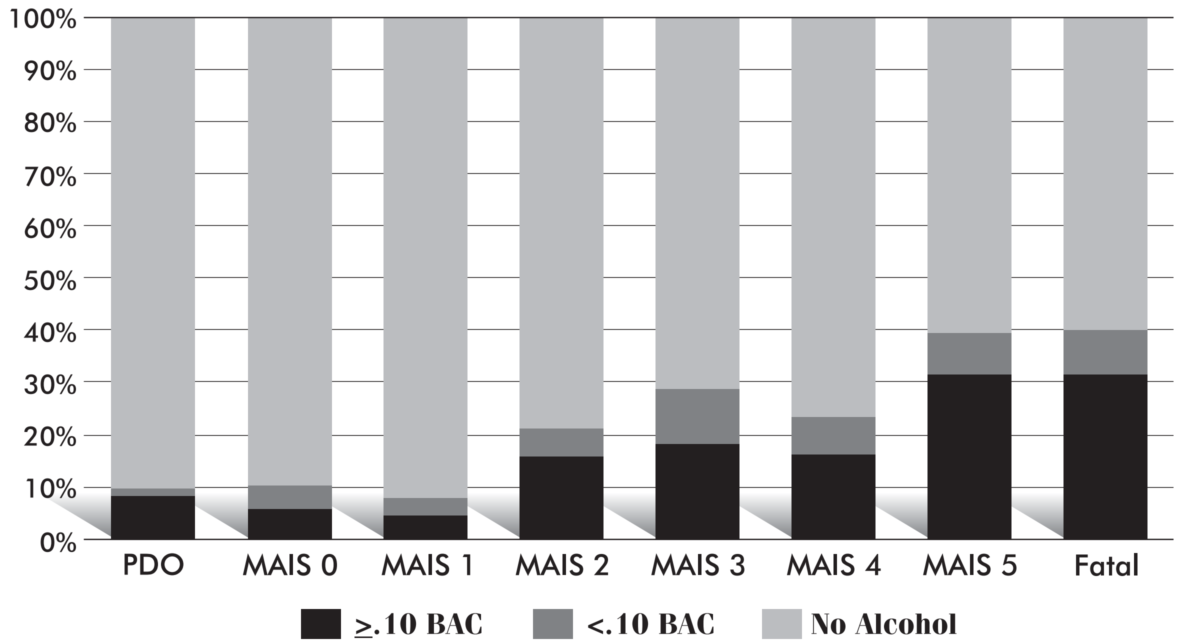
PDO Crashes

NHTSA data from the 2000 GES indicate that alcohol was involved in 6.8 percent of PDO crashes. NHTSA knows of no studies relating police alcohol reporting rates to actual BACs for crashes that do not involve injury. Generally, injury based studies indicate that police are more successful detecting alcohol in the more serious crashes involving higher BACs. For this study, it will be estimated that police successfully detect alcohol in PDOs at the same rate as for injuries, i.e. 46.2 percent for cases under .10 BAC and 73.6 percent for cases over .10 BAC. The BAC distribution for PDOs is based on data from 1982-86 NASS files. These files were used because BAC data is not available on PDOs in current CDS and GES files. Given that overall alcohol involvement rates have declined since the 1982-86 period, it was possible that the BAC distribution may have shifted as well. The only accident file with consistent BAC data going back to that time period is FARS. FARS data were examined to determine whether there had been a shift in BAC ratios, and it was found that the portion of crashes that were above .10 BAC has remained fairly constant. Therefore, no adjustment was made to the BAC ratios from the 82-86 NASS data. The NASS data indicate that 90.9 percent of PDOs that were alcohol-involved also involved a driver who was legally impaired. PDO vehicles in crashes with police reported alcohol were estimated by taking the 6.8 percent rate from 2000 GES and applying it to total PDO vehicles. This was then apportioned into BAC categories using the 82-86 NASS rates. These totals were then increased using the same BAC specific rates used for injuries to reflect unreported alcohol involvement. The results are shown in Table 10. Just under 10 percent of all PDOs are estimated to have occurred in alcohol involved crashes.

Table 10
Total Incidence by Injury Level and BAC Level of Alcohol Involvement in Crash (Injured Persons and PDO Vehicles)

	<.10 BAC		= >.10 BAC		ALL Positive Alcohol		ALL Cases	
	Incidence	% Total	Incidence	% Total	Incidence	% Total	Incidence	% Total
PDO	316522	13.8%	1984677	86.2%	2301199	9.7%	23631696	100.0%
MAIS 0	101112	38.4%	161879	61.6%	262991	10.3%	2548458	100.0%
MAIS 1	150672	40.5%	221575	59.5%	372247	8.0%	4659585	100.0%
MAIS 2	22428	24.5%	69286	75.5%	91714	21.0%	436007	100.0%
MAIS 3	13184	36.4%	23060	63.6%	36244	28.8%	125903	100.0%
MAIS 4	2478	28.9%	6100	71.1%	8578	23.5%	36509	100.0%
MAIS 5	789	20.9%	2981	79.1%	3771	39.8%	9463	100.0%
MAIS 1-5	189552	37.0%	323003	63.0%	512554	9.7%	5267467	100.0%
Fatal	3515	20.9%	13277	79.1%	16792	40.2%	41821	100.0%

Figure 6
Incidence by BAC Involvement



Uninjured Occupants

The alcohol involvement for uninjured occupants was estimated by weighting the alcohol rates of injured persons according to the relative frequency of uninjured occupants in injury crashes from 2000 CDS files. This assumes a similar distribution for uninjured occupants to the overall injury distribution, which includes non-occupants as well. However, since pedestrian and pedalcyclists account for only about 4 percent of injuries, any bias caused by this assumption will have an insignificant effect. The results of this analysis are shown in Table 8.

The total incidence, by injury level and alcohol involvement, are summarized in Table 10 and Figure 6. Alcohol-involved crashes account for about 40 percent of fatalities, 10 percent of PDOs, and 10 percent of non-fatal injuries. However, alcohol involvement rates increase dramatically as the severity of non-fatal injuries rises.

Alcohol-Involved Crash Costs

As shown in Table 11, alcohol is involved in crashes that account for 21 percent of the costs that result from nonfatal injuries and 46 percent of the costs that result from fatalities. Overall, these crashes are responsible for 22 percent of total economic costs. The impact of alcohol-involved crashes on overall costs is thus higher than would be indicated by the alcohol-involved incidence rates. There are several reasons for this disproportionate influence on costs. The first is a general tendency toward greater relative severity of alcohol-involved crashes. For all crashes, fatalities are approximately 0.8 percent of injured survivors. This rate quadruples for crashes involving alcohol. Similarly, the rate for critical injuries (MAIS 5) triples for alcohol cases and for severe injuries (MAIS 4) it more than doubles. The more severe and expensive injuries represent a much higher portion of alcohol-involved cases. A second factor is demographics. Males are disproportionately represented in alcohol-involved crashes and this makes the cost for each alcohol-involved case higher. This occurs because males have higher earnings and participation in the work force than females; thus there is a higher lost productivity cost associated with these crashes. In non alcohol-involved crashes, the gender distribution is more evenly distributed. In addition, the victims of alcohol-involved crashes tend to be of an age group where lost productivity is maximized by the discounting process. Unit costs specific to alcohol-involved crashes are shown in Table 12. A comparison of these costs to those in Table 2 shows significant differences in costs for both lost productivity and medical care.

Table 11
Total Cost by Injury Level and BAC Level of Alcohol Involvement in Crash (Millions of 2000$)

	<.10 BAC		= >.10 BAC		ALL Positive Alcohol		ALL Cases	
	Cost	% Total	Cost	% Total	Cost	% Total	Cost	% Total
PDO	$801	1.3%	$5,025	8.4%	$5,827	9.7%	$59,838	100.0%
MAIS 0	$198	4.0%	$318	6.4%	$516	10.3%	$5,000	100.0%
MAIS 1	$1,687	3.4%	$2,481	5.0%	$4,168	8.5%	$49,214	100.0%
MAIS 2	$1,689	5.8%	$5,217	17.9%	$6,905	23.7%	$29,134	100.0%
MAIS 3	$2,587	11.0%	$4,526	19.3%	$7,113	30.4%	$23,430	100.0%
MAIS 4	$962	7.6%	$2,369	18.6%	$3,331	26.2%	$12,710	100.0%
MAIS 5	$964	9.3%	$3,640	35.1%	$4,603	44.4%	$10,373	100.0%
Fatal	$3,893	9.5%	$14,706	36.0%	$18,600	45.5%	$40,868	100.0%
MAIS 1-5	$7,889	6.3%	$18,231	14.6%	$26,120	20.9%	$124,862	100.0%
Total	**$12,782**	**5.5%**	**$38,280**	**16.6%**	**$51,062**	**22.1%**	**$230,568**	**100.0%**

Table 12
Summary of Unit Costs for Alcohol-Involved Crashes, 2000
2000 Dollars

	PDO	MAIS 0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
INJURY COMPONENTS								
Medical	$0	$1	$2,949	$19,134	$47,123	$153,060	$360,400	$22,095
Emergency Services	$31	$22	$97	$212	$368	$830	$852	$833
Market Productivity	$0	$0	$1,818	$27,806	$77,517	$115,717	$499,828	$714,649
HH Productivity	$47	$33	$572	$7,696	$22,111	$30,089	$169,023	$202,693
Insurance Admin.	$116	$80	$715	$7,667	$19,905	$35,602	$75,118	$37,120
Workplace Cost	$51	$34	$252	$1,953	$4,266	$4,698	$8,191	$8,702
Legal Costs	$0	$0	$172	$6,023	$17,223	$37,464	$88,753	$102,138
Subtotal	**$245**	**$170**	**$6,575**	**$70,490**	**$188,512**	**$377,460**	**$1,202,166**	**$1,088,230**
NON-INJURY COMPONENTS								
Travel Delay	$803	$773	$777	$846	$940	$999	$9,148	$9,148
Property Damage	$1,484	$1,019	$3,844	$3,954	$6,799	$9,833	$9,446	$10,273
Subtotal	**$2,287**	**$1,792**	**$4,621**	**$4,800**	**$7,739**	**$10,832**	**$18,594**	**$19,421**
Total	**$2,532**	**$1,962**	**$11,196**	**$75,290**	**$196,251**	**$388,292**	**$1,220,760**	**$1,107,651**

Note: Unit costs are on a per-person basis for all injury levels. PDO costs are on a per damaged vehicle basis.

Alcohol Crash Causation

Inebriated drivers often experience impaired perceptions that can lead to risky behavior such as speeding, reckless driving, and failure to wear safety belts. They also experience reduced reaction times, which can make it more difficult for them to perform defensive safety maneuvers. As a result, there is a general tendency to equate the presence of alcohol with crash causation. However, there are clearly some instances in which crashes would occur regardless of whether the driver had consumed alcohol. A recent study by Miller, Spicer and Levy (1999) estimated the percentages of alcohol-related crashes that are actually attributable to alcohol. In this study they examined the probability of crash involvement for drivers based on their BAC level and then removed the normal risk of crash involvement without alcohol from the overall risk found for drivers with positives BACs. Their study found that 94 percent of crashes at BACs of .10 or higher, and 31 percent of crashes with positive BACs less than .10, were actually caused by alcohol. The remaining crashes were due to bad weather, poor road conditions, non-drinking drivers, etc.

To estimate the cost of alcohol-caused crashes, these factors were applied to the data in Tables 10 and 11. The results (summarized in Tables 13 and 14) indicate that alcohol causes crashes that result in 13,570 fatalities and over 360,000 nonfatal injuries at a cost of nearly $40 billion annually. This represents nearly a third of all fatalities and 17 percent of all economic costs from crashes.

Table 13
Total Incidence in Crashes Caused by Alcohol by Injury Level and BAC Level (Injured Persons and PDO Vehicles)

	<.10 BAC		= >.10 BAC		Total	% Total	% Total
	Incidence	% Total	Incidence	% Total	Incidence	Alcohol Inv.	All Crashes
PDO	98122	5.0%	1865597	95.0%	1963718	85.3%	8.3%
MAIS 0	31345	17.1%	152166	82.9%	183511	69.8%	7.2%
MAIS 1	46708	18.3%	208281	81.7%	254989	68.5%	5.5%
MAIS 2	6953	9.6%	65129	90.4%	72082	78.6%	16.5%
MAIS 3	4087	15.9%	21676	84.1%	25763	71.1%	20.5%
MAIS 4	768	11.8%	5734	88.2%	6502	75.8%	17.8%
MAIS 5	245	8.0%	2802	92.0%	3047	80.8%	32.2%
MAIS 1-5	58761	16.2%	303622	83.8%	362383	70.7%	6.9%
Fatal	**1090**	**8.0%**	**12480**	**92.0%**	**13570**	**80.8%**	**32.4%**

Table 14
Total Costs in Crashes Caused by Alcohol by Injury Level and BAC Level (Millions of 2000$)

	<.10 BAC		= >.10 BAC		Total	%Total	% Total
	Cost	% Total	Cost	% Total	Cost	Alcohol Inv.	All Crashes
PDO	$248	5.0%	$4,724	95.0%	$4,972	85.3%	8.3%
MAIS 0	$61	17.1%	$299	82.9%	$360	69.8%	7.2%
MAIS 1	$523	18.3%	$2,332	81.7%	$2,855	68.5%	5.8%
MAIS 2	$523	9.6%	$4,904	90.4%	$5,427	78.6%	18.6%
MAIS 3	$802	15.9%	$4,254	84.1%	$5,056	71.1%	21.6%
MAIS 4	$298	11.8%	$2,226	88.2%	$2,525	75.8%	19.9%
MAIS 5	$299	8.0%	$3,421	92.0%	$3,720	80.8%	35.9%
Fatal	$1,207	8.0%	$13,824	92.0%	$15,031	80.8%	36.8%
MAIS 1-5	$2,446	12.5%	$17,137	87.5%	$19,583	75.0%	15.7%
Total	**$3,962**	**9.9%**	**$35,984**	**90.1%**	**$39,946**	**78.2%**	**17.3%**

State Costs

In recent years, states have continued to increase their involvement in establishing and enforcing laws related to motor vehicle safety. This is due, in part, to federal legislation enacted in the last few years. Legislation such as the Transportation Equity Act for the 21st Century (TEA-21) of 1998 allows for additional funds to be granted to states that adopt certain safety programs. This act encourages the passage of laws by use of a $500 million federal incentive over a six-year period.

