THE Economic COST OF MOTOR VEHICLE CRASHES 1994

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Lawrence J. Blincoe

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16. Abstract

This report presents the results of an analysis of motor vehicle crash costs in 1994. The total economic cost of motor vehicle crashes in 1994 was $150.5 billion. This represents the present value of lifetime costs for 40,676 fatalities, 5.2 million nonfatal injuries, and 27 million damaged vehicles, in both police reported and unreported crashes. Property damage costs of $52.1 billion accounted for the largest share of costs, while lost market productivity accounted for $42.4 billion. Medical expenses totalled $17 billion. Each fatality resulted in an average discounted lifetime cost of $830,000. Alcohol-involved crashes caused $45 billion or 30 percent of all economic costs, and 78 percent of these costs occurred in crashes where a driver or pedestrian was legally intoxicated (>= .10% BAC). Crashes in which police indicate that at least one driver was exceeding the legal speed limit or driving too fast for conditions cost $27.7 billion in 1994. Public revenues paid for 24 percent of medical costs, and 9 percent of all costs resulting from motor vehicle crashes. These crashes cost taxpayers $13.8 billion in 1994, the equivalent of $144 in added taxes for each household in the United States.

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SUMMARY

The cost of motor vehicle crashes that occurred in 1994 was $150.5 billion. This total represents the present value of lifetime economic costs for 40,676 fatalities, 5.2 million non-fatal injuries, 3.7 million uninjured occupants and 27 million damaged vehicles. These incidents include both police-reported and unreported crashes. Property damage costs of $52.1 billion accounted for the most significant portion of the total cost, followed by lifetime losses in marketplace production of $42.4 billion.

Economic cost components include productivity losses, property damage, medical costs, rehabilitation costs, travel delay, legal and court costs, emergency service costs, insurance administration costs, premature funeral costs and costs to employers. Injury costs are presented by severity level using the Abbreviated Injury Scale. All costs are expressed in 1994 economics.

Significant findings on cost include:

- The cost of motor vehicle crashes that occurred in 1994 was $150.5 billion, the equivalent of $580 for every person living in the United States, or 2.2 percent of this county's Gross Domestic Product.
- Each fatality resulted in lifetime economic costs to society of over $830,000. Over 85 percent of this cost is due to lost workplace and household productivity.
- The average cost for each critically injured survivor was $706,000 -- nearly as high as for a fatality. Medical costs and lost productivity accounted for 84 percent of the cost for these Maximum Abbreviated Injury Scale (MAIS) level 5 injuries.
- Present and future medical costs due to injuries occurring in 1994 were $17 billion, representing 11 percent of total costs. However, medical costs accounted for 22 percent of non-fatal injury crash costs.
- Lost market productivity totalled $42.4 billion, accounting for 28 percent of total costs, and lost household productivity totalled $12.3 billion, representing 8 percent of total costs.
- Because of their high incidence, crashes of vehicles that sustained only property damage were the most costly type of occurrence, totalling $38.9 billion and accounting for 26 percent of total motor vehicle crash costs.
- Property damage in all crashes (fatal and injury) as well as property-damage-only crashes totalled $52.1 billion and accounted for 35 percent of all costs, more than any other cost category.
- About 24 percent of medical care costs resulting from motor vehicle crashes are paid from public revenues, with Federal revenues accounting for 14 percent and states and localities 10 percent.
- Roughly 9 percent of all motor vehicle crash costs are paid from public revenues. Federal revenues account for 6 percent and states and localities paid for about 3 percent. Private

insurers pick-up 55 percent while individual crash victims absorb about 29 percent. Overall, sources other than the individual crash victims pay about 70 percent of all motor vehicle crash costs, primarily through insurance premiums and taxes.

- o Motor vehicle crash costs funded through public revenues cost taxpayers $13.8 billion in 1994, the equivalent of $144 in added taxes for each household in the United States.

Significant findings on incidence include:

- o 5.2 million persons were injured in motor vehicle crashes in 1994; 1.1 million of these, or roughly 22 percent, were injured in crashes that were not reported to police.
- o 27 million vehicles were damaged in motor vehicle crashes in 1994; 86 percent of these were damaged in property-damage-only impacts, with injuries occurring in, or pedestrian injuries caused by, the remaining 14 percent.
- o Roughly half of all property-damage-only crashes and over a fifth of all nonfatal injuries are not reported to police.

The report also includes findings on alcohol-involved crashes. Estimates were made of incidence and costs involving cases where drivers or pedestrians were legally intoxicated (.10 BAC or greater), as well as where there was alcohol involved below the level of legal impairment. Adjustments were made to reflect police underreporting of alcohol. Findings related to alcohol crash involvement include:

- o Alcohol-involved crashes resulted in $45 billion in economic costs in 1994, accounting for 30 percent of all crash costs.
- o Seventy-eight percent of all alcohol-involved crash costs occur in crashes where a driver or pedestrian had a blood alcohol content of 0.10 percent or greater, the definition of legal intoxication in most states.
- o The impact of alcohol involvement increases with injury severity. Alcohol-involved crashes accounted for 17 percent of property-damage only (PDO) crash costs, 29 percent of nonfatal injury crash costs, and 47 percent of fatal injury crash costs.

An estimate was also made of the impact of excess speed on motor vehicle crashes:

- o Crashes in which police indicate that at least one driver was exceeding the legal speed limit or driving too fast for conditions cost $27.7 billion in 1994.
- o Speed - related crashes resulted in 12,480 deaths, 710,000 nonfatal injuries, and damage to over 2.3 million vehicles in property damage only crashes in 1994. This represents 31 percent of all fatalities, 14 percent of all nonfatal injuries, and 10 percent of all PDO involved vehicles.

An analysis was conducted of trends in motor vehicle crash costs since 1990:

- o Inflation increased the cost of motor vehicle crashes by over 16 percent since 1990.

- A variety of factors including increased safety belt use, decreased driving under the influence of alcohol, safer vehicles, and improved roadways reduced the incidence of crashes, death and injury. This offset about half of the potential cost increase due to inflation, leaving costs 8.1 percent higher than in 1990.
- If fatality and injury rates had remained at 1990 levels, 1994 crash costs would have been $29.7 billion (or 20 percent) higher than the $150.5 billion measured in this study.

INTRODUCTION

In 1994, 40,676 people were killed, 5.2 million were injured, and 27 million vehicles were damaged in motor vehicle crashes. The death, injury and property damage caused by these crashes is a major cause of personal suffering and financial loss to the victims, their families and friends, and to society at large. NHTSA estimates that in 1994, the economic cost of motor vehicle crashes was $150.5 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.

Motor vehicle crashes affect both the individual crash victims and society as a whole in numerous ways. The cost of medical care, for example, is borne by the individual through payments for uninsured expenses, and by society through higher insurance premiums and through the diversion of medical resources away from other needs, such as disease control or medical research. Significant costs also are associated with the productivity that is lost when an individual's life is claimed at an early age or as a result of an injured person's disability. Those dependent on the victim suffer the immediate economic hardship from foregone income, but society also suffers through efforts to support the victim or victim's dependents and, eventually, 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 into perspective the tragic losses resulting from these crashes, and to provide information to government and private sector officials for use in structuring programs to combat these needless losses.

Total economic costs are summarized in Table 1. The total economic cost in 1994 resulting from motor vehicle crashes is estimated to have been $150.5 billion. Of this total, medical costs were responsible for $17 billion, property losses for $52.1 billion, lost productivity (both market and household) $54.7 billion, and other costs $26.6 billion.

The largest single cost component is property damage, which accounted for over a third of total economic costs. The high cost of property damage is primarily a function of the high incidence of minor crashes in which injury is either insignificant or nonexistent (see Table 3).
Although property damage costs are the largest single component of total costs, the value of market and household productivity together account for 36 percent of total costs. Medical, emergency services (EMS, which includes police, fire department and ambulance services) and vocational rehabilitation costs are responsible for about 13 percent of the total. Legal and court costs account for about 4 percent, and insurance administration costs account for about 7 percent of total costs. These costs are summarized in Tables 1 and 2, and Figures 1 thru 3.

Alcohol use is one of the major causes of motor vehicle crashes. Historically, about half of all fatalities have occurred in crashes where a driver or pedestrian had been drinking. This report focuses specifically on the cost of alcohol crashes and includes estimates of the incidence of alcohol-related crashes that were reported and not reported by police. The results indicate that alcohol is involved in crashes that account for 30 percent of all economic costs, with over 78 percent of these costs involving crashes where a driver or pedestrian was legally intoxicated, defined as Blood Alcohol Content (BAC) $\geq .10$.

The Abbreviated Injury Scale (AIS) used in this report provides a convenient, but imperfect, basis for stratifying societal costs. Significant sources of economic loss, such as medical costs and foregone 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 the crash occurs. In general, more serious injuries have more serious outcomes; however, in many instances, outcome is not accurately predicted by initial AIS code assignments. For example, some injuries with low AIS codes, such as lower extremity fractures, can result in serious 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 estimates of economic cost, and might result in a significant shift in the relative number of injuries regarded as serious.

Generally, this analysis focuses on "average" costs for injuries of different severity. This approach is valid for computing aggregate costs at a nationwide level; however, it should be noted that the cost of individual cases at each injury level can vary dramatically. While the average costs indicated in this report are significant, in individual cases they can be exceeded by factors 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 victims, the medical and rehabilitative costs, as well as the loss in wages resulting from serious injury, can be as catastrophic to the victim's economic well being as to their physical and emotional condition.

In using this report for analyzing the impact of crash and injury countermeasures, care should be taken to include only those cost elements that are applicable to the specific programs addressed. For example, programs that encourage safety belt usage may reduce costs associated with death or injury, but would not have a noticeable effect on property damage. Therefore, consideration should be given to the nature of the benefits that may result 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. Permanent disability such as paraplegia, quadriplegia, loss of eyesight, or brain damage can deprive an individual of the ability to achieve even minor goals and aspirations, and can result in dependence on others for economic support and routine physical care. Less serious but more common injuries such as whiplash can result in chronic physical pain and effectively limit the victim's physical activities for years after the crash. Serious burns, contusions, or lacerations can lead to similar results with the additional emotional trauma associated with permanent disfigurement. From an individual standpoint, these aspects can be the most devastating result of a motor vehicle crash. Moreover, they can continue to negatively affect a person's life, regardless of any economic compensation that may occur through the insurance, welfare or court systems.

While the individual crash victim bears the most severe consequence from the injuries, serious repercussions also are felt by those close to him/her. Caring for a disabled person represents a considerable burden to the family, both economically and emotionally, and result in limitations on individual and family activities. The emotional consequences of the victim's physical problems can often result in personality problems that affect family relationships and may even affect the cohesiveness of the family unit. The effects on family members can be particularly devastating when the crash leads to death. The effect of sudden, unexpected and permanent separation from parent, child, or sibling can raise feelings of grief, anguish, guilt, fear, insecurity and a sense of loss that can affect a person's emotional state for years after the accident occurred. Often individuals will attempt to deal with this loss by withdrawing either emotionally or physically from the family. In severe cases, this can lead to the breakup of previously stable family units.

Action taken by society to alleviate the individual suffering of its members or to reduce the incidence of this suffering would be justified in and of itself; i.e., to increase the overall quality of life for its 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 were 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 the toll of such crashes would be overlooked.

Users should be aware that the focus of the costs presented in this report is on the economic impact of motor vehicle crashes. They do not represent the more intangible consequences of these events to individuals and families and should therefore not be used by themselves to produce benefit-cost ratios. Measurement of the dollar value of intangible consequences such as pain and suffering has been undertaken through numerous studies. These studies have estimated values based on wages for risky occupations and purchases of products for improvements in safety among 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 $2-5 million per life saved. Appendix A of this report discusses these estimates.

Table 1
Summary of Total Costs, 1994
(Millions of 1994 Dollars)

	PDO	MAIS 0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal	Total	% Total
Injury Components:										
Medical	$0	$4	$4,423	$3,246	$4,682	$1,726	$2,453	$492	$17,026	11.32%
Prem. Funeral	$0	$0	$0	$0	$0	$0	$0	$138	$138	0.09%
EMS	$662	$70	$703	$134	$84	$20	$8	$43	$1,724	1.15%
VOC Rehab	$0	$0	$69	$39	$36	$7	$4	$0	$156	0.10%
Market Prod.	$0	$0	$6,084	$4,641	$5,969	$994	$1,274	$23,440	$42,403	28.18%
HH Productivity	$987	$104	$1,911	$1,434	$1,819	$321	$374	$5,395	$12,345	8.20%
Ins. Admin.	$2,420	$255	$2,651	$1,387	$1,872	$362	$343	$1,165	$10,456	6.95%
Workplace Cost	$1,026	$108	$1,004	$670	$612	$69	$49	$305	$3,844	2.55%
Legal Costs	$0	$0	$629	$868	$1,277	$293	$317	$2,472	$5,857	3.89%
Subtotal	$5,096	$541	$17,474	$12,421	$16,353	$3,793	$4,823	$33,449	$93,948	62.44%
Non-Injury Components:										
Travel Delay	$2,929	$395	$939	$81	$34	$3	$1	$18	$4,401	2.93%
PropDam	$30,894	$3,258	$15,096	$1,338	$963	$143	$55	$372	$52,119	34.64%
Subtotal	$33,823	$3,653	$16,035	$1,418	$997	$146	$57	$390	$56,520	37.56%
Total	**$38,919**	**$4,194**	**$33,510**	**$13,839**	**$17,349**	**$3,939**	**$4,879**	**$33,839**	**$150,469**	**100.00%**
% Total	25.86%	2.79%	22.27%	9.20%	11.53%	2.62%	3.24%	22.49%	100.00%	

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

Table 2
Summary of Unit Costs, 1994
(1994 Dollars)

	PDO	MAIS 0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
Injury Components:								
Medical	$0	$1	$956	$8,144	$28,064	$100,820	$354,819	$12,089
Prem. Funeral	$0	$0	$0	$0	$0	$0	$0	$3,389
EMS	$28	$19	$152	$337	$506	$1,150	$1,171	$1,055
Voc. Rehab.	$0	$0	$15	$99	$217	$410	$620	$0
Market Prod.	$0		$1,315	$11,645	$35,776	$58,073	$184,260	$576,266
HH Productivity	$42	$28	$413	$3,598	$10,903	$18,746	$54,119	$132,630
Ins. Admin.	$103	$69	$573	$3,481	$11,219	$21,165	$49,576	$28,646
Workplace Cost	$44	$29	$217	$1,681	$3,671	$4,043	$7,049	$7,489
Legal Costs	$0	$0	$136	$2,179	$7,655	$17,087	$45,919	$60,766
Subtotal	$218	$146	$3,777	$31,164	$98,011	$221,494	$697,533	$822,328
Non-Injury Components:								
Travel Delay	$125	$106	$203	$203	$203	$202	$203	$453
Prop. Dam.	$1,320	$877	$3,263	$3,356	$5,771	$8,346	$8,018	$9,138
Subtotal	$1,446	$983	$3,466	$3,559	$5,974	$8,548	$8,221	$9,591
Total	**$1,663**	**$1,129**	**$7,243**	**$34,723**	**$103,985**	**$230,042**	**$705,754**	**$831,919**

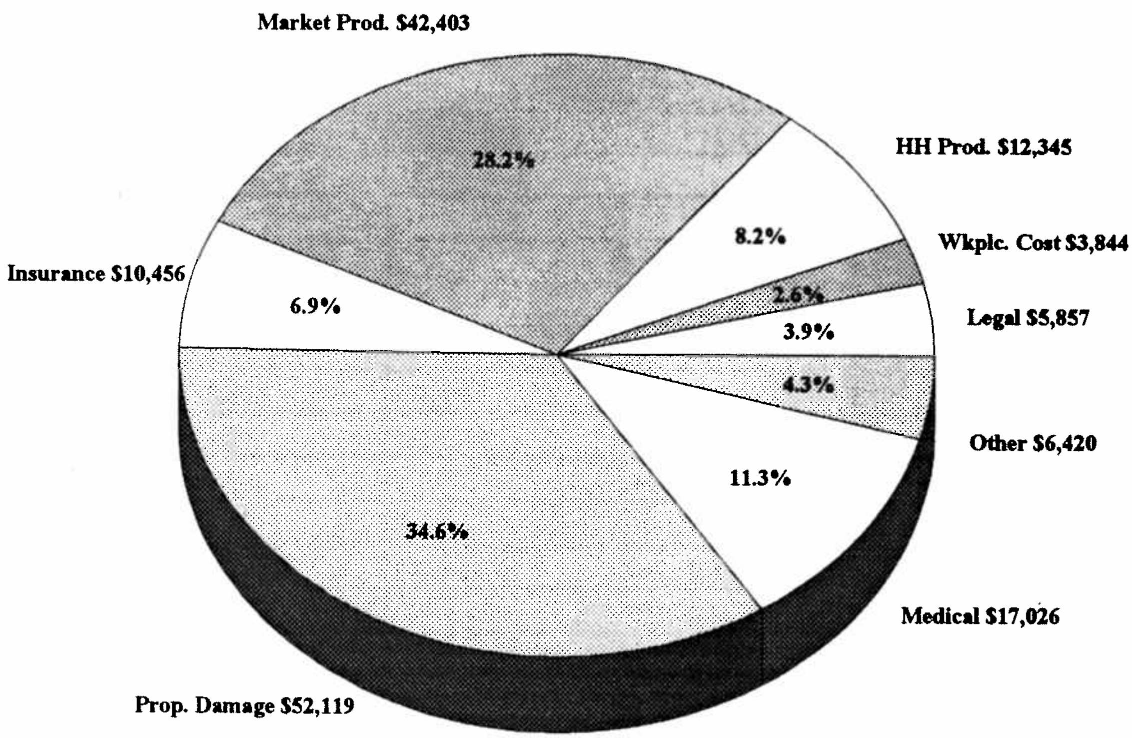
NOTE: Unit costs are on a per-person basis for all injury levels. PDO costs are on a per-damaged vehicle basis.

