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

NHTSA

DOT HS 813 403 February 2023

The Economic and Societal Impact of Motor Vehicle Crashes, 2019 (Revised)

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Suggested APA format citation:

Blincoe, L., Miller, T., Wang, J.-S., Swedler, D., Coughlin, T., Lawrence, B., Guo, F., Klauer, S., & Dingus, T. (2023, February). *The economic and societal impact of motor vehicle crashes, 2019 (Revised)* (Report No. DOT HS 813 403). National Highway Traffic Safety Administration.

A Note on the February 2023 Revision:

Shortly after initial publication of this report in December 2022, several modifications were added. These include 1) The insertion of a new Appendix H, Supporting Tables for QALY Values. 2) Modification to Table 5-2 to reflect percentages of QALYs lost per fatality instead of percentage of lifetime QALYs lost. The derivation of both tables is now discussed in the added Appendix H. 3) A correction to values in Table I-14. No conclusions or findings were affected by these changes.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 813 403		

4. Title and Subtitle	5. Report Date
The Economic and Societal Impact of Motor Vehicle Crashes, 2019 (Revised)	February 2023
	6. Performing Organization Code
7. Authors Lawrence Blincoe, Ted R. Miller, Ph.D., Jing-Shiarn Wang, M.S., David Swedler, Ph.D., Tristan Coughlin, Ph.D., Bruce Lawrence, Ph.D., Feng Guo, Ph.D., Sheila Klauer, Ph.D., Thomas Dingus, Ph.D.	8. Performing Organization Report No.
9. Performing Organization Name and Address National Center for Statistics and Analysis National Highway Traffic Safety Administration 1200 New Jersey Avenue SE Washington, DC 20590	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration 1200 New Jersey Avenue SE Washington, DC 20590	13. Type of Report and Period Covered NHTSA Technical Report 14. Sponsoring Agency Code

15. Supplementary Notes

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16. Abstract

In 2019 there were 36,500 people killed, 4.5 million people injured, and 23 million vehicles damaged in motor vehicle crashes in the United States. The economic costs of these crashes totaled $340 billion, including lost productivity, medical, legal and court costs, emergency service, insurance administration, congestion, property damage, and workplace losses. This is equivalent to $1,035 for each of the 328 million people living in the United States, and 1.6 percent of the $21.4 trillion real U.S. Gross Domestic Product in 2019. These figures include both police-reported and unreported crashes. When quality-of-life valuations are considered, the total value of societal harm from motor vehicle crashes in 2019 was nearly $1.4 trillion. Lost market and household productivity accounted for $106 billion of the $340 billion, while property damage accounted for $115 billion. Medical expenses totaled $31 billion. Congestion caused by crashes, including travel delay, excess fuel consumption, greenhouse gases, and criteria pollutants accounted for $36 billion. Each fatality resulted in an average discounted lifetime cost of $1.6 million in economic costs, and $11.3 million when quality-of-life valuations are considered. Public revenues paid for roughly 9 percent of all motor vehicle crash costs, costing taxpayers $30 billion in 2019, equal to $230 in added taxes for every household in the United States. Alcohol-involved crashes accounted for $69 billion or 20 percent of all economic costs. Alcohol was the cause of the crash in roughly 82 percent of these cases, causing $57 billion in costs. Distracted driving crashes cost $98 billion.

17. Key Words	18. Distribution Statement
economic, cost, harm, comprehensive cost, motor vehicle, crashes, accident, traffic, alcohol, speed, seat belts, distraction, helmet, motorcycle, congestion, travel delay, source of payment, fatalities, injuries, unreported crashes, property damage, pedestrian, bicyclist, interstate intersection, roadway departure	Document is available to the public from the DOT, BTS, National Transportation Library, Repository & Open Science Access Portal, https://rosap.ntl.bts.gov.

19. Security Classif. (Of this report)	20. Security Classif. (Of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	297	

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

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Executive Summary

In 2019 the total economic cost of motor vehicle crashes[1] in the United States was $340 billion. This represents the present value of lifetime economic costs for 36,500 fatalities, 4.5 million nonfatal injuries, and 23 million damaged vehicles. These figures include both police-reported and unreported crashes. Human capital costs represent the tangible losses that result from motor vehicle crashes. They define the value of resources that are used, or that would be required to restore crash victims, to the extent possible, to their pre-crash physical and financial status. These resources have been diverted from other more productive uses to merely maintain the status quo. These costs, which can be estimated through empirical measurements, include medical care, lost productivity, legal and court costs, insurance administrative costs, workplace costs, congestion impacts (travel delay, excess fuel consumption and pollution), and property damage.

However, in cases of serious injury or death, medical care cannot fully restore victims to their pre-crash status and human capital costs fail to capture the intangible value of lost quality-of-life that results from these injuries. In the case of death, victims are deprived of their entire remaining lifespan. In the case of serious injury, the impact on the lives of crash victims can involve extended or even lifelong impairment or physical pain, which can interfere with or prevent even the most basic living functions. These more intangible effects can be valued using studies that examine the willingness of consumers to pay to avoid risk of death or injury. Assessing the value of these impacts provides a more complete basis for quantifying the harmful impacts of motor vehicle crashes on society. When these quality-of-life valuations are considered, the total value of societal harm from motor vehicle crashes in 2019 was $1.37 trillion.

All costs in this report are expressed in year 2019 economics using a 3-percent discount rate. Nonfatal injury costs are stratified by severity level based on the Abbreviated Injury Scale (AIS),[2] but unit costs based on the KABCO scale commonly used in police reports are also supplied in an appendix. The cost components include productivity losses, property damage, medical costs, rehabilitation costs, congestion costs, legal and court costs, emergency services such as medical, police, and fire services, insurance administration costs, and the costs to employers. Values for more intangible consequences such as physical pain or lost quality-of-life are also examined in estimates of comprehensive costs, which include both economic cost components and quality-of-life valuations.

[1] Motor vehicle crashes includes all crashes that occur on roadways. It does not include off-road or parking lot crashes.

[2] The Abbreviated Injury Scale is an anatomically based, consensus-derived global severity scoring system that classifies each injury by body region according to its relative importance on a 6-point ordinal scale (1=minor and 6=maximal). AIS is the basis for the Injury Severity Score (ISS) calculation used for patients with more than one injury. The AIS was developed by the Association for the Advancement of Automotive Medicine (AAAM). See www.aaam1.org/ais/ for further information.

Economic Impact of Crashes

- The economic cost of motor vehicle crashes that occurred in 2019 totaled $339.8 billion (2019 $). This is equivalent to approximately $1,035 for every person living in the United States and 1.6 percent of the U.S. Gross Domestic Product.
- The lifetime economic cost to society for each fatality is $1.6 million. Over 90 percent of this amount is attributable to lost workplace and household productivity and legal costs.
- Each critically injured survivor (defined as MAIS5 on the AIS) cost an average of $979,000. Medical costs and lost productivity accounted for 81 percent of the cost for this most serious level of nonfatal injury.
- Lost workplace productivity costs totaled $75.5 billion, which equaled 22 percent of the total costs. Lost household productivity totaled $30.8 billion, representing 9 percent of the total economic costs.
- Total property damage costs for all crash types (fatal, injury, and property-damage-only [PDO]) totaled $115.3 billion and accounted for 34 percent of all economic costs.
- Property-damage-only (PDO) crashes (in which vehicles were damaged but nobody was injured) cost $101.3 billion and accounted for 29.8 percent of total economic motor vehicle crash costs.
- Present and future medical costs due to injuries occurring in 2019 were $30.9 billion, representing 9.1 percent of the total costs. Medical costs accounted for 18.3 percent of costs from nonfatal injuries.
- Congestion costs, including travel delay, added fuel usage, and adverse environmental impacts cost $36 billion, or 10.6 percent of total economic crash costs.
- Police-reported crashes account for 81 percent of the economic costs that occurs from traffic crashes. Crashes that are not reported to the police account for 19 percent of economic costs.
- Approximately 9 percent of all motor vehicle crash costs are paid from public revenues. Federal revenues accounted for 5 percent and States and localities paid for approximately 3 percent. An additional 1 percent is from programs that are heavily subsidized by public revenues, but for which the exact source could not be determined. Private insurers pay approximately 54 percent of all costs. Individual crash victims pay approximately 23 percent while third-parties such as uninvolved motorists delayed in traffic, charities, and health care providers pay about 14 percent. Overall, those not directly involved in crashes pay for roughly three-quarters of all crash costs, primarily through insurance premiums, taxes, and congestion-related costs such as travel delay, excess fuel consumption, and increased environmental impacts. In 2019 these costs, borne by society rather than by crash victims, totaled over $261 billion.

Incidence of Crashes

- Some 4.5 million people were injured in 14.2 million motor vehicle crashes in 2019, including 36,500 fatalities. Thirty-two percent of these injuries occurred in crashes that were not reported to police.
- About 22.9 million vehicles were damaged in motor vehicle crashes in 2019; some 19.3 million or 84 percent of these vehicles were damaged in incidents that incurred property damage only. The remaining 16 percent involved injuries to occupants of the vehicle, or to nonoccupants such as pedestrians or bicyclists.

- Approximately 60 percent of property-damage-only crashes and 32 percent of all injury crashes are not reported to the police. Unreported injury crashes tend to involve only minor or moderate injuries.

Alcohol Involvement in Crashes

- Alcohol-involved crashes resulted in 14,219 fatalities, 497,000 nonfatal injuries, and $68.9 billion in economic costs in 2019, accounting for 20 percent of all crash costs.
- Crashes involving drivers or nonoccupants with blood alcohol concentrations (BAC) of .08 grams per deciliter (g/dL) or higher (the legal definition of impairment in all States except Utah, which is .05 g/dL) accounted for 84 percent of the total economic cost of all alcohol-involved crashes.
- The impact of alcohol involvement increases with injury severity. Alcohol-involved crashes accounted for 14 percent of property-damage-only crash costs, 18 percent of nonfatal injury crash costs; and 39 percent of fatal injury crash costs.
- Although drinking drivers may experience impaired judgment, perceptions, and reaction times, not all crashes in which alcohol was present were caused by alcohol. Crashes in which alcohol was the cause resulted in 11,921 fatalities, 378,000 nonfatal injuries, and $57 billion in economic costs. This is approximately 84 percent of the alcohol-related fatalities and 82 percent of alcohol-related economic costs. It represents 33 percent of all fatalities and 17 percent of all costs from motor vehicle crashes.

Impact of Speed-Related Crashes

- Crashes in which at least one driver was exceeding the legal speed limit or driving too fast for conditions cost $46.4 billion in 2019.
- Speed-related crashes are associated with 10,192 fatalities, 498,000 nonfatal injuries and damage to 1.7 million vehicles in property-damage-only crashes. This represents 28 percent of all fatalities; 11 percent of all nonfatal injuries, and 9 percent of all property-damage-only crashes.
- Speed-related crashes cost an average of $141 for every person in the United States.

Seat Belt Use

- In 2019 seat belts prevented 14,653 fatalities and 450,000 serious injuries, saving $93 billion in medical care, lost productivity, and other injury-related costs.
- Seat belt non-use represents an enormous lost opportunity for injury prevention. In 2019 alone nearly 2,400 people were killed and 46,000 were seriously injured unnecessarily because they failed to wear their seat belts, costing society $11 billion.
- From 1975 through 2019 seat belts have prevented over 403,000 fatalities and 11.8 million serious injuries. This saved society $2.5 trillion in medical care, lost productivity, and other injury-related economic costs. During the same time period, over 390,000 additional fatalities and 7.1 million additional serious injuries could have been prevented by seat belts if all occupants had used them. This represents an economic loss of roughly $1.7 trillion in unnecessary expenses and lost productivity.

Distracted Driving Crashes

- Crashes in which at least one driver was identified as being distracted resulted in 10,546 fatalities, 1.3 million nonfatal injuries and damaged 5.6 million vehicles in property-damage-only crashes in 2019. These crashes cost $98.2 billion in 2019. This represents about 29 percent of all motor vehicle crashes and crash costs.

Societal Impacts of Crashes (Comprehensive Costs)

- The value of societal harm from motor vehicle crashes, which includes both economic impacts and valuation for lost quality-of-life, was $1.37 trillion in 2019. Seventy-five percent of this value represents lost quality-of-life, while 25 percent are economic impacts.
- The lifetime comprehensive cost to society for each fatality is $11.3 million. Eighty-six percent of this amount is attributable to lost quality-of-life.
- Each critically injured survivor (MAIS5) has comprehensive costs that average of $6.0 million. Lost quality-of-life accounted for 84 percent of the total harm for this most serious level of nonfatal injury.
- Alcohol-involved crashes resulted in $348 billion in comprehensive costs in 2019, accounting for 26 percent of all societal harm from motor vehicle crashes. Eighty-five percent of these costs occurred in crashes in which one driver had a BAC of .08 g/dL or greater.
- Although drinking drivers may experience impaired judgment, perceptions, and reaction times, not all crashes in which alcohol was present were caused by alcohol. Crashes in which alcohol was the cause resulted in $287 billion in societal harm in 2019. This represents 21 percent of all societal harm from motor vehicle crashes. Ninety-four percent of societal harm from crashes caused by alcohol occurs in crashes where drivers had BACs of .08 or greater.
- Crashes in which at least one driver was exceeding the legal speed limit or driving too fast for conditions caused $225 billion in comprehensive costs in 2019. This represents 16 percent of all societal harm from motor vehicle crashes.
- Crashes in which at least one driver was identified as being distracted caused $395 billion in comprehensive costs in 2019, causing roughly 29 percent of all societal harm from motor vehicle crashes.
- In 2019 seat belts prevented $667 billion in comprehensive costs to society. Over the last 45 years seat belts have prevented over $17.8 trillion in societal harm, resulting in lower economic costs to society and improved quality-of-life for millions motor vehicle occupants.

1. Introduction

In 2019 there were 36,500 people killed, 4.5 million injured, and 23 million vehicles damaged in motor vehicle crashes in the United States. The economic costs of these crashes totaled $339.8 billion. Included in these losses are medical costs, lost productivity, legal and court costs, emergency service costs (EMS), insurance administration costs, congestion costs, property damage, and workplace losses. The $340 billion cost of motor vehicle crashes represents the equivalent of $1,035 for each of the 328.2 million people living in the United States, and 1.6 percent of the $21.4 trillion real Gross Domestic Product for 2019. Aside from these economic impacts, motor vehicle crashes cause premature death and lost quality-of-life for those who survive the crashes with debilitating injuries. These impacts have quantifiable values that, when combined with economic impacts, produced societal harm from these crashes totaling $1.37 trillion in 2019.

All levels of society -- the individual crash victims and their families, their employers, and society at large -- are affected by motor vehicle crashes in many ways. The cost of medical care is borne by the individual in the form of payments for insurance, deductibles, uncovered costs, and uninsured expenses. It is borne by society through higher insurance premiums and through the diversion of medical resources away from other medical needs, such as medical research, disease prevention and control, and basic public health needs. There are also significant costs associated with the lost productivity experienced by an individual and others when the victim dies prematurely or experiences a short or long-term disability. The victim's dependents suffer immediate economic hardship in the loss of the victim's income and other contributions, while society is burdened by the necessity to support the victim or their dependents and through foregone contributions to the Nation's productivity. Aside from these economic consequences, victims suffer from physical pain, disability, and emotional impacts that can greatly reduce the quality of their lives.

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

Economic Impacts

Total economic costs are summarized in Table 1-1. The total economic cost of motor vehicle crashes in 2019 is estimated to have been $339.8 billion. Of this total, medical costs were responsible for $30.9 billion, property damage losses for $115.3 billion, lost productivity (both market and household) for $106.3 billion, and congestion impacts for $36 billion. All other crash-related costs totaled $51.4 billion.

The most significant costs were property damage and lost market productivity, which accounted for 34 and 22 percent, respectively, of the total economic costs in 2019. For lost productivity, these high costs are a function of the level of disability that has been documented for crashes involving injury and death. For property damage, costs are primarily a function of the very high incidence of minor crashes in which injury does not occur or is negligible. Medical care costs and emergency services (which include police and fire services) are responsible for about 9.5 percent of the total. Travel delay, added fuel consumption, and pollution impacts caused by congestion at the crash site accounts for 10.6 percent.

The value of lost household productivity (unpaid work performed at home such as cooking, child care, etc.) accounts for 9.1 percent of total costs. Legal and court costs account for 4.9 percent and insurance administration costs for 8.7 percent of the total. These costs are summarized in Tables 1-1, 1-2, and Figure 1-A. The incidence of injuries and crashes that produced these costs is summarized in Table 1-3.

Approximately 9 percent of all motor vehicle crash costs are paid from public revenues. Federal revenues accounted for 5 percent and States and localities paid for approximately 3 percent. An additional 1 percent is from programs that are heavily subsidized by public revenues, but for which the exact source could not be determined. Private insurers pay approximately 54 percent of all costs. Individual crash victims pay approximately 23 percent while third parties such as uninvolved motorists delayed in traffic, charities, and health care providers pay about 15 percent. Overall, those not directly involved in crashes pay for roughly three-quarters of all crash costs, primarily through insurance premiums, taxes and congestion-related costs such as travel delay, excess fuel consumption, and increased environmental impacts. In 2019 these costs, borne by society rather than by crash victims, totaled $261 billion. Figure 1-B illustrates these cost distributions.

From Table 1-3, nearly 60 percent of all PDO crashes and about 32 percent of all nonfatal injury crashes are not reported to police. However, analyses of safety countermeasures frequently rely only on police-reported incidence data. Crashes that get reported to police are likely to be more severe than unreported crashes because vehicles are more likely to require towing and occupants are more likely to require hospitalization or emergency services. These crashes are typically also likely to require more time to investigate and clear from roadways than unreported crashes. Analysis based solely on police-reported crashes should thus be based on unit costs that are specific to police-reported crashes. For injury-related costs, this is automatically accounted for by the shift in the injury severity profile. Unreported crashes have a lower average severity profile than do reported crashes. However, for non-injury-related cost components – property damage and congestion costs – there is no profile to shift. In addition, police-reported crashes have higher response rates for emergency services.

For this report costs specific to police-reported and unreported crashes have been developed. The results of this analysis are presented in Tables 1-4, to 1-7. The differences seem negligible at the more severe injury levels due to the overwhelming costs of factors such as lost productivity and medical care that do not vary by reporting status, except through the shift in injury profiles. However, at lower severity levels the unit costs are significant. Injury severity is categorized using the maximum injury level recorded for each victim under the Abbreviated Injury Scale (MAIS). For PDO vehicles and MAIS0 (uninjured) cases, police-reported crashes have costs that are three times those of unreported crashes. For minor (MAIS1) injuries, reported crashes cost 80 percent more than unreported crashes. These ratios decline as injury severity increases to only 16 percent for MAIS2 injuries and 7 percent for MAIS3 injuries. Note that for MAIS4s, MAIS5s, and fatalities, property damage costs are identical under both reported and unreported cases. Virtually all injuries at these levels are believed to be reported to police, and the original property damage cost estimate is thus assumed to represent police-reported cases. These same costs are thus listed under both scenarios.

Figure 1-C shows the proportion of each cost category that is accounted for by police-reported crashes. For most categories, the portions vary due to the differing proportions incidence across the various injury levels. For congestion, property damage, and emergency services, differing

unit costs are involved as well. Overall, police-reported crashes are estimated to account for 81 percent of the economic costs that are incurred from traffic crashes.

Alcohol consumption remains a major cause of motor vehicle crashes; 2019 data show that alcohol-involved crashes declined slightly in incidence. Historically, approximately half of all motor vehicle fatalities have occurred in crashes where the drivers or nonoccupants had been drinking, but this number has gradually declined in recent years to about 36 percent in 2010, and to 33 percent in 2019. Alcohol is involved in crashes that account for 20 percent of all economic costs, with 86 percent of these costs involving crashes in which a driver or nonoccupant had a BAC or breath alcohol content (BrAC) of .08 g/dL or higher, the legal definition of impairment for drivers in 49 of the 50 States.

The report indicates that while alcohol-involved crashes are more costly than in 2010, they account for a smaller portion of the overall crash cost. This likely reflects the impact of efforts at Federal, State, and local levels to reduce the incidence of drunk driving. The report also estimates the portion of alcohol-involved crash costs that were actually caused by impaired driving. Although drivers under the influence of alcohol may experience impaired judgment, perceptions and reaction times, not all crashes in which alcohol was present were caused by alcohol. For example, a driver with a BAC of .04 g/dL could be stopped at a light and run into by a texting driver. Crashes caused by alcohol accounted for 82 percent of all economic costs from crashes where at least one driver or nonoccupant had been drinking. The portion attributable to alcohol rises dramatically as BAC increases, with only 6 percent attribution at low BAC levels (BAC=.01 to .04), but 94 percent attribution at legally impaired (illegal per se) levels (BAC>=.08). Crashes caused by legally impaired drivers with BACs in excess of .08 g/dL account for over 90 percent of the economic and societal harm that results from all alcohol caused crashes.

This report also analyzes the impact of seat belt use as well as the cost the Nation incurs from failure to wear seat belts. Over the last 45 years, seat belts have prevented over 400,000 fatalities and 11.8 million serious nonfatal injuries, which saved $2.5 trillion in economic costs (in 2019 dollars, designated as 2019 $). During this same period, the failure of a substantial portion of the driving population to wear belts caused 390,000 unnecessary deaths and 7 million nonfatal injuries, costing the Nation $1.7 trillion in preventable medical costs, lost productivity, and other injury-related expenditures.

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

This report focuses on "average" costs for injuries of different severity. While this approach is valid for computing costs at a nationwide level, the costs of individual cases at different injury levels can vary quite dramatically. The average costs outlined in this report are significant;

however, in individual cases they can be exceeded by a factor of three or more. There is considerable evidence to indicate that the most serious injuries are not adequately covered by insurance. Depending on the financial ability and insurance coverage of the individual crash victims, the medical and rehabilitation costs, as well as the loss in wages resulting from serious injury, can be catastrophic to the victim's economic wellbeing in addition to their physical and emotional condition.

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

Societal Impacts

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

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

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

This report measures societal harm as well as economic cost impacts from motor vehicle crashes. The economic impact of motor vehicle crashes – the societal losses that can be directly measured in economic terms, represent one level of impact. However, these costs do not represent the more intangible consequences of these events and should not, therefore, be used alone to produce cost-benefit ratios. Measurement of the dollar value of intangible consequences such as pain and suffering has been undertaken in numerous studies. These studies have estimated values based on wages for high-risk occupations and prices paid in the marketplace for safety products, among other measurement techniques. These "willingness to pay" based estimates measure how society values risk reduction and capture valuations not associated with direct monetary consequences. Most researchers agree that the value of fatal risk reduction falls in the range of $5 to $15 million per life saved. In this study, comprehensive costs, which include both the economic impacts of crashes and valuation of lost quality-of-life, are also examined. Comprehensive costs represent the value of the total societal harm that results from traffic crashes. The basis for these estimates is guidance issued by the U.S. Department of Transportation for valuing mortality risk reduction that established a value of a statistical life for U.S.DOT analyses of $10.9 million in 2019 dollars.

This study also establishes new relative disutility factors stratified by injury severity level to estimate the lost quality-of-life for nonfatal injuries. These factors were derived in a research contract designed specifically for this current cost study. In this report, values related to lost quality-of-life are referred to as quality adjusted life years (QALYs). Discussion of comprehensive costs is included in more detail in Chapter 5 of this report. The total societal harm from motor vehicle crashes as measured by comprehensive costs, is shown in Tables 1-4 and 1-5, and Figure 1-C.