State legislators are often interested in the societal and economic cost of motor vehicle injury as they consider new traffic safety laws, changes to existing laws and funding for enforcement of the laws. This information can assist them in making the case to their constituencies as to the relevance of the laws designed to make the population safer.

A state-specific distribution of total economic costs has been prepared as follows:

- The year 2000 fatalities were obtained by state from FARS. The portion of total national fatalities in each state was then applied directly to the total fatality cost ($40.9 billion).
- State injury data were obtained from individual states for 1998 and 1999. In cases where data were not available, a factor based on the trend in fatalities within the state was used to update injuries from a data set for 1992 and 1993 – the last years for which complete data was available. The portion of total national nonfatal injuries in each state was applied to the total cost of all nonfatal injuries, PDOs, and uninjured occupants ($189.7 billion).
- The total costs for each state were then adjusted to reflect locality cost differences based on the ratio of costs in each state to the national total. Medical costs were adjusted based on data obtained from the ACCRA Cost of Living Index and cited by Miller and Galbraith (1995). Lost productivity, travel delay and workplace costs were adjusted based on 2000 per-capita income. Insurance administration and legal costs were adjusted using a combination of these two inflators weighted according to the relative weight of medical and lost productivity administrative costs. All other cost categories were adjusted using a composite index developed by ACCRA (also provided by Miller).

These four adjustment factors were applied separately to the fatal and nonfatal costs for each state. Weights to combine each factor were derived separately from the relative importance of each cost category to nationwide fatal and nonfatal total costs. The sum of fatal and nonfatal costs for each state was then adjusted to force the sum of all states' costs to equal the national total.

Table 15
Estimated 2000 Economic Costs Due to Motor Vehicle Crashes

State	(Millions $)	% Total	Cost Per Capita	% Per Capita Personal Income
Alabama	$2,788	1.2%	$627	2.7%
Alaska	$475	0.2%	$758	2.5%
Arizona	$4,272	1.9%	$833	3.3%
Arkansas	$1,965	0.9%	$735	3.3%
California	$20,655	9.0%	$610	1.9%
Colorado	$3,278	1.4%	$762	2.3%
Connecticut	$3,596	1.6%	$1,056	2.6%
Delaware	$706	0.3%	$900	2.9%
District of Columbia	$732	0.3%	$1,279	3.4%
Florida	$14,403	6.2%	$901	3.2%
Georgia	$7,850	3.4%	$959	3.4%
Hawaii	$655	0.3%	$540	1.9%
Idaho	$856	0.4%	$661	2.7%
Illinois	$8,984	3.9%	$723	2.2%
Indiana	$4,346	1.9%	$715	2.6%
Iowa	$2,105	0.9%	$719	2.7%
Kansas	$1,884	0.8%	$701	2.5%
Kentucky	$3,114	1.4%	$771	3.2%
Louisiana	$4,000	1.7%	$895	3.8%
Maine	$912	0.4%	$715	2.8%
Maryland	$4,237	1.8%	$800	2.4%
Massachusetts	$6,276	2.7%	$988	2.6%
Michigan	$8,069	3.5%	$812	2.7%
Minnesota	$3,065	1.3%	$623	1.9%
Mississippi	$2,106	0.9%	$740	3.5%
Missouri	$4,737	2.1%	$847	3.1%
Montana	$621	0.3%	$688	3.1%
Nebraska	$1,629	0.7%	$952	3.4%
Nevada	$1,873	0.8%	$938	3.1%
New Hampshire	$1,014	0.4%	$820	2.5%
New Jersey	$9,336	4.0%	$1,110	3.0%
New Mexico	$1,413	0.6%	$777	3.5%
New York	$19,490	8.5%	$1,027	3.0%
North Carolina	$8,270	3.6%	$1,027	3.8%
North Dakota	$290	0.1%	$452	1.8%
Ohio	$11,090	4.8%	$977	3.4%
Oklahoma	$2,593	1.1%	$751	3.2%
Oregon	$1,948	0.8%	$569	2.0%

State	(Millions $)	% Total	Cost Per Capita	% Per Capita Personal Income
Pennsylvania	$8,170	3.5%	$665	2.3%
Rhode Island	$767	0.3%	$732	2.5%
South Carolina	$3,335	1.4%	$831	3.4%
South Dakota	$498	0.2%	$659	2.5%
Tennessee	$4,628	2.0%	$814	3.1%
Texas	$19,761	8.6%	$948	3.4%
Utah	$1,594	0.7%	$714	3.0%
Vermont	$221	0.1%	$362	1.3%
Virginia	$5,203	2.3%	$735	2.4%
Washington	$5,310	2.3%	$901	2.9%
West Virginia	$1,268	0.5%	$701	3.2%
Wisconsin	$3,756	1.6%	$700	2.5%
Wyoming	$424	0.2%	$859	3.2%
Total	**$230,568**	**100.0%**	**$819**	**2.8%**

The results of this analysis are depicted in Table 15. There is considerable variation in costs among the states, with California, for example, having costs that are 93 times higher than those for Vermont. This is primarily due to the higher incidence of death and injury in California, but also to the higher cost levels in that state. However, as noted by Miller and Galbraith, cost comparisons between states that are based on state injury totals can be inaccurate because injury totals do not capture differences in nonfatal injury severity between states. This would tend to lower costs in rural states relative to urban states, which typically have lower average speeds and consequently less severe injuries. Differences between states may also result from different reporting practices that result in more or less complete recording of injuries from state to state.

Differences in roadway characteristics and state of repair may account for some of this discrepancy, though it seems likely that variation in injury reporting is also a contributing factor. Finally, the impact of crash costs must be viewed in the context of each state's economy. Smaller, less populated states may have lower absolute costs, but they may also have fewer resources available to address these costs. A significant portion of these costs is borne by the general public through state and local revenue, or through private insurance plans. The per capita costs for each state vary from roughly $600-$1,200 compared to the nationwide average of $819. This represents between 1.3 and 3.8 percent of the per capita income for each state, with an overall average of 2.8 percent.

Speeding

Excess speed can contribute to both the frequency and severity of motor vehicle crashes. At higher speeds, additional time is required to stop a vehicle and more distance is traveled before corrective maneuvers can be implemented. Speeding reduces a driver's ability to react to emergencies created by driver inattention, by unsafe maneuvers of other vehicles, by roadway hazards, by vehicle system failures (such as tire blow-outs), or by hazardous weather conditions. The fact that a vehicle was exceeding the speed limit does not necessarily mean that this was the cause of the crash, but the probability of avoiding the crash would likely be greater had the driver or drivers been traveling at slower speeds.

NHTSA has prepared an estimate of speed-related crash costs for 2000 in order to demonstrate the relative importance of speeding in relation to other risk factors for motor vehicle crashes and their economic consequences. A speed-related crash is defined as any crash in which the police indicate that one or more drivers involved was exceeding the speed limit or driving too fast for conditions. FARS data indicate that in 2000, a total of 12,350 fatalities, representing 29.5 percent of all motor vehicle fatalities, occurred in speed-related crashes, which, in turn, comprised 29 percent of all motor vehicle crashes.

Table 16
Calculation of Speed-Related Crash Costs and Incidence
Based on 1985 and 1986 NASS and FARS Speed Data

	1985-1986 Speed Related % Total	Factor	2000 Costs (000)	Speed Related Costs (000)	2000 Incidence	Speed Related Incidence	2000 Percent Speed Related
PDO	11.49%	0.3245	$59,838	$5,735	23631696	2264813	9.58%
MAIS 0	16.64%	0.4697	$5,000	$694	2548458	353519	13.87%
MAIS 1	14.95%	0.4221	$49,214	$6,135	4659585	580816	12.46%
MAIS 2	20.76%	0.5863	$29,134	$5,044	436007	75486	17.31%
MAIS 3	22.84%	0.6448	$23,430	$4,461	125903	23973	19.04%
MAIS 4	29.63%	0.8366	$12,710	$3,140	36509	9020	24.71%
MAIS 5	35.99%	1.0162	$10,373	$3,113	9463	2840	30.01%
Fatal	35.42%	1.0000	$40,868	$12,069	41821	12350	29.53%
Total Injuries					**5309288**	**704485**	**13.27%**
Total Nonfatal Injuries					**5267467**	**692135**	**13.14%**
Total Cost			**$230,568**	**$40,390**			**17.52%**

Table 17
Estimated 1994 Economic Costs Due to Motor Vehicle Crashes Where Excessive Speed Was a Factor

State	(Millions $)	% Total	Cost Per Capita	% Per Capita Personal Income
Alabama	$534	1.3%	$120	0.5%
Alaska	$87	0.2%	$139	0.5%
Arizona	$772	1.9%	$150	0.6%
Arkansas	$366	0.9%	$137	0.6%
California	$3,691	9.1%	$109	0.3%
Colorado	$601	1.5%	$140	0.4%
Connecticut	$606	1.5%	$178	0.4%
Delaware	$125	0.3%	$159	0.5%
District of Columbia	$118	0.3%	$207	0.6%
Florida	$2,572	6.4%	$161	0.6%
Georgia	$1,387	3.4%	$169	0.6%
Hawaii	$116	0.3%	$96	0.3%
Idaho	$162	0.4%	$125	0.5%
Illinois	$1,568	3.9%	$126	0.4%
Indiana	$766	1.9%	$126	0.5%
Iowa	$373	0.9%	$128	0.5%
Kansas	$345	0.9%	$128	0.5%
Kentucky	$565	1.4%	$140	0.6%
Louisiana	$707	1.8%	$158	0.7%
Maine	$158	0.4%	$124	0.5%
Maryland	$732	1.8%	$138	0.4%
Massachusetts	$1,019	2.5%	$161	0.4%
Michigan	$1,410	3.5%	$142	0.5%
Minnesota	$558	1.4%	$113	0.4%
Mississippi	$414	1.0%	$146	0.7%
Missouri	$865	2.1%	$155	0.6%
Montana	$120	0.3%	$133	0.6%
Nebraska	$281	0.7%	$164	0.6%
Nevada	$329	0.8%	$165	0.5%
New Hampshire	$172	0.4%	$139	0.4%
New Jersey	$1,529	3.8%	$182	0.5%
New Mexico	$259	0.6%	$143	0.6%
New York	$3,164	7.8%	$167	0.5%
North Carolina	$1,434	3.5%	$178	0.7%
North Dakota	$54	0.1%	$84	0.3%
Ohio	$1,846	4.6%	$163	0.6%
Oklahoma	$464	1.1%	$134	0.6%

State	(Millions $)	% Total	Cost Per Capita	% Per Capita Personal Income
Oregon	$355	0.9%	$104	0.4%
Pennsylvania	$1,443	3.6%	$117	0.4%
Rhode Island	$127	0.3%	$121	0.4%
South Carolina	$628	1.6%	$157	0.6%
South Dakota	$97	0.2%	$128	0.5%
Tennessee	$861	2.1%	$151	0.6%
Texas	$3,475	8.6%	$167	0.6%
Utah	$283	0.7%	$127	0.5%
Vermont	$44	0.1%	$72	0.3%
Virginia	$921	2.3%	$130	0.4%
Washington	$893	2.2%	$152	0.5%
West Virginia	$234	0.6%	$130	0.6%
Wisconsin	$673	1.7%	$126	0.4%
Wyoming	$84	0.2%	$170	0.6%
Total	**$40,390**	**100.0%**	**$144**	**0.5%**

The 1985 and 1986 NASS files were examined in order to estimate the economic costs that relate to speed-related crashes; these are the latest crash files that contain adequate speed information stratified by MAIS level for all crash types. Rates of speed involvement for each severity level were compared to the rate for 1985 and 1986 fatalities (from FARS) to determine a relative speed involvement factor for that severity level. This factor was applied to the speed involvement rate for 2000 fatalities to determine the rate of involvement for each nonfatal severity category. This rate was applied to total costs for that category to determine the portion of costs that were speed-related. The results of this analysis are shown in Table 16.

The costs of crashes that involved excessive speed were $40.4 billion, representing 18% of total costs. A state specific estimate of speed-related costs was developed using the same adjustments for cost levels and injury incidence described in the chapter on alcohol crash costs. The economic costs for speed-related motor vehicle crashes have been summarized and this estimate is located in Table 17. Note that this estimate does not include any adjustment for police undercounting of speed involvement. The degree to which police correctly identify speeding drivers is not known.