Table 3
Incidence Summary
1994 Total Reported and Unreported Injuries

	Police-Reported	Unreported	Total	Percent Unreported
Vehicles:				
Injury Vehicles	3,049,595	831,318	3,880,914	21.42%
PDO Vehicles	12,165,905	11,230,066	23,395,971	48.00%
Total Vehicles	15,215,500	12,061,384	27,276,885	44.22%
People:				
MAIS0 (Uninjured)	2,919,512	795,858	3,715,370	21.42%
MAIS1 (Minor)	3,574,582	1,051,913	4,626,495	22.74%
MAIS2 (Moderate)	335,465	63,088	398,553	15.83%
MAIS3 (Serious)	155,961	10,884	166,845	6.52%
MAIS4 (Severe)	17,008	115	17,123	0.67%
MAIS5 (Critical)	6,914	0	6,914	0.00%
Fatal	40,676	0	40,676	0.00%
Total Injured Persons:	**4,130,606**	**1,126,001**	**5,256,607**	**21.42%**
MAIS 1-5	4089930	1126001	5215931	21.59%
Crashes:				
PDO	6,977,132	6,440,429	13,417,561	48.00%
Injury	2,687,685	732,662	3,420,347	21.42%
Fatal	36,223	0	36,223	0.00%
Total Crashes	**9,701,040**	**7,173,091**	**16,874,130**	**42.51%**

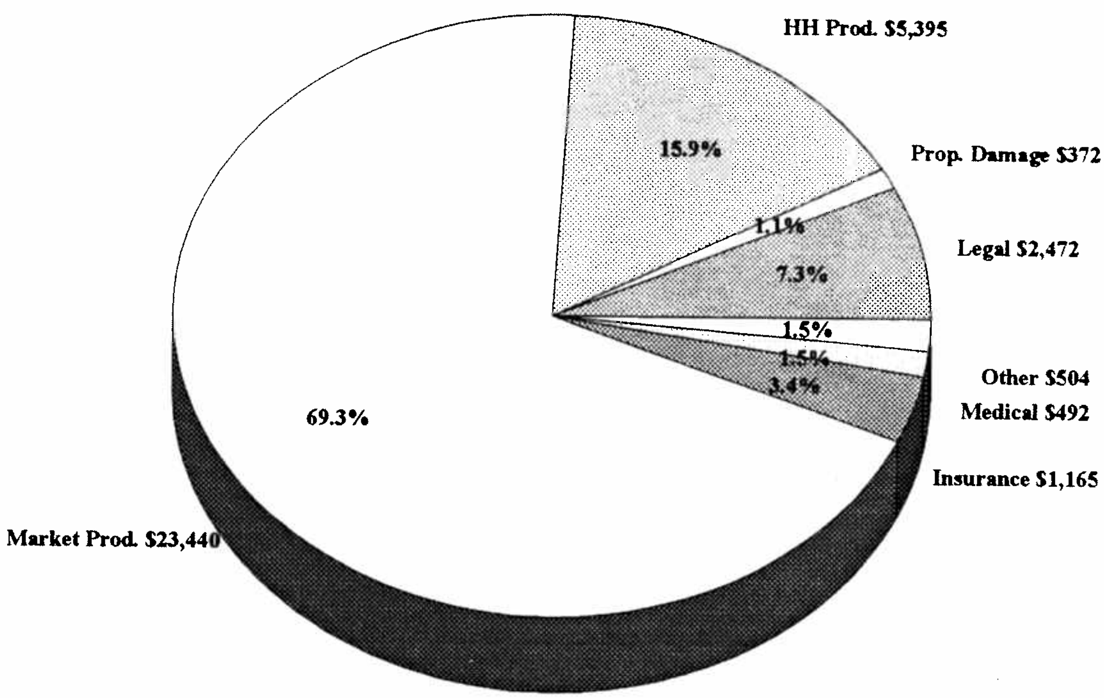
All PDO vehicles, including those involved in injury crashes, are included under PDO vehicles.

Figure 1
Components of Total Costs



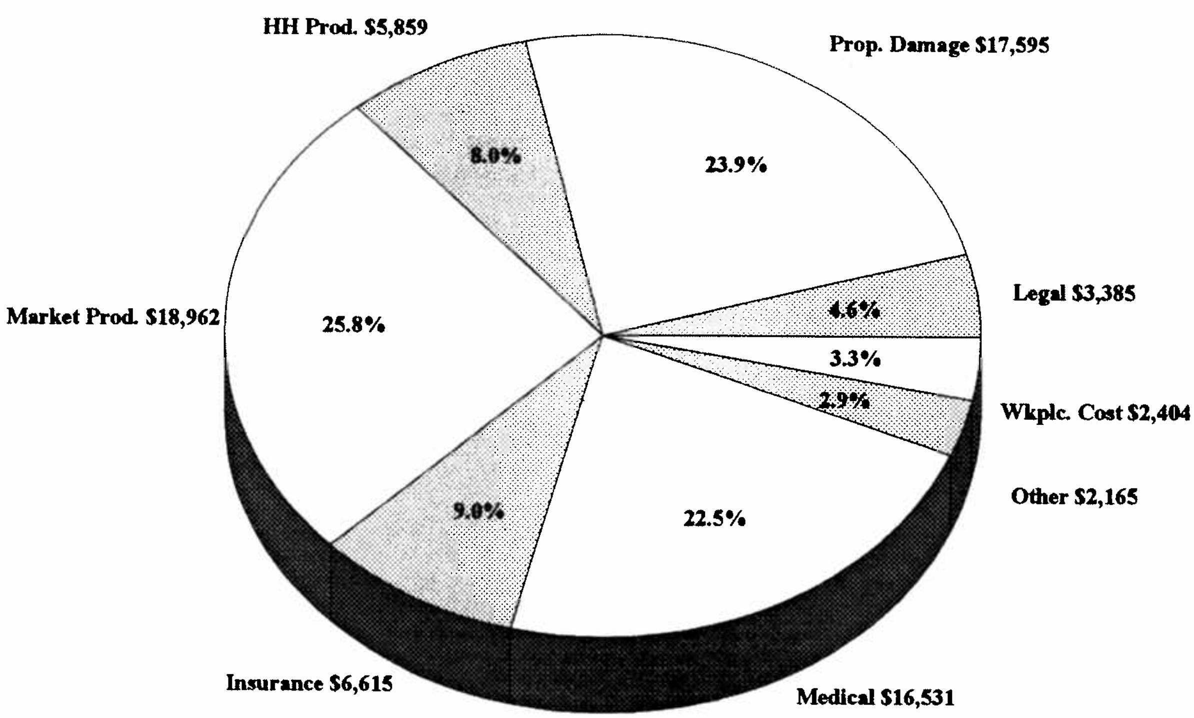
(Millions of 1994 dollars)
Other includes: prem. funeral,
emergency, voc. rehab., travel delay

Figure 2
Components of Total Costs, Fatalities



(Millions of 1994 dollars)
Other includes: workplace, prem. funeral, emergency, voc. rehab., travel delay

Figure 3
Components of Total Costs, Non-Fatal Injuries



(Millions of 1994 dollars)
Other includes: emergency, voc. rehab.,
and travel delay

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 decreases in the general health status of those injured in motor vehicle crashes. Individuals are seen as producers and consumers of a stream of output throughout their lifetime. Injured individuals are considered part of total societal impact, hence, the value of their decreased production and their decreased consumption is included in total cost. The resources consumed in response to any injury or crash that might otherwise be used for increasing the general state of well-being in society also are counted in total cost.

Direct costs include emergency treatment, initial medical costs, rehabilitation costs, long-term care and treatment, insurance administrative expenses, legal costs, and employer/workplace costs. Indirect costs are productivity costs in the workplace due to temporary and permanent disability and decreases in production in the home resulting from these disabilities. In addition, crash costs other than those directly attributable to an injury -- property damage and travel delay -- are estimated for injury and non-injury crashes. A description of each of these cost categories is included in Appendix B.

The injury and crash costs calculated using the human capital method do not include decreases in emotional well-being unless they result in medical treatment, nor do they include values for pain and suffering or permanent losses in functional capacity unless they result in permanent earnings losses. They also do not purport to measure decreases in the enjoyment of life. Due to those omissions, injury and crash cost totals calculated using the human capital methodology are not comprehensive. Therefore, these costs should not be used in direct comparisons with the costs of reducing injuries and crashes to produce benefit-cost ratios.

However, these costs can legitimately be used in the following purposes:

- o for calculating the economic cost savings from reducing a given number of injuries or crashes;
- o for demonstrating the economic magnitude of the crash problem in the U.S. or in a State;
- o for evaluating the impact of injury on a specific sub-sector of the economy such as consumption of medical resources or employer costs.

Unit costs in this report were derived from Miller et al. (1995) and Miller (1995). Miller et al. modified unit cost data from three previous reports, Miller et al. (1991), Blincoe and Faigin (1992) and Miller (1993). Modifications were as follows:

- o The short-term wage loss and travel delay costs from Miller (1993) were inflated with the Employer Cost Index rather than Average Hourly Earnings. The Employer Cost Index is preferable because it includes supervisory personnel and fringe benefits.

- o Property damage costs from Blincoe and Faigin (1992) and vocational rehabilitation, premature burial and emergency services costs from Miller (1993) were adjusted to 1994 price levels using the Consumer Price Index - All Items.
- o Nonfatal medical care and coroner costs from Miller (1993), were reinflated from their 1983 base year with medical spending per-capita rather than the Consumer Price Index for Medical Care. Miller notes that the switch in inflators better accounts for changes in medical technology and procedures. It causes the inflated costs per day of hospital stay for crash injury to keep pace with the American Hospital Association's index of average cost per hospital day (Bureau of the Census, 1994) and is consistent with recent research on medical care cost inflators (Newhouse, 1992). (The new basis raised the previously published medical care costs for 1988 by 15%.)
- o Medical payments per fatality came from national workplace injury data (National Council on Compensation Insurance, 1989) rather than the less representative data used by Miller (1993).
- o The lifetime earnings and household production loss models in Miller et al. (1991) also were updated with 1990-1991 demographic data, earnings profiles, and life tables (replacing 1985 data).
- o Employer productivity losses were recomputed with the assumptions in Miller (1993b). Miller assumed supervisor and co-worker staff time lost to a permanently disabling injury equaled the losses for a fatality.
- o New insurance administrative and legal expense models were derived. The new models placed a $100,000 average policy limit on liability claims and a $500,000 limit on average court awards for catastrophic injuries. Legal costs were reestimated with unit costs from Kakalik and Pace (1986) and probabilities of lawsuit from Hensler et al. (1991), as well as the updated medical care and productivity loss estimates.

Data from Miller et al. (1995) were further modified for this report as follows:

- o All unit costs were updated to 1994 economics using inflators consistent with Miller et al. (1995).
- o Lost productivity cost in Miller et al. were based on a 2.5% discount rate. These costs were reestimated using a 4% discount rate. This rate is consistent with that used in Blincoe and Faigin (1992). Discussion of the basis for a 4% rate was included in Appendix A of that report, and is reprinted here in Appendix C.
- o Miller et al. (1995) provided estimates grouped under 4 categories: Medical, Future Earnings, Public Program and Property Damage. In this report, these groups were disaggregated into 11 different categories consistent with previous NHTSA reports (Blincoe and Faigin, 1992).
- o The distribution of injured survivors in towed passenger vehicles (CDS crashes) by body region and MAIS was derived from 1988-1991 Crashworthiness Data System (CDS) data. Information for non-CDS cases was derived from 1982-1986 NASS data by restraint use. These data sets were then weighted together based on the incidence in the 1992 GES to determine the overall distribution of crash victims by injury severity and body region. This

distribution was used to weight the 1994 costs for each MAIS level. A similar method is used in Miller (1995).

Because of these methodology changes, the results of this report are theoretically not directly comparable to NHTSA's previous estimates. However, the impact of these changes, although significant for some individual categories such as medical care, legal costs and insurance administration, is relatively minor overall. The total cost of crashes in 1994 is estimated in this report to be $150.5 billion. A simple updating of the unit costs in the 1990 report applied to 1994 incidence results in an estimate of $145.6 billion. The structural adjustments noted above thus increased total costs by $4.9 billion or 3.2 percent, and overall costs of motor vehicle crashes have increased by 8.1 percent after accounting for the decrease in fatalities, injuries and property damage, and the increase in costs due to inflation. A full discussion of this issue is presented in the Trends section of this paper.

The costs that result from the methods described above are summarized in Tables 1 and 2, and in Figures 1, 2, and 3 in the Introduction Chapter of this report. The $150.5 billion total cost is the equivalent of roughly $580 for each of the 260 million people[1] living in the United States. It also represents the equivalent of 2.2 percent of the Nations $6.7 trillion Gross Domestic Product.[2]

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[1]Source: Statistical Abstract of the United States, 1995. Table 27.

[2]Source: Statistical Abstract of the United States 1995. Table 705.

INCIDENCE

Fatalities

Fatality estimates for 1994 were obtained from the Fatal Accident Reporting System (FARS). FARS contains information on a complete census of all fatal traffic crashes on public roads in the United States that result in death within 30 days of the crash. It is the single best source for data on these crashes. For 1994 FARS indicates a total of 40,676 fatalities in traffic crashes. This is 3,923 fewer than in 1990, the last year for which NHTSA examined economic costs. This represents an 8.8 percent decline over four years, despite an increase in population, licensed drivers, motor vehicle registrations and vehicle miles travelled during this time period. As can be seen from Table 4, fatality rates based on each of these demographic measures have been steadily declining over time. Reasons for this decline in recent years include increased usage rates for safety belts, a decline in the incidence of drinking and driving, and the introduction of air bags and other safety features into the vehicle fleet.

Nonfatal Injuries

The FARS census provides an accurate count of fatalities. However, there is no equivalent data base for injuries. Estimates of nonfatal injuries were derived from a variety of data sources including the Crashworthiness Data System (CDS), the General Estimates System (GES) the National Accident 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 data bases 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 1994 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 examination available in the CDS makes that system a more reliable predictor of injury severity.

Because they are not included in CDS, injuries incurred in non-towaway crashes, to occupants of large trucks, buses, motorcycles, bicyclists or to pedestrians, 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," "non-incapacitated," and

Table 4
Persons Killed or Injured and Fatality and Injury Rates by Population, Licensed Drivers, Registered Vehicles, and Vehicle Miles Traveled, 1966-1994

Killed

Year	Fatalities	Resident Population (Thousands)	Fatality Rate per 100,000 Population	Licensed Drivers (Thousands)	Fatality Rate per 100,000 Licensed Drivers	Registered Motor Vehicles (Thousands)	Fatality Rate per 100,000 Registered Vehicles	Vehicle Miles Traveled (Billions)	Fatality Rate per 100 Million VMT
1966	50,894	195,576	26.02	100,998	50.39	95,703	53.18	926	5.5
1967	50,724	197,457	25.69	103,172	49.16	98,859	51.31	964	5.3
1968	52,725	199,399	26.44	105,410	50.02	102,987	51.20	1,016	5.2
1969	53,543	201,385	26.59	108,306	49.44	107,412	49.85	1,062	5.0
1970	52,627	203,984	25.80	111,543	47.18	111,242	47.31	1,110	4.7
1971	52,542	206,827	25.40	114,426	45.92	116,330	45.17	1,179	4.5
1972	54,589	209,284	26.08	118,414	46.10	122,557	44.54	1,260	4.3
1973	54,052	211,357	25.57	121,546	44.47	130,025	41.57	1,313	4.1
1974	45,196	213,342	21.18	125,427	36.03	134,900	33.50	1,281	3.5
1975	44,525	215,465	20.66	129,791	34.31	125,402	35.51	1,328	3.4
1976	45,523	217,563	20.92	134,036	33.96	130,731	34.82	1,402	3.2
1977	47,878	219,760	21.79	138,121	34.66	134,887	35.49	1,467	3.3
1978	50,331	222,095	22.66	140,844	35.74	140,978	35.70	1,545	3.3
1979	51,093	224,567	22.75	143,284	35.66	144,805	35.28	1,529	3.3
1980	51,091	227,255	22.48	145,295	35.16	146,845	34.79	1,527	3.3
1981	49,301	229,637	21.47	147,075	33.52	149,330	33.01	1,553	3.2
1982	43,945	231,996	18.94	150,234	29.25	151,148	29.07	1,595	2.8
1983	42,589	234,284	18.18	154,389	27.59	153,830	27.69	1,653	2.6
1984	44,257	236,477	18.72	155,424	28.48	158,900	27.85	1,720	2.6
1985	43,825	238,736	18.36	156,868	27.94	165,382	26.50	1,774	2.5
1986	46,087	241,107	19.11	159,487	28.90	168,137	27.41	1,835	2.5
1987	46,390	243,427	19.06	161,818	28.67	172,366	26.91	1,921	2.4
1988	47,087	245,785	19.16	162,853	28.91	176,752	26.64	2,026	2.3
1989	45,582	248,239	18.36	165,555	27.53	180,792	25.21	2,096	2.2
1990	44,599	249,399	17.88	167,015	26.70	183,934	24.25	2,144	2.1
1991	41,508	252,137	16.46	168,995	24.56	186,052	22.31	2,172	1.9
1992	39,250	255,078	15.39	173,125	22.67	184,864	21.23	2,247	1.7
1993	40,150	257,908	15.57	173,149	23.19	188,453	21.31	2,297	1.7
1994	40,676	260,341	15.62	175,128	23.23	192,337	21.15	2,359	1.7

Injured

Year	Police Reported Injuries	Resident Population (Thousands)	Injury Rate per 100,000 Population	Licensed Drivers (Thousands)	Injury Rate per 100,000 Licensed Drivers	Registered Motor Vehicles (Thousands)	Injury Rate per 100,000 Registered Vehicles	Vehicle Miles Traveled (Billions)	Injury Rate per 100 Million VMT
1988	3,416,000	245,785	1,390	162,853	2,098	176,752	1,933	2,026	169
1989	3,284,000	248,239	1,323	165,555	1,984	180,792	1,816	2,096	157
1990	3,231,000	249,399	1,295	167,015	1,934	183,934	1,756	2,144	151
1991	3,097,000	252,137	1,228	168,995	1,833	186,052	1,665	2,172	143
1992	3,070,000	255,078	1,203	173,125	1,773	184,864	1,660	2,247	137
1993	3,125,000	257,908	1,212	173,149	1,805	188,453	1,658	2,297	136
1994	3,215,000	260,341	1,235	175,128	1,836	192,337	1,671	2,359	136

Source: Vehicle Miles of Travel and Licensed Drivers—Federal Highway Administration; Registered Vehicles, 1966-1974—Federal Highway Administration; Registered Vehicles, 1975-1994—R.L. Polk & Co. and Federal Highway Administration; Population—U.S. Bureau of the Census; Traffic Deaths, 1966-1974—National Center for Health Statistics, D.H.H.S., State Accident Summaries (adjusted to 30-day traffic deaths by NHTSA); Traffic Deaths, 1975-1994—Fatal Accident Reporting System (FARS), NHTSA, 30-day traffic deaths; Traffic Injuries, 1988-1994—General Estimates System (GES), NHTSA. Injury data not available for years before 1988. Table originally compiled in Traffice Safety Facts 1994.