From Table 1-8 the total societal harm from motor vehicle crashes in 2019 is estimated to have been $1.37 trillion, nearly four times the value measured by economic impacts alone. Of this total, 75 percent represents lost quality-of-life, dwarfing the contribution of all other cost categories. This highlights the importance of accounting for all societal impacts when measuring costs and benefits from motor vehicle safety countermeasures. However, the literature on VSL estimates indicates a wide range of measured estimates of VSLs – some as low as a few million dollars, some as high as over $30 million. The U. S. DOT guidance memorandum (U.S. Department of Transportation, 2021) discusses a wide feasible range of VSLs that were used to produce the central recommended values. There is thus far more uncertainty regarding the accuracy of estimates of lost quality-of-life than there is regarding economic costs. The DOT guidance update recommends sensitivity analysis VSLs of plus and minus 40 percent of the central VSL. In Appendix A comprehensive costs are estimated based on this range. The results indicate a feasible range of societal harm from motor vehicle crashes of from $869 billion to $1.76 trillion in 2019, with lost quality-of-life accounting for between 62 and 81 percent of all societal harm respectively.

Table 1-9 lists the comprehensive unit cost of crashes for both reported and unreported crashes. The cost of a fatality is valued at $11.3 million while the most serious injuries have costs ranging from $2-6 million. Tables 1-10 to 1-13 examine the total comprehensive costs of police-reported and unreported crashes. Roughly 87 percent of aggregate societal harm from motor vehicle crashes occurs in police-reported crashes. This is somewhat higher than the 81 percent for economic costs. The difference is due to the impact of quality-of-life valuations on fatalities and the most serious injuries (MAIS4+), which are all police-reported.

Changes From 2010

NHTSA last examined the cost of motor vehicle crashes in 2015 (Blincoe et al., 2015). At that time the report was based on 2010 data. This current report indicates a total cost from traffic crashes in 2019 of $340 billion, approximately 40 percent higher than our previous estimate of $242 billion in 2010. The difference in these estimates is attributable to a number of factors including inflation, which accounts for an overall rise in the cost of goods and services of approximately 17 percent, shifts in the severity of crashes and the nature of injury outcomes, and a revised basis for measuring unit costs. In addition, although the 2019 fatality rate per VMT is unchanged from 2010 the incidence of fatalities and injuries has increased, reflecting added driving exposure, in part related to increased economic activity. In 2019 there were 36,500 fatalities in motor vehicle crashes, an increase of 11 percent from 2010. A portion of this increase is due to the current inclusion of 145 cases where death occurred outside the 30-day limit used for NHTSA's Fatality Analysis Reporting System (FARS). The 2010 report reflected FARS counts only. The number of nonfatal injuries estimated for 2019 increased by 13 percent. This reflects a small increase in police-reported injuries as well as an adjustment made in this report to account for some unreported injuries that were not captured in the unreported survey NHTSA had previously conducted. This adjustment affected only the less severe injury categories, which are more likely to go unreported. Additional factors that affected incidence include revised KABCO/MAIS translators (used to determine abbreviated injury scale injury equivalents from police reports), an updated basis for the abbreviated injury scale (MAIS2015) that shifted some injury categories, and new and more accurate NHTSA data base revisions (CISS and CRSS replacing CDS and GES). Finally, property damage costs increased significantly over 2010, reflecting the ongoing shift in the on-road vehicle fleet toward more expensive light trucks and SUVs and away from less expensive passenger sedans. More recent vehicles also have more safety equipment such as multiple air bags which must be replaced after crashes.

Comprehensive costs, which reflect lost quality-of-life as well as economic impacts, were also impacted by shifts in the basis for determining these values. The value of a statistical life (VSL) used in this report reflects a re-examination of this issue by U.S. Department of Transportation that resulted in increasing the VSL by 23 percent over the 2010 basis. Moreover, as part of this report we have revised the values used to measure lost quality-of-life for nonfatal injuries to reflect more accurate and recent data sources. The results vary by injury severity, but overall, lost quality-of-life for injuries increased at most severity levels.

The specifics of these changes are described in the body of this report.

Overview

Table 1-14 summarizes both the economic and comprehensive costs of selected crash categories examined in this study. Nonfatal injuries were the most costly severity outcome, accounting for 49 percent of economic costs and 61 percent of societal harm. Damage to vehicles in which no injury occurred was the second highest economic cost outcome (30% of costs) due to the high frequency of these low impact crashes. However, in terms of societal harm, fatalities were the second most costly outcome (30% of costs) due to the life years that fatal crash victims lose.

This report examined five different types of adverse driver behavior: alcohol use, speeding, distracted driving, failure to wear seat belts, and riding a motorcycle without a helmet. The most costly of these involved distraction. Distracted driving, which includes talking on cell phones, texting, eating, and other non-driving activities, was a causal factor in crashes that accounted for 29 percent of economic costs and societal harm. However, distracted driving is difficult to detect, and it is likely that distraction plays an even larger role in causing crashes and their resulting impacts on society.

Alcohol-involved crashes, in which drivers or nonoccupants had some level of alcohol in their bloodstreams, accounted for 20 percent of economic costs and 26 percent of societal harm.

However, crashes in which alcohol was a likely cause of the crashes accounted for 17 percent of economic costs and 21 percent of societal harm. Over 80 percent of this toll occurred in crashes where the drivers were legally intoxicated (.08 g/dL BAC or greater).

Crashes in which one or more drivers were exceeding the legal speed limit or driving too fast for conditions caused 14 percent of economic costs and 17 percent of societal harm. The extent to which speed caused these crashes is uncertain, but higher speeds leave less time for drivers to react to emergency situations.

The failure of some vehicle occupants to use their seat belts accounts for roughly 3 percent of economic costs and 6 percent of societal harm. While these portions seem relatively small, they represent economic costs of $11 billion and societal harm of $78 billion annually. Likewise, failure to wear motorcycle helmets causes a small portion of the overall total, but has serious economic and quality-of-life consequences for the injured riders and their families.

Injuries to nonoccupants also have significant economic and societal impacts. Motorcyclist injuries cause 5 percent of the economic costs and 8 percent of societal harm from traffic crashes. Injuries to pedestrians and bicyclists cause 5 percent of the economic costs and 9 percent of the societal harm.

The report also examines crash costs for various roadway types and crash configurations. Among its findings, crashes on interstate highways account for roughly 12 percent of both economic costs and societal harm, while the more frequent but generally less serious crashes at intersections account for 53 percent of economic costs and 49 percent of societal harm. Crashes on urban roadways account for roughly 69 percent of all economic and 66 percent of all societal harm, while crashes on rural roadways account for roughly 31 percent of economic impacts and 34 percent of societal harm.

Table 1-1. Summary of Total Economic Costs (Millions 2019 $)

	PDO Vehicle	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**	**Total**	**% Total**
Medical	$0	$0	$8,564	$5,667	$9,789	$3,638	$2,611	$631	$30,900	9.1%
EMS	$598	$109	$411	$97	$69	$19	$7	$39	$1,348	0.4%
Market Prod.	$0	$0	$8,971	$9,865	$13,088	$4,434	$2,201	$36,900	$75,459	22.2%
Household Prod.	$1,369	$249	$3,286	$3,840	$5,506	$2,246	$919	$13,401	$30,816	9.1%
Ins. Admin. Costs	$10,088	$1,018	$8,572	$3,511	$4,051	$704	$274	$1,323	$29,540	8.7%
Workplace Costs	$1,910	$344	$217	$179	$457	$136	$56	$496	$3,795	1.1%
Legal Costs	$0	$0	$2,868	$2,667	$3,912	$1,423	$791	$5,038	$16,698	4.9%
Subtotal	$13,965	$1,720	$32,889	$25,825	$36,873	$12,600	$6,858	$57,828	$188,558	55.5%
Congestion	$25,595	$4,562	$4,677	$572	$239	$35	$13	$260	$35,954	10.6%
Prop. Damage	$61,722	$8,436	$37,396	$4,107	$2,518	$397	$167	$554	$115,297	33.9%
Subtotal	$87,317	$12,998	$42,074	$4,679	$2,756	$432	$180	$815	$151,252	44.5%
Total	$101,282	$14,718	$74,963	$30,504	$39,629	$13,031	$7,039	$58,643	$339,809	100.0%
% Total	29.8%	4.3%	22.1%	9.0%	11.7%	3.8%	2.1%	17.3%	100.0%	0.0%

Figure 1-A. Components of Total Economic Costs

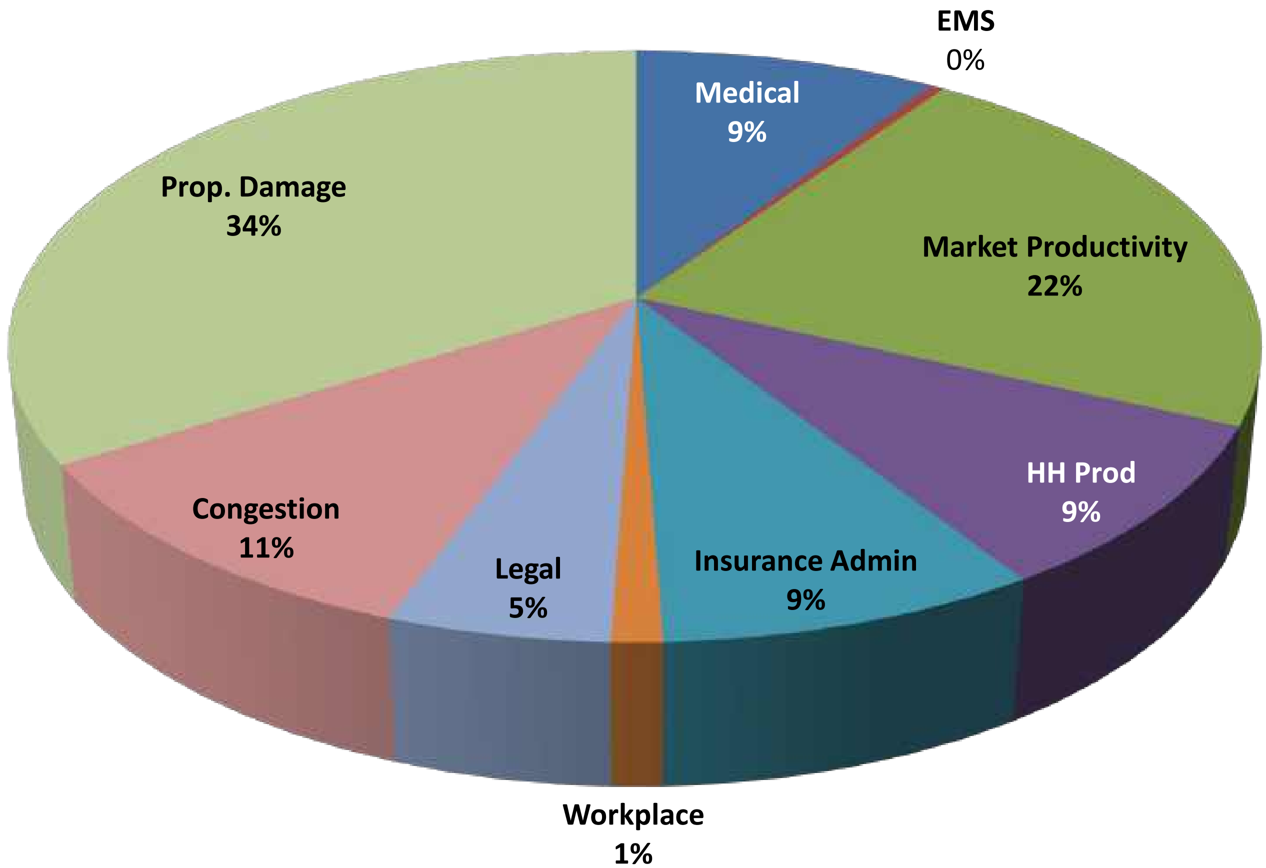


Table 1-2. Summary of Unit Costs Police-Reported and Unreported Crashes, 2019 Dollars

	PDO Vehicle	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**
Medical Care	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$31	$24	$106	$228	$486	$976	$999	$1,060
Market Prod.	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household Prod.	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance Adm.	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace Costs	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal Injury	$724	$380	$8,487	$60,464	$261,200	$653,348	$954,237	$1,584,326
Congestion	$1,327	$1,008	$1,207	$1,339	$1,691	$1,814	$1,857	$7,133
Prop. Damage	$3,200	$1,864	$9,650	$9,616	$17,835	$20,565	$23,234	$15,185
Subtotal Non-Inj.	$4,527	$2,872	$10,857	$10,955	$19,526	$22,379	$25,091	$22,318
Total	$5,251	$3,252	$19,344	$71,419	$280,726	$675,727	$979,328	$1,606,644

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

Figure 1-B. Source of Payment for Motor Vehicle Crash Costs

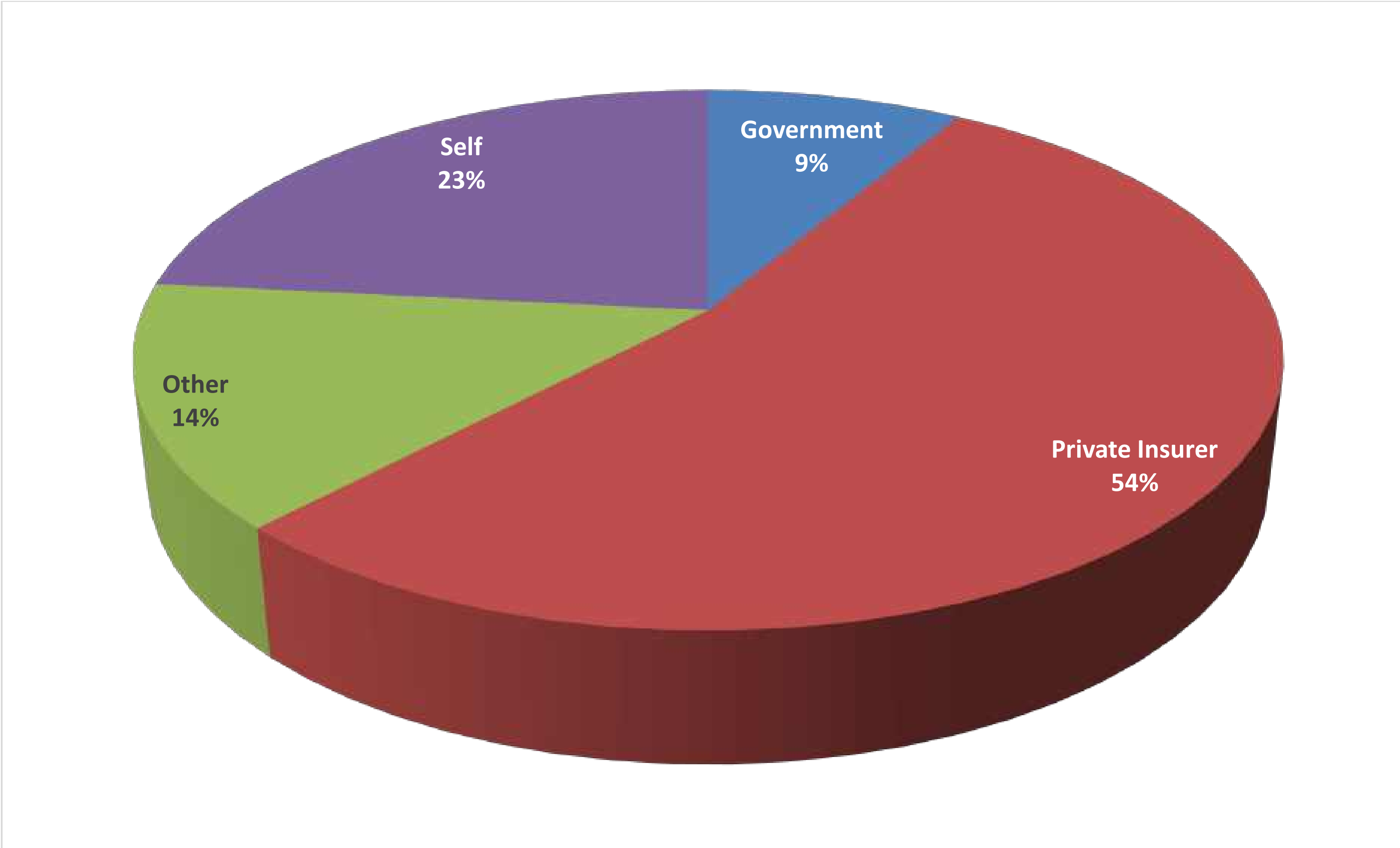


Table 1-3. Incidence Summary – 2019 Total Police-Reported and Unreported Injuries

Severity	Police-reported	Not Police-reported	Total	Percent Unreported
Vehicles				
Injury Vehicles	2,424,916	1,136,998	3,561,914	31.9%
PDO Vehicles	7,773,120	11,515,019	19,288,139	59.7%
Total Vehicles	*10,198,036*	*12,652,017*	*22,850,053*	*55.4%*
People in Injury Crashes				
MAIS0	2,349,202	2,176,700	4,525,901	48.1%
MAIS1	2,561,954	1,313,311	3,875,265	33.9%
MAIS2	310,848	116,271	427,119	27.2%
MAIS3	132,222	8,945	141,167	6.3%
MAIS4	19,285	0	19,285	0.0%
MAIS5	7,187	0	7,187	0.0%
Fatal	36,500	0	36,500	0.0%
Total	*5,417,198*	*3,615,226*	*9,032,424*	*40.0%*
Total Injuries	*3,067,996*	*1,438,526*	*4,506,523*	*31.9%*
Crashes				
PDO	4,390,169	6,503,550	10,893,719	59.7%
Injury	2,223,724	1,042,663	3,266,387	31.9%
Fatal	33,621	0	33,621	0.0%
Total Crashes	*6,647,514*	*7,546,213*	*14,193,727*	*53.2%*

Table 1-4. Summary of Unit Costs, Police-Reported Crashes, 2019 Dollars

	PDO Vehicle	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$72	$40	$139	$274	$486	$976	$999	$1,060
Market Prod.	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household Prod.	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance Admin.	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace Costs	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$765	$396	$8,520	$60,510	$261,200	$653,348	$954,237	$1,584,326
Congestion	$2,591	$1,739	$1,713	$1,758	$1,790	$1,814	$1,857	$7,133
Prop. Damage	$4,556	$2,654	$13,741	$13,692	$25,395	$20,565	$23,234	$15,185
Subtotal	$7,147	$4,393	$15,454	$15,450	$27,185	$22,379	$25,091	$22,318
Total	$7,913	$4,789	$23,974	$75,961	$288,385	$675,727	$979,328	$1,606,644

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

Table 1-5. Summary of Unit Costs, Unreported Crashes, 2019 Dollars

	PDO Vehicle*	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4*	MAIS5*	Fatal*
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$8	$7	$41	$104	$486	$976	$999	$1,060
Market Prod.	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household Prod.	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance Admin	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace Costs	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$701	$363	$8,422	$60,340	$261,200	$653,348	$954,237	$1,584,326
Congestion	$473	$220	$220	$220	$220	$220	$220	$571
Prop. Damage	$1,550	$903	$4,674	$4,657	$8,638	$20,565	$23,234	$15,185
Subtotal	$2,023	$1,123	$4,894	$4,877	$8,858	$20,785	$23,454	$15,756
Total	$2,724	$1,486	$13,315	$65,217	$270,058	$674,133	$977,691	$1,600,082

*Note: Unit costs are expressed on a per-person basis for all injury levels. PDO costs are expressed on a per-damaged-vehicle basis. Generally, all MAIS4, 5, and fatal injuries are believed to be police-reported. Values are still included here for reference to cover any exceptional case where unreported crashes might be found for these injury severity categories.