There is a significant overlap between alcohol involvement and speed. Many speed-related crashes involved alcohol and vice-versa. These two estimates should not be added together in order to account for the portion of costs that represent the combined factors of speed and alcohol.

Safety Belt Use

When properly fastened, safety belts provide significant protection to vehicle occupants involved in a crash. The simple act of buckling a safety belt can improve an occupant's chance of surviving a potentially fatal crash by from 45 to 73 percent, depending on the type of vehicle and seating position involved. They are also highly effective against serious nonfatal injuries. Belts reduce the chance of receiving an MAIS 2-5 injury (moderate to critical), by 44-78 percent.[2]

The effectiveness of safety belts is a function of vehicle type, restraint type, and seat position. Table 18 shows the estimated effectiveness of safety belts for various seating positions for passenger cars and for light trucks, vans, and sports utility vehicles (LTVs).

Table 18
Estimated Safety Belt Effectiveness Rates

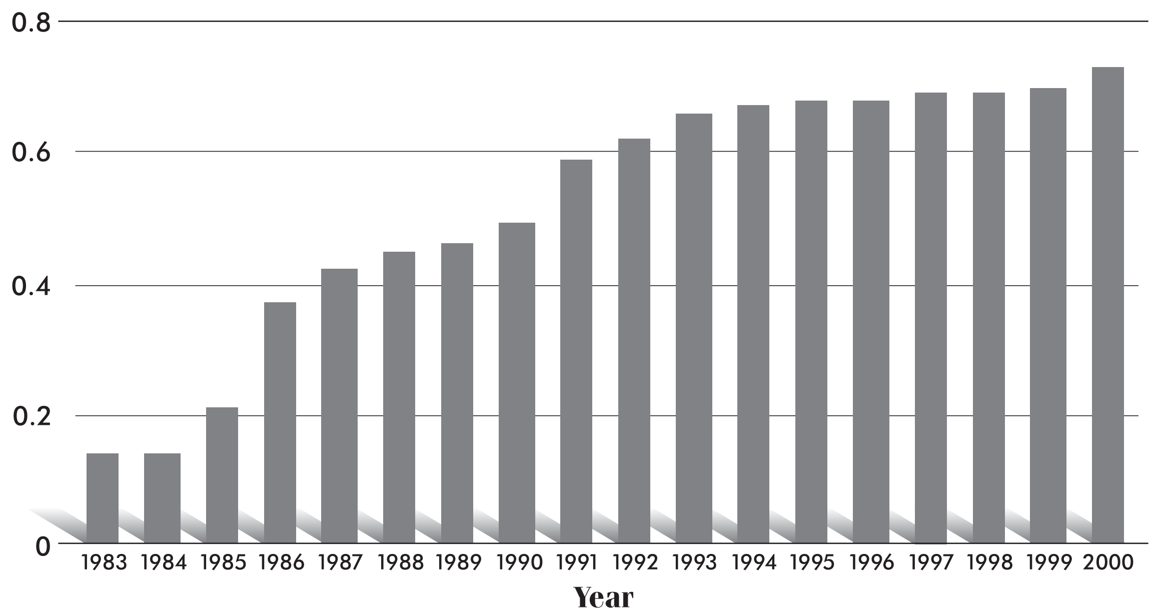
	Lap Belts	Lap/Shoulder Belts
PASSENGER CARS, FRONT SEAT		
Fatalities	35	45
MAIS 2-5 Injuries	30	50
PASSENGER CARS, REAR SEAT		
Fatalities	32	44
MAIS 2-5 Injuries	37	49
LIGHT TRUCKS, FRONT SEAT		
Fatalities	50	60
MAIS 2-5 Injuries	55	65
LIGHT TRUCKS, REAR SEAT		
Fatalities	63	73
MAIS 2-5 Injuries	68	78

Sources Kahane, 2000, Morgan, 1999, NHTSA, 1984, NHTSA, 1980

[2] NHTSA also estimates that seat belts may be 10 percent effective against minor injuries. However, this estimate is not as well supported by research. To simplify the report and to provide a more conservative estimate, minor injuries are ignored in these calculations. Savings for minor injuries typically increases the overall estimate of cost savings by 2-3 percent.

Although all passenger vehicles have been equipped with safety belts since 1968, a sizable minority of vehicle occupants still neglect to use these devices. As of February 2001, about 70 percent of occupants wear their safety belts. Usage has risen steadily throughout the last decade, largely in response to public education programs sponsored by state and Federal safety agencies, as well as private consumer and safety advocacy groups. A major factor in this increase has been the passage of safety belt use laws. As of 2001, all states except New Hampshire have some form of adult usage law. These laws can take the form of either primary enforcement laws, under which police can stop drivers specifically for failing to wear seat belts, or secondary laws, under which fines can only be levied if a driver is stopped for some other offense. Primary enforcement laws are far more effective in increasing safety belt use. Experience in a number of states indicates that usage rates rise from 10-15 percentage points when primary laws are passed. For example, usage in California jumped from 70 percent to 82 percent when a primary law was passed in 1993. Similar impacts occurred in Louisiana where usage rose 18 points, in Georgia where usage rose 17 points, in Maryland where usage rose 13 points, and in the District of Columbia where usage rose 24 points when they combined a new primary enforcement law with penalty points. Overall, states with primary belt use laws have an average belt use rate that is 17 points higher than states with only secondary enforcement. Figure 7 illustrates the nationwide trend in safety belt use rates over the last 2 decades.

Figure 7
U.S. Safety Belt Use Rates, 1983-2000



By combining safety belt use rates with effectiveness rates and national injury counts, an estimate can be made of the impact of safety belts on fatality and casualty rates. The basic methods for these calculations are well documented (Blincoe, 1994, Wang and Blincoe, 2001, Partyka and Womble, 1989). The effect of increases in safety belt use on fatalities is curvilinear, i.e., the more the observed usage rate in the general population approaches 100 percent, the more lives are saved for each incremental point increase. This occurs because those who are most resistant to buckling up tend to be in high-risk groups such as impaired drivers or persons who are risk takers in general. These persons are more likely to be involved in serious crashes and are thus more likely to actually benefit from wearing their belts. Figure 8 illustrates the relationship between lives saved and increasing rates of safety belt usage.

Figure 8
Percent Lives Saved as a Function of Belt Use

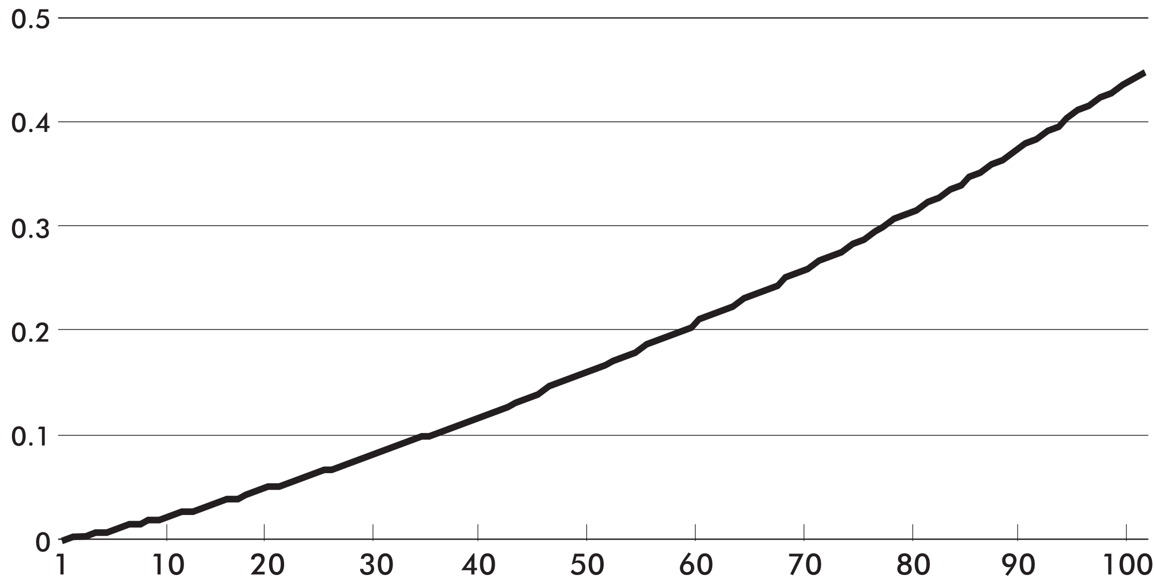


Table 19 lists the historical and cumulative impact of safety belt use on motor vehicle casualties. Over the last 26 years, safety belts have saved 135,000 lives and prevented 3.8 million serious nonfatal injuries. At current use rates, they are preventing 11,900 fatalities and 325,000 serious (MAIS 2-5) nonfatal injuries annually.

The failure of a large segment of the driving population to wear their belts also has significant safety implications. If all occupants had used safety belts properly, many more lives would have been saved. Table 19 also lists the potential safety benefits that could have been realized since 1975 had all occupants worn their safety belts. Over this period, passenger vehicles were equipped with devices that could have saved over 300,000 additional lives and prevented 5.2 million additional serious injuries if all vehicle occupants had taken a few seconds to buckle their safety belts. At current (2000) belt use rates, an additional 9,200 fatalities and 143,000 serious injuries could be prevented every year if all passengers were to wear their safety belts. This represents an enormous lost opportunity for injury prevention.

Table 19
Historical and Cumulative Impact of Safety Belt Use on Motor Vehicle Casualties

Year	Fatalities Prevented	Fatalities Preventable	Lives Lost Due To Safety Belt Nonuse	MAIS 2-5 Injuries Prevented	Injuries Preventable	MAIS 2-5 Injuries Lost Due to Safety Belt Nonuse
1975	978	14279	13301	33141	261803	228662
1976	796	14647	13851	27087	264802	237716
1977	682	15142	14460	23812	276860	253048
1978	679	16220	15541	20711	255815	235104
1979	594	16320	15726	20906	297110	276204
1980	575	16305	15730	20291	295345	275053
1981	548	15770	15222	19346	283874	264528
1982	678	13928	13250	23889	255505	231616
1983	809	13722	12913	28233	252495	224262
1984	1197	14424	13227	40638	267505	226867
1985	2435	14943	12508	77061	283956	206895
1986	4094	16822	12728	122747	328689	205941
1987	5141	17819	12678	151616	354980	203364
1988	5959	18633	12674	169154	365168	196014
1989	6333	18589	12256	190388	392899	202511
1990	6592	18353	11761	196858	389941	193083
1991	7011	17650	10639	197162	361899	164737
1992	7390	17215	9825	205511	357403	151891
1993	8347	17985	9638	230577	377766	147188
1994	9206	18726	9520	301963	476809	174846
1995	9790	19663	9873	265572	415228	149656
1996	10414	20169	9755	280080	427101	147021
1997	10750	20355	9605	285945	429528	143583
1998	11018	20370	9352	286329	422597	136268
1999	11197	20750	9553	304899	451014	146115
2000	11889	21127	9238	324823	467800	142977
Total	**135102**	**449926**	**314824**	**3848741**	**9013892**	**5165151**

Safety belt nonuse has also had a significant economic impact. Table 20 lists the economic savings that have resulted from safety belt use over the past 26 years. Since 1975, $588 billion in economic costs (2000$) have been saved due to safety belt use. At 2000 usage rates, safety belts are saving society an estimated $50 billion annually in medical care, lost productivity, and other injury related costs. Table 21 lists the potential economic savings that were lost due to nonuse. These lost savings could be viewed as costs of safety belt nonuse. Since 1975, $917 billion in unnecessary economic costs (2000$) have been incurred due to safety belt nonuse. At current usage rates, the needless deaths and injuries that result from nonuse continue to cost society an estimated $26 billion annually in medical care, lost productivity, and other injury related costs.