"possible injury." These are frequently referred to as "KABCO" designations.[3] 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 is used because it was the last available database that provided both MAIS and KABCO designations for non-CDS cases.

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 nonoccupants 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 1994 GES file to estimate total non-CDS equivalent injuries by MAIS level for 1994.

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). In 1990, this undercounting was 14.6 percent, but after adjusting for motorist reports and injuries categorized as unknown (see Blincoe and Faigin 1992 for a detailed discussion of these adjustments), the shortfall was estimated to be 12 percent. This issue was reexamined by comparing 1993 state police-reported injury counts to the 1993 GES (1993 was the latest year for which both counts were reliably available) and it was found that the ratio of police reports to GES counts was almost unchanged at 1.148. Therefore, for the current analysis, the 12 percent adjustment was also applied to the 1994 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 (PDO's) are by far the most common type of crash. Unfortunately, information on PDO's is unreliable because of the wide variety of damage reporting thresholds in the states. For this report, the ratio of PDO's to injuries from Blincoe and Faigin was applied to the 1994 injury total. Unreported crashes, which account for 48 percent of all PDO's, were also estimated from that report. A total of 12.2 million vehicles were estimated to be damaged in police-reported PDO crashes. Another 11.2 million were estimated to be damaged in non-police-reported crashes for a total of 23.4 million PDO involved vehicles.

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[3]K = killed; A = incapacitating injury; B = nonincapacitating injury; C = possible injury; O = no injury.

Unreported Injuries

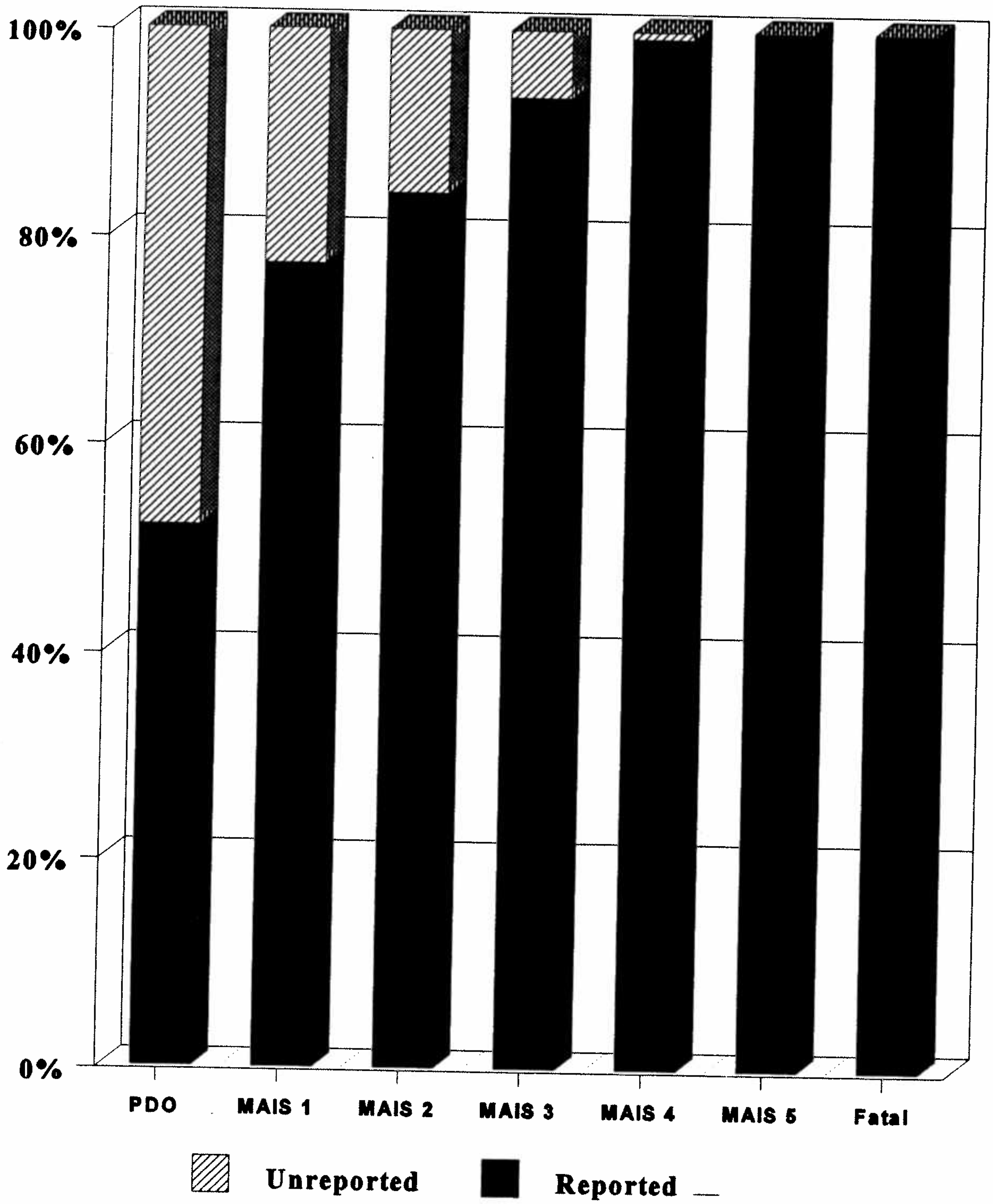
Although most crashes are reported to police, a significant number go unreported. This is most likely to occur in crashes where the injured party is at fault, and does not want to involve police for fear of insurance or legal sanction, or in which minor bicycle or pedestrian injuries occur. In addition, 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 going unreported. By contrast, all critical or fatal injuries are believed to be reported.

In the previous NHTSA analysis (Blincoe and Faigin, 1990), unreported injuries were estimated from data derived by Rice (1989) and Miller (1991) from the National Health Interview Survey (NHIS). In June 1996, the Department of Health and Human Services (HHS) announced that all motor vehicle injury estimates from the NHIS since 1982 through 1994 were in error. Apparently, a programing error resulted in multiple injuries being coded as multiple injury victims, which resulted in an overstatement of total injured persons. HHS subsequently supplied revised estimates for those years. An examination of these data indicated a large degree of variation in annual estimates, with annual injury estimates changing by as much as 40-50 percent. In some years, the NHIS total was even significantly smaller than police reported totals. This is apparently due to the small sample size; only 50-100 cases of motor vehicle injury are found in the NHIS survey annually. For these reasons, the NHIS survey was not used in the current report. Instead, a report compiled by Westat Inc. (Greenblatt et al., 1981) was used. Greenblatt et al. conducted a survey of 630 households where a driver had been injured in a motor vehicle crash to determine the portion of motor vehicle crashes that were reported to the police. They found that for every police-reported crash, there were 27.4 unreported crashes.

Blincoe and Faigin distributed the NHIS-based unreported injury total according to the relative incidence of non-hospitalized injuries. This was done because Greenblatt et al. had found no cases of unreported injury that involved hospitalization. For this report, the portions of each MAIS category that were unreported in Blincoe and Faigin were modified to reflect the total unreported injury ratio from Greenblatt et al. This was done by multiplying by the ratio of unreported to reported injuries in Greenblatt et al. (.2738) to that in Blincoe and Faigin (.2854). The resulting estimates maintain the injury distribution techniques from Blincoe and Faigin but reflect the total rate of unreported injury from Greenblatt et al. These results are reflected in Table 3 in the Introduction section of this report, and in Figure 4. These data indicate that 22 percent of all nonfatal injuries, primarily minor (MAIS1) injuries, are not reported to the police.

Figure 4

Distribution of Reported/Unreported Injuries



Uninjured Occupants in Injury Crashes

Uninjured occupants in injury crashes (MAIS 0 injuries) incur costs for lost productivity, insurance administration, travel delay, property damage, emergency services and workplace costs. The incidence of these occupants was estimated from the 1994 GES by 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 3.8 million uninjured occupants. National Center for Statistics and Analysis (NCSA) staff are of the opinion that police records do not capture all of the uninjured who are involved in injury crashes. If this is the case, then this method will produce a conservative estimate of uninjured occupants in injury crashes.

The results of this analysis of incidence are summarized in Table 3 contained in the Introduction Chapter of this report.

STATE COSTS

Over the past decade, states have become increasingly involved in establishing and enforcing laws related to motor vehicle safety. Safety belt laws, motorcycle helmet laws and increased sanctions for drunk driving have played a major role in reducing traffic injuries. The impact of traffic crashes on states is often of interest to legislators considering new traffic safety laws, changes to existing laws and funding for enforcement of these laws. Recent federal legislation allowing states to set their own speed limits on interstate highways should increase interest in this issue.

A state - specific distribution of total economic costs was made as follows:

- 1994 fatalities were obtained for each state from FARS. The portion of total national fatalities in each state was then applied directly to the total fatality cost ($33.84 billion).
- State injury data were obtained from individual states for 1992 and 1993 (the latest years for which complete data were available). The portion of total national nonfatal injures in each state was applied to the total cost of all nonfatal injures, PDO's, and uninjured occupants ($116.63 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 (ACCRA) and cited by Miller & Galbraith (1995). Lost productivity, travel delay and workplace costs were adjusted based on 1994 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 supplied 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.

The results of this analysis are shown in Table 5. There is considerable variation in costs among states, with California having costs that are 75 times as high as 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 & 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 also may result from different reporting practices that result in more or less complete recording of injuries from state to state. For example, California has 2.4 times the VMT as New York and 2.6 times as many fatalities; but California police-reported nonfatal injuries are only 15 percent higher than New York. Differences in roadway characteristics may account for some of this discrepancy, but is seems likely that variation in injury reporting is also a contributing factor. Finally, the impact of crash costs must be viewed in light of each state's economy. Smaller less populated states may have lower absolute costs, but they 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. This issue is addressed in the Source of Payment section of this report.

Table 5
Estimated 1994 Economic Costs
Due to Motor Vehicle Crashes

State	(Millions $)	% Total	Cost Per Capita
ALABAMA	$1,988	1.3%	$471
ALASKA	$316	0.2%	$522
ARIZONA	$2,539	1.7%	$623
ARKANSAS	$1,394	0.9%	$568
CALIFORNIA	$15,625	10.4%	$497
COLORADO	$1,850	1.2%	$506
CONNECTICUT	$2,117	1.4%	$646
DELAWARE	$382	0.3%	$540
DIST. OF COL.	$503	0.3%	$883
FLORIDA	$8,879	5.9%	$636
GEORGIA	$4,346	2.9%	$616
HAWAII	$636	0.4%	$539
IDAHO	$525	0.3%	$463
ILLINOIS	$6,447	4.3%	$549
INDIANA	$2,955	2.0%	$514
IOWA	$1,399	0.9%	$494
KANSAS	$1,252	0.8%	$490
KENTUCKY	$2,091	1.4%	$546
LOUISIANA	$2,736	1.8%	$634
MAINE	$669	0.4%	$540
MARYLAND	$3,360	2.2%	$671
MASSACHUSETTS	$4,011	2.7%	$664
MICHIGAN	$5,549	3.7%	$584
MINNESOTA	$1,981	1.3%	$434
MISSISSIPPI	$1,336	0.9%	$500
MISSOURI	$3,051	2.0%	$578
MONTANA	$412	0.3%	$481
NEBRASKA	$892	0.6%	$549
NEVADA	$1,000	0.7%	$686
NEW HAMPSHIRE	$441	0.3%	$388
NEW JERSEY	$6,606	4.4%	$836
NEW MEXICO	$1,084	0.7%	$655
NEW YORK	$13,156	8.7%	$724
NORTH CAROLINA	$4,741	3.2%	$671
NORTH DAKOTA	$214	0.1%	$336
OHIO	$7,125	4.7%	$642
OKLAHOMA	$1,709	1.1%	$525
OREGON	$1,418	0.9%	$459
PENNSYLVANIA	$5,436	3.6%	$451
RHODE ISLAND	$445	0.3%	$446
SOUTH CAROLINA	$1,999	1.3%	$546
SOUTH DAKOTA	$352	0.2%	$489
TENNESSEE	$3,001	2.0%	$580
TEXAS	$11,159	7.4%	$607
UTAH	$897	0.6%	$470
VERMONT	$209	0.1%	$361
VIRGINIA	$3,321	2.2%	$507
WASHINGTON	$3,205	2.1%	$600
WEST VIRGINIA	$984	0.7%	$540
WISCONSIN	$2,451	1.6%	$482
WYOMING	$279	0.2%	$586
Total	$150,469	100.0%	$578

ALCOHOL

Alcohol use is a major cause of motor vehicle crashes and injury. Historically, about half of all motor vehicle fatalities occur in crashes where a driver or pedestrian had consumed some measurable level of alcohol prior to the crash, and of these cases, roughly 80 percent involved a level of consumption which met the typical legal definition for impairment (0.10 percent Blood Alcohol Content (BAC) or greater).[4] In recent years, there has been a heightened awareness of the problems caused by drunk driving. Various groups, from NHTSA to Mothers Against Drunk Driving (MADD) and state and local agencies, have promoted the enactment of laws and launched public awareness campaigns to help combat this problem. Legal measures such as administrative license revocation/suspension have been enacted in numerous states. The effect of all this has been a marked decrease in the portion of fatalities that result from alcohol-involved crashes. Table 6 lists the portion 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 57 percent of all fatalities in 1982 to 41 percent in 1994 while legal intoxication has declined from 46 percent to 32 percent over the same period. Despite these declines, alcohol remains a significant causative factor in motor vehicle crashes.

As of April 1996, thirty-seven states define legal intoxication, the level at which DWI convictions can be made, as having a blood alcohol content of 0.10 percent or higher and 13 states have lowered this level to 0.08 percent. In this report, the definition of legal intoxication is 0.10 BAC or higher. This is consistent with most states definition and with the categories of BAC used in NHTSA publications. FARS data indicate that fatalities involving legally intoxicated drivers account for 79 percent of the fatalities arising from all levels of alcohol involvement.

Fatalities

The Fatal Accident 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 are 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. NHTSA's National Center for Statistics and Analysis (NCSA) has developed an algorithm which estimates alcohol involvement for these cases based on crash characteristics (Klein, 1986). The total number of alcohol-involved fatalities by BAC level is shown in Table 6 for 1994.

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[4]As of April 1996, a total of 13 states have changed their definition of legal intoxication to 0.08 BAC and above.

Nonfatal Injuries
In 1988, NHTSA began using a redesigned crash information system that replaced the former NASS system. In its place NHTSA now collects crash data through a two-tiered system. The NASS Crashworthiness Data System (CDS) is a probability sample of a subset of police-reported crashes in the U.S. To qualify as a CDS case, the crash must be police-reported, it must involve a harmful event (property damage and/or personal injury) resulting from the crash, and it must involve a towed passenger car or light truck or van in transport on a public road or highway.

Table 6
Alcohol-Involved and Intoxicated Traffic Fatalities, 1982-1994

Year	Total Fatalities	Alcohol-Involved (.01 BAC) Fatalities	Percent of Total	Legally Intoxicated (.10 BAC) Fatalities	Percent of Total
1982	43,945	25,165	57%	20,356	46%
1983	42,589	23,646	56%	19,174	45%
1984	44,257	23,758	54%	18,992	43%
1985	43,825	22,716	52%	18,112	41%
1986	46,087	24,045	52%	18,936	41%
1987	46,390	23,641	51%	18,529	40%
1988	47,087	23,626	50%	18,731	40%
1989	45,582	22,436	49%	17,862	39%
1990	44,599	22,084	50%	17,650	40%
1991	41,508	19,887	48%	15,930	38%
1992	39,250	17,859	46%	14,234	36%
1993	40,150	17,473	44%	13,977	35%
1994	40,676	16,589	41%	13,094	32%

Injury cases in vehicles that meet these criteria are examined in considerable detail. Insofar as alcohol involvement is concerned, data are collected on specific BAC levels of all involved drivers as well as other indications of alcohol involvement.