Table 1-6. Summary of Total Economic Costs in Police-Reported Crashes, Millions 2019 Dollars

	PDO Vehicle	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**	**Total**	**% Total**
Medical	$0	$0	$5,662	$4,125	$9,169	$3,638	$2,611	$631	$25,835	9.4%
EMS	$560	$94	$357	$85	$64	$19	$7	$39	$1,225	0.4%
Market Prod.	$0	$0	$5,931	$7,179	$12,259	$4,434	$2,201	$36,900	$68,904	25.0%
Household Prod.	$552	$129	$2,173	$2,795	$5,157	$2,246	$919	$13,401	$27,371	9.9%
Insurance Admin.	$4,065	$529	$5,667	$2,555	$3,795	$704	$274	$1,323	$18,911	6.9%
Workplace Costs	$770	$179	$143	$130	$428	$136	$56	$496	$2,338	0.8%
Legal Costs	$0	$0	$1,896	$1,941	$3,664	$1,423	$791	$5,038	$14,753	5.3%
Subtotal	$5,947	$930	$21,829	$18,810	$34,536	$12,600	$6,858	$57,828	$159,338	57.7%
Congestion	$21,115	$4,283	$4,601	$573	$248	$37	$14	$273	$31,144	11.3%
Prop. Damage	$35,418	$6,235	$35,203	$4,256	$3,358	$397	$167	$554	$85,588	31.0%
Subtotal	$56,533	$10,518	$39,804	$4,829	$3,606	$433	$181	$827	$116,732	42.3%
Total	$62,480	$11,448	$61,633	$23,639	$38,142	$13,033	$7,039	$58,655	$276,070	100.0%
% Total	22.6%	4.1%	22.3%	8.6%	13.8%	4.7%	2.5%	21.2%	100.0%	0.0%

Table 1-7. Summary of Total Economic Costs in Unreported Crashes, Millions 2019 Dollars

	PDO Vehicle	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**	**Total**	**% Total**
Medical	$0	$0	$2,902	$1,543	$620	$0	$0	$0	$5,066	8.1%
EMS	$96	$15	$53	$12	$4	$0	$0	$0	$181	0.3%
Market Prod.	$0	$0	$3,040	$2,685	$829	$0	$0	$0	$6,555	10.5%
Household Prod.	$818	$120	$1,114	$1,045	$349	$0	$0	$0	$3,445	5.5%
Insurance Admin.	$6,022	$490	$2,905	$956	$257	$0	$0	$0	$10,630	17.0%
Workplace Costs	$1,140	$165	$74	$49	$29	$0	$0	$0	$1,457	2.3%
Legal Costs	$0	$0	$972	$726	$248	$0	$0	$0	$1,946	3.1%
Subtotal	$8,076	$790	$11,060	$7,016	$2,336	$0	$0	$0	$29,278	46.9%
Congestion	$5,710	$502	$303	$27	$2	$0	$0	$0	$6,544	10.5%
Prop. Damage	$17,846	$1,965	$6,138	$542	$77	$0	$0	$0	$26,568	42.6%
Subtotal	$23,557	$2,467	$6,441	$568	$79	$0	$0	$0	$33,112	53.1%
Total	$31,632	$3,257	$17,501	$7,584	$2,416	$0	$0	$0	$62,390	100.0%
% Total	50.7%	5.2%	28.1%	12.2%	3.9%	0.0%	0.0%	0.0%	100.0%	0.0%

Figure 1-C. Percentage of Total Economic Costs From Police-Reported Crashes

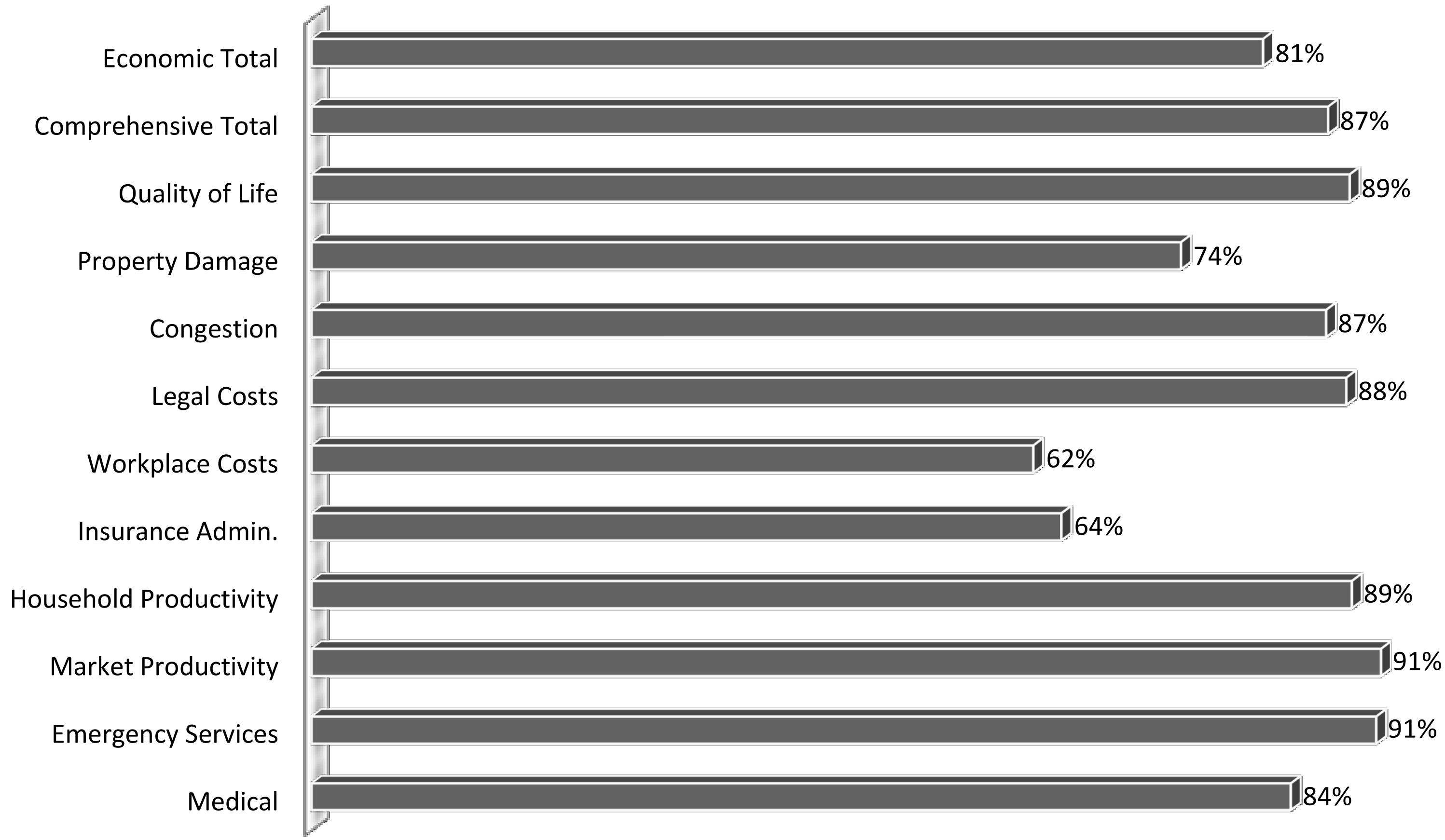


Table 1-8. Summary of Total Comprehensive Costs, Reported and Unreported Crashes (Millions 2019 $)

	PDO Vehicle	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**	**Total**	**% Total**
Medical	$0	$0	$8,564	$5,667	$9,789	$3,638	$2,611	$631	$30,900	2.3%
EMS	$598	$109	$411	$97	$69	$19	$7	$39	$1,348	0.1%
Market Prod.	$0	$0	$8,971	$9,865	$13,088	$4,434	$2,201	$36,900	$75,459	5.5%
Household Prod.	$1,369	$249	$3,286	$3,840	$5,506	$2,246	$919	$13,401	$30,816	2.3%
Insurance Admin.	$10,088	$1,018	$8,572	$3,511	$4,051	$704	$274	$1,323	$29,540	2.2%
Workplace Costs	$1,910	$344	$217	$179	$457	$136	$56	$496	$3,795	0.3%
Legal Costs	$0	$0	$2,868	$2,667	$3,912	$1,423	$791	$5,038	$16,698	1.2%
Subtotal	$13,965	$1,720	$32,889	$25,825	$36,873	$12,600	$6,858	$57,828	$188,558	13.8%
Congestion	$25,595	$4,562	$4,677	$572	$239	$35	$13	$260	$35,954	2.6%
Prop. Damage	$61,722	$8,436	$37,396	$4,107	$2,518	$397	$167	$554	$115,297	8.4%
Subtotal	$87,317	$12,998	$42,074	$4,679	$2,756	$432	$180	$815	$151,252	11.1%
Total	$101,282	$14,718	$74,963	$30,504	$39,629	$13,031	$7,039	$58,643	$339,809	24.9%
QALYs	$0	$0	$159,320	$171,847	$249,002	$56,658	$36,432	$352,293	$1,025,552	75.1%
Comp. Total	$101,282	$14,718	$234,283	$202,352	$288,631	$69,690	$43,471	$410,935	$1,365,362	100.0%
% Total	7.4%	1.1%	17.2%	14.8%	21.1%	5.1%	3.2%	30.1%	100.0%	0.0%

Table 1-9. Summary of Comprehensive Unit Costs, Reported and Unreported Crashes, 2019 Dollars

	PDO Vehicle	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$31	$24	$106	$228	$486	$976	$999	$1,060
Market Prod.	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household Prod.	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance Admin.	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace Costs	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$724	$380	$8,487	$60,464	$261,200	$653,348	$954,237	$1,584,326
Congestion	$1,327	$1,008	$1,207	$1,339	$1,691	$1,814	$1,857	$7,133
Prop. Damage	$3,200	$1,864	$9,650	$9,616	$17,835	$20,565	$23,234	$15,185
Subtotal	$4,527	$2,872	$10,857	$10,955	$19,526	$22,379	$25,091	$22,318
Total Econ.	$5,251	$3,252	$19,344	$71,419	$280,726	$675,727	$979,328	$1,606,644
QALYs	$0	$0	$41,112	$402,341	$1,763,881	$2,938,008	$5,068,923	$9,651,851
Comp.Total	$5,251	$3,252	$60,456	$473,760	$2,044,607	$3,613,735	$6,048,251	$11,258,495

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

Figure 1-D. Components of Comprehensive Costs

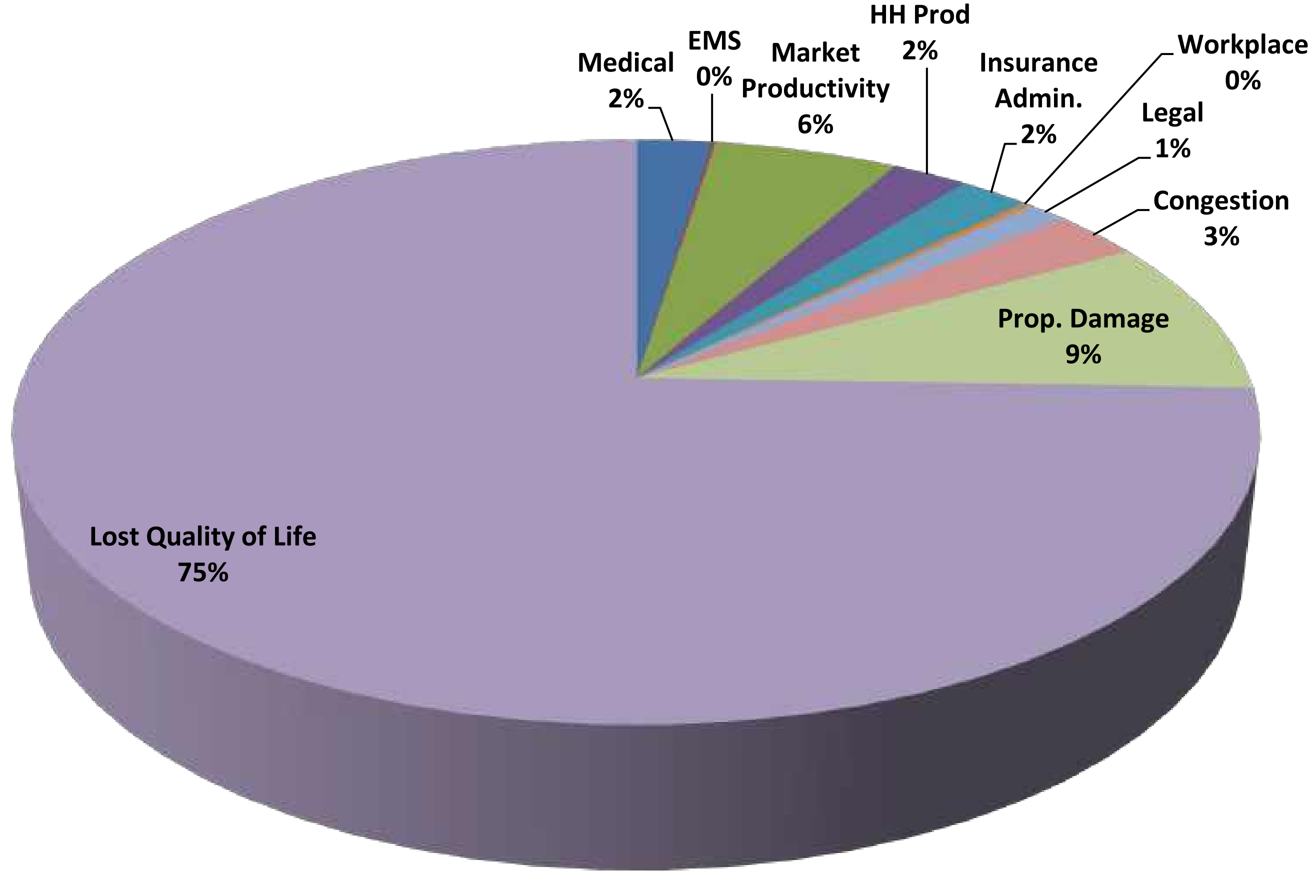


Table 1-10. Summary of Comprehensive Unit Costs, Police-Reported Crashes, 2019 Dollars

	PDO Vehicle	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$72	$40	$139	$274	$486	$976	$999	$1,060
Market Prod.	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household Prod.	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance Admin.	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace Costs	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$765	$396	$8,520	$60,510	$261,200	$653,348	$954,237	$1,584,326
Congestion	$2,591	$1,739	$1,713	$1,758	$1,790	$1,814	$1,857	$7,133
Prop. Damage	$4,556	$2,654	$13,741	$13,692	$25,395	$20,565	$23,234	$15,185
Subtotal	$7,147	$4,393	$15,454	$15,450	$27,185	$22,379	$25,091	$22,318
Total Economic	$7,913	$4,789	$23,974	$75,961	$288,385	$675,727	$979,328	$1,606,644
QALYs	$0	$0	$41,112	$402,341	$1,763,881	$2,938,008	$5,068,923	$9,651,851
Total Comp.	$7,913	$4,789	$65,086	$478,302	$2,052,266	$3,613,735	$6,048,251	$11,258,495

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

Table 1-11. Summary of Comprehensive Unit Costs, Unreported Crashes, 2019 Dollars

	PDO Vehicle	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$8	$7	$41	$104	$486	$976	$999	$1,060
Market Prod.	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household Prod.	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance Admin.	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace Costs	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$701	$363	$8,422	$60,340	$261,200	$653,348	$954,237	$1,584,326
Congestion	$473	$220	$220	$220	$220	$220	$220	$571
Prop. Damage	$1,550	$903	$4,674	$4,657	$8,638	$20,565	$23,234	$15,185
Subtotal	$2,023	$1,123	$4,894	$4,877	$8,858	$20,785	$23,454	$15,756
Total Economic	$2,724	$1,486	$13,315	$65,217	$270,058	$674,133	$977,691	$1,600,082
QALYs	$0	$0	$41,112	$402,341	$1,763,881	$2,938,008	$5,068,923	$9,651,851
Comp. Total	$2,724	$1,486	$54,427	$467,558	$2,033,939	$3,612,141	$6,046,614	$11,251,933

*Note: Unit costs are expressed on a per-person basis for all injury levels. PDO costs are expressed on a per-damaged-vehicle basis. Generally, all MAIS4, 5, and fatal injuries are believed to be police-reported. Values are still included here for reference to cover any exceptional case where unreported crashes might be found for these injury severity categories.

Table 1-12. Summary of Total Comprehensive Costs, Police-Reported Crashes (Millions 2019 $)

	PDO	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**	**Total**	**% Total**
Medical	$0	$0	$5,662	$4,125	$9,169	$3,638	$2,611	$631	$25,835	2.2%
EMS	$560	$94	$357	$85	$64	$19	$7	$39	$1,225	0.1%
Market Prod.	$0	$0	$5,931	$7,179	$12,259	$4,434	$2,201	$36,900	$68,904	5.8%
Household Prod.	$552	$129	$2,173	$2,795	$5,157	$2,246	$919	$13,401	$27,371	2.3%
Insurance Admin.	$4,065	$529	$5,667	$2,555	$3,795	$704	$274	$1,323	$18,911	1.6%
Workplace Costs	$770	$179	$143	$130	$428	$136	$56	$496	$2,338	0.2%
Legal Costs	$0	$0	$1,896	$1,941	$3,664	$1,423	$791	$5,038	$14,753	1.2%
Subtotal	$5,947	$930	$21,829	$18,810	$34,536	$12,600	$6,858	$57,828	$159,338	13.4%
Congestion	$21,115	$4,283	$4,601	$573	$248	$37	$14	$273	$31,144	2.6%
Prop. Damage	$35,418	$6,235	$35,203	$4,256	$3,358	$397	$167	$554	$85,588	7.2%
Subtotal	$56,533	$10,518	$39,804	$4,829	$3,606	$433	$181	$827	$116,732	9.9%
Total Economic	$62,480	$11,448	$61,633	$23,639	$38,142	$13,033	$7,039	$58,655	$276,070	23.3%
QALYs	$0	$0	$105,327	$125,067	$233,224	$56,659	$36,430	$352,293	$909,000	76.7%
Comp.Total	$62,480	$11,448	$166,960	$148,706	$271,366	$69,693	$43,469	$410,948	$1,185,070	100.0%
% Total	5.3%	1.0%	14.1%	12.5%	22.9%	5.9%	3.7%	34.7%	100.0%	

Table 1-13. Summary of Total Comprehensive Costs, Unreported Crashes (Millions 2019 $)

	PDO	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**	**Total**	**% Total**
Medical	$0	$0	$2,902	$1,543	$620	$0	$0	$0	$5,066	2.8%
EMS	$96	$15	$53	$12	$4	$0	$0	$0	$181	0.1%
Market Prod.	$0	$0	$3,040	$2,685	$829	$0	$0	$0	$6,555	3.7%
Household Prod.	$818	$120	$1,114	$1,045	$349	$0	$0	$0	$3,445	1.9%
Insurance Admin.	$6,022	$490	$2,905	$956	$257	$0	$0	$0	$10,630	5.9%
Workplace Costs	$1,140	$165	$74	$49	$29	$0	$0	$0	$1,457	0.8%
Legal Costs	$0	$0	$972	$726	$248	$0	$0	$0	$1,946	1.1%
Subtotal	$8,076	$790	$11,060	$7,016	$2,336	$0	$0	$0	$29,278	16.4%
Congestion	$5,710	$502	$303	$27	$2	$0	$0	$0	$6,544	3.7%
Prop. Damage	$17,846	$1,965	$6,138	$542	$77	$0	$0	$0	$26,568	14.8%
Subtotal	$23,557	$2,467	$6,441	$568	$79	$0	$0	$0	$33,112	18.5%
Total	$31,632	$3,257	$17,501	$7,584	$2,416	$0	$0	$0	$62,390	34.9%
QALYs	$0	$0	$53,993	$46,781	$15,778	$0	$0	$0	$116,551	65.1%
Comp.Total	$31,632	$3,257	$71,494	$54,365	$18,194	$0	$0	$0	$178,942	100.0%
% Total	17.7%	1.8%	40.0%	30.4%	10.2%	0.0%	0.0%	0.0%	100.0%	

Table 1-14. Economic and Societal Costs for Selected Crash Types

	Economic Cost	% Total	Comprehensive Cost	% Total
Outcome Severity:				
Fatalities	$58,643	17.3%	$410,935	30.1%
Nonfatal Injuries	$165,167	48.6%	$838,426	61.4%
PDO Vehicles	$101,282	29.8%	$101,282	7.4%
Uninjured (MAIS0)	$14,718	4.3%	$14,718	1.1%
Total	$339,809	100.0%	$1,365,362	100.0%
Adverse Driver Behavior:				
Belt Non-Use	$10,952	3.2%	$78,452	5.7%
Helmet Non-Use	$1,410	0.4%	$9,410	0.7%
Police-reported Distraction	$46,183	13.6%	$169,892	12.4%
Observed Distraction	$98,183	28.9%	$394,500	28.9%
Alcohol Involvement	$68,854	20.3%	$348,281	25.5%
Alcohol Causation	$56,543	16.6%	$286,528	21.0%
Speed	$46,377	13.6%	$225,113	16.5%
Nonoccupants:				
Motorcyclists	$16,879	5.0%	$107,141	7.8%
Pedestrians	$13,977	4.1%	$99,825	7.3%
Bicyclists	$4,402	1.3%	$25,586	1.9%
Crash Types:				
Roadway Departure Crashes	$72,488	21.3%	$321,211	23.5%
Single Vehicle Crashes	$97,614	28.7%	$495,155	36.3%
Crash Location:				
Interstate Highway Crashes	$42,124	12.4%	$163,751	12.0%
Intersection Crashes	$179,484	52.8%	$664,968	48.7%
Urban Roadways	$233,636	68.8%	$893,866	65.5%
Rural Roadways	$106,174	31.2%	$471,495	34.5%

2. Incidence

Crash costs are driven by the incidence of fatalities, injuries, and damaged vehicles that result from motor vehicle crashes. Most serious crashes are reported in police records within individual States and jurisdictions, but many crashes that are less serious are either not reported to police, or are reported but not recorded because their severity falls below a local reporting threshold. In this section we estimate the incidence of both the police-reported and unreported crashes that occur annually on our roadways.

Fatalities

The incidence of fatalities that result from motor vehicle crashes is derived from the FARS, an annual census of all fatal roadway crashes. FARS collects data on all fatal traffic crashes within the 50 States, the District of Columbia, and Puerto Rico. To be included in FARS, a crash must involve a motor vehicle travelling on a roadway customarily open to the public and result in the death of a person (occupant of a vehicle or a nonoccupant) within 30 days of the crash.

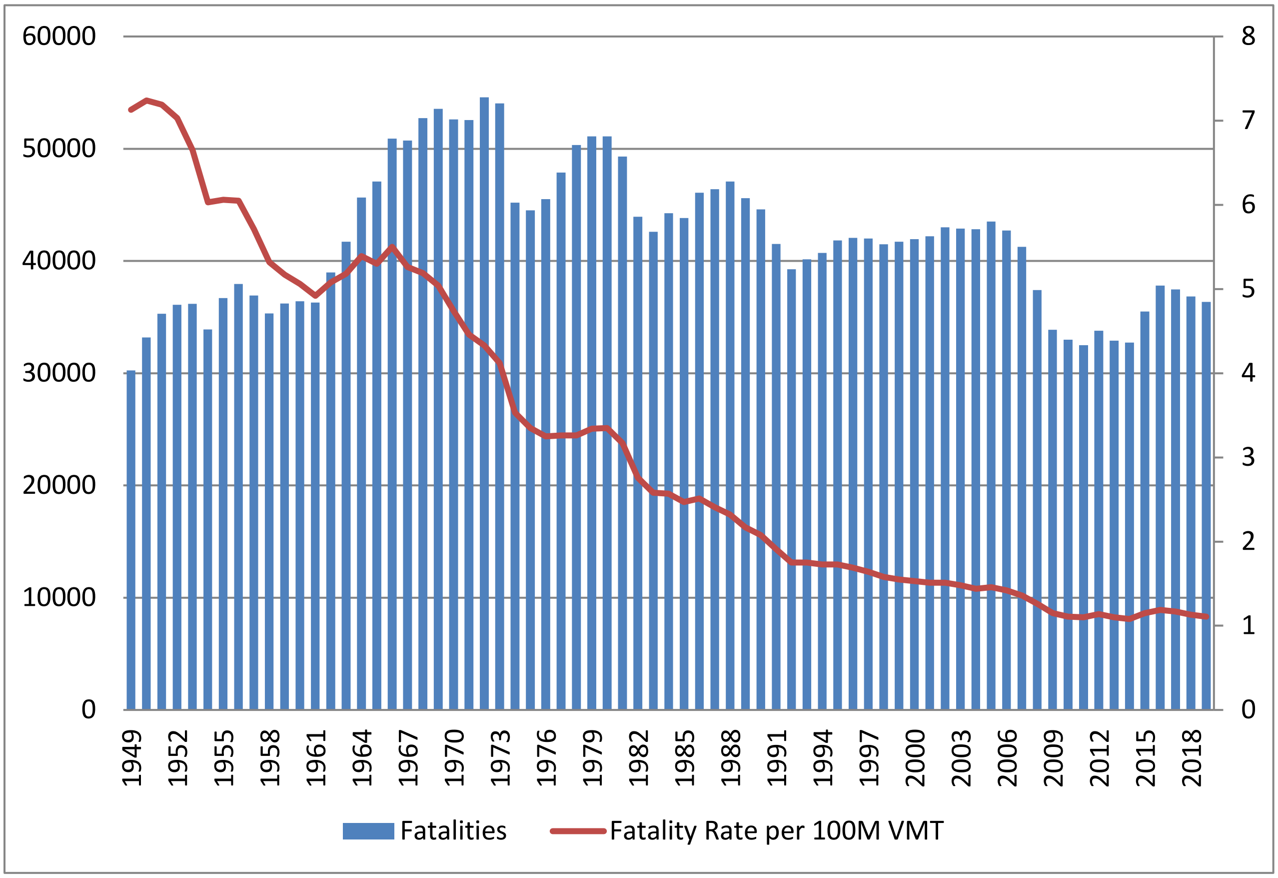
FARS collects information on over 100 different coded data elements that characterize the crash, the vehicle, and the people involved.