Table 20
Historical and Cumulative Impact of Safety Belt Use on Motor Vehicle Casualties and Economic Costs

Year	Fatalities Prevented	Cost/Fatality	MAIS 2-5 Injuries Prevented	MAIS 2-5 Cost/Injury Current $	Total Cost Savings (Millions)	
					Current $	2000$
1975	978	$299,239	33141	$37,010	$1,519	$4,863
1976	796	$316,481	27087	$39,142	$1,312	$3,971
1977	682	$337,061	23812	$41,687	$1,223	$3,474
1978	679	$362,646	20711	$44,852	$1,175	$3,104
1979	594	$403,806	20906	$49,942	$1,284	$3,045
1980	575	$458,314	20291	$56,684	$1,414	$2,954
1981	548	$505,591	19346	$62,531	$1,487	$2,817
1982	678	$536,739	23889	$66,383	$1,950	$3,479
1983	809	$553,981	28233	$68,516	$2,383	$4,119
1984	1197	$577,898	40638	$71,474	$3,596	$5,960
1985	2435	$598,478	77061	$74,019	$7,161	$11,461
1986	4094	$609,602	122747	$75,395	$11,750	$18,462
1987	5141	$631,850	151616	$78,147	$15,097	$22,884
1988	5959	$657,992	169154	$81,380	$17,687	$25,745
1989	6333	$689,696	190388	$85,301	$20,608	$28,619
1990	6592	$726,961	196858	$89,910	$22,492	$29,633
1991	7011	$757,553	197162	$93,694	$23,784	$30,071
1992	7390	$780,357	205511	$96,514	$25,602	$31,423
1993	8347	$803,718	230577	$99,403	$29,629	$35,308
1994	9206	$824,298	301963	$101,948	$38,373	$44,587
1995	9790	$847,658	265572	$104,838	$36,141	$40,836
1996	10414	$872,687	280080	$107,933	$39,318	$43,152
1997	10750	$892,711	285945	$110,410	$41,168	$44,169
1998	11018	$906,616	286329	$112,130	$42,095	$44,471
1999	11197	$926,639	304899	$114,606	$45,319	$46,842
2000	11889	$957,787	324823	$118,458	$49,865	$49,865
Total	**135102**		**3848741**		**$483,430**	**$585,314**

Table 21
Historical and Cumulative Impact of Safety Belt Non-Use on Motor Vehicle Casualties and Economic Costs

Year	Lives Lost Due to Safety Belt Nonuse	Cost/Fatality	MAIS 2-5 Injuries Lost Due to Safety Belt Nonuse	MAIS 2-5 Cost/Injury Current $	Total Cost Savings Forgone (Millions)	
					Current $	2000$
1975	13301	$299,239	228662	$37,010	$12,443	$39,826
1976	13851	$316,481	237716	$39,142	$13,688	$41,426
1977	14460	$337,061	253048	$41,687	$15,423	$43,825
1978	15541	$362,646	235104	$44,852	$16,181	$42,735
1979	15726	$403,806	276204	$49,942	$20,145	$47,781
1980	15730	$458,314	275053	$56,684	$22,800	$47,648
1981	15222	$505,591	264528	$62,531	$24,237	$45,915
1982	13250	$536,739	231616	$66,383	$22,487	$40,128
1983	12913	$553,981	224262	$68,516	$22,519	$38,934
1984	13227	$577,898	226867	$71,474	$23,859	$39,543
1985	12508	$598,478	206895	$74,019	$22,800	$36,488
1986	12728	$609,602	205941	$75,395	$23,286	$36,586
1987	12678	$631,850	203364	$78,147	$23,903	$36,233
1988	12674	$657,992	196014	$81,380	$24,291	$35,358
1989	12256	$689,696	202511	$85,301	$25,727	$35,728
1990	11761	$726,961	193083	$89,910	$25,910	$34,137
1991	10639	$757,553	164737	$93,694	$23,494	$29,704
1992	9825	$780,357	151891	$96,514	$22,327	$27,403
1993	9638	$803,718	147188	$99,403	$22,377	$26,667
1994	9520	$824,298	174846	$101,948	$25,673	$29,830
1995	9873	$847,658	149656	$104,838	$24,059	$27,184
1996	9755	$872,687	147021	$107,933	$24,381	$26,759
1997	9605	$892,711	143583	$110,410	$24,427	$26,208
1998	9352	$906,616	136268	$112,130	$23,758	$25,099
1999	9553	$926,639	146115	$114,606	$25,598	$26,458
2000	9238	$957,787	142977	$118,458	$25,785	$25,785
Total	**314824**		**5165151**		**$581,579**	**$913,390**

Figure 9
Savings at 2000 Belt Use Rates
Compared to Potential Savings at 100 Percent Belt Use

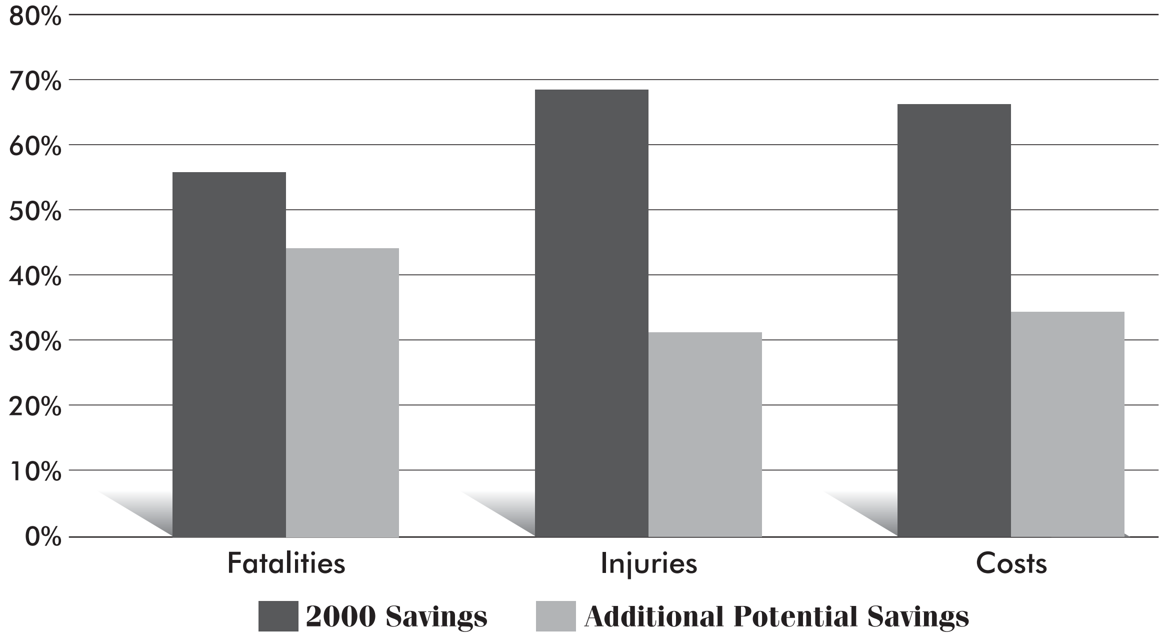


Figure 9 compares the portion of safety belt benefits that were achieved at 2000 belt use rates to those that could be achieved if all occupants wore belts. Belt usage in 2000 prevented 56 percent of the fatalities that could be saved by belts with full usage. It also prevented 69 percent of the serious injuries and 66 percent of the potential cost savings.

Source of Payment

The economic toll of motor vehicle crashes is borne by society through a variety of payment mechanisms. The most common of these are private insurance plans such as Blue Cross-Blue Shield, HMOs, commercial insurance policies, or worker's compensation. Medicare is the primary payer for people over the age of 65. When these sources are not available, government programs such as Medicaid may provide coverage for those who meet eligibility requirements. Expenses not covered by private or governmental sources must be paid out-of-pocket by individuals, or absorbed as losses by health care providers.

For this report, estimates of payment distributions for motor vehicle crashes will be based on those found in Blincoe (1996). These are the most recent data available at this time with injury stratification that is compatible with this report. Table 22 shows the distribution of the portion of crash related costs that are borne by private insurers, governmental sources, individual crash victims, and other sources. These distributions are quite variable depending on the nature of the cost category.

Table 22
Estimated Source of Payment by Cost Category

	Federal	State	Total Government	Insurer	Other	Self	Total
Medical	14.40%	9.77%	24.16%	54.85%	6.36%	14.62%	100.00%
Emergency Services	3.87%	75.75%	79.62%	14.74%	1.71%	3.93%	100.00%
Market Productivity	16.20%	3.06%	19.26%	41.09%	1.55%	38.10%	100.00%
HH Productivity			0.00%	41.09%	1.55%	57.36%	100.00%
Insurance Admin	0.89%	0.51%	1.40%	98.60%			100.00%
Workplace Costs					100.00%		100.00%
Legal/Court				100.00%			100.00%
Travel Delay					100.00%		100.00%
Property Damage				65.00%		35.00%	100.00%

Source: Blincoe, 1996

In Table 23, total costs are distributed according to the proportions listed in Table 22. The results indicate that approximately $21 billion, or 9 percent of all costs are borne by public sources, with federal revenues accounting for 6 percent and states accounting for just under 3 percent. This is the equivalent of $203 in added taxes for every household in the United States.[3] Private insurers paid $116 billion, or 50 percent, while individual crash victims absorbed $60 billion or 26 percent. Other sources, absorbed $33 billion (14 percent) of the total cost. This reflects unpaid charges borne by health care providers and charities, but the bulk of it occurs because of travel delay costs, which are borne by other drivers who are delayed by motor vehicle crashes.

[3] *Based on 103,874,000 households in 1999. (Source:* Statistical Abstract of the United States, 2000*)*

To some extent it is illusory to disaggregate costs across payment categories because ultimately, it is individuals who pay for these costs through insurance premiums, taxes, direct out-of-pocket cost, or higher charges for medical care. A real distinction can be made, however, between costs borne by those directly involved in the crashes and costs that are absorbed by the rest of society. Costs paid out of federal or state revenues are funded by taxes from the general public. Similarly, costs borne by private insurance companies are funded by insurance premiums paid by policyholders, most of whom are not involved in crashes. Even unpaid charges, which are absorbed by health care providers are ultimately translated into higher costs that are borne by a smaller segment of the general public – users of health care facilities. From this perspective, perhaps the most significant point from Table 23 is that society at large picks up nearly ¾ of all crash costs that are incurred by individual motor vehicle crash victims.

Table 23
Estimated Source of Payment by Cost Category
2000 Motor Vehicle Crash Costs
(Millions of 2000$)

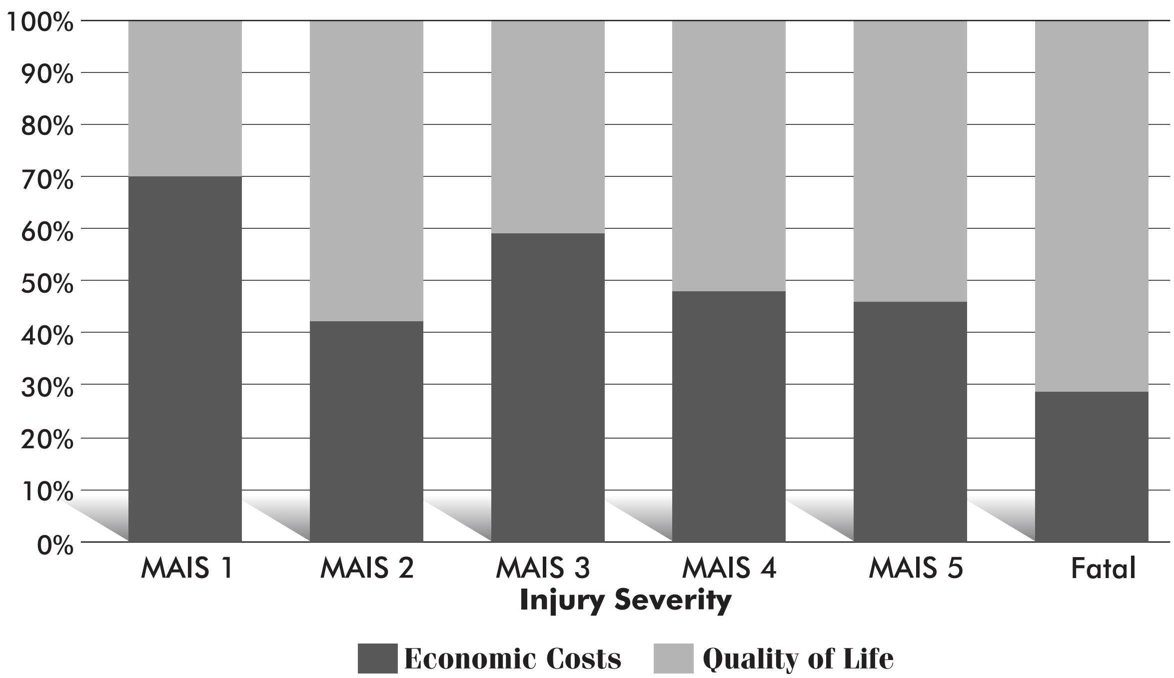
	Federal	State	Total Government	Insurer	Other	Self	Total
Medical	$4,698	$3,187	$7,885	$17,893	$2,075	$4,769	$32,622
Emergency Services	$56	$1,100	$1,157	$214	$25	$57	$1,453
Market Productivity	$9,881	$1,866	$11,747	$25,061	$945	$23,238	$60,991
HH Productivity				$8,280	$312	$11,559	$20,151
Insurance Admin	$135	$77	$212	$14,955			$15,167
Workplace Costs					$4,472		$4,472
Legal/Court				$11,118			$11,118
Travel Delay					$25,560		$25,560
Property Damage				$38,373		$20,663	$59,036
Total	**$14,769**	**$6,231**	**$21,000**	**$115,894**	**$33,388**	**$60,285**	**$230,568**
% Total	**6.41%**	**2.70%**	**9.11%**	**50.26%**	**14.48%**	**26.15%**	**100.00%**

Appendix A

Comprehensive Costs

The costs examined in the body of this report are the economic costs that result from goods and services that must be purchased or productivity that is lost as a result of motor vehicle crashes. They do not represent the intangible consequences of these events to individuals and families, such as pain and suffering and loss of life. Measurement of the dollar value of those consequences has been undertaken through numerous studies. These studies have estimated values based on wages for high-risk occupations and purchases of safety improvement products, along with other measurement techniques. These "willingness-to-pay" costs can be an order of magnitude higher than the economic costs of injuries. Currently, most authors seem to agree that the value of fatal risk reduction lies in the range of $2-7 million per life saved.

Figure A-1
Distribution of Comprehensive Costs



An estimate of "comprehensive costs," which combines both economic costs and values for "intangible" consequences, was made 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 (See Gold et al., 1996). QALY loss is determined by the duration and severity of the health problem. To compute it, the 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 were used.

Each impairment fraction was estimated by body part, AIS-85, and fracture/dislocation. The resulting estimates in AIS-85 were applied to NHDS and NHIS cases and the respective AIS-90 estimates were computed. QALY losses in future years are discounted to present value using a 4 percent discount rate.