The General Estimates System (GES) by contrast, 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 universe of crashes, it collects less information on each crash. Thus, for alcohol involvement, cases in the GES system are limited to a yes, no, or unknown indication on the police crash report. No BAC test results are available for these crashes.

To estimate alcohol involvement in nonfatal injuries, a combination of these two systems has been used. The 1992-1994 CDS system, which provides more detailed investigations of the injuries it covers, was the source of estimates of alcohol involvement in injuries to occupants of passenger vehicles in tow-away crashes. The use of current files is a relevant consideration in this case because alcohol involvement has generally been declining in fatal crashes and considerable effort has been made in recent years to reduce the incidence of drunk driving. However, data on alcohol involvement is scarce enough that there is considerable variation from year to year. This variation causes occasional "spikes" in results which can produce absurd or misleading estimates. CDS alcohol distributions were therefore taken from 1992-94 averages for all injury levels which demonstrated these spikes (MAIS 1-4).

Alcohol involvement in all other categories of injuries (e.g., non-CDS injuries) was estimated from GES data. The BAC distribution of these non-CDS alcohol-related injuries was more complex. An examination of 1984-1986 NASS injuries indicated that non-CDS injury crashes have a different BAC profile than CDS equivalent crashes do. An adjustment was applied to the respective CDS profiles to produce the non-CDS equivalent profile for each MAIS level. Details of this method are described in Blincoe and Faigin.

Underreported Alcohol

Police underreporting of alcohol involvement has been well documented in numerous studies. Typically, these studies compare the results of BAC tests administered in a medical care facility to police reports of alcohol presence. In a 1982 study of injured drivers, Terhune found that police correctly identified only 42 percent of drivers who had been drinking. Identification rates improved at the higher BAC levels with correct identification of only 18.5 percent of these who had BAC's of .01 - .09, 44.1 percent of those with BAC's of .10 - .19 and 58.1 percent of those with BAC's of .20 and over.

Table 7
Portion of Drivers Correctly Identified as Drinking by Police

Study	Legally Intoxicated	Involved But Not Intoxicated	All + BAC's
General Hospital Injuries			
Terhune, 1982	48.9%	18.5%	41.9%
Trauma Center Injuries			
Soderstrom, 1991	51.5%	45.5%	50.0%
Soderstrom, 1990	70.7%		70.7%
Dischinger & Cowley, 1988	51.7%	28.6%	47.3%
Maull et at, 1984	57.1%		57.1%
Total	**57.4%**	**36.0%**	**54.9%**
Fatals			
Baker & Fisher, 1977	29.0%	20.0%	26.8%
Total	**52.1%**	**25.8%**	**47.7%**
Total Less Fatals	54.6%	26.9%	50.3%

In a 1990 study, Soderstrom et al. found that police correctly indicated alcohol use in only 71 percent of intoxicated injured drivers. In 1984, Maull et al. found that police only identified 57.1 percent of intoxicated drivers. Dischinger and Cowley (1989) found that police correctly identified only 51.7 percent of intoxicated drivers and 28.6 percent of involved but not intoxicated drivers.

In a 1991 study of injured motorcycle drivers, Soderstrom et al. found that police correctly identified only half of those with positive alcohol readings. In 1977, Baker and Fisher found that police only identified 29 percent of motorcycle drivers who had been drinking.

These studies are summarized in Table 7. From these studies, there appears to be a rough consensus that police are only identifying just over half of all legally intoxicated drivers, and only about a quarter of all drivers who were alcohol involved but not legally intoxicated. Coincidentally, the number of cases of involved vs. intoxicated drivers in these studies corresponds closely with the national experience, and the average experience for all cases were roughly 50 percent correct identifications. With the exception of Soderstrom's 1990 study and Baker and Fisher's 1977 study of motorcycle fatalities, all of these studies found fairly consistent results, indicating that police identified just over half of all legally intoxicated drivers. No such consensus is apparent for the involved but not intoxicated cases, with results ranging from 19-46 percent among injury studies. This variation may be a function of the low number of cases examined. These estimates were used to adjust police-reported estimates of legal intoxication and alcohol involvement levels.

In this study, adjustments were made for underreported alcohol using methods described in Blincoe and Faigin. An exception was made to those methods for MAIS 4 and MAIS 5 injuries, which were constrained to a level consistent with the estimated rate of alcohol use in fatal crashes.

This was done for several reasons:

- An examination of crash time-of-day characteristics indicates that MAIS 4 and 5 injuries share similar event-time profiles with fatals. Alcohol involvement rates are largely a function of time of day and day of week. It is thus unlikely that they would differ significantly in their alcohol-involvement rates.
- The relatively small number of MAIS 4 and 5 cases in the 1994 files produced levels of alcohol-involvement which, if adjusted directly, would result in unrealistically high alcohol involvement rates, nearly double those predicted for fatalities using the NCSA algorithm.

The method used to adjust MAIS 4 and MAIS 5 injuries was as follows:
The alcohol involvement rate for fatals was computed using raw data and compared to the revised estimate based on the algorithm derived by NCSA (Klein, 1986). The percent increase resulting from the application of this algorithm was then applied to the police-reported percent alcohol involvement rates previously computed from CDS and GES data to determine a rate that was consistent with that for fatals. This rate was used to calculate the total increase in alcohol-

calculated using the rates and methods described in Blincoe and Faigin. These results were used to determine the relative frequency of unreported cases for each BAC category. These were used as weights to distribute the total increase in alcohol cases for each BAC category. Increases in alcohol involvement were then deducted from the uninvolved totals.

Data from the 1994 GES indicate that alcohol was involved in 4.5 percent of PDO crashes. This number was adjusted to reflect underreported alcohol using methods established in Blincoe and Faigin.

Alcohol involvement for uninjured occupants was estimated by distributing the totals according to the relative portions of each of the BAC categories that reflected uninjured occupants in the 1992-94 GES. These portions are shown in Table 8.

The incidence and cost distribution by level of alcohol involvement is summarized in Tables 8 and 9 and in Figure 5. Alcohol-involved crashes account for 17 percent of PDO's, 20 percent of injuries and 41 percent of fatalities. By contrast, they account for 30 percent of nonfatal costs and 47 percent of fatal costs. This disproportionate impact on costs is due to two factors. The first is the greater relative severity of alcohol-involved crashes. In Table 10, injury severity incidence is expressed in relation to the total number of injured survivors. For all cases, fatalities are about 0.8 percent of injured survivors. This rate doubles for crashes involving alcohol. Similarly, the rate for critical injuries (MAIS 5) triples for alcohol cases and for severe injuries (MAIS 4) it nearly doubles. A higher portion of alcohol-involved cases therefore involve the more severe and expensive injuries.

A second factor is demographics. The cost for each alcohol-involved case of the same injury level is higher than for other cases because males are disproportionately involved in alcohol-involved crashes. Since males have higher work force participation and average earnings than females, the demographics of alcohol-involved crashes cause higher lost productivity than for non-alcohol-involved crashes, where gender distribution is more evenly spread. In addition, victims of alcohol-involved crashes tend to be of an age group where this lost productivity is maximized by the discounting process.

Table 8
Total Incidence by Injury Level and BAC Level

	<.10 BAC		>.10 BAC		ALL Positive Alcohol		ALL Cases	
	Incidence	% Total	Incidence	% Total	Incidence	% Total	Incidence	% Total
PDO	353,027	1.5%	3,560,797	15.2%	3,913,824	16.7%	23,395,971	100.0%
MAIS 0	408,218	11.0%	579,822	15.6%	988,040	26.6%	3,715,370	100.0%
MAIS 1	179,892	3.9%	669,917	14.5%	849,809	18.4%	4,626,495	100.0%
MAIS 2	54,145	13.6%	92,926	23.3%	147,071	36.9%	398,553	100.0%
MAIS 3	16,008	9.6%	42,139	25.3%	58,147	34.9%	166,845	100.0%
MAIS 4	1,569	9.2%	5,108	29.8%	6,677	39.0%	17,123	100.0%
MAIS 5	304	4.4%	2,396	34.6%	2,699	39.0%	6,914	100.0%
MAIS 1-5	251,919	4.8%	812,485	15.6%	1,064,404	20.4%	5,215,931	100.0%
Fatal	3,495	8.6%	13,094	32.2%	16,589	40.8%	40,676	100.0%

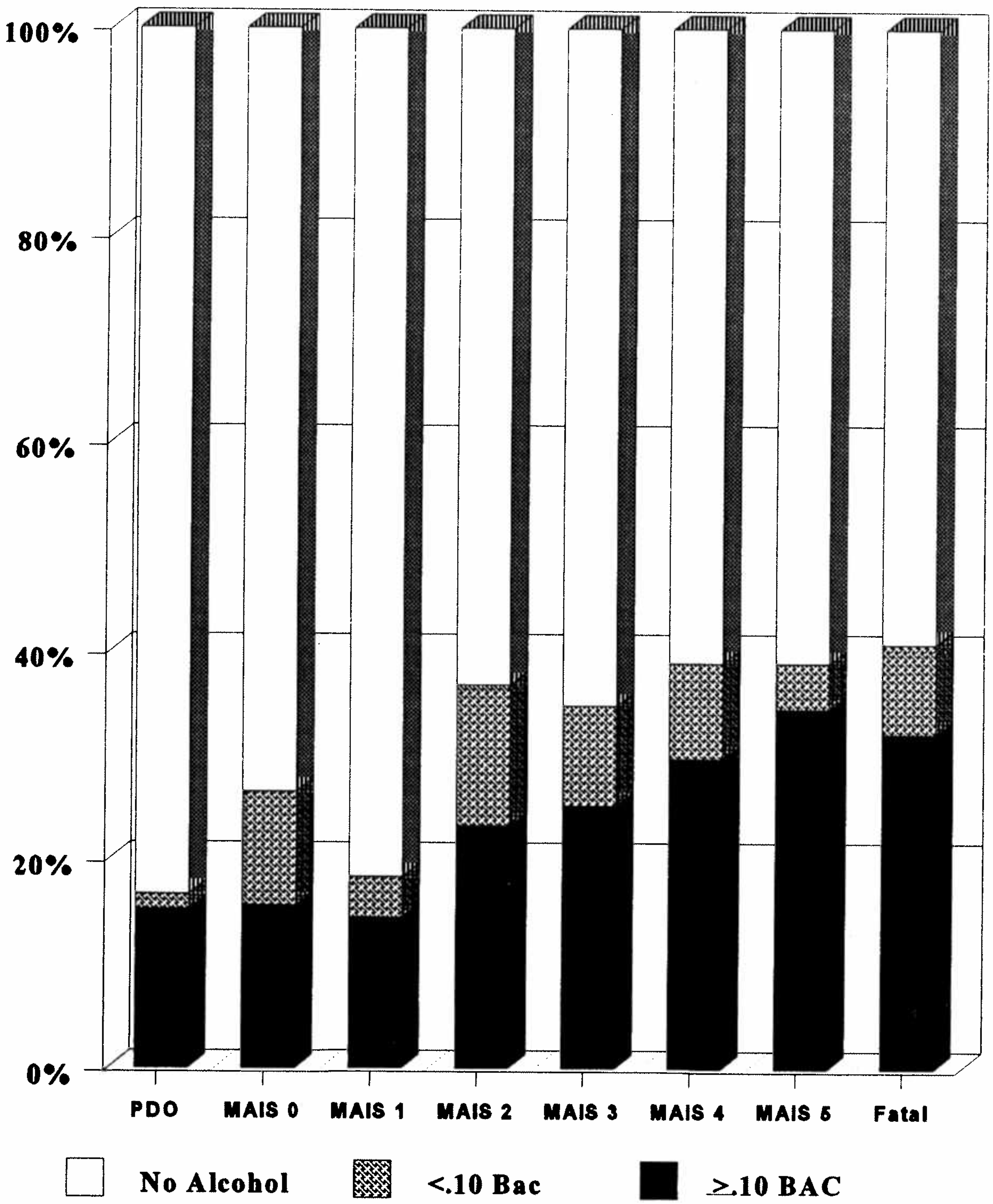
Table 9
Total Cost by Injury Level and BAC Level (Millions of 1994$)

	<.10 BAC		>.10 BAC		ALL Positive Alcohol		ALL Cases	
	Cost	% Total	Cost	% Total	Cost	% Total	Cost	% Total
PDO	$587	1.5%	$5,923	15.2%	$6,511	16.7%	$38,919	100.0%
MAIS 0	$461	11.0%	$655	15.6%	$1,115	26.6%	$4,194	100.0%
MAIS 1	$1,344	4.0%	$4,998	14.9%	$6,343	18.9%	$33,510	100.0%
MAIS 2	$1,973	14.3%	$3,376	24.4%	$5,349	38.7%	$13,839	100.0%
MAIS 3	$1,743	10.0%	$4,574	26.4%	$6,317	36.4%	$17,349	100.0%
MAIS 4	$374	9.5%	$1,215	30.8%	$1,589	40.3%	$3,939	100.0%
MAIS 5	$222	4.5%	$1,745	35.8%	$1,967	40.3%	$4,879	100.0%
Fatal	$3,141	9.3%	$12,626	37.3%	$15,768	46.6%	$33,839	100.0%
Total	**$9,846**	**6.5%**	**$35,113**	**23.3%**	**$44,959**	**29.9%**	**$150,469**	**100.0%**
MAIS 1-5	$5,656	7.7%	$15,909	21.6%	$21,566	29.3%	$73,517	100.0%

Table 10
Incidence by BAC Level and Injury Severity
Relative to Total Nonfatal Injuries

			All Positive	
	<.10 BAC	>.10 BAC	Alcohol	All Cases
MAIS 0	162.0%	71.4%	92.8%	71.2%
MAIS 1	71.4%	82.5%	79.8%	88.7%
MAIS 2	21.5%	11.4%	13.8%	7.6%
MAIS 3	6.4%	5.2%	5.5%	3.2%
MAIS 4	0.6%	0.6%	0.6%	0.3%
MAIS 5	0.1%	0.3%	0.3%	0.1%
MAIS 1-5	100.0%	100.0%	100.0%	100.0%
Fatal	1.4%	1.6%	1.6%	0.8%

Figure 5
Incidence by BAC Involvement



SPEED

Excess speed can contribute to both the frequency and severity of motor vehicle crashes. At higher speeds, more time is required to stop a vehicle and more distance is travelled before corrective maneuvers can be accomplished. Less time is available for drivers to react to the loss of control of their own vehicle, or to avoid vehicles or objects that are in their path. The fact that a vehicle was exceeding the speed limit does not necessarily mean that this was the cause of the crash, but there probably would have been a better chance of avoiding the crash had the driver or drivers been travelling at slower speeds.

To put the speed issue in context with overall costs, an estimate of speed-related crash costs was made for 1994. A speed-related crash is defined as any crash in which the police indicate that one or more of the drivers involved was exceeding the speed limit or driving too fast for conditions. FARS data indicate that in 1994, a total of 12,480 fatalities, representing 31 percent of all motor vehicle fatalities, occurred in speed-related crashes (which comprise 30 percent of all motor vehicle crashes).

To estimate the portion of economic costs that occurred in speed-related crashes, 1985 and 1986 NASS files were examined. These files were used because they are the latest accident 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 1994 fatalities (30.68%) 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 11. A total of $27.7 billion in costs, representing 18 percent of total costs, occurred in crashes that involved excess speed. Note that, unlike the alcohol cost estimates, the speed estimate does not include any adjustment for police undercounting of speed involvement. The degree to which police correctly identify speeding drivers is not known.

A state-specific estimate of speed-related crash costs was developed using the same adjustments for cost levels and injury incidence described in the section of this paper that discusses alcohol crash costs. These estimates are summarized in Table 12.

Previously NHTSA has estimated that speed-related crashes cost about $23 billion. The previous estimate was derived by using rates of speed involvement from Bowie and Walz (1994). Bowie and Walz examined data from the Crash Avoidance Research Data file (CARD file), the Indiana Tri-Level study, and FARS to determine the role of speeding in crash causation. Their study found that speed was a factor in 34.2 percent of fatals, 17.1 percent of incapacitating (A) injuries, 14.6 percent of non-incapacitating (B) injuries, 10.9 percent of possible (C) injuries, and 10.2, percent of uninjured cases.

In the previous NHTSA estimate, the three injury categories (A, B, & C) were combined using incidence rates from Bowie & Walz to produce an average nonfatal injury rate of 12.96 percent. Speed involvement for fatalities was derived from 1994 FARS data. The rate of speed involvement for nonfatal injuries was based on the relative rates found in Bowie & Walz (12.96/34.2). The rate for PDO's was based on the relative rates of uninjured persons and fatalities (10.2/34.2). The rates were applied to injury & PDO estimates to determine total speed involvement by state and highway system. This resulted in the previous $23 billion estimate.

The $23 billion estimate was based on data stratified by KABCO but not by MAIS levels. An average speed involvement rate was therefore calculated for all injury levels. Since speed is a more prevalent factor in more serious crashes, basing all injuries on the same average rate produces a conservative estimate of crash costs. The current estimate reflects the higher speed involvement rates of more serious crashes. In addition, the state-specific costs that were previously calculated were based on national rates of injuries and PDOs-to-fatalities, and on average nationwide cost levels. The current state estimates reflect adjustments for different rates of injury to fatal experience, and for state-specific price levels. Note, however, that these estimates are subject to the same caveats discussed previously for State Costs, i.e., that differences in injury severity or the completeness of nonfatal injury reporting practices can distort state-to-state comparisons.