In 2019 there were 36,500 fatalities in motor vehicle crashes. Table 2-1 and Figure 2-A illustrate the trend in fatalities over the past 70 years, along with the trend in the fatality rates. Over this period fatality rates have exhibited steady decline, but fatality counts rose during the 1960s in response to rapid increase in the driving population associated at least in part by the demographic shift of the baby boom generation into the driving cohort. From 1999 to 2019 fatal crashes and fatality rates declined due to a variety of factors including safer vehicles, safer roadways, improved driver behavior such as increased seat belt use and decreased impaired driving, increased congestion, which reduces travel speeds, more use of mass transit, and, during recovery from the 2007 recession, reduced economic activity. In 2010, when NHTSA last examined this issue, there were roughly 33,000 fatalities from motor vehicle crashes, a 21 percent decline from the 2000 total of roughly 42,000 fatalities. Fatalities remained relatively stable near this level through 2014 as the economy reached full recovery from the recession, but then rose to roughly 37,000 in 2015 and hovered at that level through 2019, stabilizing at roughly 5,000 fewer fatalities than the pre-recession level. This is an encouraging trend, and is even more impressive in light of the increased population and generally rising rates of travel over time. Some aspects of this decline are likely to remain and even accelerate as the older on-road fleet is replaced by more modern vehicles with advanced safety features such as automatic emergency braking and other advanced crash avoidance systems. Also, 2019 was the last pre-COVID year, and initial indications are that COVIDs impacts were complex, reducing travel due to the economic shutdown, but enabling more speeding due to less traffic congestion. These impacts may be temporary, but the long-term impact of COVID on workplace habits, specifically by normalizing telecommuting, may have more significant implications for traffic crashes in future years.

Table 2-1. Fatalities and Fatality Rates, 1949-2019

Year	**Fatalities**	**Fatality Rate per 100M VMT**		**Year**	**Fatalities**	**Fatality Rate per 100M VMT**
1949	30,246	7.13		1985	43,825	2.47
1950	33,186	7.24		1986	46,087	2.51
1951	35,309	7.19		1987	46,390	2.41
1952	36,088	7.03		1988	47,087	2.32
1953	36,190	6.65		1989	45,582	2.17
1954	33,890	6.03		1990	44,599	2.08
1955	36,688	6.06		1991	41,508	1.91
1956	37,965	6.05		1992	39,250	1.75
1957	36,932	5.71		1993	40,150	1.75
1958	35,331	5.32		1994	40,716	1.73
1959	36,223	5.17		1995	41,817	1.73
1960	36,399	5.06		1996	42,065	1.69
1961	36,285	4.92		1997	42,013	1.64
1962	38,980	5.08		1998	41,501	1.58
1963	41,723	5.18		1999	41,717	1.55
1964	45,645	5.39		2000	41,945	1.53
1965	47,089	5.30		2001	42,196	1.51
1966	50,894	5.50		2002	43,005	1.51
1967	50,724	5.26		2003	42,884	1.48
1968	52,725	5.19		2004	42,836	1.44
1969	53,543	5.04		2005	43,510	1.46
1970	52,627	4.74		2006	42,708	1.42
1971	52,542	4.46		2007	41,259	1.36
1972	54,589	4.33		2008	37,423	1.26
1973	54,052	4.12		2009	33,883	1.15
1974	45,196	3.53		2010	32,999	1.11
1975	44,525	3.35		2011	32,479	1.10
1976	45,523	3.25		2012	33,782	1.14
1977	47,878	3.26		2013	32,893	1.10
1978	50,331	3.26		2014	32,744	1.08
1979	51,093	3.34		2015	35,484	1.15
1980	51,091	3.35		2016	37,806	1.19
1981	49,301	3.17		2017	37,473	1.17
1982	43,945	2.76		2018	36,835	1.13
1983	42,589	2.58		2019	36,355	1.11
1984	44,257	2.57				

Figure 2-A. Fatalities and Fatality Rates, by Year



Fatalities Beyond 30 Days

The vast majority of all fatalities from fatal crashes occur within 30 days of the crashes. However, some injuries such as traumatic brain injury (TBI) can result in long-term unconsciousness with life support that ultimately ends in death. These types of injuries can extend beyond the 30-day criteria collected in FARS. In addition, some deaths occur due to complications that occur over time such as Infections associated with subsequent operations or treatments, and some occur years later as patients' health declines due to injuries sustained in crashes.

Vital Statistics Multiple Cause of Death (MCOD) data are compiled by the National Center for Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention (CDC). They are the U.S. Government's official counts of deaths in the United States. The file captures all death certificates for deaths in the United States during the year, including both the certificate as written by the death registrars and edited by the State, as well as a second version of causation that NCHS creates by editing to uniformity and reorganizing from the State submissions. Each death in the file records a cause. For disease, the cause is a diagnosis, but for injury, it is an external cause that identifies mechanism and intent (e.g., accidental death of a pedestrian hit by a motor vehicle on a public road). At least during 2015 to 2019, MCOD did not record any homicides or suicides by MV crash; all crash deaths were "accidental" in the terminology of the police crash reports (PCRs).[3]

The death certificate lists many contributing factors, but it also clearly indicates the “Underlying Cause of Death.” Rather than the death certifier’s determination of underlying cause, we used the final underlying cause death registrar's determination of principal cause, as recoded by NCHS using its TRANSAX system. CDC's WISQARS and WONDER systems exclusively provide death counts based on that recoded cause. We analyzed these data and found that 26 percent of the non-FARS deaths occurred in hospitals. In 2019 there were 145 crash deaths during initial hospital visits with a length of stay greater than 30 days. The diagnosis distribution of these cases was 48 percent TBI (e.g., long-term unconsciousness with life support), 14 percent SCI, 31 percent internal organ injury, and 7 percent lower-limb Injury. In addition, 80 deaths occurred during follow-up hospital stays (readmissions during the acute phase of injury, e.g., for sepsis or further surgery) and 270 deaths occurred during admissions for injury sequelae (e.g., bed-bound TBI and SCI patients discharged to home or to nursing homes who developed medical complications over time). Each year's sequelae deaths may well be from crashes in prior years. In addition, motor vehicle crashes were indicated as underlying cause of death for 437 hospice deaths, 337 deaths at home, 300 deaths in nursing homes, 27 deaths during follow-up and sequelae visits to emergency departments, and 282 deaths with details unclear.

All MAIS injuries have some probability of death, and nonfatal injury totals used in this report represent only cases designated as survivors. Fatality cases detected in either CISS or CRSS are ignored since all fatality cases are derived from FARS. However, since CISS analysts code from hospital discharge records, we believe that the 145 hospitalized people who died after 30 days would have been correctly noted by CISS analysts as deaths. By contrast, the other categories of fatalities are more likely to have occurred after initial hospital discharge, in some cases even a year or more after discharge. These deaths would not be detected by CISS analysts and would instead be coded as MAIS survivors, with most probably coded as the more serious MAIS cases. Hypothetically, they would already be accounted for in our incidence profile as nonfatal injuries, and so will not be added to the fatality total for purposes of this report. However, the 145 cases who died more than 30 days after the crash during initial hospitalization represent additional injured people that must be accounted for by adding to the fatality total, giving a total of 36,500 fatalities due to motor vehicle crashes in 2019. Table 2-2 below summarizes these cases.

[3] The older term was “police accident report,” PAR, but NHTSA now uses “police crash report,” PCR. The two terms are used interchangeably. PAR may appear in older reports.

Table 2-2. Summary of 2019 Deaths Associated With Motor Vehicle Crashes

Type	**Fatalities**
FARS cases*	36,355
>30 days hospitalized	145
Readmissions for sepsis or further surgery	80
Readmissions TBI and SCI patients from sequelae	270
Deaths in hospice	437
Deaths at home	337
Deaths in nursing home	300
Follow up and sequelae deaths in ED	27
Unknown status	282
Subtotal MCOD non-FARS	1,878
Total MV underlying cause	38,233
Long-term fatalities accounted for by MAIS	1,733
Total unique Fatalities	36,500

*Final revised FARS total as of March 2022. Earlier annual report file (ARF) estimates listed 36,096 FARS fatalities. The additional 259 cases involved prosecution for criminal or civil litigation related to the crashes. NHTSA could not access these records until the litigation was completed.

Nonfatal Police-Reported Injuries

While FARS provides a dependable census of all fatal crashes, there is no equivalent data source for nonfatal injuries. Nonfatal injuries have been estimated in several NHTSA databases. The National Automotive Sampling System (NASS) was established in the 1970s to support vehicle/highway safety research, policy making, and regulation program development. NASS is comprised of two nested probability sampling systems – the General Estimates System (GES) and the Crashworthiness Data System (CDS). The GES collected general information of the traffic crashes from police crash reports only. The CDS collected detailed information from the crashes involving passenger vehicles to better understand the crashworthiness of vehicles and consequences to occupants in crashes. NHTSA developed and implemented CDS in the 1980s. The CDS was a nationally representative sample of roughly 5,000 crashes annually. CDS contains detailed information on police-reported injuries incurred by passengers of towed passenger vehicles. CDS employs trained crash investigators to obtain data from police-reported crash sites, studying evidence such as skid marks, fluid spills, broken glass, and bent guard rails. They locate the vehicles involved, photograph them, measure the crash damage, and identify interior locations that were struck by the occupants. These researchers follow up on their on-site investigations by interviewing crash victims and reviewing medical records to determine the nature and severity of injuries. This lets researchers properly categorize injury severity based on the AIS, the basis for stratifying injury severity in this report. Crashes covered by the CDS represented about 62 percent of all police-reported injuries and typically involve the most serious injuries to vehicle occupants.

CDS was based upon a three-stage, stratified, random sample of primary sampling units (PSUs), police jurisdictions (PJs), and police crash reports (PCRs). The CDS 24-PSU sample is a subsample of the GES 60-PSU sample. The same PSU and PJ samples have been used for CDS data collection since 1989.

Over the past two decades, however, the general population, vehicles, and highway safety measures have changed dramatically, so that crash characteristics and distributions have changed over the PSU and PJ frame. In addition, the research interest of the transportation community has expanded to topics such as driver performance, crash avoidance, and the effects of new technologies on crash amelioration.

NHTSA recognized the need to undertake a redesign of NASS to better support its own and stakeholders' data needs. In 2012 NHTSA undertook a significant effort to re-design and modernize its crash data collection system (GovTrack.us, 2022). NHTSA identified three major areas for improvement – re-designing the survey sample, modernizing the information technology infrastructure, and revamping its data collection protocols and technology.

The redesign started in January 2012. Most of the work was in the formation of conceptual research designs, establishment of sampling frames, selection of data collection locations and sources, and documentation of protocol and results for the new surveys. During this process, two new national, probability-based crash sampling systems were designed – the Crash Report Sampling System (CRSS) and Crash Investigation Sampling System (CISS) - to replace GES and CDS.

After its assessment of research objectives and operational considerations, NHTSA decided to design the CISS independently from CRSS in order to optimize both CISS and CRSS. Therefore, unlike the current NASS, the formation and selection of the CISS PSUs were independent of the CRSS PSU formation and selection.

CISS has a stratified, three-stage sample design similar to CDS: PSU, PJ, and PCR. The CISS PSUs were formed so that a minimum number of severe crashes could be selected from as many PSUs as possible. To keep travel time for data technicians under control, different driving distance constraints were imposed to rural PSUs and urban PSUs. The PSUs are deeply stratified and selected with probability proportional to the expected number of severe crash counts based on previous experience. In addition, the CISS PSU sample has been designed to be scalable to accommodate future budgetary fluctuation without completely reselecting the PSU sample.

Pareto sampling (Rosén, 1997) was used for both PJ and PCR sample selection. The Pareto sampling method produces overlapping samples when new samples are selected. This reduces the changes to the existing sample when a new sample needs to be selected. For PJ sample selection, Pareto sampling produces a PJ sample with selection probabilities approximately proportional to the PJ's crash counts. Pareto sampling makes it easier to handle PJ frame changes such as the creation, closure, or splitting of PJs. For PCR sample selection, Pareto sampling not only allows cases of high interest to be selected with larger selection probability but also allows the PCR sample to be expanded to effectively replace non-responding cases (i.e., crashes with key vehicle information missing) with additionally sampled cases.

An optimization technique was applied to find an approximately optimal sample allocation: the best combination of PSU, PJ, and PCR sample sizes that minimize anticipated variance under a fixed budget. The optimization results indicate when budget is available the most effective way to reduce the standard error of an estimate is to increase the PSU sample size while maintaining the number of PJs per PSU and the number of PCRs per PJ at certain levels.

In summary, the CISS has been designed as a stratified, multi-stage and multi-phase sampling with unequal selection probabilities. The scalability designed into PSU sample and the Pareto sampling used in PJ and PCR sample selection provide options to adjust for uncertainties such as future budgetary fluctuations, administrative changes in the police jurisdictions or replacing cases that are missing critical information that will enable NHTSA to monitor and react to achieve desired sample allocations.

Injuries that occur in non-tow-away crashes, to occupants of large trucks, buses, motorcycles, bicyclists, or to pedestrians, are not included in CDS or the CISS system that replaced it. The incidence of these injuries historically was derived from the GES. Data for GES came from a nationally representative sample of police-reported motor vehicle crashes of all severity and vehicle types. For a crash to be eligible for the GES sample a police crash report (PCR) must be completed, it must involve at least one motor vehicle traveling on a traffic way, and it must have resulted in property damage, injury, or death.

These crash reports were chosen from 60 areas that reflected the geography, roadway mileage, population, and traffic density of the GES data collectors make weekly visits to approximately 400 police jurisdictions in the 60 areas across the United States, where they randomly sample about 50,000 PCRs each year. No other data were collected beyond the selected PCRs. As a result, the only severity stratification in GES was that obtained from the PCR. In most States this is typically based on what is commonly known as the KABCO system. Police at the scene of the crash make their best determination of the status of each involved driver or occupant or pedestrian and categorize it as either killed (K), incapacitating injury (A), non-incapacitating injury (B), possible injury (C), or uninjured (O). Unlike the AIS severity stratification that can be obtained from CDS or CISS, which is derived from medical records, these designations reflect only the initial opinion of responders who are not medical specialists. The KABCO results from GES thus provided only vague and sometimes inaccurate information regarding injury severity.

NHTSA replaced the GES system in 2016 with the CRSS, which builds on the previous system. CRSS is a sample of police-reported crashes involving all types of motor vehicles, pedestrians, and cyclists, ranging from property-damage-only crashes to those that result in fatalities. CRSS is used to estimate the overall crash picture, identify highway safety problem areas, measure trends, drive consumer information initiatives, and form the basis for cost and benefit analyses of highway safety initiatives and regulations. However, like its GES predecessor, CRSS stratifies injury severity based on PCRs, which reflect the vague designations that are characteristic of the KABCO system.

To address this problem, “translators” have been developed to convert KABCO ratings into specific MAIS ratings. Previous versions these translators were developed from 1982-1986 data from the NASS, the primary injury data system used by NHTSA through 1986. It was replaced in 1989 by the GES and CDS systems. Both NASS and CDS contain severity designations on MAIS and KABCO bases, which allows for an examination of the actual injury severity levels that are contained in each KABCO category.

Since the last version of this report, which was published in 2015 (Blincoe et al., 2015), there have been notable changes in NHTSA’s databases involving a significant redesign of the systems, with CISS and CRSS replacing CDS and GES, and a shift to the newest version of the AIS. Due to these changes, revised translators have been developed based on the CISS data bases. We examined alternate methods of developing KABCO-to-MAIS translators based on 2000-2015 CDS and on 2017-2019 CISS. These translators were designed to control for significant changes in CDS over the years and for changes in design from CDS to CISS. These changes included revisions to the AIS and changes to the scope of injury reporting. CDS reported two versions of AIS: the AIS 1990 version/updated in 1998 (noted as MAIS1998 for translators) from 2000-2015 and the AIS 2005 version/updated 2008 (noted as MAIS2008) from 2010 onward. Other than the AIS revision, CDS implemented injury reporting scope changes in 2009 by limiting the injury reporting to occupants in passenger vehicles aged less than 11 years old when crash occurred. CISS is a modernized version of CDS but with a completely different sampling design. Its crash sample included cases where at least one-passenger vehicle was towed and not “towed due to damage” as imposed in CDS. With this, CISS would contain relatively more less severe crashes than would CDS. In addition, CISS injury reporting is applicable to all involved vehicles and without the age constraint that was implemented in 2009-2015 CDS. Furthermore, CISS recorded only MAIS2015. Therefore, CDS and CISS are treated as two totally different data sources. Table 1 presents the table indexes for the current and five new translators, along with its corresponding MAIS version, years of data, and the data sources. As shown, Translators 1-3 are for MAIS1998 separately for 2000-2008 CDS (Old CDS), 2009-2015 CDS (New CDS), and 2000-2015 CDS (All CDS). Translator 4 is for MAIS2008 based on 2010-2015 CDS. Translator 5 is for MAIS2015 from CISS.

Table 2-3. KABCO-to-MAIS Translators by MAIS Version and Data Source

Translators	MAIS Versions	Years of Data	Data Sources
Current	Mixed MAIS1990 and older versions	1982 – 1984 2000 - 2008	Old NASS CDS
1	MAIS1990	2000 - 2008	CDS
2	(Updated 1998)	2009 - 2015	CDS
3		2000 - 2015	CDS
4	MAIS2005 (Updated 2008)	2000 - 2015	CDS
5	MAIS2015	2017 – 2019	CISS

We considered the two most updated versions of these translators for this study. Translator 1-3 were rejected because their MAIS basis (MAIS1990) were considered out of date with current data bases. Translator 4, while more current than translators 1-3, is still not consistent with the MAIS2015 basis for current NHTSA databases Translator 5 is based on MAIS2015, which defines the injury profile for NHTSA’s CISS data bases. To be consistent with the serious injury definitions used in CISS, we chose Translator 5 as the basis for this study. The development of this translator is documented by Wang (in press). The selected translators used in this report are summarized in Appendix C, which also presents two broader translators that can be applied to all CISS equivalent cases or to all injuries combined.

An example of these translators is shown in Table 2-4 for Non-CISS cases involving nonoccupants and motorcyclists. The results indicate the importance of expressing injuries on an MAIS basis rather than relying on the KABCO ratings from PCRs. About 26 percent of the cases that police coded as uninjured were actually injured. Eleven percent of the cases coded as possible injury (C level injuries) were actually uninjured, as were 2.2 percent of cases coded Non-incapacitating (B level injuries), 0.6 percent of those coded as incapacitating (A level injuries), and 2.5 percent of those coded Injured Severity Unknown (ISU) were uninjured. There are also significant differences in the distribution of severities among those who are injured. Thirty-two percent of cases coded as incapacitating, the most severe injury category under the KABCO system, actually experienced only a minor injury (MAIS1) and another 31 percent only experienced a moderate injury (MAIS2).

Table 2-4. KABCO/MAIS Translator, Nonoccupants and Motorcyclists

	O	**C**	**B**	**A**	
MAIS	**No Injury**	**Possible Injury**	**Non-incapacitating Injury**	**Incapacitating Injury**	**Injured Severity Unknown**
0	0.7370	0.1057	0.0221	0.0060	0.0254
1	0.2359	0.7397	0.7456	0.3196	0.6788
2	0.0220	0.1185	0.1685	0.3144	0.2167
3	0.0048	0.0319	0.0598	0.2861	0.0572
4	0.0004	0.0032	0.0027	0.0349	0.0029
5	0.0000	0.0010	0.0005	0.0259	0.0026
Fatal	0.0000	0.0000	0.0008	0.0132	0.0165
Total	1.0000	1.0000	1.0000	1.0000	1.0000

Although CISS contains the more accurate MAIS injury severity estimates, its smaller sample size makes it a less reliable indicator of aggregate incidence. To derive a national nonfatal injury profile for 2019, CISS was used to establish an initial incidence and distribution for cases fitting the CISS profile – crashes each involving at least one towed passenger vehicle. These cases were then increased by the ratio of CISS equivalent injury cases from the CRSS to the CISS total. This normalization process acknowledges the smaller standard error that results from the more robust sample that CRSS uses.

A different approach was used for occupant cases not covered by CISS. These include occupants in non-towaway crashes, nonoccupants, and motorcyclists. Non-CDS cases were isolated from the 2017-2019 CRSS files and split according to their seat belt status. Belt status was examined separately because belts have a significant impact on injury profiles and belt use changes over time. Three separate categories were examined: belted occupants, unbelted occupants, and nonoccupants including motorcyclists.[4] A separate translator was developed for each of these categories. These translators were applied to their corresponding annual average non-CISS equivalent cases from the 2017-2019 CRSS files to estimate non-CISS equivalent injuries by MAIS level. This 3-year annual average was used to represent 2019 nonfatal injuries in order to minimize the impact of sample variation, especially on estimates of more severe injuries, which are rare in these databases.

[4] Occupants with unknown belt status were proportionately distributed among cases with known belt status prior to application of the belt specific translators.

For nonoccupants including motorcyclists, pedestrians, and bicyclists, we retained the original translators derived from 1982-86 NASS data (shown above in Table 2-4). This was done because CISS does not inform KABCO/MAIS relationships for nonoccupant cases. Further, we believe the substantial improvements made in motor vehicle crash protection over the past decade would distort KABCO/MAIS ratios for nonoccupants (who remain as vulnerable to crash impacts).

The combined CISS and non-CISS cases represent police-reported injuries as estimated in these systems. While the data systems noted previously estimate national level totals of injuries based on samples, individual States collect police-reported injury totals from the various jurisdictions within that State. State data systems thus provide a potential census of all crashes for which a police report was filed. At one time these data were gathered and published by the Federal Highway Administration (FHWA), however, FHWA no longer compiles these data so they must be obtained from other sources.

Since the early 1980s NHTSA has been obtaining from various States computer data files coded from data recorded on PCRs. A PCR is completed by a police officer at a motor vehicle traffic crash scene and contains information describing characteristics of the crash, the vehicles, and the people involved. The data recorded on these forms are computerized into a central crash data file at the State level. Information will vary from State to State because each State has different data collection and reporting standards. NHTSA refers to the collection of these computerized State crash data files as the State Data System (SDS).

The State crash data files are requested annually from the State agencies that maintain the files. In most instances, this agency is the State police, the State Highway Safety Department, or the State Department of Transportation. The data are received in various formats and converted to Statistical Analysis System (SAS) data files. The SAS files are placed on NHTSA's local area network, where they are available for

the analytical needs of the NHTSA staff. The State crash data files in SDS are not available for research outside NHTSA unless permission has been granted from the State to release the crash data. The State crash data files are obtained to support NHTSA's efforts to identify traffic safety problems, to help develop and implement vehicle and driver countermeasures, to evaluate motor vehicle standards, and to study crash avoidance issues, crashworthiness issues, and regulations.

Because only 34 States participate in this system, SDS data were supplemented by directly contacting or accessing the websites of non-participating States. 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 to 15 percent (Blincoe & Faigin, 1992, Blincoe et al., 2002). These previous analyses have focused on the difference in State injury counts and GES estimates.

A similar attempt was made to examine these counts for the 2015 analysis, however, it was found that State injury reporting practices had become too dissimilar and fragmented to produce a reliable injury count for this comparison. For example, definitions of specific injury levels often overlap between States, hospital follow-up requirements vary by jurisdiction, and use of the "Unknown" severity appears to vary by jurisdiction as well. Instead, for that report, a comparison was made between total police-reported crashes in all States to those derived from GES. The ratio of State to GES crashes was found to be 1.107, implying that GES understated total crashes by 10.7 percent. This was consistent with past estimates based on injury counts, which were in the 10- to 15-percent range. In that report our final estimate of police-reported injuries was derived by inflating the nonfatal injury profile by this 1.107 factor.