These estimates, expressed in 2000 economics, are summarized in Table A-1. The total Comprehensive cost for a fatality is approximately $3.4 Million. Most of this is due to lost life years and lost productivity. The portion of comprehensive costs that is represented by economic costs decreases as the severity of injuries rises (see figure A-1). This reflects the relatively small values of lost quality of life found for less severe injuries.

The relative value of fatalities and non-fatal injuries is useful for conducting cost-effectiveness analysis. These values are used to express nonfatal injuries as fatality equivalents in order to calculate a cost per equivalent fatality. In some instances, the countermeasure being examined will only impact costs associated with injuries. This would be the case for countermeasures aimed at protecting occupants in the event a crash occurs. If the countermeasure influences the prevalence of the crash itself, then all costs would be relevant to the analysis. Comprehensive ratios for both scenarios are provided in Table A-1.

Table A-1
Summary of Unit Costs, 2000
2000 Dollars

	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
INJURY COMPONENTS								
Medical	$0	$1	$2,380	$15,625	$46,495	$131,306	$332,457	$22,095
Emergency Services	$31	$22	$97	$212	$368	$830	$852	$833
Market Productivity	$0	$0	$1,749	$25,017	$71,454	$106,439	$438,705	$595,358
HH Productivity	$47	$33	$572	$7,322	$21,075	$28,009	$149,308	$191,541
Insurance Admin.	$116	$80	$741	$6,909	$18,893	$32,335	$68,197	$37,120
Workplace Cost	$51	$34	$252	$1,953	$4,266	$4,698	$8,191	$8,702
Legal Costs	$0	$0	$150	$4,981	$15,808	$33,685	$79,856	$102,138
Subtotal	**$245**	**$170**	**$5,941**	**$62,020**	**$178,358**	**$337,301**	**$1,077,567**	**$957,787**
NON-INJURY COMPONENTS								
Travel Delay	$803	$773	$777	$846	$940	$999	$9,148	$9,148
Property Damage	$1,484	$1,019	$3,844	$3,954	$6,799	$9,833	$9,446	$10,273
Subtotal	**$2,287**	**$1,792**	**$4,621**	**$4,800**	**$7,739**	**$10,832**	**$18,594**	**$19,421**
Total	**$2,532**	**$1,962**	**$10,562**	**$66,820**	**$186,097**	**$348,133**	**$1,096,161**	**$977,208**
QALYs	$0	$0	$4,455	$91,137	$128,107	$383,446	$1,306,836	$2,389,179
Comprehensive	**$0**	**$0**	**$15,017**	**$157,958**	**$314,204**	**$731,580**	**$2,402,997**	**$3,366,388**
Total Comprehensive ratio/Fatal		0.45%	4.69%	9.33%	21.73%	71.38%	100.00%	
Injury Component ratio/Fatal			0.31%	4.58%	9.16%	21.53%	71.24%	100.00%

Note: Unit costs are on a per-person basis for all injury levels. PDO costs are on a per damaged vehicle basis.

Appendix B

Psychic Morbidity Resulting from Motor Vehicle Injuries

Summary

An extensive literature review shows that a significant number of people experience mental disorders as a result of being involved in a motor vehicle crash. A preliminary estimate of the incidence of these disorders, believed to be a conservative lower bound, is that at least 31,000 people have post traumatic stress symptoms at one year post injury and at least 62,000 people have major depressive symptoms at one year post injury, with some unknown overlap of these two populations. There is evidence that the actual incidence is likely to be much higher. The literature also reports that a portion of the persons with these conditions at one-year post injury continue to have them for some time in the future, and there is an additional number of people not injured or not involved in the crash who also experience some of the same disorders.

Introduction

In addition to the possibility of physical injury as the result of a motor vehicle crash behavioral or emotional changes can occur when a person experiences a motor vehicle crash. These emotional experiences can be feelings of terror, helplessness or fear of dying. These feelings can result in a psychological reaction that can have a major impact on a person's life, independent and separate from the physical outcome of the injury. An exploratory study was undertaken in order to begin to quantify these effects. An extensive review of the literature, primarily based on a MEDLINE search for the period 1990 to 2000, resulted in a number of citations of prospective clinical studies of mental conditions following injury, many specifically focused on motor vehicle injuries. The results of the literature review show definite patterns of incidence over time for two conditions, Post Traumatic Stress Disorder (PTSD) and Major Depressive Episode (MDE). Coupling these data with appropriate injury incidence data results in a national level estimate of the lower bound of the incidence of these two mental disorders.

Post Traumatic Stress Disorder and Related Disorders

Definition

The fact that people experience psychological stress after being exposed to traumatic situations has been known for some time. The American Psychiatric Association (APA) first officially recognized PTSD as a mental disorder in 1981 when it was included in the third edition of the Diagnostic and Statistical Manual of Mental Disorders, DSM III. This was largely in response to veterans groups who wanted recognition that what had been called "post-Vietnam syndrome" was a real disorder (Helzer et al 1987). In the definition the APA recognized that combat trauma was not the only potential cause of these symptoms.

One of the difficulties in interpreting the literature concerning PTSD is the proliferation of definitions and the instruments used to diagnose the condition. The practical significance of this is that the estimates of incidence developed at different times and using different instruments are not fully comparable, as they depend on which definition or instrument was used in the diagnosis.

Although the formal definition of PTSD has changed since 1981 the broad outline has remained the same, including four clusters of symptoms: re-experiencing, where the person recalls the traumatic situation; avoidance, where the person attempts to minimize exposure to the stimuli that evoke the re-experiencing; numbing, where the person exhibits inability to care for others; and hyperarousal, where the person experiences sleep disturbance, irritability or outbursts of anger, difficulty concentrating, hypervigilance and an exaggerated startle response (Davidson 2000). In all cases the person had to experience a traumatic event such as injury or assault. The current definition of PTSD requires the symptoms to last for at least one month. Acute PTSD is defined as having symptoms for less than 3 months, chronic PTSD is defined as having symptoms for more than 3 months, and delayed onset PTSD is defined as having the onset of the symptoms at least 6 months after the stressing event

Although not part of the formal definition of PTSD in DSM, the literature also describes instances where some but not all of the conditions in the definition of PTSD are met. These are variously identified as subsyndormal PTSD, partial PTSD, Post Traumatic Stress Syndrome or Post Traumatic Stress Symptoms. In addition, Acute Stress Disorder (ASD) was added to the definitions of mental disorders in DSM-IV (Barton et al. 1996). It is a similar condition to PTSD, in the sense that it is the result of experiencing a traumatic event, but by definition it lasts for a maximum of 4 weeks and occurs within 4 weeks of the trauma. If the symptoms of ASD continue after 4 weeks, it can then be determined whether or not the person meets the definition of PTSD.

Prognosis

Prognosis PTSD is a very persistent condition (Davidson 2000). The prognosis for PTSD is not favorable. "Most individuals who, shortly after trauma, express symptoms of PTSD recover within a year," but "those who remain ill for one year rarely recover completely" (Freedman et al. 1999). Similarly, based on a random survey of 2,493 persons, "in about one third (of people with PTSD) symptoms persisted for more than three years" (Helzer et al. 1987), and in another national survey of 5,877 people, "more than one third of people" with PTSD "fail to recover even after many years" (Kessler et al. 1995). An interesting result of a small non-random sample showed that the rate of remission was the same whether or not people received treatment (Blanchard et al. 1997).

Prevalence in the Overall Population

Estimates of the prevalence of PTSD in the general population vary widely, as summarized in the table below. The first listed estimated was cited as "the best epidemiologic study of PTSD in the general American population," (Blanchard et al. 1998).

Prevalence of PTSD in the U.S. Population

There is considerable evidence that females may be more likely to develop PTSD than males (Merikangas KR and Weissman MM. 1986, Blanchard et al. 1995, Blanchard et al. 1996, Fommberger et al.1998, Malt 1988, Davidson 2000, among others), but this is disputed as possibly being an artifact of the data collection methods (Blaszczynski et al. 1998) or that females are more likely to report symptoms (Malt 1988).

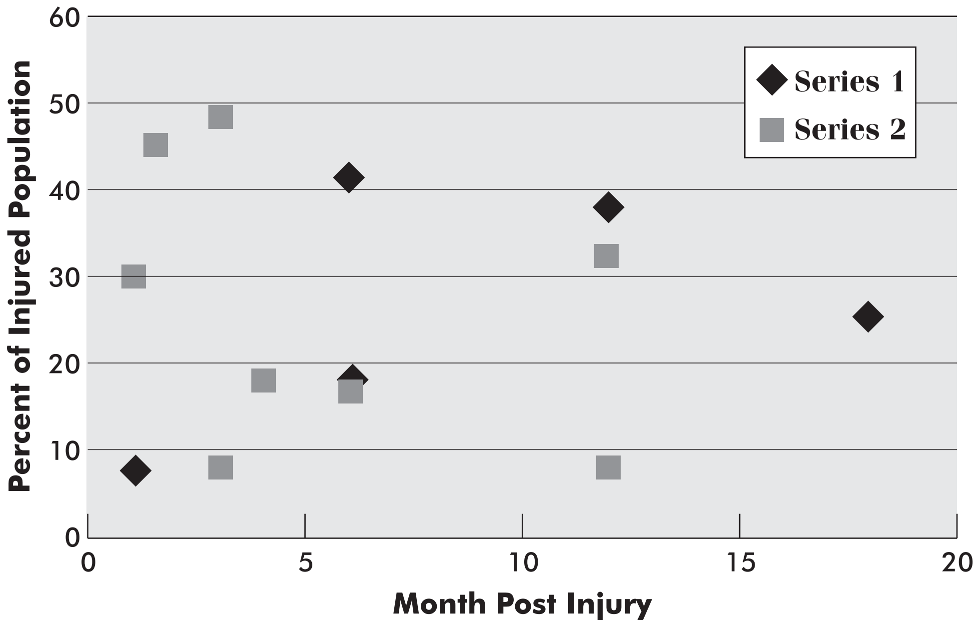
Prevalence Estimate, Percent	Author	Year
7.8	Kessler et al.	1995
.5 for men, 1.3 for women	Helzer et al.	1987
1	Davis and Breslau	1994
9	Davis and Breslau	1994
1.3	Davidson	2000
6.2	Davidson	2000

Some authors suggest that the incidence of PTSD following motor vehicle injury does not appear to be a function of chronological age (Blanchard et al. 1995), even for children (Mirza et al. 1998), but there is not general agreement on this point.

Results

The relevant data on PTSD incidence following motor vehicle crash related injuries as reported in the literature are plotted in Figure 1. In this figure, Series 1 represents data relevant to injured persons treated at a trauma center and Series 2 represents data relevant to injured persons treated at an emergency department. The figure is labeled "Post Traumatic Stress" to indicate that not all of the points would meet the current formal definition of PTSD as shown in DSM-IV, but that they were judged to exhibit the appropriate symptoms at the time the data were developed. Note that these data represent the portion of the initial study population diagnosed with PTSD at the time of diagnosis. Some patients not showing symptoms of PTSD at the beginning of the study begin to exhibit them at later times. In other words, the population is somewhat dynamic, with some people having remission of their symptoms and other people beginning to exhibit them. Two relevant data points are not included in Figure 1. One of these indicates 5 percent of the initial population with PTSD at 5 years post injury and was not included in order to

Figure B-1
Incidence of Post Traumatic Stress



focus on the one-year post injury time period. The other indicates 93 percent of the patient population with PTSD at 3 weeks post injury. This point was excluded because the current definition of PTSD requires symptoms to continue for at least a month before the condition can be considered PTSD. Also not shown is a report of the prevalence of PTSD in a series of patients of mixed severity seen in an English hospital emergency department (Mayou et al. 1997). That study reported that PTSD symptoms affected approximately 10 percent of the study population from 3 months to 5 years.

Although there is considerable scatter in the data shown in Figure B-1, the visual impression of these data is that about 40 percent of those persons treated at a trauma center, presumably on average more seriously injured, and about 20 percent of those treated at an emergency department would be experiencing post traumatic stress.

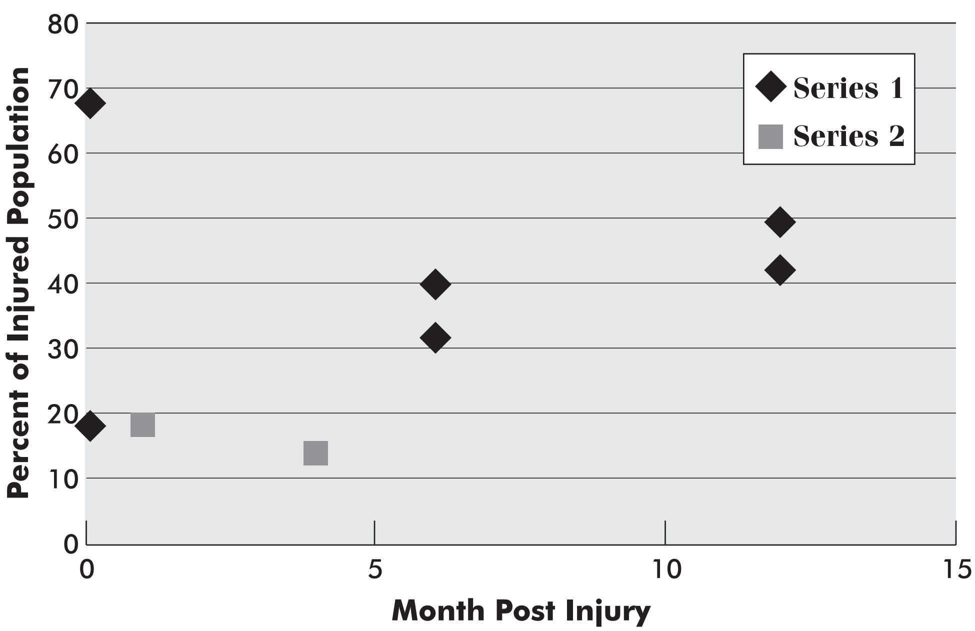
Depression

Major Depressive Episode (MDE) is a condition within the category of mood disorders in DSM-IV. Similar to the situation with PTSD, diagnostic criteria for MDE have evolved over the years. In general the diagnostic criteria require the person to have depressed mood, or loss of interest or diminished ability to derive pleasure from everyday activities plus some mix of other symptoms such as change in weight, sleeplessness, etc. Some of the symptoms overlap with those of PTSD, but these are two different conditions even though they may occur simultaneously.