Note that there is undoubtedly a considerable overlap between alcohol involvement and speed. Many speed-related crashes involved alcohol and visa-versa. These two estimates should <u>not</u> be added together in an effort to account for the portion of costs that are represented by the combined factors of speed and alcohol.

Table 11
Calculation of 1994 Speed Related Crash Costs and Incidence
Based on 1985 and 1986 NASS and FARS Speed Data

	1985-1986 Speed Related % Total	Factor*	1994 Costs	Speed Related Costs**	1994 Incidence	Speed Related Incidence***	1994 Percent Speed Related
PDO	11.49%	0.3245	$38,919	$3,875	23,395,971	2,329,605	9.96%
MAIS0	16.64%	0.4697	$4,194	$605	3,715,370	535,478	14.41%
MAIS1	14.95%	0.4221	$33,510	$4,340	4,626,495	599,166	12.95%
MAIS2	20.76%	0.5863	$13,839	$2,489	398,553	71,690	17.99%
MAIS3	22.84%	0.6448	$17,349	$3,432	166,845	33,007	19.78%
MAIS4	29.63%	0.8366	$3,939	$1,011	17,123	4,395	25.67%
MAIS5	35.99%	1.0162	$4,879	$1,521	6,914	2,156	31.18%
Fatal	35.42%	1.0000	$33,839	$10,382	40,676	12,480	30.68%
Total Injuries					5,256,606	722,895	13.75%
Total Nonfatal Injuries					5,215,930	710,415	13.62%
Total Cost			$150,469	$27,656			18.38%

* Factor is calculated by dividing each speed related % total by that for Fatals (35.42%).

** Speed related costs are calculated by multiplying each factor by the 1994 percent speed related for fatals (30.68%) and then multiplying this product by the 1994 costs.

*** Speed related incidence is calculated the same way as speed related costs, but based on 1994 incidence.

Table 12
Estimated 1994 Economic Costs Due to Motor Vehicle Crashes Where Excessive Speed was a Factor

State	(Millions $)	% Total
ALABAMA	$417	1.5%
ALASKA	$60	0.2%
ARIZONA	$484	1.8%
ARKANSAS	$271	1.0%
CALIFORNIA	$2,912	10.5%
COLORADO	$355	1.3%
CONNECTICUT	$370	1.3%
DELAWARE	$72	0.3%
DIST. OF COL.	$88	0.3%
FLORIDA	$1,678	6.1%
GEORGIA	$824	3.0%
HAWAII	$113	0.4%
IDAHO	$106	0.4%
ILLINOIS	$1,183	4.3%
INDIANA	$561	2.0%
IOWA	$267	1.0%
KANSAS	$243	0.9%
KENTUCKY	$397	1.4%
LOUISIANA	$498	1.8%
MAINE	$122	0.4%
MARYLAND	$599	2.2%
MASSACHUSETTS	$665	2.4%
MICHIGAN	$1,020	3.7%
MINNESOTA	$384	1.4%
MISSISSIPPI	$276	1.0%
MISSOURI	$592	2.1%
MONTANA	$84	0.3%
NEBRASKA	$166	0.6%
NEVADA	$192	0.7%
NEW HAMPSHIRE	$83	0.3%
NEW JERSEY	$1,112	4.0%
NEW MEXICO	$209	0.8%
NEW YORK	$2,220	8.0%
NORTH CAROLINA	$877	3.2%
NORTH DAKOTA	$42	0.2%
OHIO	$1,233	4.5%
OKLAHOMA	$329	1.2%
OREGON	$273	1.0%
PENNSYLVANIA	$1,005	3.6%
RHODE ISLAND	$75	0.3%
SOUTH CAROLINA	$390	1.4%
SOUTH DAKOTA	$71	0.3%
TENNESSEE	$591	2.1%
TEXAS	$2,048	7.4%
UTAH	$170	0.6%
VERMONT	$41	0.1%
VIRGINIA	$622	2.3%
WASHINGTON	$566	2.0%
WEST VIRGINIA	$184	0.7%
WISCONSIN	$456	1.6%
WYOMING	$60	0.2%
Total	$27,656	100.0%

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, HMO's, commercial insurance policies or workers compensation plans. Medicare is the primary payor for most 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 the payment mechanism for motor vehicle crashes have been derived from a variety of sources. Estimates for property damage, travel delay, legal costs and insurance administration are taken directly from the 1991 Urban Institute Study "The Costs of Highway Crashes" (UI). Lost market and household productivity was derived by isolating the market productivity portion of the total productivity estimates provided in the UI report and recomputing the distribution separately under the assumption that lost household productivity would be split between self, private insurance and other, while lost market productivity would be split among these groups plus state and federal funds. Vocational rehabilitation costs were assumed to be distributed in the same fashion as medical care. Premature funeral costs were assumed to be borne entirely by the individual.

The distribution of medical care payments has been measured in a number of NHTSA sponsored studies (Harris, CODES). These studies indicate significantly different distributions for medical costs, however. The 1992 study by Harris used E-codes to isolate motor vehicle crash injuries in 5 states. Harris examined charges for discharged hospital inpatients only. No ambulatory or long term rehabilitation cases were included. Harris found government sources accounting for 29 percent of all cases, private insurance accounting for 52 percent, individual injury victims (self) accounting for 11 percent and other sources for 8 percent.

By contrast, a recent study conducted by NHTSA (CODES) found that only 16 percent of all costs were covered by government sources, with 69 percent covered by private insurance and the remaining 15 percent covered by self and others. The CODES study linked all passenger vehicle drivers involved in police-reported motor vehicle crashes to EMS, hospital, and other injury records. CODES analyzed passenger vehicle drivers for whom safety belt utilization was known from the crash report, and for whom hospital admission are known from the linkage.

The sharp difference between the findings of the Harris and CODES studies was of particular concern. However, an analysis of these studies indicated that results for Missouri, the one state common to both, were quite similar (see Table 13). This seemed to imply that the reason for the difference in the two studies' results may be related to real differences in the particular states involved. A second possibility was that the use of all occupants in the Harris study, and only drivers in the CODES study had caused the difference, possibly due to the added liability of drivers as controlling parties. However, New York provided data on both drivers and occupants for the CODES study, and the difference in payment distribution between the two groups was insignificant.

Harris obtained data from New York and California after publication of her 1992 report. Although these data have not been published, they are available for inclusion in this analysis.

For the reasons discussed above, it was concluded that the basic difference between the CODES and Harris reports was due to real differences in the payment experience of two different samples of states. Data from both studies were then combined to produce a more broadly representative sample of source of payment experience across the U.S. Several different weighting schemes were considered for this sample. Weighting the results according to injury population would seem a logical choice. However, in the new combined sample of 12 states, California and New York had injury populations that overwhelmed most other states, and would dominate in the resulting estimates. Since these two states are at the extreme ends of the public payment spectrum, it was not clear that this would provide an estimate that was representative of the U.S. overall.

A simple average was also considered. However, this poses the opposite problem, in that it gives all states equal weight, regardless of the population they represent.

One possible reason for the different experiences among states is that some states have no-fault auto insurance while others do not. In states with compulsory first party no-fault laws, automobile insurance is automatically considered the primary source of payment for motor vehicle injuries. An analysis of state auto insurance laws indicates that there is a strong correlation between no-fault laws and low public (or high private) payments for motor vehicle injuries. Four of the five states with the lowest public involvement (Hawaii, Utah, New York and Pennsylvania) have compulsory first party no-fault requirements. The remaining eight states do not.

Based on this analysis, a weighting scheme based on the states' insurance laws was devised, with the sampled no-fault states carrying the weight for all no-fault states and the other eight states representing all states without compulsory first party no-fault laws. The basis for these weights was 1993 police-reported injuries listed in Table 14. Average U.S. source of payments were calculated as follows:

Table 13
Summary of State Source of Payment Data
from Harris and CODES Studies

	Total Public	Insurance	Self	Other	Total
Hawaii**	8.0%	92.0%	0.0%	0.0%	100.0%
Utah**	10.7%	79.8%	7.2%	2.3%	100.0%
New York*	11.8%	66.0%	8.8%	13.4%	100.0%
Vermont*	13.1%	63.9%	12.8%	10.2%	100.0%
Pennsylvania**	16.7%	74.9%	6.3%	2.0%	100.0%
Wisconsin**	18.3%	75.4%	4.8%	1.5%	100.0%
Missouri*	22.9%	55.0%	15.4%	6.7%	100.0%
Washington*	25.4%	56.9%	17.5%	0.2%	100.0%
Maine**	27.6%	55.3%	13.1%	4.1%	100.0%
Rhode Island*	34.9%	34.9%	13.2%	17.0%	100.0%
California*	36.8%	44.6%	17.5%	1.0%	100.0%
Arizona*	40.1%	46.1%	0.0%	13.8%	100.0%
Simple Average =	22.2%	62.1%	9.7%	6.0%	100.0%
Additional Data Not Used in Average					
Missouri**	23.2%	59.8%	13.0%	4.1%	100.0%
New York**	8.7%	64.2%	20.6%	6.5%	100.0%
New York, Drivers**	8.2%	63.6%	21.4%	6.7%	100.0%

* From Harris study
** From CODES study

For each payment source (Medicare, Medicaid, private insurance, self, etc.).

$$x = [\sum s_n\, r_n]\;\; w_f + [\sum s_z\, r_z]\;\; w_e$$

Where: x = average portion of hospitalized costs paid by specific payment source
s_n = portion of payments made by specific source in no-fault state n
r_n = relative weight of sampled state n among other sampled no-fault states as defined by the relative number of police-reported injuries in each state
w_f = relative weight of all no-fault states defined by the relative number of police-reported injuries in such states to all states (36.11%)
s_z = portion of payments made by specific source in tort state z
r_z = relative weight of sampled state z among other tort states as defined by the relative number of police-reported injuries in each state
w_e = relative weight of all tort states defined by the relative number of police-reported injuries in such states to all states (63.89%)

The results of this analysis are shown in the "Hospitalized" column of Table 15.
Both the Harris and the CODES studies examined hospital inpatients. A third NHTSA study, "Low Threat-to Life Motor Vehicle Injuries, a Profile of Motor Vehicle Injuries in Emergency Departments", (NHTSA 1995c) examined the source of payment for persons who are not admitted to hospitals as inpatients. This study found that about 15.8 percent of the costs of these "ambulatory" patients were covered by government sources, while 45.3 percent were covered by private insurance, 25.7 percent by self, and 13.2 percent by other sources. The study was based on a sample of 1649 cases treated in emergency departments as a result of motor vehicle crash injuries.

An estimate of the long-term rehabilitation cost distribution was obtained from the Rehabilitation Institute of Chicago (RIC). Data obtained from RIC for admission due to motor vehicle injuries between August 1993 and December 1995 found that, for 322 cases examined, 49.6 percent of costs were covered by government programs, 50.2 percent by private insurance, and only 0.2 percent by self.

To estimate source of payment for medical care, data from the CODES, Harris, NHTSA 1995c, and the RIC studies were used. Medicaid costs were broken out according to their federal and state shares. In 1992, federal funds accounted for 57.4% of nationwide Medicaid expenditures with the states accounting for 42.6%. Medicare expenditures are paid primarily by the Federal government (80%) with private individuals picking up about 20% of the cost of this program. The portion of costs associated with unspecified government programs was allocated to state costs.

Table 14 1993 Police-Reported Injuries by State and Insurance Status		
	Tort and All Other States	Compulsory First-Party No-Fault States
Alabama	44183	
Alaska	5686	
Arizona	63037	
Arkansas	39148	
California	315184	
Colorado		43021
Connecticut	43963	
Delaware		8344
Dist. of Col.	10190	
Florida		212497
Georgia	109463	
Hawaii		13884
Idaho	11593	
Illinois	155590	
Indiana	75614	
Iowa	35510	
Kanasa		30142
Kentucky		55205
Louisiana	77896	
Maine	17216	
Maryland		62976
Massachusetts		90732
Michigan		134548
Minnesota		44987
Mississippi	33999	
Missouri	77517	
Montana	9288	
Nebraska	26117	
Nevada	21264	
New Hampshire	10384	
New Jersey		129953
New Mexico	28032	
New York		273709
North Carolina	129535	
North Dakota		5507
Ohio	206213	
Oklahoma	47147	
Oregon		32718
Pennsylvania		131503
Rhode Island	10445	
South Carolina	50349	
South Dakota	8410	
Tennessee	76490	
Texas	298891	
Utah		25763
Vermont	4573	
Virginia	77852	
Washington	76332	
West Virginia	28149	
Wisconsin	60902	
Wyoming	5845	
Total		1295489
% Total	63.89%	36.11%
SOURCE: Individual state transportation agencies.		

Table 15
Source of Medical Payments by Specific Governmental Payor

	Emergency Room	Inpatient	Rehabilitation
Medicaid:	0.071	0.137	0.435
Federal	0.041	0.078	0.250
State	0.030	0.058	0.185
Medicare:	0.054	0.075	0.061
Federal	0.043	0.060	0.048
Self	0.011	0.015	0.012
Other Government:	0.033	0.037	
Federal			
State	0.033	0.037	
Private Insurance:	0.453	0.580	0.502
Self:	0.257	0.117	0.002
Other:	0.132	0.054	
Total	**1.000**	**1.000**	**1.000**

The relative cost of the three hospital categories was a function of cost-per-case and frequency. Average costs were obtained from different sources. Emergency room costs were taken from data provided by the state of Utah for the CODES report, rehabilitation costs were based on data from RIC and inpatient costs were based on a weighted average of the charge data from Harris and CODES. Frequency data for ER and inpatient admissions were obtained from 1982-86 NASS files. Frequence data for rehabilitation centers were obtained from the state of Utah. Utah data indicated that, of those who experience some form of hospital treatment, 0.6% are admitted to long term rehabilitation centers. Similar data were not available from other states.

Payments from all sources were then combined into five basic source of payment categories: Federal, State, Private Insurance, Self, and Other ("Other" includes costs absorbed by health care providers or charities). Within each category, the three hospital status categories were weighted together based on their relative cost. These weights were applied to the data from

Table 15 to produce final estimates of source of payment. This process is illustrated in Table 16. The net results indicate about 14 percent of all medical care costs are paid from federal revenues and 10 percent from state revenues, for a total governmental share of 24 percent. Private insurance pays the largest portion, 55 percent, while individuals pay roughly 15 percent out of their own funds. The variation in payment distributions for different treatment levels is illustrated in Figure 6.

It should be noted that this estimate is based on hospitalized cases, but does not include any source of payment data on costs that are incurred from visits to private physicians. In addition, for most states, there was no source of payment data for physician visits to hospitalized victims. This analysis assumes that the source of payment profile for those cases is similar to that for all hospitalized cases.

Table 16
Calculation of Weights and Average Source of Payments for Medical Care

	ER	Inpatient	Rehabilitation	Total
% Who Exp Treatment (a)	86.52%	13.48%	0.56%	
Cost/Treatment Cat. (b)	$591	$14,549	$47,362	
Total Relative Costs (axb)	$512	$1,961	$265	$2,737
Weights	18.69%	71.63%	9.68%	100.00%
Federal	8.39%	13.89%	29.81%	14.40%
State	6.28%	9.49%	18.53%	9.76%
Private Insurance	45.33%	57.96%	50.20%	54.85%
Self	26.79%	13.23%	1.46%	14.62%
Other	13.21%	5.43%		6.36%