For this current report we revisited this issue by again examining State crash totals and comparing them to CRSS crash counts. State data are now available from several sources, including NHTSA’s Electronic Data Transfer (EDT) system. EDT collects data directly from State crash databases. However, we found that EDT results often disagree with official State counts obtained directly from official State data bases. The reasons for these differences vary, but reflect issues with timing of files, definitions injury, police-reporting practices within each State, etc. We note that these differences also occur across non-EDT States, thus adding to the uncertainty of using these sources as a nationwide injury total. We were thus unable to isolate an accurate estimate for many of the States. Given these caveats, we examined the ratio of each State’s total to the CRSS total under a number of different scenarios. These include the following.

- State DOT default, which consists of all State DOT totals
- EDT default, which uses EDT total for the 18 EDT States, but State DOT totals for all other States
- Lowest total, which accepts the lowest total for the 18 States that have both EDT and DOT crash counts
- Highest total, which accepts the highest total for the 18 States with both EDT and DOT crash counts
- Mixed total, which uses information from some States to judgmentally pick a most likely estimate for the 18 EDT States

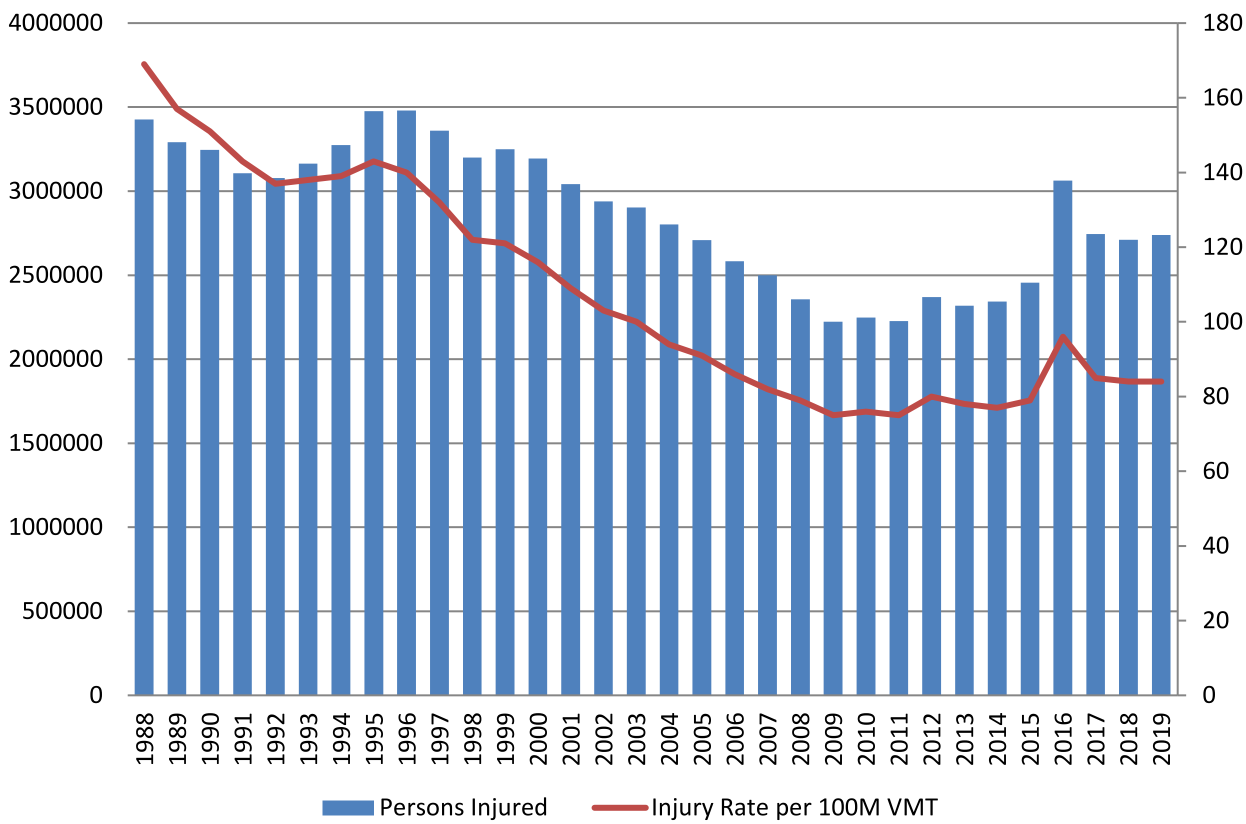
Table 2-5 summarizes the results of these analyses. The large 10- to 15 percent differentials that existed prior to the establishment of the new CISS and CRSS data systems are no longer apparent. Instead, the new CRSS totals match up well with State DOT totals in all but the worst-case scenario, where the highest totals were derived from among the data bases, and even in this case, the difference has been cut in half. Given the large uncertainty inherent in these data sources across different States, it is difficult to conclude that the State data provide a more precise basis for estimating the incidence of crashes than CRSS. It is likely that the improvements inherent in the CRSS sample design have mitigated the causes of the differences noted in previous studies. We also note that the State DOT scenario most closely matches the basis for our previous findings of a 10- to 15-percent undercount, and it now indicates only an insignificant third decimal place difference from CRSS. We therefore did not make a further adjustment to the CRSS injury totals to reflect the minor differences with State data totals noted below.

Table 2-5. Analysis of State DOT/CRSS Crash Counts

Scenario	Ratio/CRSS
State Default	1.004
EDT Default	1.041
Lowest Total	0.967
Highest Total	1.077
Mix	1.026

Unadjusted CRSS data (the sum of A, B, and C police-reported injury designations) indicate an estimated 2.74 million injuries were documented in police reports in 2019. This is an increase from the 2.25 million estimated from GES in 2010. This trend is illustrated in Figure 2-B. Note however that Figure B only reflects the raw injury counts from the GES and CRSS systems. It does not reflect adjustments for MAIS injury translation or non-police reported injuries. The trendline through 2015 is based on GES data and reflects a variety of factors including safer vehicles, safer roads, increased belt use, increased enforcement of alcohol countermeasures, and, after 2007, an economic slowdown that reduced driving and exposure. The trendline from 2016 forward reflects the higher (and more accurate) injury counts found in the new CRSS system, rather than a sudden increase in the incidence of nonfatal injury.[5] Adjusting for this, nonfatal injury totals have been relatively stable for the past decade.

Figure 2-B. People Injured and Injury Rate, by Year



Source: General Estimates System 1988-2015, Crash Investigation Sampling System 2016-2019

Table 2-6 below summarizes the results of our current analysis, including translating KABCO injuries from non-CISS cases to MAIS equivalents. This analysis indicates that an estimated total of 3.03 million injuries occurred in 2019, with over 70 percent of them occurring in the more serious towaway crashes measured in CISS.

[5] The spike in incidence indicated in 2016 is considered an artifact of start-up issues associated with the initiation of the new CRSS system. Subsequent adjustments corrected this and produced the relatively flat trendline noted for 2017-2019.

Table 2-6. Police-Reported Nonfatal Injuries

Severity	CDS	Non-CDS Unbelted	Non-CDS Belted	GES Non-Occupant	Total
MAIS0	1,246,228	17,619	1,079,966	5,389	2,349,202
MAIS1	1,759,384	23,490	634,349	144,731	2,561,954
MAIS2	247,014	3,900	21,306	38,628	310,848
MAIS3	96,439	1,185	14,362	20,237	132,222
MAIS4	16,262	246	787	1,990	19,285
MAIS5	5,844	112	0	1,232	7,187
Total	3,371,170	46,552	1,750,769	212,207	5,380,698
Total Injuries	2,124,942	28,933	670,804	206,817	3,031,496
% Total	70.10%	0.95%	22.13%	6.82%	100.00%

Unreported Crashes and Injuries

The primary basis for incidence estimates used in this report are databases maintained by NHTSA that examine police-reported crashes. As discussed above, FARS is a census of all fatal crashes, while CRSS and CISS sample a broader set of police-reported crashes, including nonfatal crashes as well. These sources provide a basis for estimating the incidence of all police-reported crashes nationwide. However, a significant number of crashes are not reported to police.

In a previous NHTSA analysis of this issue (Blincoe & Faigin, 1992), unreported injury crashes were estimated from data derived from Rice et al. (1989), and Miller et al. (1991) from the National Health Interview Survey (NHIS), while unreported property damage crashes were estimated based on a comparison of insurance claims data to national estimates of police-reported PDOs (Blincoe & Faigin, 1992) . In subsequent NHTSA analysis, (Blincoe, 1996, Blincoe et al., 2002), the unreported PDO estimate was retained but the unreported injury basis was derived from a study by Greenblatt et al. (1981). The switch in the unreported injury basis occurred because the Department of Health and Human Services announced that it had discovered a programming error that affected all motor vehicle injury estimates in the NHIS from 1982 through 1994. The most recent estimates of unreported crashes were thus based on injury survey data that are currently over 30 years old, and PDO insurance data that are over 20 years old. NHTSA was concerned that changes in police reporting practices, insurance coverage, vehicle costs, litigation practices, real incomes, and the proliferation of cell phones may have shifted the unreported crash proportion over the past two to three decades. To address this concern, NHTSA contracted with M. Davis and Company (MDAC) to conduct a comprehensive nationally representative survey of households to determine the relative incidence of reported and unreported crashes (NHTSA, 2011c). In late 2009 and the first half of 2010, MDAC conducted interviews with roughly 2,300 households where the respondent had experienced a motor vehicle crash during the previous 12 months. The interviews addressed the rate of reporting to police, the rate of reporting to insurance agencies, the severity of the crash, the location of vehicle damage, the types of injuries experienced in the crash, the cost of medical care, vehicle repair costs, the reasons why the crash was not reported, the crash location, and the number of vehicles involved in the crash. Most data elements were stratified separately for injury crashes and PDO crashes.

In Blincoe et al. (2015) unreported crashes were estimated based on the MDAC survey as well as other sources including NHTSA police reported data bases, State police reports, the National Health Interview Survey (NHIS), and the National Electronic Injury Surveillance System (NEISS) (Consumer Product Safety Commission, n.d.).

For this current analysis, we adopt the unreported crash and injury rates derived in Blincoe et al. (2015), with an adjustment to reflect injuries not captured in the original interviews conducted by MDAC. The MDAC survey (NHTSA, 2011c) contained detailed information regarding injuries for each respondent, and this was used to develop an injury profile for unreported injuries. However, there was no injury profile for injuries to non-respondent occupants so the 2015 report reflected unreported injuries from survey respondents but did not include an estimate for other vehicle occupants who may have been injured. For this update we will include an estimate for these cases. To adjust for these cases, we accessed responses to questions Q2f and Q3f from that survey, which specified whether there were others in the vehicle who were also injured. We added positive responses from these questions to the injury totals based on respondents to determine an estimate of total vehicle occupant injuries and computed a ratio of the revised total to the total from respondents. This ratio, 1.51, was used to adjust the original unreported rates derived in Blincoe et al. to compute a revised unreported rate. Since there were no details provided regarding the nature of injuries for these non-respondents, we assumed the same injury profile as established for respondents.

Property-Damage-Only Crashes

While crashes that involve death or injury produce the most serious consequences, they are relatively rare events. The vast majority of crashes are low-speed crashes that damage vehicles but leave vehicle occupants unharmed. Although these crashes impose a lower unit cost on society, their frequency makes this the most costly single type of crash overall. Although police records include a large number of property-damage-only (PDO) crashes, they tend to be significantly undercounted in police records due to a variety of factors including relatively high reporting thresholds in various States, as well as the failure of drivers to report them to police. A full analysis of PDOs must therefore address not only police records but other sources as well.

The starting point for our estimate of PDOs are police reports. Because injury is not involved, the primary cost from a PDO crash is damage to the vehicle. Therefore, PDOs are analyzed on a per-damaged vehicle basis. Blincoe et al. (2015) adjusted police-reported PDOs using State data to account for undercounting of police reports in the GES data base. As noted in previous discussion, revisions implemented in the new CRSS data base that replaced GES have negated the need to make this adjustment, so our police-reported PDO estimate is calculated directly from CRSS data. To allow for sample variation, it reflects the annual average number of cases during the 2017-2019 period.

Data from the CRSS for 2017 to 2019 indicate that there were an average of 9,734,004 vehicles damaged without injury caused to either the vehicle occupants or to pedestrians. Of these, 8,346,974 occurred in crashes where nobody was injured, while 1,387,029 occurred in crashes where injury occurred, but not to vehicle occupants. These later cases are classified in this current report as MAIS0 injuries so they will not be addressed as PDOs. The PDO category thus will ultimately represent only vehicles damaged in PDO crashes. However, of the 8.3 million vehicles that were damaged in PDO crashes, some portion were incorrectly identified as PDOs. We thus applied the revised all cases translator for MAIS0 cases to this total to adjust for incorrect police reports. This reduces the total to 93 percent of initial reported PDOs or 7,773,120 vehicles in police-reported crashes.

Reporting a crash to police does not assure that a PCR will actually be filed. Individual police jurisdictions typically have reporting thresholds, especially for crashes that only involve property damage. A person may report a crash, but if police determine that the crash does not meet the damage threshold, police may not file a crash report. Reporting thresholds vary by State and sometimes by jurisdiction. Table 2-7 lists damage reporting thresholds by State.

Table 2-7. State PDO Reporting Thresholds

State	PDO Reporting Thresholds		State	PDO Reporting Thresholds
Alabama	$500		Missouri	$500
Alaska	$2,000		Montana	$1,000
Arizona	$300		Nebraska	$1,000
Arkansas	$1,000		Nevada	$750
California	$1,000		New Hampshire	$1,000
Colorado	Not Required		New Jersey	$500
Connecticut	$1,000		New Mexico	$500
Delaware	$500		New York	$1,500
D.C.	Not Required		North Carolina	$1,000
Florida	$500		North Dakota	$1,000
Georgia	$500		Ohio	$1,000
Hawaii	$3,000		Oklahoma	$500
Idaho	$1,500		Oregon	$2,500
Illinois	$1,500		Pennsylvania	Towed Vehicle
Indiana	Not Required		Rhode Island	$1,000
Iowa	$1,500		South Carolina	$1,000
Kansas	$1,000		South Dakota	$1,000
Kentucky	$500		Tennessee	$1,500
Louisiana	$500		Texas	$1,000
Maine	$1,000		Utah	$2,500
Maryland	Not Required		Vermont	$3,000
Massachusetts	$1,000		Virginia	$1,500
Michigan	$1,000		Washington	$1,000
Minnesota	$1,000		West Virginia	$1,000
Mississippi	$500		Wisconsin	$1,000
			Wyoming	$1,000

Source: State DOTs

To estimate unreported PDOs, we adopt the rates derived in Blincoe et al. (2015). In that report the authors examined results from a number of alternate sources to estimate unreported PDO crashes. The first source considered in Blincoe et al. was the previously discussed MDAC survey (NHTSA, 2011c), which gathered data on police and insurance reporting for both injuries and for damaged vehicles. Based on 2010 crashes, MDAC found a total of 9.1 million vehicles damaged in crashes in which the driver or occupant of that vehicle wasn't injured that were reported to police, and an additional 5.1 million that were not reported to police. MDAC also reported that of these 14.2 million cases, 11.2 million were reported to insurance companies and 3.0 million were not. MDAC published a table illustrating the interaction of these cases. Table 2-8 reproduces this table, which indicates that 64.2 percent of all cases were reported to police while 78.8 percent were reported to insurance and 58.4 percent were reported to both police and insurance.

Table 2-8. Reproducing Table 3.2b in MDAC Report

		PDO Reported to Police?		
		Yes	**No**	**Total**
Reported to Insurance?	Yes	58.4%	20.4%	78.8%
	No	5.8%	15.3%	21.2%
	Total	64.2%	35.8%	100.0%

The second source considered in the 2015 report was insurance data. These data indicated that there were significantly more vehicle claims in crashes where the vehicle owners were not injured than were reflected in either GES data or the MDAC survey. Because these data were gleaned from actual insurance records, they were considered to be a more accurate estimate of insurance reported PDOs than the survey-based totals from GES and MDAC.

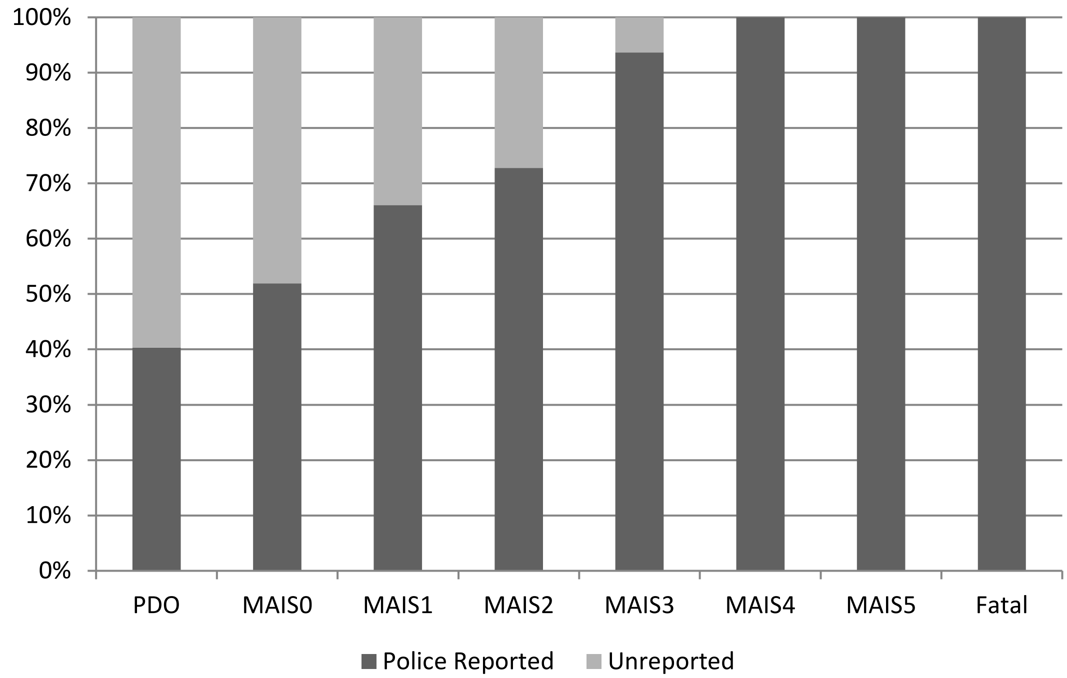
We thus applied the same methods established in Blincoe et al. (2015) to the current PDO counts modified to represent 2017-2019 annual average counts of PDO vehicles and proportions of these vehicles in PDO crashes versus injury crashes. The results are summarized in Table 2-9. These data indicates that roughly 7.8 million PDO vehicles were documented in police reports, but another 11.5 million occurred that were not reflected in police reports, for a total of 19.3 million PDO vehicles. Only about 40 percent of all PDO vehicles are thus reflected in police reports. A combination of factors previously discussed, including crashes unreported by drivers and high damage reporting thresholds within police jurisdictions, are responsible for this low reporting rate.

Table 2-9 and Figure 2-C summarize our estimates of injury, vehicle, and crash incidence. In 2019 there were 36,500 people killed in motor vehicle crashes. Another 3.1 million were injured in police-reported crashes, with an additional 1.4 million incurring injuries, mostly minor, that were not reported to the police. About 19.3 million vehicles were damaged in PDO crashes, with only 40 percent of those reported to police. Unreported cases make up a significant portion of PDOs and uninjured occupants, as well as minor, moderate, and serious injuries (MAIS levels 1-3).

Table 2-9. Incidence Summary, 2019

Severity	Police-Reported	Not Police-Reported	Total	Percentage Unreported
Vehicles				
Injury Vehicles	2,424,916	1,136,998	3,561,914	31.9%
PDO Vehicles	7,773,120	11,515,019	19,288,139	59.7%
Total Vehicles	*10,198,036*	*12,652,017*	*22,850,053*	*55.4%*
People in Injury Crashes				
MAIS0	2,349,202	2,176,700	4,525,901	48.1%
MAIS1	2,561,954	1,313,311	3,875,265	33.9%
MAIS2	310,848	116,271	427,119	27.2%
MAIS3	132,222	8,945	141,167	6.3%
MAIS4	19,285	0	19,285	0.0%
MAIS5	7,187	0	7,187	0.0%
Fatals	36,500	0	36,500	0.0%
Total	*5,417,198*	*3,615,226*	*9,032,424*	*40.0%*
Total Injuries	*3,067,996*	*1,438,526*	*4,506,523*	*31.9%*
Crashes				
PDO	4,390,169	6,503,550	10,893,719	59.7%
Injury	2,223,724	1,042,663	3,266,387	31.9%
Fatal	33,621	0	33,621	0.0%
Total Crashes	*6,647,514*	*7,546,213*	*14,193,727*	*53.2%*

Figure 2-C. Distribution of Police Reported/Unreported Injuries



3. Human Capital Costs

Human capital costs are defined as economic impacts that result from motor vehicle crashes, including the costs for goods and services that are required to treat injury, repair damage, or address the legal or administrative consequences of the crash, as well as productive opportunities such as lost wages or other productive activities that are forgone due to injury or delay that results from the crash.

Categories of human capital costs include the following:

Congestion Costs: The value of travel time delay for people who are not involved in traffic crashes, but who are delayed in the resulting traffic congestion from these crashes, as well as the value of excess fuel consumed, greenhouse gases, and criteria pollutants emitted due to traffic congestion caused by the crash.

Emergency Services: Police and fire department response costs.

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

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

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

Market Productivity: The present discounted value (using a 3-percent discount rate) of the lost wages and benefits over the victim's remaining life span.

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

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

Vocational Rehabilitation: The cost of job or career retraining required due to disability caused by motor vehicle injuries. These costs are grouped with medical costs in this report.

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

Estimating crash costs requires estimates of the number of people and vehicles involved in a crash, the severity of each person's injuries, and the costs of those injuries. The first section of this chapter describes the methods used to estimate the incidence and severity of motor vehicle crashes. The succeeding sections explain how the unit costs of injuries were estimated and present those estimates.

Crash Data and Severity Estimation

Police reports, which usually provide the basis for crash databases, often do not accurately describe the severity of motor vehicle crashes. Accordingly, we made several adjustments to more accurately reflect the severity of crashes. To estimate injury incidence and severity, we followed procedures developed by Miller and Blincoe (1994) and Miller, Galbraith, et al. (1995) and later applied in Blincoe (1996); Miller, Levy, et al. (1998); Miller, Lestina, and Spicer (1998); Miller, Spicer, et al. (1999); Blincoe et al. (2002); Zaloshnja et al. (2004); Blincoe et al. (2015), and Zaloshnja et al. (2016). Below we summarize the procedures and describe the adjustments.

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

KABCO ratings are coarse and inconsistently coded between States and over time. The codes are selected by police officers without medical training, typically without benefit of a hands-on examination. Some victims are transported from the scene before the police officer who completes the crash report even arrives. Miller, Viner, et al. (1991) and Blincoe and Faigin (1992) documented the great diversity in KABCO coding across cases. O'Day (1993) more carefully quantified the wide variability in use of the A-injury code between States. Viner and Conley (1994) explained the contribution to this variability of differing State definitions A-injury. Miller, Whiting, et al. (1987) found that police-reported injury counts by KABCO severity systematically varied between States because of differing State crash reporting thresholds (the rules governing which crashes should be reported to the police). Miller and Blincoe (1994) found that State reporting thresholds often changed over time.