Untreated, symptoms of depression may last 6 months or longer. Although complete remission is common,
20 to 30 percent of the people experience some of the symptoms for months or years. About 5 to 10 percent of the people diagnosed with this disorder can experience the full set of symptoms for 2 years or more. (American Psychiatric Association 1994).

The available data on the incidence of depression in the motor vehicle injured population are shown in Figure B-2. The same definitions apply as in Figure 1. Here too there is considerable scatter in the data, with a hint of a "U" shaped time relationship in the trauma center related data. Visually, it appears that about 40 percent of the motor vehicle injured population treated at a trauma center would be expected to be experiencing depression one year after the injury. There are insufficient data relevant to emergency department treated injury victims to draw any conclusions. Not shown is the result of a five-year post injury assessment of depression and anxiety disorders in a population that included 67 percent motor vehicle injuries. In that population 11 percent had a pure anxiety disorder, 12 percent had a pure depression disorder, 15 percent had a mix of anxiety and depression disorders and an additional 5 percent had sub-clinical mood disorder five years post injury (Piccinelli et al. 1999).

Figure B-2
Incidence of Depression



Injury Data

Estimates of the number of people treated in emergency departments and trauma centers as the result of a motor vehicle injury were developed to provide a basis for applying the percentage values derived from the case studies to the national level.

NCHS data (National Center for Health Statistics web site) show 4,259,000 people injured in motor vehicle crashes treated in an emergency department in the U. S. in 1998. The data shown in this report suggest that this number may be low. Rounding the estimates in Table 3 to two significant figures, there were over 2.5 million people experiencing MAIS 0 injuries, nearly 4.7 million experiencing MAIS 1 injuries, nearly 440,000 people experiencing MAIS 2 injuries, nearly 130,000 people experiencing MAIS 3 injuries, more than 36,000 people experiencing MAIS 4 injuries and nearly 9,500 people experiencing MAIS 5 injuries. It is known that some people with MAIS 0 injuries are taken to emergency departments (Luchter 1995) and presumably most people with MAIS 1 and 2 injuries would likely visit an emergency department. Since the NCHS data are based on emergency department visits and the NASS data are based on the number of crashes with follow-up to determine injury levels from hospital records, the NCHS estimate will be used as the more conservative estimate.

There are no comparable national level data showing the number of people injured in motor vehicle crashes treated in trauma centers. Here there is no choice but to estimate the number of people treated at that level based on the NASS data. Although people receiving injuries at the MAIS 3 or greater level would likely benefit from being treated in a trauma center one cannot assume that all of them would receive that level of care. Arbitrarily assuming that 90 percent of those injured in motor vehicle crashes are treated at a trauma center, the data in Table 3 suggest that 155,000 people are treated in trauma centers in the U.S. each year as the result of motor vehicle injuries.

Incidence of PTSD and MDE

It is not possible to develop definitive estimates of the incidence of PTSD and MDE following motor vehicle crashes based on the available data. However, it does appear possible to estimate a reasonably conservative lower bound of the possible range. The data suggest that between 10 and 30 percent of the people treated in an emergency department as the result of a motor vehicle injury experience PTSD at one year post injury, and for those treated at trauma centers the range appears to be between about 20 to 40 percent. Using the emergency department incidence of 4,259,000 cited above, between .4 and 1.3 million people injured in motor vehicle crashes would be suffering form PTSD one-year post injury. Using the 155,000 estimate of people treated in a trauma center 31,000 and 62,000 people would be suffering from PTSD one year post injury. This results is a broad range of between 31,000 and 1.3 million.

There is only one report of MDE following treatment for a motor vehicle crash in the emergency department, and thus no attempt is made to develop a definitive estimate for that population. For persons treated in a trauma center, the percentage with MDE at one-year post injury appears to be in the 40 to 50 percent range or 62,000 to 78,000 based on the estimated 155,000 cited in the prior paragraph.

Discussion

An extensive review of the literature revealed several case studies of people injured in motor vehicle crashes who were diagnosed with symptoms of depression and posttraumatic stress at some time after the injury. Specifically, three reports of the incidence of PTSD in patients treated at trauma centers and five reports on the incidence of PTSD in patients treated in emergency departments were found. In addition, three reports on the incidence of MDE for patients treated in trauma centers and one for patients treated in an emergency department were found. There is considerable scatter in these data. Applying the percentage of person treated in these facilities who were diagnosed to have these disorders at one year post injury to an estimate of the national level of the total number of persons receiving that level of treatment for motor vehicle injuries results in lower bound estimates of the national level incidence. On that basis, at least 31,000 people who had been injured in a motor vehicle crash are experiencing the symptoms of PTSD one year post injury, and 62,000 people are experiencing the symptoms of MDE. There is evidence that for some of these people, the symptoms would continue for some time. For example, the American Psychiatric Association indicates that about 5 to 10 percent of the people diagnosed with MDE can experience the full set of symptoms for 2 years or more, Mayou et al. (1997) cites 10 percent of an English population treated in an emergency department having PTSD symptoms at 5 years, and Piccinelli et al. (1999) shows more than 25 percent of the persons diagnosed with these disorders were still experiencing they at 5 years post injury.

Assuming that the average injury severity is lower for people treated at an emergency department than those treated at a trauma center, the data suggest a relationship between injury severity and either posttraumatic stress or major depression. This is in agreement with some authors (Holbrook et al. 1994, Fommberger 1998) but counter to some others (Koren et al. 1999). Age does not appear to be a major factor but sex does, with females reported to have a higher incidence. Prior history of mental disorders also does appear to be more frequent in persons diagnosed with depression or posttraumatic stress.

The results reported here should be considered as a preliminary estimate only as there are several limitations in the available data and the method by which they have been combined. The case reports are based on different populations from different geographical areas and there is little consistency in the diagnostic instruments used. However, there is some likelihood that the estimates are low for two reasons: the reports in the literature only relate to people who were injured sufficiently to seek medical care, and as far as could be ascertained from the literature, all of the case studies included in the results reported here excluded persons with head injuries. It is frequently the case that persons with head injuries experience a variety of behavioral problems. Also, it is known that persons not directly involved in the crash often suffer symptoms of depression and posttraumatic stress (Lehman et al.1987, Harris et al.1989). Neither of these categories is included in the estimated incidence. Whatever the incidence value is at present, at least one author suggests that the problem is likely to increase as the survival rates of motor vehicle crashes increases (Blaszczynski et al.1998).

Appendix C

Functional Losses Resulting from Motor Vehicle Crashes

Introduction

When an injury occurs, not only is the injured person affected, but families and society as a whole experience economic, functional and behavioral impacts as well. Methods for estimating the economic consequences resulting from injury are the most highly developed, and have been applied in the body of this report. There is a growing realization, however, that economics do not tell the entire story –real people experience long-term health consequences that affect their lives in a very direct way. This Appendix considers the functional limitations resulting from motor vehicle injuries. Appendix B discusses the current state of knowledge of behavioral outcomes of motor vehicle injuries.

The Functional Capacity Index (FCI), has been developed by NHTSA as an approach to quantifying the long term changes in a person's ability to function in daily living[1, 2.] Based on Multi-Attribute Utility Theory, the Index considers each year of life to be intrinsically valuable, regardless of the earning capacity of the individual. The FCI classifies normal adult function into ten domains (eating, excretory, sexual, ambulation, hand and arm, bending and lifting, visual, auditory, speech and cognitive) and assigns a value between 0 and 1 to each domain to indicate the predicted reduction in function resulting from a specific injury. A value of 0 denotes no loss of function and a 1 value denotes complete loss of function in that domain. For each domain, discrete levels of function were described. An expert panel predicted the expected level of function at one year post injury in each of the ten domains for every injury listed in the 1990 Abbreviated Injury Scale[3]. A convenience sample representing of a cross section of society performed exercises from which were derived a relative value for each domain and each level of function. An algorithm was developed for combining these values into an overall FCI value for each injury. Initial clinical validation studies[2, 4] confirm that the Index indeed does measure functional outcome and have identified areas for further improvement. FCI values assigned to the most severe functional levels of each of the ten domains are shown in Table C-1 and FCI values for some typical injuries are shown in Table C-2.

Table C-1
FCI Values for the Most Severe Levels of Each Domain

Total Hearing Loss	0.35
Total Blindness	0.41
No Sexual Function	0.46
Cannot Bend or Lift	0.49
Completely Dependent Ambulation	0.67
Severe Difficulty Speaking	0.68
Severe Incontinence	0.74
Tube Feeding Required	0.75
Complete/Near Paralysis, Two Upper Limbs	0.75
Complete Cognitive Dependence	1.00

Table C-2
FCI Values for Typical Injuries

Most Minor Injuries	0.00
Bilateral Lung Contusion	0.14
Most femur fractures	0.14
Eye Injury NFS	0.21
Pancreas Avulsion	0.29
Degloving Injury, Arm	0.41
Sciatic Nerve, Complete laceration	0.54
Unconscious > 24 hours	0.86
Cervical spine complete cord syndrome	0.98

The FCI by itself provides a relative measure of the long-term outcome of an injury. For example, an injury with an FCI value of 0.6 means that a person with that injury has their functional capacity reduced by 60 percent compared to that of a fully functioning person. Multiplying the FCI value by a person's life expectancy results in a measure called Life-years Lost to Injury (LLI), a measure of the life-long effect of the injury. Changes in the FCI with time can be taken into account, as can the possibility that certain injuries result in reduced life expectancy. If the LLI values are aggregated over an injured population, an indication of the relative effect particular injuries have on society can be estimated.

FCI and Crash Related Injuries

The FCI was applied to data from the National Automotive Sampling System Crashworthiness Data System (NASS CDS) for the years 1993-1994[5]. The sample included surviving crash occupants with at least one injury for whom demographic data were available. FCI values were assigned to the most severe injury within each body region. LLI were computed based on the age and gender of the injured occupants.

Ninety-three percent of the crash related injuries were not associated with any predicted loss of function (FCI = 0). Approximately 105,000 persons injured in motor vehicle crashes experience some loss of function at one year post injury; nearly half of these persons were affected in only one dimension. More than 10% experienced decrements in cognitive functioning. Among the 20 most frequently occurring injuries that result in functional limitations, 95% are injuries to the extremities. These injuries accounted for 78% of all LLI.

Other Applications of the FCI

The FCI has recently been used in cost effectiveness studies of motor vehicle injuries[6, 7] as well as is assessments of other types of injury[8, 9]. In studies of air bag effectiveness[6, 7], the FCI was used to account for diminished health-related quality of life resulting from motor vehicle crashes. Based on findings from these studies, it was demonstrated that cost-effectiveness ratios for air bags are comparable to other well-accepted measures in preventive medicine; the authors also estimated benefits of properly restraining children in the rear seat of air bag equipped vehicles.

References

[1] *MacKenzie EJ, Damiano AM, Miller TR, Luchter S. Development of the Functional Capacity Index (FCI). National Highway Traffic Safety Administration. DOT HS 808 160; 1994.*

[2] *MacKenzie EJ, Damiano AM, Miller TR, Luchter S. The development of the Functional Capacity Index. J Trauma 1996; 41(5)799-807.*

[3] *Association for the Advancement of Automotive Medicine: The Abbreviated Injury Scale, 1990 Revision, Des Plaines, Illinois.*

[4] *Mackenzie EJ, Sacco WJ, Luchter S, Ditunno JF, Forrester-Staz, C, Gruen GS, Marion DW, Schwab WC: Validating the Functional Capacity Index as a measure of outcome following blunt multiple trauma. J Trauma 2002; in press.*

[5] *Segui-Gomez M: Application of the Functional Capacity Index to NASS CDS Data. National Highway Traffic Safety Administration DOT HS 808 492, 1996.*

[6] *Graham JD, Thompson KM, Goldie SJ, Segui-Gomez M, Weinstein MC: The cost-effectiveness of air bags by seating position. JAMA 1997; 278(17):1418-1425.*

[7] *Segui-Gomez M: Driver air bag effectiveness by severity of the crash. Am J Public Health 2000; 90(10):1575-1581.*

[8] *Hemingway D, Segui-Gomez M:The cost effectiveness of home and recreational injury prevention. Final Report. Centers for Disease Control and Prevention R49/CCR115279-02-1, 2001.*

[9] *Segui-Gomez M, Keuffel E, Frick KD: Cost and effectiveness of hip protectors among the elderly. IJHTA 2002, in press.*

Appendix D

Definitions of Economic Costs

Medical Costs
The cost of all medical treatment associated with motor vehicle injuries including that given during ambulance transport. Medical costs include emergency room and inpatient costs, follow-up visits, physical therapy, rehabilitation, prescriptions, prosthetic devices, and home modifications.