Figure 6

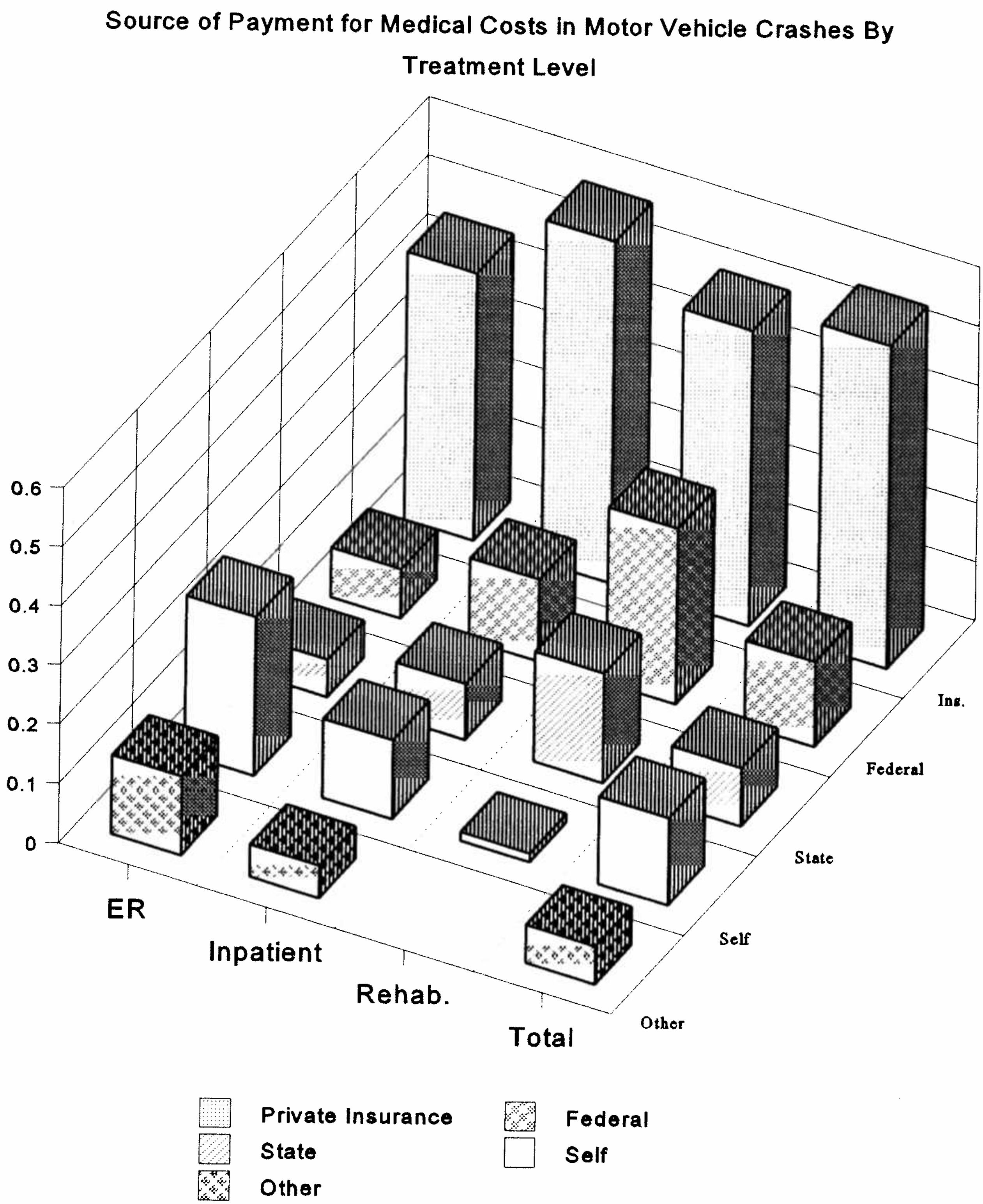

Source of Payment for Medical Costs in Motor Vehicle Crashes By Treatment Level
0.6
0.5
0.4
0.3
0.2
0.1
0
ER
Inpatient
Rehab.
Total
Ins.
Federal
State
Self
Other
Private Insurance
State
Other
Federal
Self

Table 17
Estimated Source of Payment by Cost Category

	Federal	State	Total Govt.	Insurer	Other	Self	Total
Medical	14.40%	9.76%	24.16%	54.85%	6.36%	14.62%	100.00%
Pre-funeral			0.00%			100.00%	100.00%
Emergency Services	3.87%	75.75%	79.62%	14.74%	1.71%	3.93%	100.00%
Voc. Rehab.	14.40%	9.76%	24.16%	54.85%	6.36%	14.62%	100.00%
Market Prod.	16.20%	3.06%	19.26%	41.09%	1.55%	38.10%	100.00%
HH Prod.			0.00%	41.09%	1.55%	57.36%	100.00%
Ins. Adm.	0.89%	0.51%	1.40%	98.60%			100.00%
Wkplce Costs			0.00%		100.00%		100.00%
Legal/Court			0.00%	100.00%			100.00%
Travel Delay			0.00%		100.00%		100.00%
Prop. Damage			0.00%	65.00%		35.00%	100.00%

In Table 17, the distribution of sources of payment is summarized for each cost category. Governmental sources are estimated to account for a significant share of medical care costs, emergency services, vocational rehabilitation and lost productivity.

In Table 18, this distribution is applied to each cost category. Roughly $13.8 billion or 9 percent of all costs are borne by public sources, with federal revenues accounting for 6 percent and states accounting for 3 percent. Private insurers paid $82.2 billion or 55 percent, while individual crash victims absorbed $44.2 billion or 29 percent. The $13.8 billion cost in public revenues is the equivalent of $144 in added taxes for each of the roughly 96 million households[5] in the United States.

[5]Source: Statistical Abstract of the United States 1995. Table 69.

Table 18
Estimated Source of Payment
1994 Motor Vehicle Crash Costs
(Millions of 1994 $)

	Federal	State	Total Govt.	Insurer	Other	Self	Total
Medical	$2,452	$1,662	$4,114	$9,339	$1,083	$2,490	$17,026
Pre-funeral	$0	$0	$0	$0	$0	$138	$138
Emergency Service	$67	$1,306	$1,373	$254	$29	$68	$1,724
Voc. Rehab.	$23	$15	$38	$86	$10	$23	$156
Market Prod.	$6,869	$1,300	$8,169	$17,421	$657	$16,155	$42,403
HH Prod.	$0	$0	$0	$5,072	$191	$7,082	$12,345
Ins. Adm.	$93	$53	$146	$10,309	$0	$0	$10,456
Wkplce Costs	$0	$0	$0	$0	$3,844	$0	$3,844
Legal/Court	$0	$0	$0	$5,857	$0	$0	$5,857
Travel Delay	$0	$0	$0	$0	$4,401	$0	$4,401
Prop. Damage	$0	$0	$0	$33,877	$0	$18,242	$52,119
Total	**$9,503**	**$4,337**	**$13,840**	**$82,215**	**$10,217**	**$44,197**	**$150,469**
% Total	6.32%	2.88%	9.20%	54.64%	6.79%	29.37%	100.00%

To some extent, it is illusory to disagregate costs across these types of payment categories because ultimately, it is individuals who pay for these costs through insurance premiums, taxes, direct out-of-pocket payments, 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 impact society at large. Costs paid out of federal and state revenue are funded by taxes from the general public. Similarly, costs borne by private insurance companies are funded by insurance premiums paid by policyholders, not all of whom are 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 the health care facility. From this perspective, perhaps the most significant point from Table 18 is that society at large picks up over 70 percent of all crash costs that are incurred by individual motor vehicle crash victims.

Although data on source of payment is becoming more accessible through ongoing studies such as CODES, there are still major gaps in our knowledge of this issue. These include the following:

- As previously noted, there is no data on source of payment for physician visits. Data from Utah imply that over 40 percent of all injured crash victims are not treated in any hospital environment. It is likely that most of these see a private physician.
- All data collected in the Harris and CODES reports represent estimates of the anticipated primary payor. In reality, the process of subrogation commonly results in many different payors picking up a share of the cost. Until more detailed studies are conducted which follow cases through to their final settlement, it is assumed that aggregate estimates of primary payors are a reasonable proxy for the actual cost distribution.
- Data on medical rehabilitation centers are scarce. In this analysis, a single center supplied both payment distribution and average cost data, and a single state provided incidence data. Because both the cost, and the distribution of costs for rehabilitation are much different from those for inpatient and ER treatment, even a shift of a few percentage points in incidence could have a significant impact on the estimated distribution of payments.

Future efforts to address these problems could provide significant improvements in our understanding of the "who pays" issues.

COST TRENDS 1990 vs. 1994

Prior to this report, the last year examined by NHTSA for motor vehicle crash costs was 1990. Costs for 1990 were estimated to be $137.5 billion. Since then a number of trends have emerged:

- Increased safety belt use (up 37 percent), decreased driving while under the influence of alcohol (down 18%) and the increased production of safety devices such as air bags have resulted in fewer deaths and injuries. Fatalities declined from 44,599 in 1990 to 40,676 in 1994. Reductions also occurred in nonfatal injuries (5.4 million in 1990, 5.2 million in 1994) and in vehicles damaged (28 million vehicles vs. 27 million vehicles).
- Inflation has driven up the overall cost of living by 13.4 percent. Medical care costs have increased even higher, by 32.3 percent.
- Demographic and economic factors have increased travel exposure as measured by vehicle miles travelled (VMT) by 9.5 percent.

The costs estimated in this paper reflect the impact of these trends, but also reflect changes in methodology which give improved estimates of costs. This clouds the relationship between the current and previous cost estimates. This analysis will address several questions. These include:

- What impact did improved methodology have on the 1994 cost estimates?
- What has happened to crash costs during the 1990s, and what factors contributed to this trend?
- To what extent has improved safety mitigated the impact of inflation on crash costs?
- What impact has improved safety had on crash costs compared to 1990 accident rates?

Impact of Revised Methods

The revised cost methodology described in this analysis had an impact on cost estimates. To determine this impact, a simple inflation adjusted basis for 1990 unit costs was calculated. Individual 1990 cost components were inflated using the CPI All Items and Medical Care indices, as well as average hourly earnings indices where appropriate. These 1994 equivalent costs were then multiplied by the 1994 incidence to determine the total cost without the specific unit cost adjustments discussed earlier under "Human Capital Costs." This resulted in a total cost of $145.6 billion, implying that the methodology changes made to individual cost components by Miller, and for this report, resulted in an upward adjustment of $4.9 billion. This represents 3.2 percent of the 1994 cost estimate of $150.5 billion.

Trends and Causes
In order to estimate the real trend in motor vehicle crash costs since 1990, several adjustments were made to bring 1990 costs up to a common basis with 1994. The first change was made to the 1990 incidence to reflect a change in the method used to calculate MAIS 0 injuries in injury crashes. The 1990 report reflected an estimate of these cases that is significantly lower than that found in the current report (0.28 per injured occupant vs. 0.74 per injured occupant). When the method currently used was applied to 1990 data, it was found that the rate should have been 0.67. The original 1990 estimate is therefore considered to be understated.

A second adjustment to 1990 incidence was made to fatalities. In the 1990 report, preliminary data were used which indicated a total of 44,531 fatalities. Since then, NHTSA has revised this number up to 44,599. Adjustments were made to the 1990 MAIS 0 and fatality incidence estimates consistent with the corrected data.

A third adjustment to 1990 incidence was made to MAIS 5 injuries. In the 1990 report, the estimate of MAIS 5 injuries was based on NASS data from the 1982-86 period. The resulting estimate (11,386) was significantly higher than the number of MAIS 5 injuries predicted using data from the CDS and GES in the current report (6,885). Since a decrease this dramatic seemed unlikely, CDS data from 1990-94 was examined. The CDS estimate of MAIS 5 injuries has remained fairly consistent during this period, with the 1994 estimate being 2.6 percent higher than 1990. Since the earlier 1990 estimate was based on 1982-89 data, and since there have been dramatic increases in safety belt use since that period, it is possible that there is some validity to this large decline in these rare but serious injuries. However, the CDS data seem to indicate that this trend did not occur since 1990, and it appears that applying 1982-86 experience to 1990 was not accurate. To correct for this, the 1990 MAIS 5 estimate was revised by applying the rate of change in CDS MAIS 5 injuries to the total MAIS 5 injury estimate for 1994.

A fourth adjustment was made to 1990 incidence to reflect corrected estimates of unreported injuries. These corrections were required because of the recent announcement by HHS that all their published NHIS data on motor vehicle injuries from 1982-1994 was incorrect. As discussed in the "Unreported Injuries" secton of this report NHIS data was used as a basis for unreported injuries in the 1990 report. A different study by Wastat Inc. (Greenblatt et al.) was used to calculate unreported injuries in the current report, and this same study was used to modify 1990 incidence to a corrected basis.

Unit costs were then adjusted back from their 1994 level to 1990 using the cost-specific inflators that were used to estimate 1994 unit costs. Combining these with the corrected 1990 incidence yielded an estimate of $139.2 billion for 1990. This represents a corrected 1990 estimate which reflects the methodological improvements used in the current report. Comparing this to the equivalent 1994 estimate of $150.5 billion indicates that costs from motor vehicle crashes have increased by $11.3 billion or 8.1% since 1990.

The conflicting trends that have resulted in the current level of crash costs can be seen from Figure 7. To generate this figure, data for medical expenditures per capita, the CPI All Items Index, the total number of fatalities, the portion of fatalities involving alcohol, total wage compensation, VMT, and the rate of safety belt use were turned into indices with 1990 as the base. The year-to-year change thus represents the percent change each year over the 1990 base. Crash costs were only available for 1994 and 1990 (the 1990 costs are the recomputed costs discussed above). For 1991-93, crash costs were estimated by using a factor derived from the relative incidence of fatalities or injury and the weighted average of the 3 inflators used in this report. Weights for this average were derived by calculating the percent of total costs that each cost category represents for each injury severity level. Medical care weight was applied to medical expenditures per-capita. Weights for market and household productivity, workplace costs and travel delay were applied to the total compensation index. All other expenditures weights were applied to the CPI All Items. This resulted in the following equation:

$$r_n = (w_a a_n + w_b b_n + w_c c_n)*f_n$$

Where:

- r_n = weighted factor for year n relating year n costs to 1990 costs
- a_n = CPI All Items index based in 1990
- b_n = medical expenditures per-capita index based in 1990
- c_n = total compensation index based in 1990
- f_n = incidence index based in year 1990 (FARS for fatalities, CDS for MAIS 2-5, GES total injuries for PDO, MAIS 0 and MAIS 1)
- w_a = portion of specific injury levels costs due to EMS, premature funeral, vocational rehabilitation, insurance administration, legal costs, and property damage
- w_b = portion of specific injury levels costs due to medical care
- w_c = portion of specific injury levels costs due to market and household productivity, travel delay, and property damage

This formula was applied separately for each injury severity level. For MAIS 2, 3, 4 and 5 injuries, f_n was the CDS MAIS specific index based in 1990. For PDO's, MAIS 0 and MAIS 1 injuries, f_n was the GES total injury index based in 1990. For fatalities, f_n was the fatality index based in 1990.

The FARS based index gives a perfect prediction of 1994 fatal costs when applied to the 1990 cost. This is to be expected since the same factors are used to predict both years' numbers. Similarly, the CDS MAIS 5 index, which was used to estimate revised 1990 MAIS 5 injuries, gives a perfect prediction of critical injuries. However, CDS and GES are less perfect predictors of other severity levels. This can be seen from the "error" line in Table 19, where there are significant differences indicated for MAIS 0 and 2 costs. The estimates for 1991-1993 were therefore adjusted by the ratio of actual to predicted costs to correct for this imprecision in the algorithm, and produce results consistent with 1994 costs. The inputs and indices that resulted are summarized in Table 20.

GES police-reported injuries were used to estimate the trend in PDO's, MAIS 0 and MAIS 1 injuries. Both logic and experimentation indicated that GES provides a better prediction of trends in these lower severity categories. Roughly 90 percent of all GES injuries are minor severity.

Table 20 and Figure 7 reveal a gradual 13.4 percent increase in overall consumer costs and a steep 32.3 percent increase in medical care costs over this period. There were also steady increases of 15.4 percent in total average compensation and 9.5 percent in driving exposure as measured by vehicle miles travelled (VMT). All of these factors tended to increase the cost or incidence of motor vehicle crashes.

At the same time that inflation and VMT were tending to increase crash costs, a significant change was occurring in the driving habits of the American public. Observed safety belt use rates climbed from 49 percent in 1990 to 67 percent in 1994. The importance of belt usage in protecting vehicle occupants has been verified in numerous reports. Belt usage is estimated to increase an occupants' chance of surviving a potentially fatal crash by 45 percent, and to decrease their chance of serious injury by 50 percent (NHTSA, 1984).

Concurrent with the increase in belt use, the incidence of driving under the influence of alcohol declined. The portion of fatalities that occurred in alcohol-involved crashes dropped from 50 percent in 1990 to 41 percent in 1994. This reflects an overall decline in the incidence of impaired driving that resulted in fewer motor vehicle crashes.

A third factor favoring the decline in deaths is the steady increase in the portion of the vehicle fleet that has improved safety features. Air bags, for example, were in 2% of the on-road passenger car fleet in 1990. By 1994 they were in 17%. Other significant safety features that became more common during this period include antilock brakes, rear seat lap/shoulder belts and center high mounted stop lamps.

Another trend that occurred during this period was an increase in the popularity of light trucks and utility vehicles, which rose from 29 percent of registered passenger vehicles in 1990 to 33 percent in 1994. These vehicles have lower fatality rates for occupants than passenger cars. However, they are also more aggressive when they impact a passenger car. It is not clear which of these factors holds the edge in the overall safety picture.