Thus, police reporting does not accurately describe injuries medically. To minimize the effects of variability in severity definitions by State, reporting threshold, and police perception of injury severity, we turned to NHTSA Crash Investigation Sampling System (CISS) data sets that included both police-reported KABCO and medical descriptions injury in the Occupant Injury Coding system (OIC; AAAM, 1990, 1985, 2008, 2015). OIC codes in CISS include AIS severity score coded in the 2015 Edition of AIS, body region, and more detailed injury descriptors.

Unit Cost Estimates

The second step required to estimate average crash costs was to generate costs per crash victim by maximum AIS (MAIS), body part, and whether the victim suffered a fracture. A 41-level body part descriptor was created based on information provided by the NASS/CDS variables describing the body region, system/organ, lesion, and aspect of each injury. Burns were classified as a separate category due to the lack of location information for burn injuries.

The sections that follow describe unit medical costs, work loss costs, the value of quality of life loss (QoL), and selected ancillary costs. In addition, Appendix E describes the costing methods. Medical and work loss costs cover three mutually exclusive categories that reflect injury severity: (1) injuries resulting in death, including post-injury deaths in a healthcare setting; (2) injuries resulting in hospitalization with survival to discharge; and (3) injuries requiring an ED visit not resulting in hospitalization (ED-treated injuries). To estimate mean costs across all surviving crash victims, we needed to add costs for cases treated only in physicians' offices or outpatient departments to the cost for cases treated in hospital emergency departments or admitted to hospitals. To estimate these additional costs, we multiplied unit costs for ED-treated injuries by body part and nature of injury (as per the Barell injury-diagnosis matrix) times ratios of ED-treated injuries versus injuries treated only in doctor's offices or outpatient departments found in Finkelstein et al. (2006). We then took averages across treatment settings. We computed costs from a societal perspective, which means we included all costs regardless of who paid for them.

We estimated mean costs per surviving victim by maximum AIS (MAIS), body part, and fracture involvement from combined Healthcare Cost and Utilization Project (HCUP), Nationwide Inpatient Sample (NIS), and Nationwide Emergency Department Sample (NEDS) files. (For descriptions these files, see Appendix E.) We used software developed by the AAAM Injury Scaling Committee to attach an AIS2008 score to each injury of each road crash patient in the HCUP NIS and NEDS files. The AAAM coding provides scores by International Classification of Disease, 9th Edition,- Clinical Modification (ICD-9-CM) diagnosis code (CDC, 2022). The Maximum AIS (MAIS) is the highest AIS score among a patient's injuries. In descriptive analysis we found that this method identified almost no injury patients as MAIS4, although CISS identified many MAIS4 brain injuries. AAAM trainers suggested that this resulted because single ICD9-CM codes are too coarse to identify definitive AIS scores for brain injuries. Their convention is to code down when in doubt. Therefore, we turned to older artificial intelligence software data (Clark et al., 2018) to AIS-score the brain injuries. The Clark MAIS was generated in RStudio v. 1.3.1056 and R v. 4.0.2. We estimated standard errors of means with the SURVEYMEANS command in SAS 9.4, which accounts for sample stratification.

Unit Costs of Medical Care, Work Loss, and Quality-of-Life Loss

Table 3-1 presents HCUP crash costs per surviving victim at a 3 percent discount rate by MAIS. The mean and standard error (SE) for work loss, medical care costs, monetized quality-of-life (Qol) and the unmonetized QALYs that Qol values in dollars, as well as annual inpatient and ED incidence were generated from the 2013-2014 NIS and NEDS databases. The 2018 incidence counts from the NIS and NEDS are presented for comparison. Using the procedures described at the end of Appendix E, the MAIS1 costs were reduced to account for injuries that were treated only in physicians' offices/clinics or were not treated by a medical professional except possibly at the crash scene. The NIS and NEDS Medical Costs data in Table 3-1 involves a slightly different calculation than the other three costs.[6] Among cases with missing MAIS, fewer cases are missing medical costs than the other three costs, resulting in different Inpatient and ED annual counts.

[6] For more detail on these procedures see Appendix E of this report.

Table 3-1. Medical Costs, Work Loss, Monetized Quality-of-Life (QoL), and Unmonetized Quality-Adjusted Life Years (QALYs) for Survivors Injured in Road Crashes and Treated in Hospitals by MAIS (2019 dollars, 3 percent discount rate)

MAIS	Cost Category	Mean	Standard Deviation	2013-14 Inpatient Count per Year	2013-14 ED Count per Year	2018 Inpatient Count	2018 ED Count
1	Medical	2,860	33	16,733	1,967,582	19,265	1,769,053
1	Household	1,019	18	16,730	1,965,170		
1	Wages	2,775	64	16,730	1,965,170		
1	Qol 3%	0.11	0	16,730	1,965,170		
1	QALY 3%	56,833	1,779	16,730	1,965,170		
2	Medical	13,145	193	87,653	227,110	95,215	253,266
2	Household	9,010	71	87,640	226,997		
2	Wages	23,161	219	87,640	226,997		
2	Qol 3%	0.84	0	87,640	226,997		
2	QALY 3%	420,371	4,836	87,640	226,997		
3	Medical	69,075	998	78,375	18,039	59,875	12,558
3	Household	39,050	310	78,445	18,024		
3	Wages	92,829	886	78,445	18,024		
3	Qol 3%	3.93	0	78,445	18,024		
3	QALY 3%	1,965,673	17,734	78,445	18,024		
4	Medical	188,295	3,752	13,048	227	13,635	185
4	Household	116,493	968	13,055	227		
4	Wages	230,165	3,268	13,055	227		
4	Qol 3%	6.46	0	13,055	227		
4	QALY 3%	3,233,202	50,653	13,055	227		
5	Medical	341,516	11,180	3,960		24,105	957
5	Household	122,194	2,344	3,955			
5	Wages	288,796	8,654	3,955			
5	Qol 3%	12.03	0	3,955			
5	QALY 3%	6,018,877	166,611	3,955			
6	Medical	1,279,308	60,070	93		115	8
6	Household	357,332	19,158	93			
6	Wages	1,028,210	43,788	93			
6	Qol 3%	27.56	2	93			
6	QALY 3%	13,789,314	1012,666	93			
5 & 6	Medical	362,922	11,933	4,053		24,220	963
5 & 6	Household	127,568	2,571	4,048			
5 & 6	Wages	305,694	9,106	4,048			
5 & 6	Qol 3%	12.39	0	4,048			

MAIS	Cost Category	Mean	Standard Deviation	2013-14 Inpatient Count per Year	2013-14 ED Count per Year	2018 Inpatient Count	2018 ED Count
5 & 6	QALY 3%	6,196,459	173409	4,048			
Any	Medical	7,314	225	209,125	2,883,449	215,390	2,241,853
Any	Household	4,117	71.0	202,417	2,475,229		
Any	Wages	10,071	190.0	202,417	2,475,229		
Any	Qol 3%	225,204	4,217	202,417	2,475,229		
Any	QALY 3%	0.45	0.01	202,417	2,475,229		
Fatal	Medical	17,289	137.3	N/A	N/A	N/A	N/A
Fatal	Work Loss	1,378,118	775,629				
Fatal	Qol 3%	9,521,882	3,274,332				
Fatal	QALY 3%	19.91	6.85				

Note: The missing standard errors for MAIS cases resulted from too few cases across strata to allow for error calculation in the SURVEYMEANS procedure.

All costs in Table 3-1 are modeled, as described in Appendix E. The models parallel and refine those used in Miller et al. (1991) and Blincoe et al. (2006, 2015). The medical costs start from facility charges provided by HCUP, apply a HCUP-provided cost-to-charge ratio,[7] then multiply times factors to add professional fees associated with the hospital visit, and any follow-up medical care needed across the patient's lifespan. The data on follow-up care needs and costs are amalgamed from varied data sets and publications. Work loss costs include temporary wage and household work losses during acute recovery from injury and lifetime losses in the event of death or permanent disability. These costs were calculated from Worker's Compensation and Medical Expenditure Panel Survey data. Quality-of-life losses build on trauma system data and expert assessments of clinicians to estimate functional capacity losses resulting from the injury over time. Those losses are valued based on published systematic reviews of how people value functional losses relative to perfect health and what they routinely pay or say they would pay for small reductions in their probability of death or disabling injury.

Table 3-2 breaks down the costs per injured crash survivor from Table 3-1 by body region, fracture involvement, and MAIS. Its Minor Injury category consists of MAIS1 contusions and lacerations.

[7] Charges always exceed costs in the U.S. medical system, and the billers only expect partial payment, with the percentage paid varying from payer to payer. HCUP provides costs-to-charge ratios for use with the HCUP files. They build the ratios from mandatory hospital cost reporting to CMS. The cost-to-charge ratios tend to be in the 25 percent to 40 percent range.

Table 3-2. Medical Costs, Earnings Loss, and Household Production Loss per Survivor Treated at Hospital, by Body Region, Fracture Involvement, and MAIS (2019 $, 3% discount rate)

Body Region	Fracture	MAIS	Mean Medical	SD Medical	Mean Household	SD Household	Mean Wages	SD Wages
TBI	N/A	1	$2,625	$173	$1,503	$259	$4,269	$794
TBI	N/A	2	$14,948	$625	$16,060	$539	$42,945	$1,661
TBI	N/A	3	$119,734	$2,865	$90,576	$765	$215,375	$2,650
TBI	N/A	4	$190,091	$4,372	$134,196	$841	$262,931	$3,892
TBI	N/A	5 or 6	$500,438	$47,471	$181,832	$4,944	$426,387	$18,212
Spinal Cord	No	1						
Spinal Cord	No	2						
Spinal Cord	No	3	$428,095		$134,675		$339,997	
Spinal Cord	No	4	$614,745		$170,150		$319,932	
Spinal Cord	No	5 or 6	$738,984	$23,776	$209,305	$5,035	$550,891	$19,711
Other Head/Neck	No	1	$2,703	$60	$1,150	$57	$3,481	$214
Other Head/Neck	No	2	$5,019	$328	$3,426	$324	$10,048	$1,121
Other Head/Neck	No	3	$15,443	$1,542	$17,726	$1,445	$46,676	$4,733
Other Head/Neck	No	4						
Other Head/Neck	No	5 or 6	$57,084	$16,138	$104,975	$5,830	$276,038	$31,431
Other Head/Neck	Yes	1	$6,072	$184	$1,838	$205	$5,583	$681
Other Head/Neck	Yes	2	$15,529	$651	$7,961	$497	$22,538	$1,572
Other Head/Neck	Yes	3	$27,833	$1,159	$22,918	$850	$61,889	$2,587
Other Head/Neck	Yes	4	$54,034		$58,244		$128,966	
Other Head/Neck	Yes	5 or 6	$94,812	$12,039	$102,714	$5,639	$255,737	$20,929

Body Region	Fracture	MAIS	Mean Medical	SD Medical	Mean Household	SD Household	Mean Wages	SD Wages
Trunk	No	1	$2,500	$80	$1,356	$39	$3,601	$143
Trunk	No	2	$17,548	$502	$6,620	$178	$16,865	$493
Trunk	No	3	$41,033	$974	$17,691	$497	$39,323	$1,065
Trunk	No	4	$102,420	$5,596	$35,362	$2,302	$71,434	$4,863
Trunk	No	5 or 6	$90,098	$6,005	$48,479	$2,985	$97,043	$6,424
Trunk	Yes	1	$3,935	$240	$1,724	$56	$4,227	$333
Trunk	Yes	2	$18,041	$431	$12,766	$191	$29,231	$586
Trunk	Yes	3	$35,564	$805	$19,289	$339	$41,242	$823
Trunk	Yes	4	$105,249	$6,270	$46,242	$2,288	$102,981	$4,790
Trunk	Yes	5 or 6	$115,673	$8,754	$83,791	$4,935	$156,201	$9,702
Upper Extremity	No	1	$3,681	$110	$1,059	$59	$2,962	$183
Upper Extremity	No	2	$4,785	$332	$1,813	$146	$5,584	$477
Upper Extremity	No	3	$37,884	$3,302	$25,162	$1,732	$58,793	$3,804
Upper Extremity	No	4	$96,417		$91,191		$250,230	
Upper Extremity	No	5 or 6						
Upper Extremity	Yes	1	$2,655	$448	$2,079	$93	$5,920	$502
Upper Extremity	Yes	2	$9,891	$210	$7,284	$67	$19,466	$284
Upper Extremity	Yes	3	$54,601	$1,305	$37,336	$654	$92,252	$1,604
Upper Extremity	Yes	4	$96,625		$55,036		$144,208	
Upper Extremity	Yes	5 or 6	$85,516	$13,280	$91,657	$4,836	$154,934	$11,720
Lower Extremity	No	1	$1,736	$86	$786	$60	$2,199	$238
Lower Extremity	No	2	$6,614	$404	$2,757	$118	$7,810	$380

Body Region	Fracture	MAIS	Mean Medical	SD Medical	Mean Household	SD Household	Mean Wages	SD Wages
Lower Extremity	No	3	$79,135	$4,078	$34,132	$1,668	$92,117	$4,834
Lower Extremity	No	4	$121,357		$70,007		$215,069	
Lower Extremity	No	5 or 6						
Lower Extremity	Yes	1	$2,135	$196	$1,170	$89	$3,337	$268
Lower Extremity	Yes	2	$21,703	$373	$14,121	$71	$36,993	$313
Lower Extremity	Yes	3	$81,281	$1,153	$27,105	$255	$68,533	$568
Lower Extremity	Yes	4	$167,619		$51,375		$100,998	
Lower Extremity	Yes	5 or 6	$151,417	$11,143	$81,849	$3,248	$140,854	$7,530
Burns	N/A	1	$1,827	$195	$1,144	$36	$3,058	$238
Burns	N/A	2	$6,645	$935	$2,586	$117	$7,468	$412
Burns	N/A	3	$59,537	$10,743	$15,913	$2,701	$37,866	$6,207
Burns	N/A	4						
Burns	N/A	5 or 6	$276,728	$30,436	$23,000	$2,472	$49,372	$6,182
Minor Injury	N/A	1	$1,665	$32	$333	$9	$820	$29

Appendix B provides variants of Table 3-2 at different discount rates for earnings and household productivity loss. Table 3-3 breaks out injury costs by person-type. The nonfatal victim counts in this table are weighted counts of 2018 HCUP data cases coded as initial visits for injuries in motor vehicle crashes on public roads. The counts for motorcyclists, pedestrians, and pedalcyclists greatly exceed the police-reported estimates from CRSS.

The costs per injured pedestrian or motorcyclist are roughly three times the costs per injured occupant. Pedalcyclist costs are elevated to a lesser extent. As Table3-3 shows, this pattern results from a higher fatality rate and a higher hospital admission rate among nonfatal injuries.

Table 3-3. Fatality Rate and Nonfatal Hospital Admission Rate of People Injured in Motor Vehicle Crashes by Person Type

	% Fatal	**% Admitted of Nonfatal**
Occupant	1.0%	5.1%
Motorcyclist	3.3%	23.5%
Pedestrian	5.5%	18.9%
Pedalcyclist	1.0%	9.8%

A major limitation of the costs presented is that some cost components are unavoidably quite old. No recent source exists for the percentage of lifetime medical costs that is incurred more than 18 months post-injury, probabilities of permanent disability by detailed diagnosis and whether hospital admitted, or the ratio of household workdays lost to wage workdays lost.

Table 3-4. Number of People Injured and Injury Costs Per Person in Road Crashes by Person Type, 2018 (in 2019 $)

Occupant	**All**	**Admitted**	**ED only**	**Medical**	**Wages & Fringe**	**Household Work**	**Quality-of-life**	**Legal**	**Insurance Administration**	**Total**
MAIS1	2,056,736	11,449	2,045,287	2,890	2,759	1,037	55,104	923	1,100	63,812
MAIS2	292,604	62,765	229,839	13,078	21,671	9,333	448,268	6,084	7,256	505,691
MAIS3	52,098	40,791	11,307	62,490	83,942	37,460	1,938,534	25,382	30,269	2,178,077
MAIS4	2,057	2,057		178,544	216,902	116,527	3,156,475	70,665	41,891	3,781,003
MAIS5	6,327	6,327		394,888	321,950	139,095	6,590,076	118,140	41,891	7,606,041
Fatal	24,332			15,000	990,638	359,764	9,455,112	138,025	41,891	11,000,430
All	*2,434,154*	*123,389*	*2,286,433*	*6,678*	*17,655*	*6,856*	*256,246*	*3,801*	*3,013*	*294,249*
Motorcyclist	**All**	**Admitted**	**ED only**	**Medical**	**Wages & Fringe**	**Household Work**	**Quality-of-life**	**Legal**	**Insurance Administration**	**Total**
MAIS1	71,198	1,890	69,308	2,727	3,294	853	76,147	949	1,131	85,100
MAIS2	54,856	16,904	37,952	12,972	27,074	7,643	374,859	6,582	7,850	436,981
MAIS3	15,816	13,876	1,940	74,701	108,405	38,386	2,131,391	30,571	36,458	2,419,911
MAIS4	795	795		209,447	281,374	114,962	4,170,479	83,613	41,891	4,901,765
MAIS5	1,541	1,541		303,732	266,955	96,780	5,933,787	92,127	41,891	6,735,272
Fatal	4,985			20,061	1,144,402	415,606	9,821,407	138,025	41,891	11,581,392
All	*149,192*	*35,006*	*109,201*	*18,913*	*65,514*	*22,786*	*811,797*	*12,123*	*9,347*	*940,480*

Pedestrian	**All**	**Admitted**	**ED only**	**Medical**	**Wages & Fringe**	**Household Work**	**Quality-of-life**	**Legal**	**Insurance Administration**	**Total**
MAIS1	70,049	1,393	68,656	2,596	2,428	827	92,933	808	963	100,554
MAIS2	29,760	10,339	19,421	18,662	30,507	12,365	594,130	8,493	10,129	674,287
MAIS3	10,518	9,203	1,315	104,143	113,244	51,133	2,553,670	37,062	41,891	2,901,143
MAIS4	457	457		224,884	242,222	118,849	3,357,360	80,876	41,891	4,066,082
MAIS5	899	899		311,719	307,125	123,523	6,766,275	102,465	41,891	7,652,997
Fatal	6,471			23,045	917,340	333,145	9,059,972	138,025	41,891	10,513,418
All	*118,154*	*22,291*	*89,392*	*20,014*	*72,718*	*27,802*	*992,726*	*14,569*	*9,626*	*1,137,455*
Pedalcyclist	**All**	**Admitted**	**ED only**	**Medical**	**Wages & Fringe**	**Household Work**	**Quality-of-life**	**Legal**	**Insurance Administration**	**Total**
MAIS1	54,981	799	54,182	2,522	2,738	691	80,778	821	980	88,530
MAIS2	26,792	4,050	22,743	11,062	24,786	7,651	374,593	6,004	7,160	431,256
MAIS3	3,957	3,266	690.3209	76,751	121,826	43,787	2,127,780	33,452	39,894	2,443,490
MAIS4	128	128		170,345	253,710	117,064	3,594,655	74,688	41,891	4,252,354
MAIS5	314	315		587,810	377,490	123,887	7,473,032	138,025	41,891	8,742,135
Fatal	883			26,474	918,975	333,739	8,923,911	250,954	41,891	10,495,944
All	*87,055*	*8,557*	*77,615*	*11,127*	*25,951*	*8,786*	*385,788*	*7,040*	*5,273*	*443,965*

Source: Nonfatal case counts 2018 NIS and NEDS; fatal and CRSS counts, Traffic Safety Facts 2018, Table 54, with unknown non-motorist allocated in proportion to knowns. Costs were tabulated from costed 2013-2014 NIS and NEDS files and 2019 Multiple Cause of Death File.

Property Damage, Insurance, and Legal Costs

Some crash costs are most easily estimated from insurance data. These include not only insurance claims processing and legal costs but also costs of property damage. Insurance data also are a critical input when analyzing who pays the costs of crashes.

To analyze the insurance-related costs, we purchased data from the Insurance Services Office, a data-pooling organization that aggregates claims data from a large cross-section of auto insurers. We bought data that detailed insurance premiums collected and claims paid by selected insurers in 2018. We used those data in conjunction with national insurance statistics and crash data to analyze (1) property damage costs per vehicle, (2) numbers of people receiving insurance claims payments due to crash injury, and (3) transaction costs of compensation through the insurance and legal systems. This chapter describes the data we purchased, our analyses of them, and what they showed.

Auto Insurance Data Description and Loss Cost Computations

Insurance Services Office structured its data report around a spreadsheet developed by the Motorcycle Insurance Committee of the National Association of Independent Insurers (NAII, Miller & Lawrence, 2003). ISO was able to break out data only by motorcycle versus other personal auto versus commercial auto, with commercial auto decomposed by vehicle type. They provided data on seven categories of insurance coverage:

1. Bodily injury liability (coverage if the policyholder’s vehicle injures someone; mandatory in most States; in no-fault insurance States this coverage compensates losses that exceed the no-fault threshold). For motorcycles, some companies separated passenger liability coverage from other bodily injury coverage.
2. Property damage liability (coverage if the policyholder’s vehicle damages or destroys someone else’s property; mandatory in many States).
3. Own medical payments (coverage for the policyholder’s own injury treatment costs up to a modest ceiling, typically $1,000; often mandatory in States without no-fault insurance).
4. Personal injury protection (no-fault coverage for the policyholder’s own losses up to a modest ceiling, typically $15,000–$25,000; mandatory in some States).
5. Collision (coverage for damage to the policyholder’s vehicle when the policyholder is at fault in the crash or no one is; typically required by the lender if vehicle purchase was financed).
6. Comprehensive (coverage for theft or non-crash damage to the policyholder’s vehicle; typically required by the lender if vehicle purchase was financed).
7. Uninsured and underinsured motorist (coverage for injuries to the policyholder and other occupants of the policyholder’s vehicle, as well as the policyholder’s property damage when a driver without insurance is at fault or when the at-fault driver has too little insurance to fully compensate the policyholder’s losses; mandatory in many States).

For each category we obtained four data items for policies written in 2018. Coverage in a policy is for a maximum of one year:

- Earned exposure (the number of vehicles covered by insurance for this risk).
- Earned premiums (how much policyholders paid for this coverage, net of any dividends or rebates to policyholders).
- Incurred losses (the amount paid or reserved for future payment of claims against the policies, including amounts that will be paid by reinsurers).
- Incurred claim count (the number of damage claims that the insurance paid for or anticipates paying for as lawsuits and other disputes are resolved).

From the data collected, by vehicle and coverage type, we computed:

- Claims per 1,000 covers (incurred claim count divided by earned exposure, i.e., the number of claims filed per 1,000 policies that offer the specific coverage).
- Claim severity (incurred losses divided by incurred claim count, i.e., the average payments per claim paid).
- Average loss cost (incurred losses divided by earned exposure, a measure influenced by both the frequency of claims and claim severity, i.e., losses per cover).
- Percentage of total losses (by vehicle type, incurred losses for each coverage divided by total incurred losses for all coverages).
- Loss ratio (the ratio of incurred losses to earned premiums, i.e., the percentage of premiums that is paid to settle claims).