Emergency Services
Police and fire department response costs

Vocational Rehabilitation
The cost of job or career retraining required as a result of disability caused by motor vehicle injuries

Market Productivity
The present discounted value (using a 4 percent discount rate for 2000 dollars) of the lost wages and benefits over the victim's remaining life span.

Household Productivity
The present value of lost productive household activity, valued at the market price for hiring a person to accomplish the same tasks.

Insurance Administration
The administrative costs associated with processing insurance claims resulting from motor vehicle crashes and defense attorney costs.

Workplace Costs
The costs of workplace disruption that is due to the loss or absence of an employee. This includes the cost of retraining new employees, overtime required to accomplish work of the injured employee, and the administrative costs of processing personnel changes.

Legal Costs
The legal fees and court costs associated with civil litigation resulting from traffic crashes.

Travel Delay
The value of travel time delay for persons who are not involved in traffic crashes, but who are delayed in the resulting traffic congestion from these crashes.

Property Damage
The value of vehicles, cargo, roadways and other items damaged in traffic crashes.

Psychosocial Impacts
Psychological or emotional trauma resulting from a motor vehicle crash that inhibits, limits, or otherwise negatively influences a person’s life.

Functional Capacity Index
An approach to quantifying the long-term changes in a person’s ability to function in daily living, expressed as a proportion of complete whole body functioning.

Appendix E

Discount Rates

When a person is disabled or killed in a motor vehicle crash, the victim's future productive contribution to society is reduced or eliminated. In addition, they may incur ongoing medical or rehabilitation costs throughout much of the remainder of their life. Because these losses occur in a future time period, they are not directly comparable to costs that occur in the year of the crash, and they must be adjusted to reflect society's preference for current consumption or investment opportunities. This adjustment is accomplished through the process known as discounting.

Discounting reflects the fact that a dollar invested today can earn a real (net of inflation) rate of return that would result in more than a dollar's purchasing power in a future year. Although economists are in general agreement that discounting should take place, there is considerable controversy regarding which rate to use.

There is general agreement within the economic community that the appropriate basis for determining discount rates is the marginal opportunity cost of lost or displaced funds. When these funds involve capital investment, the marginal, real rate of return on capital must be considered. However, when these funds represent lost consumption, the appropriate measure is the rate at which society is willing to trade off future for current consumption. This is referred to as the "social rate of time preference," and it is generally assumed that the consumption rate of interest, i.e. the real, after-tax rate of return on widely available savings instruments or investment opportunities, is the appropriate measure of its value.

The production that is lost by individual crash victims, as well as the medical and other costs that must be incurred in an attempt to restore them to their pre-crash physical and material status, are a measure of the consumption that is lost (or diverted to no-net-gain uses) to the injured parties and their dependents. It could be argued that the portion of these lost earnings that are invested rather than consumed represent foregone capital investment and should be discounted at a rate that reflects the opportunity cost of capital. However, savings rates are extremely low in the United States. In the latter part of the 1990's into 2000, the savings rate has been a negative rate of disposable personal income. As a practical matter, therefore, foregone consumption is the dominant consideration in establishing a discount rate for crash costs, and the social rate of time preference is the appropriate measure.

Estimates of the social rate of time preference have been made by a number of authors. Robert Lind (1982) estimated that it is between zero and six percent, reflecting the rates of return on Treasury bills and stock market portfolios. More recently, Kolb and Sheraga (1991) put the rate at between one and five percent, based on returns to stocks and three-month Treasury bills. Moore and Viscusi (1990) calculated a two percent real rate of time preference for health, characterized as being consistent with financial market rates for the period covered by their study.

This analysis will be based on a 4% discount rate. This rate was selected because most long-term cumulative rates of return on stocks cluster around that number. Investors appear to prefer the higher, riskier returns from stocks to the more conservative Treasury Bills by a significant margin. Four percent is a fairly conservative choice within the estimate range that has been derived from the analysis described in this Appendix and other analyses. See Blincoe 1996 for a more complete presentation of this issue.

Appendix F

Detailed Methodology for Selected Human Capital Unit Cost Estimates

Legal Costs

Legal costs include the legal fees and court costs associated with civil litigation resulting from motor vehicle crashes. Legal costs were calculated with the following formula:

LC= (Medical+Wage+Household)*Pwl*58%*29%*1.492*24.9%
if MAIS=1

LC= (Medical+Wage+Household)*Plw*58%*29%*1.492*55%
if MAIS in [2,5] and (Medical+Wage+Household)<$740,000

LC= $740,000*Plw*58%*29%*1.492*55%
if (Medical+Wage+Household)>$740,000 or MAIS=6

LC .... legal costs

Medical .... medical costs

Wage .... lost wages

Household .... lost household productivity

Plw .... probability of losing work, estimated by MAIS, body part, and fracture/dislocation diagnosis from the NASS/CDS file;

58% .... percentage of claimers who hired an attorney (Hensler et al., 1991);

29% .... estimated plaintiff's attorney fees, as an average percentage of losses recovered (Hensler et al., 1991; AIRAC, 1988);

1.492 .... ratio of total legal costs (excluding defense attorney fees) over plaintiff's attorney fees (Kakalik and Pace,1986);

24.9% .... percentage of motor vehicle crash victims with MAIS=1 and work loss who claim (Hensler et al., 1991); and

55% .... percentage of motor vehicle crash victims with MAIS in [2,5] and work loss who claim (Hensler et al., 1991); and

$740,000 .... limit on average court awards for catastrophic injuries (Hensler et al., 1991).

In estimating probabilities of losing work, by MAIS, body part, and fracture/dislocation diagnosis from the NASS/CDS file, a procedure similar to the procedure for estimating medical costs was used to fill cells for which no information on the workdays lost was available.

Insurance Administration Costs

Insurance administration costs include the administrative costs associated with processing insurance claims resulting from motor vehicle crashes and defense attorney fees.

Insurance administrative costs were calculated with the following formula:

When MAIS=1 then:

IA= 7.46%*Medical + 24.9%*18.3%*Pwl*(Wage+Household) + 3.24%*Wage
+ 1.67%*(Wage+Household) + 3.61%*(Wage+household) + 1.76%*Wage
+ 7.85%*PropDamage

When MAIS in [2,5] and (Wage+Household)<=$148,000 then:

IA= 7.46%*Medical + 55%*18.3%*Pwl*(Wage+Household) + 3.24%*Wage
+ 1.67%*(Wage+Household) + 3.61%*(Wage+household) + 1.76%*Wage
+ 7.85%*PropDamage

When (Wage+Household)>$148,000 then:

IA= 7.46%*Medical + 55%*18.3%*Pwl*($148,000) + 3.24%*Wage
+ 1.67%*($148,000) + 3.61%*($148,000) + 1.76%*Wage
+ 7.85%*PropDamage

When MAIS=6 then:

IA= 7.46%*Medical + 55%*18.3%*($148,000) + 9%*($54,800) + 7.85%*PropDamage

Legend

7.46%*Medical .... the insurance administrative costs related to medical expenses claims;

24.9%*18.3%*Pwl*(Wage+Household) . the insurance administrative costs related to liability claims;

3.24%*Wage .... the insurance administrative costs related to disability insurance;
1.67%*(Wage+Household) the insurance administrative costs related to Workman's Compensation;

3.61%*(Wage+household) .... the administrative costs related welfare payments;

1.76%*Wage .... the administrative costs related to seek leave;

7.85%*PropDamage .... the insurance administrative costs related to property damages;

9%*($54,800) .... the insurance administrative costs related to life insurance; and

148,000 .... the average policy limit on liability claims.

The formula's coefficients came from Miller, Viner, et al., (1991).

Appendix G

Hours of Delay per Heavy Vehicle Crash by Roadway Class, Location, and Severity

Road Class/Location	PDO	Injury	Fatal
URBAN			
Interstate	2260	7344	21749
Other Freeway	1766	5737	16990
Major Arterial	949	3082	9127
Minor Arterial	594	1929	5711
Collector	31	102	301
Local Street	9	28	83
RURAL			
Interstate	814	2646	7835
Major Arterial	416	1350	3999
Major Arterial	255	829	2454
Major Collector	10	34	100
Major Collector	4	14	42
Local Street	1	4	12

Note: Delay on local streets includes vehicles unable to exit from driveways as planned and therefore not in operation. Each hour of delay is valued at $13.86 in urban areas and $16.49 in rural areas. The cost differential is due to the differences in vehicle occupancy.

Appendix H

Nonfatal Injury Unit Cost By Body Region, 2000$

	Medical	Emergency Services	Market Productivity	Household Productivity	Insurance Admin.	Workplace Cost	Legal Costs	Travel Delay	Property Damage	Total
SCI										
MAIS 1	0	0	0	0	0	0	0	0	0	0
MAIS 2	0	0	0	0	0	0	0	0	0	0
MAIS 3	355082	368	141692	47936	26596	4266	68867	944	6799	769604
MAIS 4	824887	830	227881	60870	94751	4698	106488	1003	9833	2975590
MAIS 5	1088896	852	311615	50066	115009	8191	106488	5247	9446	4032158
BRAIN										
MAIS 1	30405	97	6484	2053	3488	252	1436	780	3844	66467
MAIS 2	31323	212	22371	6102	7296	1953	6113	850	3954	246660
MAIS 3	193785	368	67813	19340	29342	4266	30225	944	6799	668333
MAIS 4	206592	830	142195	36663	44003	4698	48867	1003	9833	1205085
MAIS 5	280228	852	610880	224427	72424	8191	99556	5247	9446	2700521
LOWER EXTREMITY										
MAIS 1	1285	97	987	328	470	252	81	780	3844	11491
MAIS 2	8592	212	28260	9131	7355	1953	5468	850	3954	102419
MAIS 3	31258	368	97920	30368	21901	4266	16359	944	6799	276057
MAIS 4	41473	830	214681	50146	36038	4698	41628	1003	9833	482811
MAIS 5	209623	852	358968	105678	56122	8191	93066	5247	9446	823972
UPPER EXTREMITY										
MAIS 1	859	97	850	252	408	252	39	780	3844	7381
MAIS 2	5490	212	20779	6652	4312	1953	2052	850	3954	46254
MAIS 3	17274	368	56689	16855	13738	4266	9698	944	6799	126631
MAIS 4	0	0	0	0	0	0	0	0	0	0
MAIS 5	0	0	0	0	0	0	0	0	0	0
TRUNK, ABDOMEN										
MAIS 1	1248	97	1998	657	632	252	151	780	3844	9659
MAIS 2	11384	212	34838	8861	8542	1953	6230	850	3954	76824
MAIS 3	32692	368	53111	16166	15260	4266	13049	944	6799	142655
MAIS 4	52963	830	74723	20402	21694	4698	19919	1003	9833	206065
MAIS 5	62967	852	148817	48056	34233	8191	35581	5247	9446	353390

	Medical	Emergency Services	Market Productivity	Household Productivity	Insurance Admin.	Workplace Cost	Legal Costs	Travel Delay	Property Damage	Total
FACE/OTHER HEAD/NECK										
MAIS 1	1183	97	1959	655	596	252	95	780	3844	9461
MAIS 2	12020	212	21409	5041	5819	1953	4505	850	3954	55763
MAIS 3	56149	368	55734	14502	17392	4266	16225	944	6799	172379
MAIS 4	178285	830	83313	23648	31735	4698	30946	1003	9833	364291
MAIS 5	92107	852	385159	96199	48664	8191	79152	5247	9446	725017
MINOR EXTERNAL										
MAIS 1	1085	97	759	274	425	252	73	780	3844	7589
BURNS										
MAIS 1	9515	97	8826	3121	2148	252	369	780	3844	28952
MAIS 2	61889	212	18847	6629	8621	1953	7283	850	3954	110238
MAIS 3	198791	368	84821	22864	32739	4266	42301	944	6799	393893
MAIS 4	0	0	0	0	0	0	0	0	0	0
MAIS 5	162046	852	203047	43221	44763	8191	56358	5247	9446	533171
UNKNOWN BODY REGION										
MAIS 1	1085	97	759	274	425	252	73	780	3844	7589

References

AAAM. (1985) *The Abbreviated Injury Scale 1985.* Des Plaines IL: Association for the Advancement of Automotive Medicine.

AAAM. (1990) *The Abbreviated Injury Scale 1990.* Des Plaines IL: Association for the Advancement of Automotive Medicine.

AIRAC (1988) *Attorney Involvement in Auto Injury Claims.* Oak Brook, IL: All-Industry Research Advisory Council.

American Psychiatric Association 1981. *Desk Reference to the Diagnostic Criteria from DSM-III.* Washington, DC, American Psychiatric Association, 1981

American Psychiatric Association 1987. *Diagnostic and Statistical Manual of Mental Disorders, Third Edition-Revised DSM-III-R.* Washington, DC, American Psychiatric Association, 1987

American Psychiatric Association 1994. *Diagnostic and Statistical Manual of Mental Disorders,* Fourth Edition. Washington, DC, American Psychiatric Association, 1994

Annest, J.L., Mercy, J.A., Gibson, D.R., and G.W. Ryan. National estimates of nonfatal firearm-related injuries: beyond the tip of the iceberg, *Journal of the American Medical Association* 273:22, 1749-1754, 1995.