Figure 7
Trend in Factors Affecting Motor Vehicle Crash Costs, 1990-1994

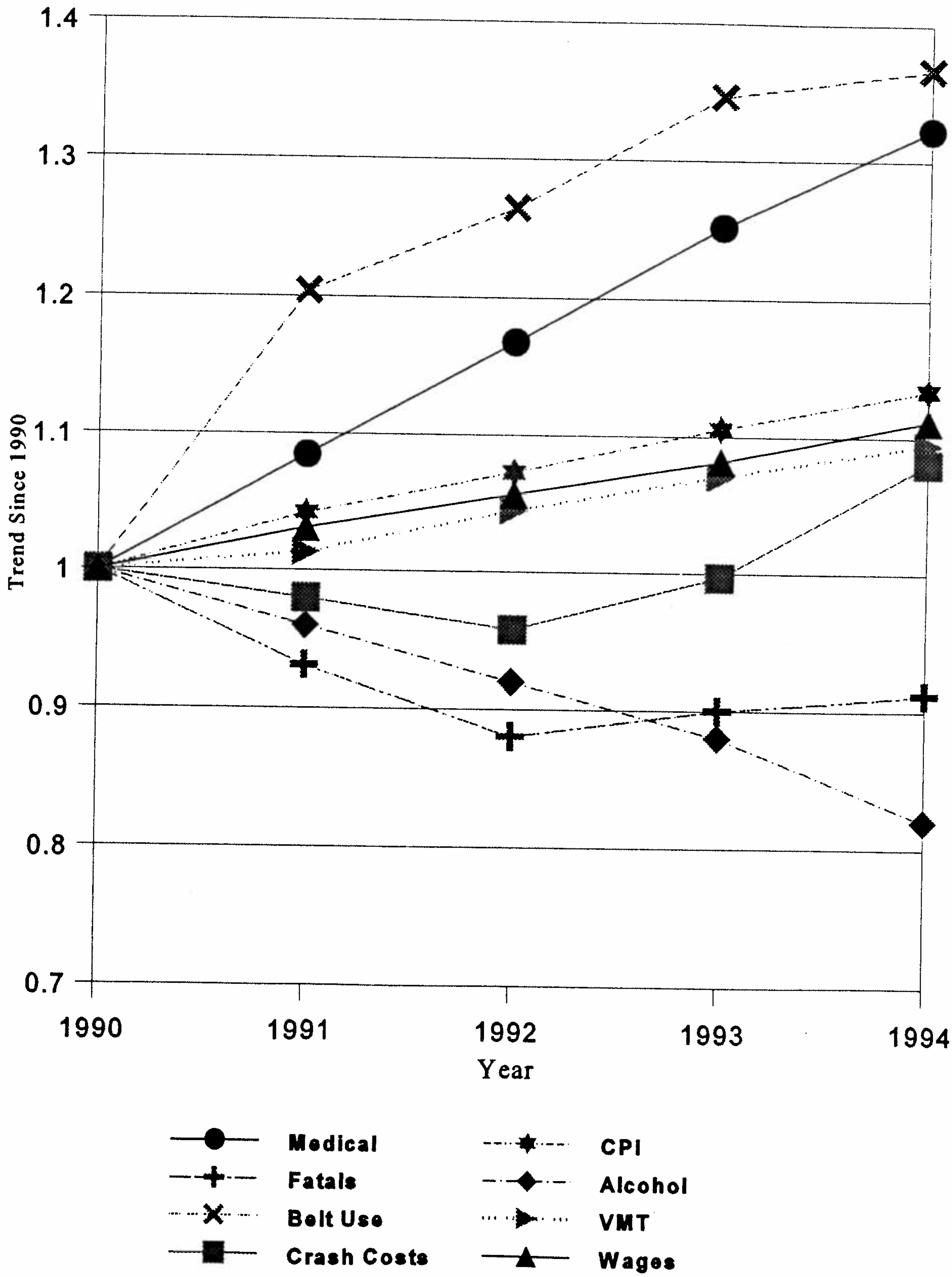


Table 19a
Weights and Factors for Trend Analysis

	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	FATAL
Weights								
CPI	87.50%	85.65%	58.56%	28.42%	25.60%	22.48%	16.18%	12.60%
Med.	0.00%	0.08%	11.59%	20.98%	24.27%	40.33%	46.73%	1.27%
Wage	12.50%	14.27%	29.85%	50.59%	50.13%	37.18%	37.09%	86.14%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Factors								
1990	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1991	0.9991	0.9991	1.0041	0.9596	0.8011	0.6407	0.9276	0.9718
1992	1.0208	1.0210	1.0324	0.7527	0.6551	0.6995	1.4585	0.9510
1993	1.0710	1.0714	1.0898	0.6342	0.8371	0.8434	1.2058	1.0079
1994	1.1308	1.1313	1.1562	0.6842	1.1367	0.9092	1.2617	1.0523
1995	1.1991	1.1996	1.2289	0.7234	1.2031	0.9673	1.3446	1.1038

Table 19b
Trend Analysis Results

	PDO	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**FATAL**	**TOTAL**
1990	$35,183	$3,260	$28,440	$16,493	$15,684	$4,108	$3,867	$32,157	$139,192
1991	$34,385	$3,704	$29,103	$19,410	$12,226	$2,776	$3,587	$31,252	$136,444
1992	$35,132	$3,785	$29,922	$15,226	$9,999	$3,031	$5,641	$30,582	$133,317
1993	$36,861	$3,972	$31,585	$12,828	$12,776	$3,654	$4,663	$32,410	$138,749
1994	$38,919	$4,194	$33,510	$13,839	$17,349	$3,939	$4,879	$33,839	$150,469
Predicted 1994	$39,785	$3,689	$32,881	$11,284	$17,829	$3,735	$4,879	$33,839	$147,921
Ratio	1.022	0.879	0.981	0.815	1.028	0.948	1.000	1.000	
% Error	2.23%	-12.06%	-1.88%	-18.46%	2.76%	-5.17%	0.00%	0.00%	
	$38,919	$4,194	$33,510	$13,839	$17,349	$3,939	$4,879	$33,839	
Predicted 1995	$41,271	$4,448	$35,619	$14,633	$18,362	$4,191	$5,200	$35,494	$159,217
% CH. 1995/1994	1.0604	1.0603	1.0629	1.0574	1.0584	1.0639	1.0657	1.0489	1.0581

Table 20
Inputs for Figure 7 and Trend Algorithm

Inputs

Year	Medical Per Capita	CPI All Items	Total Comp.	Fatals % Alcohol	% Belt Use	VMT (Billions)	Fatals	GES Injuries	Crash Costs (Millions)
1990	2,105.2	130.7	$107.0	0.5	0.49	2,144	44,599	3,231,000	$139,192
1991	2,283.7	136.2	$111.7	0.48	0.59	2,172	41,508	3,097,000	$136,444
1992	2,459.8	140.3	$115.6	0.46	0.62	2,240	39,250	3,070,000	$133,317
1993	2,635.4	144.5	$119.8	0.44	0.66	2,297	40,150	3,125,000	$138,749
1994	2,785.9	148.2	$123.5	0.41	0.67	2,347	40,676	3,215,000	$150,469
Index 1990 = 1									
1990	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1991	1.085	1.042	1.044	0.960	1.204	1.013	0.931	0.959	0.980
1992	1.168	1.073	1.080	0.920	1.265	1.045	0.880	0.950	0.958
1993	1.252	1.106	1.120	0.880	1.347	1.071	0.900	0.967	0.997
1994	1.323	1.134	1.154	0.820	1.367	1.095	0.912	0.995	1.081

Inputs, Continued

	MAIS2	MAIS3	MAIS4	MAIS5
1990	305,169	87,812	14,028	3,446
1991	278,378	66,779	8,479	3,008
1992	209,421	52,301	8,806	4,486
1993	169,273	64,022	10,114	3,524
1994	176,355	83,878	10,473	3,535
Index 1990 = 1				
1990	1.000	1.000	1.000	1.000
1991	0.912	0.760	0.604	0.873
1992	0.686	0.596	0.628	1.302
1993	0.555	0.729	0.721	1.023
1994	0.578	0.955	0.747	1.026

The net impact of all these factors was an overall decline in both fatalities and crash costs in 1991 and 1992. Fatalities then edged back up in 1993 and again in 1994, to a level roughly 9 percent lower than the 1990 level. Spurred by inflation in medical care and other cost categories, the cost of motor vehicle crashes rose in 1993 to a level roughly equal to the 1990 cost. In 1994, costs rose again to a level 8.1 percent above 1990.

The estimated costs for 1990-94 in Table 20 were expressed in the economic terms of each specific year. They thus reflect inflationary factors as well as real increases in costs due to changes in incidence or the nature of costs incurred. The "real" trend in costs can be examined by removing the impact of increases in the overall cost of living from earlier years estimates. This was done using the Implicit GDP Price Deflator to adjust these estimates. Table 21 lists the adjustment factors and results of this calculation. Although absolute costs have risen since 1990, real costs have declined.[6] The real decline primarily reflects the lower incidence of fatalities, injuries, and damaged vehicles that occurred compared to 1990, whereas the increase in absolute costs was primarily driven by inflation.

Mitigation of Inflationary Impacts

By substituting 1 for f_n in the formula discussed previously, an estimate can be made of the percent change that would have occurred if the incidence of crashes and injuries had remained the same as in 1990. This is essentially the same as substituting the corrected 1990 incidence for the 1994 incidence and recalculating 1994 costs. This yields a predicted 1994 cost of $161.8 billion, an increase of $22.6 billion or 16.2 percent over 1990 costs. This represents the potential impact of inflation on crash costs over this time period if there were no change in the incidence of motor vehicle crashes. As noted previously, the actual rise in costs was only $11.3 billion or 8.1 percent. Improved driving habits, roadways and motor vehicles safety features have thus cut the expected impact of inflation on 1994 motor vehicle crash costs by 50 percent, and saved $11.3 billion in economic costs.

Savings from Reduced Injury Rates

The rate of fatal and nonfatal injury as a function of driving exposure (VMT) has declined steadily for over two decades. A variety of improvements in motor vehicles, roadways and driving behavior are responsible for this trend. In 1990, the fatality rate per 100 million VMT was 2.1 and the police reported injury rate was 151. By 1994, these rates had declined to 1.7 and 137 respectively. A more comprehensive way to view the impact of safety improvements is to

[6]Note that the GDP deflator factors out inflation in overall price levels. The specific market basket of costs associated with motor vehicle crashes has increased by more than the general level of inflation (16.2% based on 1990 incidence). An even larger decline in real costs would be indicated if adjustments were based on each years actual crash cost profile.

compare costs to what they would have been had no safety improvements occurred while driving continued to increase. To accomplish this, the fatality and police-reported injury rate per 100 million VMT (from Table 4) were applied to actual VMT from 1991-1994. The resulting estimates for fatals and injuries are shown in Table 22. These numbers were substituted for actual incidence in the method described under Trends and Causes. This produced an estimate of $180.2 billion. Improved safety has thus reduced the potential economic impact of motor vehicle crashes in 1994 by $29.7 billion, a 16.5 percent reduction from the cost level that would have resulted from 1990 injury rates.

Outlook for 1995

Since preliminary 1995 data are now available for the variables used in this trend analysis, a preliminary estimate of 1995 costs can be made. Applying the cost estimating algorithm to 1995 data yields an estimate of $159.2 billion, roughly 5.8 percent higher than 1994. This reflects inflationary increases of 5.5 percent in medical costs, 2.2 percent in total wage compensation and 2.8 percent in consumer prices, as well as increases in injury incidence of 3.2 percent in police-reported nonfatal injuries, and 2.5 percent in fatalities.

Table 21
Estimated Trend in Crash Costs, 1994$

	GDP Deflator	Adj. Factor	Current Dollars	1994 $
1990	113.3	1.113	$139,192	$154,918
1991	117.6	1.072	$136,444	$146,306
1992	120.9	1.043	$133,317	$139,051
1993	123.5	1.021	$138,749	$141,670
1994	126.1	1.000	$150,469	$150,469

Table 22
Predicted CDS Survivors Based on 1990 VMT

	MAIS2	MAIS3	MAIS4	MAIS5	Fatals	Injuries
1990	305,169	87,812	14,028	3,446	44,599	3,231,000
1991	282,014	67,651	8,590	3,047	45,181	3,273,196
1992	218,798	54,643	9,200	4,687	46,596	3,375,672
1993	181,353	68,591	10,836	3,775	47,782	3,461,570
1994	193,053	91,820	11,465	3,870	48,822	3,536,920

Table 23
Summary of Total Cost Estimates Used in Trend Analysis
(Dollar Estimates in Billions of Current Dollars)*

	Total Cost	Difference From 1994 Cost	% Diff. From 1994 Cost	% Diff. From 1990 Cost	1994 % Diff. From Adjusted Cost
Original 1990 estimate	$137.5	NA	NA	NA	NA
Revised 1990 estimate/	$139.2	($11.3)	-7.5%	0.0%	8.1%
1994 Costs	$150.5	$0.0	0.0%	8.1%	0.0%
1994 Incidence adj. for inflation	$145.6	($4.9)	-3.2%	4.6%	3.3%
1994 costs @ 1990 corrected incidence	$161.8	$11.3	7.5%	16.2%	-7.0%
1994 costs @ incidence adj for 1990 VMT	$180.2	$29.7	19.7%	29.4%	-16.5%
1995 preliminary cost estimate	$159.2	$8.7	5.8%	14.4%	-5.5%

*Current dollars refers to the year specified in each row. Thus a 1990 estimate is in 1990 dollars and a 1994 estimate is in 1994 dollars.

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 more intangible consequences of these events to individuals and families such as pain, 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 risky occupations and purchases of products for improvements in safety among 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 $2-5 million per life saved.

An estimate of "comprehensive costs", which combines both economic costs and values for "intangible" consequences was made based on a comprehensive analysis previously undertaken by Miller (1991). These estimates, updated to 1994 economics, are summarized in Table A-1.

Table A-1
Comprehensive Fatality and Injury Costs

Injury Severity	1994 Values*
MAIS1	$10,840
MAIS2	$133,700
MAIS3	$472,290
MAIS4	$1,193,860
MAIS5	$2,509,310
Fatal	$2,854,500

*Includes the economic cost components from this report and a valuation for reduced quality of life.

APPENDIX B

DEFINITIONS OF ECONOMIC COSTS

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

Emergency Services: The cost of ambulance or helicopter EMS transport and care, as well as police and fire department response costs.

Vocational Rehabilitation: The cost of job or career retraining needed due to disability caused by motor vehicle injuries.

Market Productivity: The present discounted value (at 4 percent discount rate) of lost wages and fringe benefits over the victims remaining life span.

Household Productivity: The present value of lost productive household activity, valued at the market price to hire someone else to accomplish these tasks.

Insurance Administration: The administrative costs associated with processing insurance claims resulting from motor vehicle accidents.

Workplace Cost: The cost of workplace disruption due to the loss or absence of an employee. Includes the cost of retraining new employees, overtime needed to accomplish work of injured employee, and administrative costs of processing personal changes.

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

Premature Funeral Cost: The present discounted value of paying for a funeral in the present instead of at the end of the victim's normal expected lifespan.

Travel Delay: The value of travel time delay for persons who are not involved in traffic crashes, but who are delayed in traffic congestion caused by these crashes.

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

APPENDIX C

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. Since the mid-1980's the savings rate has only totalled about four percent 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 the social rate of time preference is between zero and 6 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, which they characterize as being consistent with financial market rates for the period covered by their study. Moore and Viscusi's estimate was derived by estimating the implicit discount rate for deferred health benefits exhibited by workers in their choice of job risk.

With the exception of Moore and Viscusi, the basis for most estimates of the social rate of time preference has been historical rates of return on investment opportunities. Readily accessible instruments such as 3-month Treasury bills and common stocks are usually considered the most appropriate measure. Past performance by these instruments is taken as a proxy for the rate of time preference in future years, and this in itself causes uncertainty about the accuracy of any rate selected on this basis. This uncertainty would be mitigated to some extent if past rates showed some reasonable measure of consistency, but this does not appear to be the case.

Tables C-1 and C-2 show estimates of the real after tax rate of return on stocks and three month Treasury bills. An examination of the last three columns in either table indicates that there is considerable variation from year to year, and that the time period on which any estimate is based can have a significant influence on the results. For example, an estimate made in 1985 based on the performance of the stock market that year would use a 10.7 percent rate. Based on the previous 5 years, a 4.7 percent rate would be chosen, and based on the previous 10 years, a 1.9 percent rate would be used. As it turned out, the average real rate of return over the following 5 years was 8.1 percent.

Long-term cumulative averages show a similar variation. For the 51 years from 1940-1990, real rates of return averaged 4 percent. As the period examined decreases, returns rise slightly but then dip to a low of 1.5 percent for the 21 years from 1970-1990. During the last decade, returns have averaged 5.6 percent and during the last 6 years, they have averaged 8.1 percent.

Treasury bills show considerably more stability than stocks. Although individual years can show significant variation, historically they have given average negative returns of less than one percent for most cumulative periods since 1945. Since 1980 cumulative returns have been positive but modest. Treasury bills are a relatively conservative investment and it appears that investors in Treasury bills are willing to accept real returns that essentially maintain their current wealth rather than increase it. The higher rates of return that are available from stocks are reflected in consumer investment patterns. Individuals invest roughly five times as much money in stocks and mutual funds as they do in Treasury bills.

Another problem with using historical rates of return as a proxy for the marginal rate of time preference is that actual inflation rates may not match expected rates. Lind (1982) noted that if the individual systematically understates the rate of inflation, as he might do in a period of rapidly rising inflation rates, the actual real rates of return will understate his marginal rate of time preference. From the mid - seventies through the early eighties, inflation was generally much higher than in previous times. For this time period, real rates of return on stocks and

Treasury bills were negative. In the mid - 1980's, after a decade of higher inflation rates, inflation began to return to more modest levels. In this type of scenario investors would be expected to overestimate inflation. As a result of this, and the sustained radical growth in stocks during the mid to late 1980's, actual real rates of return may have overstated the real rate of time preference during that period.

The best way to address these concerns is to examine rates over a long period of time. This allows temporary fluctuations to offset each other and gives less weight to isolated fluctuations that are not balanced out by cyclical response. The long-term cumulative average rates for stocks are in the 2-5 percent range, and the average rate of return for Treasury Bills appears to be zero or slightly negative. These rates are consistent with Lind's 1982 estimate of 0-6 percent and Kolb and Scheraga's 1988 estimate of 1-5 percent.

This analysis will be based on a discount rate of 4 percent. Four percent was chosen because most long-term cumulative rates of return on stocks cluster around that number. As previously noted, investors seem to prefer the higher, although riskier, returns from stocks over the more conservative Treasury Bills by a significant margin. Four percent is a mid to slightly conservative selection within the range of estimates that have been derived from the analysis described in this Appendix and from other analyses.