We used national data on premiums written and loss ratios (Glenn, 2010) to estimate coverage and representativeness of Insurance Services Office data and to factor up ISO data to national estimates. As Table 3-5 shows, ISO data include 26.3 percent of private passenger auto premiums and 23.8 percent of commercial auto premiums. Like Miller and Lawrence (2000) found in 1998–1999, losses in Insurance Services Office data were typical of all auto policies.

Table 3-6 summarizes premiums and exposures earned and policy results.

Property Damage Costs

Across commercial and personal lines, property damage payments averaged $3,551 per liability claim for damage to other vehicles and $4,321 per collision claim for damage to the insured's vehicle, with an overall average of $3,960. For personally owned or leased passenger vehicles, the means are $3,450, $4,202, and $3,855, compared to $4,817, $6,943, and $5,663 for commercial vehicles. Collision claims are a combination of single vehicle crashes and multi-vehicle crashes. In general, collision coverage for the policyholder's vehicle is subject to a deductible but liability is first-dollar coverage, meaning it has no deductible. Note that the average insurance payment for both personal and commercial policies is higher for claims on the insured's vehicle than for other vehicles. This is because people do not file small damage claims for their own vehicles due to fear of increased insurance rates, or when a claim amount is below their deductible.

We estimated how often people do not file a claim for property damage. Ratioing number of earned car-years of exposure from Table 3-6 indicates that 75 percent of insured drivers carry collision coverage with minimal variation between personal and commercial lines. About one-third of crashes are single vehicle, with most of the rest involving two vehicles. So, if all crashes with meaningful damage led to claims, we would expect to see ***1.5*** (2×0.75) times as many own-vehicle claims as liability claims. Indeed, this multiplier could be even higher since drivers share fault in some crashes. The actual ratio in the Insurance Services Office data is ***1.130***. The remaining 0.37 (1.50 – 1.130) smaller claims are not filed. That means claims are not filed for 24.67 percent of damaged vehicles (0.37/1.50 = 24.67%), presumably because the damage is near or below the deductible.

Among claims for damage to one's own vehicle, the Insurance Services Office data show the amount claimed averages $4,321 plus deductible (see table 3-6). We adjusted that amount by adding the deductible. A website that specializes in insurance quotes (www.carinsurance.com/what-is-collision-coverage-insurance) states that insurance professionals suggest collision policies carry a $500 deductible. Similarly, in Insurance Services Office data on commercial passenger vehicles, the mean deductible was $584 in 2018. With a $500 deductible, the total vehicle damages where a claim is filed for damage to one's own vehicle would average $4,821 ($4,321 + $500).

Insurance Services Office reports liability claims for damage to someone else's vehicle average $3,552 with no deductible.

Across all vehicles with property damage compensated by insurers in the Insurance Services Office data, damage costs per vehicle would average $4,225 ($4,821 * 2,958,906 own-vehicle claims + $3,552 * 2,618,123 liability claims)/(2,958,906 + 2,618,906)). That average is our best estimate of the damage per vehicle in a police-reported crash.

We next computed the average loss for the 27.66 percent of damaged vehicles where the insured chose not to file a claim under their collision coverage. To do so, we assume that the $3,551 average cost that Insurance Services Office reports for liability claims for damage to someone else's vehicle should mirror the average cost of damage to one's own vehicle. Then for the remaining 24.67 percent of damaged vehicles, costs would average $369 ([$3,552 average liability claim − $4,225 average own-vehicle claim plus deductible × (1-0.2766)]/0.2766). That lower property damage cost is our best estimate of the average property damage per vehicle in unreported crashes without injury.

Property Damage Cost per Vehicle and per Crash by MAIS Severity

As the next-to-last row in Table 3-5 shows, insurance compensated $83.1 billion in crash damage in 2018. This section decomposes those costs and the associated costs of uncompensated damage into property damage per vehicle and per crash by MAIS severity.

Decomposing the costs requires estimating the number of crashes and vehicles by MAIS severity. That task is challenging. NHTSA last collected crashes by MAIS and vehicles per crash-by-crash MAIS in 2006 for crashes included in the Crashworthiness Data System and in 1984-86 NASS for other crashes. Table 3-7 shows a matrix that Blincoe et al. (2015) developed from those data for use in computing the number of crashes by crash MAIS from the MAIS distribution of injured people. To illustrate how this matrix is used, the number of MAIS5 crashes is computed as (8,010 MAIS5 survivors – 33,919 fatal crashes * 0.032998 MAIS5 survivors per fatal crash)/(1.017526 MAIS5 survivors per MAIS5 nonfatal crash) = 6,772 MAIS5 nonfatal crashes.

Table 3-8 shows the computed crash counts as well as property damage per vehicle and per crash-by-crash MAIS, expressed in 2018 dollars. To estimate the costs, we multiplied ratios from

Blincoe and Luchter (1983) times the $4,225 average property damage in reported crashes to estimate damage per vehicle by MAIS crash severity. Table 3-8 shows those ratios and the estimated property damage per vehicle by MAIS crash severity. Table 3-8 also shows vehicle counts by crash MAIS computed from 1984-86 NASS data, which were the last to collect vehicle per crash by MAIS for all crash types. In this table, rather than applying the Blincoe and Luchter ratio to compute vehicles in PDO crashes, we computed vehicles in insurer-reported PDO crashes as (vehicles with claims in Insurance Services Office divided by the percentage of property damage claims costs in Insurance Services Office) minus (vehicles where someone had an injury reported in CRSS).

To break the property damage costs down into cost per person involved in a crash by injury severity, we followed the method used by Miller, Viner, Rossman, et al. (1991) and Blincoe et al. (2015). Using a combination of 2010 CDS and reweighted 1984-86 NASS data, Blincoe et al. (2015) first cross-tabulated the number of people in a crash by the AIS severity of their maximum injury (MAIS) and by the maximum MAIS of anyone in the crash (AIS). Second, they used that cross-tabulation to iteratively estimate costs by MAIS. We divided the cost for a PDO crash by the uninjured people involved in a PDO crash to get a cost per uninjured person. Next, they used that cost per uninjured person to compute the cost of an MAIS1 crash net of the costs associated with uninjured people. Dividing by the number of MAIS1 injury victims in a crash then yields the cost per MAIS1 victim. This process was repeated sequentially to compute the costs shown in Table 3-4 for all MAIS levels.

Table 3-9 shows that 2017-2019 CRSS and 2009 GES estimates of vehicles per crash by police-reported KABCO severity are virtually identical to the 1984–1986 NASS estimates. These ratios have remained remarkably stable over time, so it seems likely that the NASS ratios we used by MAIS also are stable. For unknown reasons, the GES/NASS ratio for fatal crashes of 1.63–1.66 is much higher than the ratio of 1.54 for 2018 from FARS. We used the FARS ratio.

Number of People Who Auto Insurance Compensates for Injury

Insurance Services Office includes 5,577,029 property damage claims (Table 3-6). By line of business, the percentage of property damage premiums covered by Insurance Services Office insurers varies only slightly from the percentage of claims paid (Table 3). Thus, drivers covered by these insurers either (1) have slightly lower crash risks than other insureds, (2) suffer slightly less damage per crash, or (3) buy slightly more costly insurance. Depending on which of these possibilities is correct, insurers paid for damage to 18.3 to 18.8 million crashed vehicles in 2018. Similarly, exclusive of uninsured motorist coverage, auto insurers paid 4.62 to 5.14 million injury claims in 2018. We computed these ranges as Insurance Services Office claims incurred divided by percentage of premiums or claims payments in Insurance Services Office.

Some own-medical claims and no-fault claims, however, are for injuries that also generate bodily injury claims, resulting in some injured people making claims under several policies. Roughly one-third of crashes involve a single vehicle. Thus, at most one-third of drivers (half of drivers in multi-vehicle crashes) might be in crashes where another driver was at fault. Those drivers generally would receive bodily injury compensation as their insurer recovered own-medical losses from the at-fault driver's insurance. Because some bodily injury claims are for recovery above no-fault limits, we assume 10 percent of no-fault claims also involve a bodily injury claim. Removing those overlaps by reducing own-medical claims by one-third and no-fault claims by

10 percent suggests liability insurance compensated 5,383,000 injured people in 2018. This estimate accounts for insured drivers, but not the uninsured.

Despite preponderant State laws mandating liability coverage, an estimated 12.6 percent of U.S. drivers were uninsured in 2018 (Insurance Information Institute, 2022). Uninsured/underinsured motorist coverage compensates bodily injury and in some States, either by mandate or at buyer option, property damage. A single claim can capture both categories of losses. This coverage is not mandatory everywhere; only 86.7 percent of personal auto liability insurance buyers purchased it in 2018. We estimate that it compensated another 296,000 injury claims for insured drivers (86.7% with coverage × 12.6% of drivers uninsured × 680,553 Insurance Services Office bodily injury claims against insured drivers/25.1 percent of all bodily injury claims in the Insurance Services Office data). That brings the total number of auto insurance compensation claims for injury in 2018 to 5,679,000.

If uninsured drivers had average crash risks, then 6,211,000 people would have been injured in 2018 (5,679,000/86.7% insured).

Comparison to Other Crash Injury Counts

How does this number compare with estimates from NHTSA data systems and health care administrative system? Using NHTSA data systems and surveys, Chapter 2 estimated that 4,507,000 people were injured in crashes in 2019, including 3,068,000 injured in police-reported crashes. Table 3-10 summarizes the estimates. It also uses the cost estimates in Table 3-1 to estimate total cost of these injuries. Like in the 2015 report, our insurance-based estimate is far higher.

HCUP NIS and NEDS offer a further estimate of nonfatal crash injury incidence. They indicate that 3,034,524 people were treated and released for crash injuries and 238,085 crash survivors were admitted to hospital in 2018. Adding 400,368 survivors treated only in physician offices and clinics based on factors from Finkelstein et al. (2006), we estimate 3.7 million crash survivors were medically treated annually in 2018. The comparable totals were 4.2 million in 2000 and 3.6 million in 2008.

Portion of Injury Costs Compensated and Payments for Fraudulent Claims

Blincoe et al. (2002, 2015) adopted estimates from Miller et al. (1991) that auto liability policy limits averaged $100,000 per person injured in 1988 ($254,500 inflated to $2019 and that 55 percent of those suffering moderate (MAIS2) to fatal injuries made a claim. Blincoe et al. (2015) concluded the 55 percent rate also applied to MAIS1 injuries. Since States have not been shifting liability regimes (e.g., changing to no-fault insurance or raising minimum liability coverage requirements), we assume that these factors are unchanged. Among the remaining 45 percent, following Miller (1989), Miller et al. (1989) and Blincoe et al. (2015), roughly half are covered by no-fault coverage up to an average of roughly $25,000 and 90 percent of the remaining 22.5 percent by an average of roughly $3,500 in own-medical coverage.

Shifting to 2019 dollars, the insurance data reported $73.8 billion in insurance compensation for bodily injury (inflated from the $72.5 billion in Table 3-4). Combining the coverage factors in the preceding paragraph with the cost and incidence data in earlier chapters, we compute that insurance compensated $66.7 billion in legitimate crash injury medical and work losses (Table 3-10), or 90.3 percent of total compensation (66.7/73.8). The remaining $7.1 billion (9.7%) pays for fraudulent and built up or inflated claims. Consistent with that estimate, a 2015 Insurance Research Council study estimated fraud and build-up losses were $6.2-$8.6 billion in 2012 (inflated to 2019 $).

Overall, Table 3-10 shows that motor vehicle insurance compensated an estimated 39 percent of the injury costs including 76 percent of the medical costs and 35 percent of the work losses.

Auto Insurance Administration and Legal Costs per Person

The last two rows of Table 3-10 show the motor vehicle insurance administration and legal costs per claim. Insurance administration costs cover defense, cost containment, adjusting, and other claim-specific expenses. Insurance Services Office and Insurance Information Institute (2022) data indicate they add 16.46 percent to the loss costs shown above. This includes 4.27 percent for defense and cost containment, plus 12.19 percent for adjusting. We estimated legal costs from medical and work losses using the same formula as Blincoe et al. (2015). Specifically, by MAIS, legal cost exclusive of defense costs (which instead are included in insurance administration) equal the medical and work loss costs X the percentage of costs compensated by insurance X 58 percent of claimers hire attorneys (Hensler et al., 1991) X 29 percent of losses equal plaintiff's attorney fees (Hensler et al., 1991) X 1.492 ratio of total legal costs net of defense attorney fees to plaintiff attorney fees.

Table 3-5. Policyholders in 2018 Pooled, Multi-Insurer Insurance Services Office Data as a Percentage of Insured Vehicles, and Representativeness of Loss Ratios in ISO Data

Coverage	Premiums Written		% of Premiums in ISO Data	Loss Ratio		% of Losses in ISO Data	Losses compensated nationally in 2018
	Nationally	In ISO Data		Nationally	In ISO Data		
Private Passenger Auto Liability	$144,438,315,000	$39,703,320,768	27.5%	63.5%	58.4%	25.3%	$91,726,649,000
Private Passenger Property Damage*	$96,469,904,000	$23,653,236,957	24.5%	60.9%	69.4%	27.9%	$58,763,318,000
Total Private Passenger	$240,908,219,000	$63,356,557,725	26.3%	62.5%	62.5%	26.3%	$150,489,967,000
Commercial Auto Liability	$26,952,071,000	$6,312,155,737	23.4%	65.9%	67.4%	23.9%	$17,774,673,000
Commercial Property Damage*	$8,778,794,000	$2,177,718,274	24.8%	56.9%	57.5%	25.1%	$4,993,846,000
Total Commercial	$35,730,865,000	$8,489,874,011	23.8%	63.7%	64.9%	24.2%	$22,768,519,000
All Auto Liability	$171,390,386,000	$46,015,476,505	26.8%	63.9%	59.6%	25.0%	$109,501,322,000
All Own Property Damage*	$105,248,698,000	$25,830,955,231	24.5%	60.6%	68.4%	27.7%	$63,757,164,000
Grand Total	$276,639,084,000	$71,846,431,736	26.0%	62.6%	62.8%	26.0%	$173,258,486,000
							$0
All Bodily Injury/ Uninsured Motorist**	$124,165,516,368	$31,821,795,070	25.6%	58.4%	57.3%	25.1%	$72,471,411,822
All Property Damage**	$132,030,284,766	$32,847,651,820	24.9%	63.0%	67.3%	26.6%	$83,148,063,377
All Comprehensive	$30,236,364,866	$7,176,984,846	23.7%	58.3%	66.6%	27.1%	$17,639,010,801

* Includes comprehensive (non-crash) coverage but excludes State high-risk funds

** Includes State high-risk funds but excludes comprehensive. National liability insurance was split between bodily injury and property damage in proportion to the Insurance Services Office split. State funds = Direct premiums written – Net premiums written.

National data from Insurance Information Institute (2020), Insurance Services Office data from unpublished tables produced by the Insurance Services Office.

Table 3-6. Earned Premiums, Exposures, Claims, and Losses by Auto Insurance Line and Coverage in 2018 Pooled, Multi-Insurer Insurance Services Office (ISO) Data

	Earned Premiums	**Earned Car Years**	**Incurred Claims**	**Claims/ 1,000 Covers**	**Incurred Losses**	**Cost/Claim**	**% of Total Losses**	**Loss ratio**
PERSONAL LIABILITY								
Bodily Injury	$15,783,827,986	62,286,282	680,945	10.9	$8,857,714,919	$13,008	38.1%	56.1%
Property Damage	$12,813,885,505	62,955,733	2,424,596	38.5	$8,365,843,583	$3,450	36.0%	65.3%
Personal Injury Protection	$5,256,907,111	26,471,639	556,403	21.0	$3,295,596,331	$5,923	14.2%	62.7%
Medical Payments	$884,658,213	26,723,971	197,520	7.4	$582,777,243	$2,950	2.5%	65.9%
Uninsured/Under-insured Motorist	$4,961,115,371	53,816,369	190,709	3.5	$2,163,456,737	$11,344	9.3%	43.6%
Total	$39,700,394,187	228,836,324	4,050,173	17.7	$23,265,388,813	$5,744	100.0%	58.6%
PERSONAL AUTO PHYSICAL DAMAGE								
Collision	$16,839,623,247	47,317,758	2,830,127	59.8	$11,892,596,611	$4,202	72.4%	70.6%
Comprehensive	$6,572,906,680	55,748,603	3,177,341	57.0	$4,530,119,777	$1,426	27.6%	68.9%
Total	$23,412,529,927	103,066,361	6,007,468	58.3	$16,422,716,388	$2,734	100.0%	70.1%
COMMERCIAL LIABILITY & NO FAULT								
Liability	$6,164,063,396	7,376,587	256,577	34.8	$4,188,948,154	$16,326	98.4%	68.0%
Bodily Injury*	$4,784,267,465	7,376,587	61,905	8.4	$3,251,272,266	$52,520	76.4%	68.0%
Property Damage*	$1,379,795,931	7,376,587	194,672	26.4	$937,675,886	$4,817	22.0%	68.0%
No Fault	$148,092,341	2,384,658	8,565	3.6	$67,560,194	$7,888	1.6%	45.6%
Total	$6,312,155,737	9,761,245	265,142	27.2	$4,256,508,348	$16,054	100.0%	67.4%
COMMERCIAL AUTO PHYSICAL DAMAGE								
Collision	$1,573,640,108	5,403,157	128,779	23.8	$894,176,497	$6,943	71.4%	56.8%
Comprehensive	$604,078,166	5,389,310	119,334	22.1	$358,003,860	$3,000	28.6%	59.3%
Total	$2,177,718,274	10,792,467	248,113	23.0	$1,252,180,357	$5,047	100.0%	57.5%
ALL POLICIES EXCEPT UNINSURED MOTORIST AND COMPREHENSIVE								
Property Damage	$32,606,944,790	123,053,235	5,578,174	45.3	$22,090,292,577	$3,960	57.9%	67.7%
Liability	$14,193,681,435	70,332,320	2,619,268	37.2	$9,303,519,469	$3,552	24.4%	65.5%
Own (Deductible)	$18,413,263,355	52,720,915	2,958,906	56.1	$12,786,773,108	$4,321	33.5%	69.4%
Bodily Injury/No Fault/Medical Only	$26,857,753,117	125,243,137	1,505,338	12.0	$16,054,920,953	$10,665	42.1%	59.8%

* Premiums distributed in proportion to losses. Personal lines coverages include private passenger vehicles and motorcycles.

Table 3-7. By Crash Severity, Injured People Involved by MAIS Injury Severity, Based on 2006 CDS and Reweighted 1984-1986 NASS Data on Non-CRSS Strata, With fatalities per fatal Crash from 2019 FARS

	Fatal Crash	MAIS5 Crash	MAIS4 Crash	MAIS3 Crash	MAIS2 Crash	MAIS1 Crash
MAIS1 Survivors						1.378038
MAIS2 Survivors					1.107458	0.733569
MAIS3 Survivors				1.095094	0.165856	0.737777
MAIS4 Survivors			1.004974	0.064920	0.184264	0.695304
MAIS5 Survivors		1.017526	0.031973	0.058288	0.281744	0.799106
Fatalities	1.06418	0.032998	0.053140	0.127011	0.260838	0.525004

*Table 3-8. Property Damage and Its Compensation in Crashes by Maximum AIS in the Vehicle, 2018, in 2018 Dollars**

Vehicle AIS	Fraction of Mean Cost	Property Damage/ Vehicle With Compensation	Vehicles With Property Damage Coverage	Total Compensated Damage	Property Damage/ Vehicle	Total Damaged Vehicles	Total Property Damage	Crashes	Property Damage/ Crash	Property Damage/ Person
PDO	0.6540	$2,773	15,868,196	$40,992,083,264	$2,583	19,181,537	$53,189,451,088	11,887,478	$4,474	$1,790
1	1.9172	$7,573	4,332,913	$32,812,936,271	$7,573	4,659,122	$35,283,304,272	2,532,132	$13,934	$9,311
2	2.2420	$8,856	570,988	$5,056,618,668	$8,856	613,975	$5,437,313,308	354,899	$15,321	$9,278
3	3.5032	$13,838	195,562	$2,706,124,306	$13,838	210,285	$2,909,858,675	123,697	$23,524	$17,229
4	4.7898	$18,920	26,285	$497,312,613	$18,920	28,264	$534,753,492	17,234	$31,028	$19,870
5	4.7898	$18,920	8,899	$168,371,061	$18,920	9,569	$181,047,113	5,981	$30,272	$22,452
Fatal	4.7898	$18,920	48,625	$919,975,695	$18,920	52,286	$989,237,357	33,378	$29,637	$14,655
1-Fatal	2.0593	$8,134	5,183,273	$42,161,338,614	$8,134	5,573,503	$45,335,514,217	3,067,321	$14,780	$5,697
All	1.0000	$3,552	21,051,469	$83,153,421,878	$3,950	24,755,040	$98,524,965,305	14,954,799	$6,588	$3,148

* Excludes comprehensive (non-crash) coverage. Includes damage to own vehicle if the insured did not have collision coverage. Computed from percentage of claims payments in Insurance Services Office. Among 14,126,304 vehicles damaged in crashes involving an insurance claim, 13,176,522 generated property damage compensation.

Table 3-9. Vehicles per Crash by Police-Reported Crash Severity

Crash Severity	CRSS 2017-19	GES 2009	NASS 1982-86
O – Property Damage Only	1.79	1.75	1.75
C – Possible Injury	1.95	1.94	1.93
B – Non-incapacitating Injury	1.77	1.76	1.75
A – Incapacitating Injury	1.64	1.71	1.74
K – Fatal Injury	1.54	1.66	1.63
All	1.79	1.78	1.76

Table 3-10. People Injured in Crashes by Injury Severity, Their Medical and Work Loss Costs, and the Percentage Compensated by Auto Insurance (2019 $) See ISO Compensation File

MAIS	1	2	3	4	5&6	Fatal	Total
Cases Adjusted for Under-reporting	3,875,265	427,119	141,167	19,285	7,187	36,500	4,506,523
Medical per Case	2,195	13,145	69,075	188,295	362,922	17,289	6,822
Work Loss per Case	3,165	32,171	131,879	346,658	433,262	1,378,118	23,238
Total Liability Medical (millions)	4,678	3,088	5,363	1,997	1,006	347	16,480
Total Liability Work Loss (millions)	6,746	7,557	10,239	702	0	5,354	30,599
No-Fault Medical (millions)	1,914	1,263	794	108	40	142	4,262
No-Fault Work Loss (millions)	2,760	1,139	0	0	0	63	3,962
Uninsured Motorist Medical (millions)	1,723	303	100	14	5	26	2,170
Total Medical (millions)	8,315	4,654	6,257	2,119	1,052	515	22,912
% of Medical Compensated	98%	83%	64%	58%	40%	82%	75%
Total Work Loss (millions)	9,506	8,697	10,239	702	0	5,418	34,561
% of Work Loss Compensated	78%	63%	55%	11%	0%	11%	33%
Auto Insurance Paid (millions)	17,820	13,351	16,497	2,822	1,052	5,932	57,473
% of Injury Costs Compensated	86%	69%	58%	27%	18%	12%	42%
Insurance Claims Administration per Case	755	5,135	19,196	24,033	24,033	26,699	2,095
Legal Cost per Case	740	6,255	27,737	73,837	109,893	138,025	3,707

Miscellaneous Costs

In this chapter we examine various costs not covered in the previous chapters, including those incurred by State and local governments, such as crash-related damage to public property and public services like police and fire department attendance at crash sites.