Barton KA et al. 1996 Antecedents and consequences of acute stress disorder among motor vehicle accident victims. *Behav Res Ther* 1996 34:805-13

Berkowitz, M.; O'Leary, P.K., Kruse, D.L., and Harvey, C. (1998) *Spinal Cord Injury: An Analysis of Medical and Societal Costs.* New York, NY: Demos Medical Publishing, Inc.

Blanchard EB et al. 1996 Who develops PTSD from motor vehicle accidents. *Behav Res Ther* 34(1):1-10 1996

Blanchard EB et al. 1997 Prediction of remission of acute posttraumatic stress disorder in motor vehicle accident victims. *J Trauma Stress* 1997 Apr;10(2):215-34

Blanchard EB et al. 1998 Postraumatic stress disorder and comorbid major depression: is the correlation an illusion? *J Anxiety Disord* 1998 Jan-Feb;12(1):21-37

Blaszczynski A et al. 1998 Psychiatric morbidity following motor vehicle accidents: a review of methodological issues. *Compr Psychiatry* 1998 39(3):111-21

Davidson JRT 2000. Trauma: the impact of post-traumatic stress disorder. *J Psychopharmacol* 2000;14(2) Suppl I:S5-12

Blincoe, L.J. (1994) *Estimating the Benefits From Increased Safety Belt Use.* Washington,DC: National Highway Traffic Safety Administration, DOT HS 808 133

Blincoe, L.J. (1996) *The Economic Costs of Motor Vehicle Crashes 1994.* Washington,DC: National Highway Traffic Safety Administration, DOT HS 808 425.

Blincoe, L.J.and Faigin, B.M. (1992) *The Economic Cost of Motor Vehicle Crashes, 1990.* Washington DC: National Highway Traffic Safety Administration, DOT HS 807 876.

Blincoe, L.J. and Luchter S. (1983) *The Economic Cost to Society of Motor Vehicle Accidents.* National Highway Traffic Safety Administration, Washington DC: NHTSA, 1983, DOT HS 806 342.

Bureau of the Census (1994) *Statistical Abstract of the United States 1994.* U.S. Government Printing Office, Washington, DC.

Bureau of the Census (1999) *1997 Economic Census – Vehicle Inventory and Use Survey.* U.S. Government Printing Office, Washington, DC.

Chang, J.L., and Hu, P.S., *Delays and Congestion Costs Caused by Truck Incidents – An Exploratory Analysis,* The Second International Truck and Bus Safety Symposium, October 1999.

Chin, S.M, Franzese, O., Greene, D.L., Hwang, H.L., *Temporary Losses of Capacity Study.* National Transportation Research Center, Oak Ridge National Laboratory, Oak Ridge TN, 2002

Council of Economic Advisers (2000). *Economic Report of the President.* US Government Printing Office: Washington, DC.

Expectancy Data (1999) *The Dollar Value of a Day – 1997 Dollar Valuation,* Expectancy Data: Shawnee Mission, KS

Frommberger UH et al. 1998 Prediction of posttraumatic stress disorder by immediate reactions to trauma: a prospective study in road traffic accident victims. *Eur Arch Psychiatry Clin Neurosci* 1998 248: 316-21

Garthe, E.A., Ferguson, S.A., and Early, N. (1996) A Method for Converting Injury Severity in NASS93 (AIS90) to NASS88 (AIS 85), in *40th Annual Proceedings, Association for the Advancement of Automotive Medicine,* AAAM, Des Plaines IL, 477-494.

Gold MR, J.E. Siegel, L.B. Russell, M.C. Weinstein, ed. *Cost-effectiveness in Health and Medicine,* New York: Oxford University Press, 1996.

Helzer JE et al. 1987 Post-traumatic stress disorder in the general population. Findings of the epidemiologic catchment area survey. *N Engl J Med* 1987 Dec 24;317(26):1630-4

Hensler, D.R., Marquis, M.S., Abrahams, A.F., Berry, S.H., Ebener, P.A., Lewis, E.G., Ling, E.A., MacCoun, R.J., Manning, W.G., Rogowski, J.A., and Vaiana, M.E. (1991) *Compensation For Accidental Injuries In The United States,* Report R-3999-HHS/ICJ, RAND: Santa Monica, CA.

Johns Hopkins University and Tri-Analytics, Inc. (1997) ICDMAP-90 Software User's Guide.

Kahane, Charles J. (2000), "*Fatality Reduction by Safety Belts for Front Seat Occupants of Cars and Light Trucks, Updated and Expanded Estimates Based on 1986 – 99 FARS Data.*" Page 3. U.S. Department of Transportation. National Highway Traffic Safety Administration. December 2000, DOT HS 809 199.

Kakalik, JS, and Pace, NM (1986) *Costs And Compensation Paid In Tort Litigation,* Report R-3391-ICJ, RAND: Santa Monica, CA

Kessler RC et al. 1995 Posttraumatic stress disorder in the national comorbidity survey. *Arch Gen Psychiatry* 1995 52:1048-60

Klein, T.M. (1986) *A Method for Estimating Posterior Distributions for Persons Involved in Fatal Traffic Accidents.* National Highway Traffic Safety Administration. 1986, DOT HS 807 094

Krusei, F. E. and McFadden, N.E. (1996) *Update of Value of Life and Injuries for Use in Preparing Economic Evaluations.* Office of the Secretary of Transportation, Washington, DC.

Lan, Chang-Jen and Hu, Patricia S. (2000) Personal communications.

Lawrence, B., Miller, T.R., Jensen, A. Fisher, D., and Zamula, W. (1999) Estimating the Costs of Nonfatal Consumer Product Injuries in the United States, *Proceedings of the 7th International Conference on Product Safety Research,* 40-68.

Luchter S. 1995 *A Profile of Motor Vehicle Injuries Treated in Emergency Departments,* American Public Health Association Annual Conference, San Diego, California October 1995

Malt U. 1988 The long-term psychiatric consequences of accidental injury. A longitudinal study of 107 adults. *Br J Psychiatry* 1988 153:810-8

Mayou R et al. 1997 Long-term outcome of motor vehicle accident injury. *Psychosomatic Medicine* 1997 59:576-584

Merikangas KR, Weissman MM. 1986 Epidemiology of anxiety disorders in adulthood. in Psychiatry, Robert Michels, Chairman, Editorial Board, J. B. Lippincot & Co. Philadelphia 1986.

McCormick W. and Shane J. (1993) *Treatment of Value of Life and Injuries in Preparing Economic Evaluations.* Office of the Secretary of Transportation, Washington, DC.

Miller, T.R. (1993) Costs and Functional Consequences of US Roadway Crashes. *Accident Analysis and Prevention.* 25, 593-607.

Miller, T.R. (1997) Societal Costs of Transportation Crashes, in *The Full Social Costs and Benefits of Transportation,* D Greene, D Jones, M Delucchi, ed., Springer-Verlag, Heidelberg, 281-314.

Miller, T.R.; Blincoe, L.J. (1994) Incidence and Cost of Alcohol-Involved Crashes in the United States. *Accident Analysis and Prevention* 26:583-592.

Miller, T.R., Brigham P.A., Cohen M.A., Douglas J.B., Galbraith M.S., Lestina D.C., Nelkin V.S., Pindus N.M., Smith-Regojo P. (1993) *Societal Cost of Cigarette Fires,* Research Report, Washington, DC: Consumer Product Safety Commission.

Miller T.R.; Cohen, M. Wiersema, B (1996) *Victim Costs and Consequences: A New Look,* Research Report, Washington, DC: National Institute of Justice.

Miller, T.R., Galbraith, M.S., Lestina D.C., Schlax T., Mabery P., Deering R., Massie D., Campbell K. (1995) Understanding the Harm from US Motor Vehicle Crashes. *39th Proceedings, A.A.A.M.,* Des Plaines, IL :327-342.

Miller, T.R.,Lawrence, B., Jensen, A., Waehrer, G., Spicer, R., Lestina, D., Cohen, M. (1998) *Estimating the Cost to Society of Consumer Product Injuries: The Revised Injury Cost Model:* U.S. Consumer Product Safety Commission. Bethesda, MD.

Miller, T.R., Lestina, D.C. and Spicer, R.S. (1998) Highway Crash Costs in the United States by Driver age, Blood Alcohol Level, Victim Age and Restraint Use. *Accident Analysis and Prevention* 30, 2, 137-150.

Miller, T.R., Levy, D.T., Spicer, R.S., Lestina, D.C. (1998) Allocating the Costs of Motor Vehicle Crashes Between Vehicle Types, *Transportation Research Record,* 1635, 81-87.

Miller, T.; Pindus, N.; Douglass, J. Motor vehicle injury costs by body region and severity, *J. Trauma* 34:270-275; 1993.

Miller, T.R., Pindus, N.; Douglass, J.; Rossman, S. (1995) *Databook on Nonfatal Injury – Incidence, Costs, and Consequences.* The Urban Institute Press: Washington D.C.

Miller, T.R., Romano, E., and Spicer, R.S. (2000) The Cost of Unintentional Childhood Injuries and the Value of Prevention, *The Future of Children,* 10,1, 137-163.

Miller, T.R., Spicer R.S., D Lestina, D.C. and Levy, D.T. (1999) Is It Safest to Travel By Bicycle, Car or Big Truck?, *Journal of Crash Prevention and Injury Control,* 1:1, 25-34.

Miller, T.R., Spicer R.S., and Levy, D.T. (1999) How Intoxicated are Drivers in the United States? Estimating the Extent, Risks, and Cost per Kilometer of Driving by Blood Alcohol Level, *Accident Analysis and Prevention,* V.31 No. 5, 1999.

Miller, T. R., Viner, J., Rossman, S., Pindus, N., Gellert, W., Dillingham, A., and Blomquist, G. (1991) *The Costs of Highway Crashes.* The Urban Institute, Washington DC.

Miller T. R., Whiting, B., Kragh, B., and Zegeer, C. (1987) Sensitivity of a Highway Safety Resource Allocation Model to Variations in Benefit Computation Parameters, *Transportation Research Record* 1124, 58-65.

Mirza KAH et al. 1998 Post-traumatic stress disorder in children and adolescents following road traffic accidents. *Br J Psychiatry* 1998 172:443-7

Morgan, Christina (1999), *"Effectiveness of Lap/Shoulder Belts in the Back Outboard Seating Positions,"* Pages 20 and 88, Evaluation Division Plans and Policy, National Highway Traffic Safety Administration, Washington, D.C. June 1999. DOT HS 808 945.

National Highway Traffic Safety Administration (1984), *"Final Regulatory Impact Analysis Amendment to FMVSS No 208. Passenger Car Front Seat Occupant Protection,"* page IV-2. National Highway Traffic Safety Administration, Plans and Programs Office of Planning and Analysis, July 1984.

National Highway Traffic Safety Administration (1990), *Final Regulatory Impact Analysis Extension of the Automatic Restraint Requirements of FMVSS 208 to Trucks, Buses, and Multi-Purpose Passenger Vehicles with a Gross Weight Rating of 8,500 Pounds or Less and an Unloaded Vehicle Weight of 5,500 Pounds or Less,* page 23. National Highway Traffic Safety Administration, Plans and Policy, Office of Regulatory Analysis, November 1990.

National Highway Traffic Safety Administration (1995) National Accident Sampling System Crashworthiness Data System 1991-1993. Washington, D.C.

National Highway Traffic Safety Administration (1987) National Accident Sampling System 1986. Washington, D.C.

National Safety Council. (1990) *Manual on Classification of Motor Vehicle Traffic Accidents, Fifth Edition* (ANSI D-16.1-1989). Itasca, IL.

National Vital Statistics Reports, Vol 47, No. 28 (12/13/99): *United States Life Tables,* 1997

O'Day, J., ed. (1993) *Accident data quality: A Synthesis of Highway Practice.* National Cooperative Highway Research Program Synthesis 192, Transportation Research Board, National Research Council, National Academy Press: Washington, DC.

Piccinelli M et al. 1999 Anxiety and depression disorders 5 years after severe injuries; a prospective follow-up study. *J Psychosom Res* 1999 46(5):455-64

Rice, D., MacKenzie, E. and Associates. *Cost of injury in the United States: a report to Congress, Institute for Health & Aging,* University of California, and Injury Prevention Center, The Johns Hopkins University, San Francisco, CA, 1989.

Rubin, Donald B., Schafer, Joseph L., Subramanian, Rajesh, *Multiple Imputation of Missing Blood Alcohol Concentration (BAC) Values in FARS.* U.S. Department of Transportation. National Highway Traffic Safety Administration. October 1998, DOT HS 808 816.

U.S. DOT. (1997) The Value of Travel Time: Departmental Guidance for Conducting Economic Evaluations. (memorandum)

Viner, J.G.; Conley, C. *Consistency of Police Reported "Incapacitating Injuries" Between States.* Working Paper; Federal Highway Administration; 1994.

Wang, J, and Blincoe, L.J. (2001), *BELTUSE Regression Model Update,* U.S. Department of Transportation. National Highway Traffic Safety Administration, Office of Plans and Policy, June 2001, Research Note.

DOT HS 809 446
May 2002