Table C-1
Real After-Tax Return on Stocks, 1940-1990

Year	Dividend Yield (%)	S&P 500 Index	S&P 500 Index Percent Change	CPI	Percent Change	Total Marg. Tax Rate	Real After-tax Return	5-Year Moving Average	10-Year Moving Average	Cumul. Average to 1990
1939		12.06		41.6						
1940	5.59	11.02	-0.086	42.0	0.010	0.087	-0.037			0.040
1941	6.82	9.82	-0.109	44.1	0.050	0.138	-0.081			
1942	7.24	8.67	-0.117	48.8	0.107	0.226	-0.128			
1943	4.93	11.50	0.326	51.8	0.061	0.296	0.191			
1944	4.86	12.47	0.084	52.7	0.017	0.300	0.074	0.004		
1945	4.17	15.16	0.216	53.9	0.023	0.308	0.152	0.042		0.044
1946	3.85	17.08	0.127	58.5	0.085	0.261	0.034	0.065		
1947	4.93	15.17	-0.112	66.9	0.144	0.261	-0.166	0.057		
1948	5.54	15.53	0.024	72.1	0.078	0.207	-0.014	0.016		
1949	6.59	15.23	-0.019	71.4	-0.010	0.200	0.047	0.011	0.007	
1950	6.57	18.40	0.208	72.1	0.010	0.225	0.200	0.020	0.031	0.048
1951	6.13	22.34	0.214	77.8	0.079	0.261	0.115	0.037	0.051	
1952	5.80	24.50	0.097	79.5	0.022	0.282	0.087	0.087	0.072	
1953	5.80	24.73	0.009	80.1	0.008	0.280	0.041	0.098	0.057	
1954	4.95	29.69	0.201	80.5	0.005	0.255	0.180	0.125	0.068	
1955	4.08	40.49	0.364	80.2	-0.004	0.261	0.304	0.146	0.083	0.037
1956	4.08	46.62	0.151	81.4	0.015	0.269	0.124	0.147	0.092	
1957	4.35	44.38	-0.048	84.3	0.036	0.271	-0.038	0.122	0.105	
1958	3.97	46.24	0.042	86.6	0.027	0.270	0.031	0.120	0.109	
1959	3.23	57.38	0.241	87.3	0.008	0.279	0.187	0.122	0.123	
1960	3.47	55.85	-0.027	88.7	0.016	0.279	-0.010	0.059	0.102	0.024
1961	2.98	68.27	0.222	89.6	0.010	0.285	0.168	0.068	0.108	
1962	3.37	66.27	-0.029	90.6	0.011	0.289	-0.008	0.074	0.098	
1963	3.17	69.87	0.054	91.7	0.012	0.293	0.048	0.077	0.099	
1964	3.01	81.37	0.165	92.9	0.013	0.269	0.127	0.065	0.093	
1965	3.00	88.17	0.084	94.5	0.017	0.248	0.067	0.081	0.070	0.016
1966	3.40	85.26	-0.033	97.2	0.029	0.257	-0.027	0.042	0.055	
1967	3.20	91.93	0.078	100.0	0.029	0.295	0.048	0.053	0.063	
1968	3.07	98.69	0.074	104.2	0.042	0.247	0.035	0.050	0.064	
1969	3.24	97.84	-0.009	109.8	0.054	0.258	-0.034	0.018	0.041	
1970	3.83	83.22	-0.149	116.3	0.059	0.237	-0.136	-0.023	0.029	0.015
1971	3.14	98.29	0.181	121.3	0.043	0.228	0.116	0.006	0.024	
1972	2.84	109.20	0.111	125.3	0.033	0.230	0.072	0.011	0.032	
1973	3.06	107.40	-0.016	133.1	0.062	0.241	-0.049	-0.006	0.022	
1974	4.47	82.85	-0.229	147.7	0.110	0.250	-0.223	-0.044	-0.013	
1975	4.31	86.16	0.040	161.2	0.091	0.305	-0.031	-0.023	-0.023	0.034
1976	3.77	102.00	0.184	170.5	0.058	0.313	0.089	-0.028	-0.011	
1977	4.62	98.20	-0.037	181.5	0.065	0.291	-0.055	-0.054	-0.021	
1978	5.28	96.02	-0.022	195.4	0.077	0.304	-0.051	-0.054	-0.030	
1979	5.47	103.00	0.073	217.4	0.113	0.329	-0.024	-0.014	-0.029	
1980	5.26	118.80	0.153	246.8	0.135	0.347	-0.001	-0.008	-0.016	0.056
1981	5.20	128.10	0.078	272.4	0.104	0.358	-0.018	-0.030	-0.029	
1982	5.81	119.70	-0.066	289.1	0.061	0.347	-0.062	-0.031	-0.042	
1983	4.40	160.40	0.340	298.4	0.032	0.325	0.220	0.023	-0.016	
1984	4.64	160.50	0.001	311.1	0.043	0.324	-0.010	0.026	0.006	
1985	4.25	186.80	0.164	322.2	0.036	0.290	0.107	0.047	0.019	0.081
1986	3.49	236.30	0.265	328.4	0.019	0.308	0.185	0.088	0.029	
1987	3.08	286.80	0.214	340.4	0.037	0.273	0.136	0.127	0.048	
1988	3.64	265.80	-0.073	354.3	0.041	0.272	-0.065	0.071	0.047	
1989	3.45	322.80	0.214	371.3	0.048	0.272	0.127	0.098	0.062	
1990	3.48	333.60	0.033	391.4	0.054	0.272	-0.004	0.076	0.061	

Table C-2
Real After-Tax Return on 3-Month Treasury Bills

Year	3-monthT-bills	Real After-tax Return	5-Year Moving Average	10-Year Moving Average	Cumul. to 1990
1945	0.375	-0.020			-0.009
1946	0.375	-0.076			
1947	0.594	-0.122			
1948	1.04	-0.064			
1949	1.102	0.019	-0.053		
1950	1.218	-0.000	-0.049		-0.004
1951	1.552	-0.063	-0.046		
1952	1.766	-0.009	-0.024		
1953	1.931	0.006	-0.009	-0.033	
1954	0.953	0.002	-0.013	-0.033	
1955	1.753	0.017	-0.009	-0.029	-0.003
1956	2.658	0.004	0.004	-0.021	
1957	3.267	-0.011	0.004	-0.010	
1958	1.839	-0.013	-0.000	-0.005	
1959	3.405	0.016	0.003	-0.005	
1960	2.928	0.005	0.000	-0.005	-0.004
1961	2.378	0.007	0.001	0.002	
1962	2.778	0.009	0.005	0.004	
1963	3.157	0.010	0.009	0.005	
1964	3.549	0.013	0.009	0.006	
1965	3.954	0.012	0.010	0.005	-0.006
1966	4.881	0.007	0.010	0.005	
1967	4.321	0.002	0.009	0.007	
1968	5.339	-0.002	0.006	0.008	
1969	6.677	-0.004	0.003	0.006	
1970	6.458	-0.009	-0.001	0.004	-0.009
1971	4.348	-0.009	-0.005	0.003	
1972	4.071	-0.002	-0.005	0.002	
1973	7.041	-0.008	-0.006	0.000	
1974	7.886	-0.046	-0.015	-0.006	
1975	5.838	-0.047	-0.022	-0.012	-0.007
1976	4.989	-0.022	-0.025	-0.015	
1977	5.265	-0.026	-0.030	-0.017	
1978	7.221	-0.024	-0.033	-0.020	
1979	10.041	-0.041	-0.032	-0.023	
1980	11.506	-0.053	-0.033	-0.028	0.005
1981	14.029	-0.012	-0.031	-0.028	
1982	10.686	0.008	-0.024	-0.027	
1983	8.63	0.025	-0.015	-0.024	
1984	9.58	0.021	-0.002	-0.017	
1985	7.48	0.017	0.012	-0.011	0.010
1986	5.98	0.022	0.019	-0.006	
1987	5.82	0.006	0.018	-0.003	
1988	6.69	0.008	0.015	0.000	
1989	8.12	0.011	0.012	0.005	
1990	7.51	0.001	0.009	0.011	

APPENDIX D

Nonfatal Injury Unit Cost By Body Region, 1994 $											
	Medical	Voc. Rehab.	Household Productivity	Market Prod.	Workplace Cost	Travel Delay	Insurance Admin.	Legal Costs	(EMS)	Prop. Damage	Total
SCI											
MAIS 1	0	0	0	0	0	0	0	0	0	0	0
MAIS 2	0	0	0	0	0	0	0	0	0	0	0
MAIS 3	36425	207	17642	57940	3876	203	17358	11951	506	5771	151879
MAIS 4	698434	3406	116743	288841	5814	203	79586	59675	1151	8353	1262207
MAIS 5	822272	5511	113402	442065	6931	203	88798	59675	1171	8018	1548046
Brain											
MAIS 1	1381	13	705	2268	305	203	817	192	152	3263	9298
MAIS 2	6651	98	2700	8767	203		2672	1658	337	3356	28009
MAIS 3	24994	192	10925	35870	3445	203	10946	7317	506	5771	100168
MAIS 4	121996	229	18841	62553	4102	203	26781	22562	1151	8353	266771
MAIS 5	443224	199	66381	219908	8358	203	60521	59675	1171	8018	867658
Lower Extremity											
MAIS 1	1256	10	346	1054	253	203	542	138	152	3263	7217
MAIS 2	13915	98	4366	14055	1784	203	4591	3141	337	3356	45846
MAIS 3	40218	225	12186	39971	4185	203	13332	9336	506	5771	125935
MAIS 4	57764	197	17724	60052	5433	203	20015	15058	1151	8353	185949
MAIS 5	0	0	0	0	0	0	0	0	0	0	0
Upper Extremity											
MAIS 1	1066	23	623	1992	296	203	728	179	152	3263	8526
MAIS 2	8272	56	5292	17190	2005	203	4754	2580	337	3356	44044
MAIS 3	18020	113	11763	38621	3826	203	10977	7151	506	5771	96951
MAIS 4	0	0	0	0	0	0	0	0	0	0	0
MAIS 5	0	0	0	0	0	0	0	0	0	0	0
Trunk, Abdomen											
MAIS 1	1228	9	384	1196	267	203	566	155	152	3263	7422
MAIS 2	5781	210	2857	9118	1369	203	2692	1852	337	3356	27776
MAIS 3	17706	274	7114	23336	2740	203	7320	5084	506	5771	70055
MAIS 4	34463	316	10129	34208	3750	203	11717	9193	1151	8353	113482
MAIS 5	57964	360	13784	46681	4230	203	16876	13446	1171	8018	162732
Face, Other Head/Neck											
MAIS 1	1983	51	584	1881	275	203	783	183	152	3263	9359
MAIS 2	5570	58	3612	11747	1732	203	3272	2073	337	3356	31960
MAIS 3	22005	203	15928	52285	4464	203	14551	9078	506	5771	124993
MAIS 4	51304	44	14276	47759	4687	203	16544	12820	1151	8353	157142
MAIS 5	39473	244	39805	132890	8928	203	35398	21528	1171	8018	287657
Minor External											
MAIS 1	497	4	317	1008	172	203	468	108	152	3263	6190

REFERENCES

Association for the Advancement of Automotive Medicine. The Abbreviated Injury Scale 1985, Des Plaines IL: Association for the Advancement of Automotive Medicine, 1985.

Baker, Susan P. and Russell S. Fisher. "Alcohol and Motorcycle Fatalities." American Journal of Public Health, Washington, DC: American Public Health Association (APHA), 67:3, March 1977

Blincoe, LJ and Faigin, BM. The Economic Cost of Motor Vehicle Crashes, 1990. Washington, DC: U.S. Department of Transportation, NHTSA, DOT HS 807 876; 1992.

Blincoe, LJ and Luchter, S. The Economic Cost of Motor Vehicle Accidents. Washington, DC: U.S. Department of Transportation, NHTSA, DOT HS 806 342, January 1983.

Bowie, NN and Walz M. "Data Analysis of the Speed-Related Crash Issue." Auto & Traffic Safety Vol. 1, No. 2, Winter 1994, Washington, DC: U.S. Department of Transportation, NHTSA, 1994.

Committee on Injury Scaling. "The Abbreviated Injury Scale -- 1985 Revision." Des Plaines, IL: Association for the Advancement of Automotive Medicine, 1985.

Dischinger, Patricia C. and R. Adams Cowley. "Alcohol Use Among Victims of Vehicular Crashes Admitted to a Level I Trauma Center." 33rd Proceedings of the Association for the Advancement of Automotive Medicine, Des Plaines, IL: AAAM, October 1989.

Greenblatt, J., Merrin, M.B., Morganstein, D., Schwartz, S. National Accident Sampling System Nonreported Accident Survey Washington, DC: US Department of Transportation, NHTSA, DOT HS-902128, November 1981.

Harris, Joan S., Source of Payment for the Medical Cost of Motor Vehicle Injuries in the United States, 1990, Washington, DC: US Department of Transportation, NHTSA, DOT HS 807800, January 1992.

Hensler, DR, Marquis, MS, Abrahamse, AF, Berry, SH, Ebener, PA, Lewis, EG, Ling, EA MacCoun, RJ, Manning, WG, Rogowski, JA, and Vaiana, ME. Compensation for Accidental Injuries in the United States, Report R-3999-HHS/ICJ, Santa Monica CA: RAND, 1991.

Johnson, Sandra W., and Walker, Johathan, NHTSA Technical Report: The Crash Outcome Evaluation System (CODES). DOT HS 808338. Washington, DC; National Hightay Traffic Safety Administration, January 1996.

Kakalik, JS and Pace, NM. Costs and Compensation Paid in Tort Litigation, Report R-3391-ICJ, Santa Monica CA: RAND, 1986.

Kakalik, JS and Pace, NM. Costs and Compensation Paid in Tort Litigation, Report R-3391-ICJ, Santa Monica CA: RAND, 1986.

Klein, T.M. A Method for Estimating Posterior BAC Distributions for Persons Involved in Fatal Traffic Accidents, DOT HS 807094, Washington, DC: NHTSA; 1986.

Maull, Kimball I., Linda S. Kunning, and Julian K. Hickman. "Culpability and Accountability of Hospitalized Injured Alcohol-Impaired Drivers." Journal of the American Medical Association (JAMA), 252:14, October 12, 1984.

Miller, Ted R. "Costs and Functional Consequences of U.S. Roadway Crashes, AAP, v 25, No. 5, Torytown, NY, 593-607, October 1993.

Miller, TR and Blincoe, LJ. "Incidence and Cost of Alcohol-Involved Crashes in the United States," AAP, V26, No. 5, Irvine CA, 583-591, 1994.

Miller, Ted R., D. Lestina, M. Galbraith, T. Schlox, P. Mabey, R. Deering D. Morsie and K Cambell. "Understanding the Harm from U.S. Motor Vehicle Crashes" 39th Annual Proceedings, AAAM, Des Plaines, ILL., 327-342, 1995.

Miller, TR. Costs of Injuries to Employers: A NETS compendium, (2 volumes), Washington DC: NHTSA, 1993b.

Miller, Ted R., Viner, JG, Rosman, SB, Pindus, NM, Gellert, GW, Douglass, JB, Dillingham, AE, and Plomquist, GC. The Costs of Highway Crashes, Washington DC: The Urban Institute, 1991.

Miller, Ted R., "Societal Cost of Transportation Crashes" Presentation at Bureau of Transportation Statistics Conference on Measuring the Full Social Costs and Benefits of Transportation, Irvine California. July 6-8, 1995.

Miller, Ted R. and M. Galbraith, Traffic Safety and Health Care: State and National Estimates of Employer Costs. DOT HS 808234, Washington, DC June 1995.

National Center for Health Statistics (NCHS). "Current Estimates from the National Health Interview Survey." Vital and Health Statistics Series 10. Washington, DC: U.S. Department of Health and Human Services (USDHHS), annual.

National Council on Compensation Insurance. 1985 Insurance Expense Exhibit, Boca Raton FL: NCCI, 1989.

Newhouse, JP. Medical Care Costs: How Much Welfare Loss?, Journal of Economic Perspectives, 6(3):3-21, 1992.

NHTSA. "Fatal Accident Reporting System, 1994." Washington, DC: NCSA, 1995a.

NHTSA. Final Regulatory Impact Analysis, Amendment to Federal Motor Vehicle Safety Standard 208, Passenger Car Front Seat Occupant Protection, Washington, DC: Office of Regulatory Analysis, July 1984.

NHTSA. "General Estimates System, 1994." Washington, DC: NCSA, 1995b.

NHTSA, Low-Threat-to-Life Motor Vehicle Injuries, a Profile of Motor Vehicle Injuries in Emergency Departments. DOT HS 808329, Washington, DC, September, 1995c.

NHTSA, Report to Congress in Benefits of Safety Belts and Motorcycle Helmets, Based on Data from the Crash Outcome Evaluation System (CODES). DOT HS 808347. Washington DC, February 1996.

Rice, DP and MacKenizie, E.J. Cost of Injury in the United States, A Report to Congress 1989. San Francisco, CA: Institute for Health and Aging, University of California and Injury Prevention Centers, The John Hopkins University, 1989.

Soderstrom, Carl A., J.M. Birshbach and P.C. Dischinger. "Injured Drivers and Alcohol Use: Culpability, Convictions, and Pre- and Post-Crash Driving History." The Journal of Trauma, 30:10, 1990.

Soderstrom, Carl A., P.C. Dishinger, and M.T. Soderstrom. "Alcohol Use, Driving Records, and Crash Culpability Among Injured Motorcycle Drivers." 35th Proceedings of the Association for the Advancement of Automotive Medicine, Des Plaines: IL: AAAM, October 1991.

Terhune, K.W. The Role of Alcohol, Marijuana and Other Drugs in the Accidents of Injured Drivers. Janaury 1982.

U.S. Bureau of the Census, Statistical Abstract of the United States: 1994 Washington DC: US Government Printing Office, 1994.

U.S. Bureau of the Census, Statistical Abstract of the United States: 1995 (115 the edition) Washington, DC, 1995.

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

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