Adding Roadside Furniture Damage to Property Damage

The insurance data suggest property damage averages $3,032 per crash-involved vehicle damaged seriously enough to prompt an insurance claim, with 18.3 to 18.8 million vehicles damaged that extensively in 2009. These estimates exclude most costs of damage to signs, lampposts, guardrails, and other roadside furniture. State and local governments absorb the roadside furniture costs not covered by insurance.

Estimated costs of roadside furniture damage by crash severity came from 1,462 crashes in 2008 tracked by the Missouri Claims Recovery Department. The data excluded costs not recovered from at-fault drivers and their insurers. As Table 9 shows, in 2019 dollars, the costs average $89 per fatal crash and $44 per injury crash. These results, based on a single year in a single State, should be treated with caution, as explained below.

Public Services

Public services costs are paid almost entirely by State and local government. Using the data underlying the crash cost estimates (Miller et al., 1991), we separated out EMS, police, fire, vocational rehabilitation, and court costs.

Missouri and Washington provided average incident management costs that Miller et al. (2011) analyzed. Inflated to 2019 dollars, they estimated mean cost per crash attendance was $98 for 315 crashes in Missouri and $149 for 3,880 crashes in Washington. As they recommended, we adopted Washington State's estimate because the Missouri data were missing costs for many crashes that involved incident response. Using data on the percentage of crashes attended, we broke the estimate down by police-reported crash severity.

To break the costs of incident management and of roadside furniture damage down into cost per person involved in a crash by injury severity, we followed the same method that we used above to break down property damage.

Table 3-12 shows the resulting estimated costs per person injured by MAIS severity, as well as estimates for police, fire department, vocational rehabilitation, and workplace costs inflated from prior NHTSA crash cost studies. These factors are small, but the limited geographic coverage of the data underpinning them and the age of some of them mean their uncertainty is wide. A recent National Cooperative Highway Research Program project charged with updating most of these costs was unable to obtain data from additional jurisdictions.

Table 3-11. Crashes by Severity, Portion Involving Roadside Furniture Damage, Costs per Crash With Costs and Cost per Crash, Missouri, 2008 (2019 $)

Severity	Crashes	With Furniture Damage	$/Crash With Costs	Cost/Crash
Fatal	619	102	$539	$89
Injury	21,055	2,178	$424	$44

Table 3-12. Selected Ancillary Crash Costs per Person by MAIS (2019 $)

MAIS	Roadside Furniture	Incident Management	Police	Fire Department	Vocational Rehabilitation	Workplace
0	$14	$2	$14	$8	$0	$76
1	$26	$2	$93	$11	$20	$56
2	$26	$1	$116	$111	$124	$418
3	$26	$92	$127	$267	$270	$3,240
4	$26	$88	$138	$750	$331	$7,077
5	$26	$88	$147	$764	$307	$7,794
Fatal	$37	$133	$290	$637	$0	$13,589

Motor vehicle crashes also result in added societal costs due to congestion and workplace disruption. Congestion costs, which include travel delay, excess fuel consumption, and added greenhouse gases and criteria pollutants are examined in chapter 4 of this report. Workplace costs were estimated by adjusting the workplace costs from Blincoe et al., 2002 to 2010 levels using the employment cost index for total compensation published by the Bureau of Labor Statistics (BLS).

Unit Cost Summary

Table 3-13 summarizes the unit costs by injury severity and cost component for 2019. All injury unit costs are expressed on a per person injured basis. The costs for PDO's are expressed on a per-damaged-vehicle basis. Note that Medical costs include both medical care from Table 3-2 and vocational rehabilitation costs from Table 3-12. Property damage costs include both vehicle damage and roadside furniture from Table 3-12. Emergency services includes incident management, fire department, and police from Table 3-12. Market and household productivity are from Table 3-2. Legal and insurance administration costs are from Table 3-10.

Each fatality results in economic impacts of roughly $1.6 million, due primarily to lost productivity and legal costs. MAIS5 injuries are also very costly at nearly $1 million. The most costly impact for these most serious of survivor injuries is the cost of medical care, but there are also significant costs from lost productivity, legal costs, and insurance administrative costs. For all cost categories, injury costs gradually decline as severity decreases.

Table 3-13. Summary of Unit Costs, Police-Reported and Unreported Crashes, 3% Discount Rate (2019 $)

	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$31	$24	$106	$228	$486	$976	$999	$1,060
Market	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$724	$380	$8,487	$60,464	$261,200	$653,348	$954,237	$1,584,326
Congestion	$1,327	$1,008	$1,207	$1,339	$1,691	$1,814	$1,857	$7,133
Prop. Damage	$3,200	$1,864	$9,650	$9,616	$17,835	$20,565	$23,234	$15,185
Subtotal	$4,527	$2,872	$10,857	$10,955	$19,526	$22,379	$25,091	$22,318
Total	$5,251	$3,252	$19,344	$71,419	$280,726	$675,727	$979,328	$1,606,644

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

Police-Reported Versus Unreported Crash Costs

As noted in Chapter 2, nearly 60 percent of all PDO crashes and about a 30 percent of all nonfatal injury crashes are not reported to police. However, analyses of safety countermeasures frequently rely only on police-reported incidence data. Crashes that get reported to police are likely to be more severe than unreported crashes because vehicles are more likely to require towing and occupants are more likely to require hospitalization or emergency services. These crashes are typically also likely to require more time to investigate and clear from roadways than unreported crashes. Analysis based solely on police-reported crashes should thus be based on unit costs that are specific to police-reported crashes. For injury-related costs, this is more or less automatically accounted for by the shift in the injury severity profile. Unreported crashes have a lower average severity profile than do reported crashes. However, for non-injury-related cost components – property damage and congestion costs – there is no difference in profile. In addition, emergency services have higher involvement rates for police-reported crashes.

A separate set of costs was developed in Chapter 4 for police-reported and unreported congestion costs. To estimate separate costs for property damage, we used property damage cost data from the MDAC survey. Data were derived separately for reported and unreported crashes. Table 3-14 lists the results. The mean property damage cost of a crashed vehicle in the MDAC survey was $4,476. However, the mean property damage cost for vehicles in crashes reported to the police was $5,607, and the mean cost for a vehicle in crashes not reported to the police was $1,907. To estimate separate unit costs for vehicles in reported and unreported crashes, we took the ratio of each of these two crash types to the mean overall cost and applied these factors to the average property damage cost previously derived from insurance data. Since these ratios were derived independently from both the main incidence and property damage analyses, a further adjustment was made to normalize the unit costs so that the sum of reported and unreported crashes matched the overall totals.[8] A similar approach was used for emergency services. Emergency services consists of separate police, fire, and incident management components. Each component was distributed assuming that unit costs per case were identical for both reported and unreported cases of a specific severity for any case for which police, fire, or incident management teams actually responded. The difference in unit costs for reported and unreported cases is thus a function of differing response rates. For police-reported cases, response rates are assumed to be 100 percent by definition. This is confirmed by the 100 percent rates reported in the MDAC survey for police-reported cases. For unreported cases, MDAC survey police response rates were reported to be 100 percent for all injury cases MAIS3 and greater. Police response rates for unreported MAIS0, MAIS1, MAIS2, and PDO cases were reported to be 17.1 percent, 29.2 percent, 37.8 percent, 11.5 percent respectively.

Fire response is assumed to be a subset of police response cases. Fire response rates derived from Blincoe et al. (1992) were thus assumed for police-reported cases, and were further modified by the relative unreported/reported police response rate in the MDAC survey for unreported cases.

Incident management response rates were estimated based on data from Washington State cited in NCHRP Working Paper 4 (Bahar & Miller, 2010), which indicate response rates of 23.2 percent for K and A injuries, 2.3 percent for B and C injuries, and 5.9 percent for O injuries. In order to translate these into equivalent MAIS levels, a KABCO/MAIS injury matrix was established. In order to reflect the fact that within each KABCO level, incident response rates were likely to be more heavily weighted toward the more serious crashes, the initial incidence matrix was modified by applying the relative Fire Department response rates across MAIS severities as a model proxy. For each MAIS category, relative weights were then computed across the 5 KABCO categories, and these weights were applied to the corresponding average incident management response rates and then summed to calculate an average response rate by MAIS severity level. These rates were assumed to represent police-reported cases. As with Fire response, they were further modified using the relative unreported/reported police response rate from the MDAC survey to estimate incident management response rates for unreported cases. Table 3-15 summarizes the inputs and results of this process for each EMS component.

The results of this analysis for congestion, property damage, and emergency services are presented in Tables 3-16for police-reported crashes and 3-17 for unreported crashes, together with the other cost components that did not vary by reporting status. The differences seem negligible at the more severe injury levels due to the overwhelming costs of factors such as lost productivity and medical care that do not vary by reporting status, except through the shift in injury profiles. However, at lower severity levels the unit costs are significant. For PDO vehicles and MAIS0s, police-reported crashes have costs that are three times those of unreported crashes. For minor (MAIS1) injuries, reported crashes cost 79 percent more than unreported crashes. These ratios decline as injury severity increases to only 17 percent for MAIS2 injuries and 7 percent for MAIS3 injuries. Note that for MAIS4s, MAIS5s, and Fatalities, property damage costs are identical under both reported and unreported cases. All injuries at these levels are

[8] This consisted of calculating a simple normalizing factor by comparing the results of the main analysis to the sum of the separately calculated reported and unreported analyses. This factor was then applied back to the unit costs. This process maintains the relative differences found in the MDAC analysis, while remaining consistent with the original unit costs and incidence totals, which were derived from a more robust data set.

believed to be reported to police, and the original property damage cost estimate is thus assumed to represent police-reported cases. These same costs are thus listed under both scenarios.

Table 3-14. Per-Vehicle Property Damage in MDAC Survey

Statistic	All Crashes		
	All	Reported	Unreported
Number	1847	1256	591
Mean	$4,476	$5,607	$1,907
Median	$1,698	$2,000	$762
SE of Mean	$846	$1,200	$408
95% LCL of Mean	$2,816	$3,251	$1,107
95% UCL of Mean	$6,136	$7,962	$2,708
Minimum	$0	$0	$0
25th Percentile	$576	$884	$241
75th Percentile	$3,685	$4,265	$1,755
Maximum	$310,000	$310,000	$300,000
Mean Ratio to All	1.000	1.253	0.426

Table 3-15. Summary of Police-Reported and Unreported Emergency Services Unit Costs

	Response Rates				Unit Costs	
	Reported Crashes	Unreported Crashes	Average Unit Cost	Percent Unreported	Reported Crashes	Unreported Crashes
Police Response						
Fatal	100.00%	100.00%	$247.00	0.00%	$247.00	$247.00
MAIS0	100.00%	17.16%	$12.00	53.14%	$21.44	$3.68
MAIS1	100.00%	29.17%	$79.00	25.45%	$96.37	$28.11
MAIS2	100.00%	37.84%	$99.00	19.95%	$113.01	$42.76
MAIS3	100.00%	100.00%	$108.00	4.31%	$108.00	$108.00
MAIS4	100.00%	100.00%	$118.00	0.00%	$118.00	$118.00
MAIS5	100.00%	100.00%	$126.00	0.00%	$126.00	$126.00
PDO	100.00%	11.54%	$17.00	59.72%	$36.04	$4.16
Fire Department Response						
Fatal	95.00%	95.00%	$543.00	0.00%	$543.00	$543.00
MAIS0	1.00%	0.17%	$7.00	53.14%	$12.50	$2.15
MAIS1	1.00%	0.29%	$9.00	25.45%	$10.98	$3.20
MAIS2	15.00%	5.68%	$95.00	19.95%	$108.45	$41.04
MAIS3	35.00%	35.00%	$227.00	4.31%	$227.00	$227.00
MAIS4	90.00%	90.00%	$639.00	0.00%	$639.00	$639.00
MAIS5	95.00%	95.00%	$651.00	0.00%	$651.00	$651.00
PDO	1.00%	0.12%	$9.00	59.72%	$19.08	$2.20

	Response Rates				Unit Costs	
	Reported Crashes	Unreported Crashes	Average Unit Cost	Percent Unreported	Reported Crashes	Unreported Crashes
Incident Management Response						
Fatal	22.45%	22.45%	$112.00	0.00%	$112.00	$112.00
MAIS0	5.80%	1.00%	$2.00	53.14%	$3.57	$0.61
MAIS1	5.65%	1.65%	$1.00	25.45%	$1.22	$0.36
MAIS2	9.78%	3.70%	$0.00	19.95%	$0.00	$0.00
MAIS3	15.67%	15.67%	$81.00	4.31%	$81.00	$81.00
MAIS4	17.85%	17.85%	$81.00	0.00%	$81.00	$81.00
MAIS5	20.49%	20.49%	$78.00	0.00%	$78.00	$78.00
PDO	5.80%	0.67%	$2.00	59.72%	$4.24	$0.49
Total Emergency Services						
Fatal			$902.00	0.00%	$902.00	$902.00
MAIS0			$21.00	53.14%	$37.51	$6.44
MAIS1			$89.00	25.45%	$108.57	$31.67
MAIS2			$194.00	19.95%	$221.46	$83.80
MAIS3			$416.00	4.31%	$416.00	$416.00
MAIS4			$838.00	0.00%	$838.00	$838.00
MAIS5			$855.00	0.00%	$855.00	$855.00
PDO			$28.00	59.72%	$59.36	$6.85

Table 3-16. Summary of Unit Costs, Police-Reported Crashes, 3% Discount Rate (2019 $)

	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$72	$40	$139	$274	$486	$976	$999	$1,060
Market	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$765	$396	$8,520	$60,510	$261,200	$653,348	$954,237	$1,584,326
Congestion	$2,591	$1,739	$1,713	$1,758	$1,790	$1,814	$1,857	$7,133
Prop. Damage	$4,556	$2,654	$13,741	$13,692	$25,395	$20,565	$23,234	$15,185
Subtotal	$7,147	$4,393	$15,454	$15,450	$27,185	$22,379	$25,091	$22,318
Total	$7,913	$4,789	$23,974	$75,961	$288,385	$675,727	$979,328	$1,606,644

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

Table 3-17. Summary of Unit Costs, Unreported Crashes, 3% Discount Rate (2019 $)

	PDO	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$8	$7	$41	$104	$486	$976	$999	$1,060
Market	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$701	$363	$8,422	$60,340	$261,200	$653,348	$954,237	$1,584,326
Congestion	$473	$220	$220	$220	$220	$220	$220	$571
Prop. Damage	$1,550	$903	$4,674	$4,657	$8,638	$20,565	$23,234	$15,185
Subtotal	$2,023	$1,123	$4,894	$4,877	$8,858	$20,785	$23,454	$15,756
Total	$2,724	$1,486	$13,315	$65,217	$270,058	$674,133	$977,691	$1,600,082

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

4. Congestion Impacts

Motor vehicle crashes result in significant time delays to other motorists who are inconvenienced by lane closures, police, fire, or emergency services activity, detours, and general traffic slowdowns resulting from rubbernecking and chain reaction braking. This results in a significant time penalty for those affected, which can be valued based on wage rates and the value people place on their free time. It also results in wasted fuel, increased greenhouse gas production, and increased pollution as engines idle while drivers are caught in traffic jams and slowdowns. These impacts affect drivers' transportation costs and negatively impact the health and economic welfare of the Nation.

Assessing congestion costs is difficult because virtually every crash occurs under unique circumstances. Differences in crash severity, vehicle involvement, roadway type, time of day, traffic density, emergency services response time, weather, hazardous material spillage, lane configurations, driver behavior, and other variables can influence the extent of congestion and the resulting societal impacts. While there are a number of studies that document the impact of crashes on roadway congestion, most focus very narrowly on impacts for a specific roadway, and in most cases, these roadways are urban interstates.

A few studies have attempted to project congestion impacts from crashes at a higher level. Chin et al. (2004), used traffic engineering modeling methods to derive estimates of delay impacts. Nationally for freeways and principal arterials. Zaloshnja et al. (2000) used relative traffic density data to scale results from a study of urban interstates in Minneapolis- St.Paul to estimate the delay hours for police-reported crashes involving trucks and buses with a gross vehicle weight rating over 10,000 pounds across six different urban and rural roadway categories.

The Federal Motor Carrier Safety Administration (FMCSA) contracted the U.S. DOT/Volpe Center to produce a simulation-based estimate of the per-crash impacts of congestion from commercial vehicle crashes (Hagemann et al., 2013). This study involved traffic simulation measurements using TSIS-CORSIM, a micro-simulation tool developed by the University of Florida McTrans Center. TSIS-CORSIM simulates traffic responses to specific roadway and crash scenarios and produces estimates of aggregate vehicle delay hours and added fuel consumption. The authors of the study then linked the TSIS-CORSIM results to the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) model to produce estimates of greenhouse gas and criteria pollutant emissions. The estimation process involved Monte Carlo simulations 77 different crash scenarios in order to capture the variety of possible outcomes across numerous sets of crash circumstances. These results were then weighted based on nationwide crash incidence, producing average impacts for crashes on 5 different categories of roadways varying by three different crash severities (fatal crashes, injury crashes, property-damage-only crashes). While any simulation process is subject to uncertainty, the FMCSA study is arguably the most sophisticated attempt thus far to estimate nationwide congestion costs from crashes. However, the FMCSA study's focus on commercial vehicle crashes limited its applicability to the larger crash problem, which involves all motor vehicle crashes.

Commercial vehicle crashes make up only about 5 percent of all police-reported crashes nationwide. More importantly, they typically have more serious congestion consequences than other crashes. This results from several factors, most notably, that they are more likely to involve lane closings, that they take longer to clear from the roadway (especially in the case of hazardous waste or cargo spillage), and that they are more likely to occur during normal weekday hours, when traffic density is highest, and less likely to occur on weekends and at night when traffic density is lighter.

For the previous societal cost of crashes report (Blincoe et al., 2015) NHTSA normalized the FMCSA model to reflect all motor vehicle crashes. The approach taken in that study involved a synthesis of past approaches. It used empirical data derived from both current data sources and previous literature to develop a basic congestion model. This model estimated the congestion impacts from lane closings, rubbernecking, and subsequent traffic dispersal across the same roadway categories examined in the FMCSA study. The model was run once with data and assumptions appropriate for the universe of all crashes, and then again with data appropriate for commercial vehicle crashes. The results of these two sets of outputs were then used to compute normalizing factors that were applied to the FMCSA results for commercial vehicle crashes, to derive an estimate that is more representative of the overall universe of traffic crashes. This linkage to the FMCSA report was motivated by the ability of its simulation methods to capture several aspects that are not easily estimated using more conventional approaches. These include the impact of detours, and more importantly, the ability to capture non-linear impacts that cause disproportionate congestion under extreme circumstances that cannot be reflected using average input values.

For this 2019 report we adopt the per-crash unit impact estimates that were derived in the 2015 report on the 2010 costs (Blincoe et al., 2015). Unit values in that report were stratified according to motor vehicle crash severity, i.e., fatal crashes, injury crashes, and PDO crashes, and were specific to 5 different roadway types including urban interstate expressways, urban arterials urban other, rural interstate/principle arterials, and rural other. These were essentially measures of lost time, added fuel, increased greenhouse gases, and increases in criteria pollutants associate with an average fatal, injury, or property damage crash within each roadway type. These were measured in terms of lost manhours, gallons of fuel, and short tons of tailpipe vehicle and upstream pollutants. We believe it is reasonable to assume that per-crash unit impacts will not have shifted significantly over the past 9 years (DeSilver, 2021).[9] We apply these unit impacts to 2019 incidence data by crash type, and we update the unit costs of lost time, fuel, and pollutants to be consistent with more current and relevant values.

Added Criteria Pollutant Costs

We updated the unit cost values of criteria pollutants to be consistent with the data sources adopted by NHTSA for use in its Preliminary Regulatory Impact Analysis (PRIA) supporting the Notice of Proposed Rulemaking for model year 2021-2026 light duty CAFE standards, with some modifications. For tailpipe emissions, these values were derived from a study by Wolfe et al. (2019), which in turn was based on separate studies by Krewski et al. (2009) and Lepeule et al. (2012). Krewski and Lepeule's groups advocated significantly different values for criteria

[9] We note that the increased prevalence of electric vehicles will, over time, modify these results. Currently, a combination of all-electric and hybrid electric vehicles make up only about 2 percent of new U.S. vehicle sales and only a tiny portion of the on-road fleet currently consists of such vehicles (DeSilver, 2021).

pollutants based on different findings regarding mortality from emissions concentrations. In the NPRM, NHTSA used a simple average of the two studies to measure societal impacts in its CAFE PRIA. However, prior to the final rule, EPA recommended reliance solely on the Krewski study, which is the more conservative estimate. For this study, we adopt the Krewski study with minor adjustments Starting with unrounded unit values from Krewski, we adjust these values, which were derived in 2015 economics, to 2019 dollars using the GDP deflator. The Wolf et al. paper reflects values from Krewski that are expected for calendar year 2025. To estimate values for CY 2019, we used a 2018 EPA Technical Support Document that estimated the value of NOx, Sox, and PM2.5 for 2016, 2020, 2025, and 2030 (U.S. EPA, 2018). Using these data, we interpolated intervening years and calculated an adjustment factor to convert the 2025 values into 2019 values. We then rounded the resulting values to remove any suggestion of over-precision. The results of this process are summarized in Table 4-1 below.

For upstream emissions, we adopted the refinery values included in the 2018 EPA technical support document (U.S. EPA, 2018). In that document the authors provided values for CY 2016, 2020, 2025, and 2030 from both Krewski et al. (2009) and Lepeule et al. (2012). As with tailpipe emissions, we adopted the Krewski values and interpolated intervening years to estimate the values for 2019. We then adjusted the TSD values from 2015 dollars to 2019 dollars using the GDP deflator, and rounded the results to avoid the unwarranted appearance of precision.

Added Greenhouse Gas Costs

As with criteria pollutants, we adopt greenhouse gas values consistent with those used in NHTSA’s MY 2021-2026 light vehicle CAFE PRIA. The value used consistent with the 3 percent discount rate used in this study was $50 in 2018 dollars. We adjust this value to 2019 dollars using the GDP deflator. We then adjust it to convert from metric tons to short tons to be consistent with the measurements that were used in the TSIS-CORSIM model developed by FHWA (Hagemann, 2013), which provided the basis for unit calculations. The results are shown in Table 4-1 below, which summarizes unit costs for all tailpipe and upstream emissions analyzed for this analysis.

Table 4-1. Criteria Pollutant and GHG 2019 Values/Short Ton

	NOx	**SOx**	**PM2.5**	**CO2**
Tailpipe Emissions				
Light Vehicles	$7,000	$120,000	$700,000	$46
Heavy Vehicles	$6,000	$190,000	$460,000	$46
All Vehicles	$7,000	$130,000	$600,000	$46
Upstream Emissions	$8,000	$80,000	$380,000	$46

Added Fuel Consumption Costs

The unit cost per-crash estimates that were derived in the 2010 report are expressed in gallons of fuel consumed per crash. These gallons are valued using the average price per gallon of gasoline, minus Federal and State taxes, which are transfer payments from one segment of society to another, and are thus not counted as a societal cost. Based on data from the U.S.

Energy Information Administration (2022), the average cost per gallon of gasoline excluding taxes in 2019 was $2.245. We apply this value to the total number of gallons consumed due to congestion in traffic crashes to estimate the value of added fuel consumption in these crashes. This is a function of the total number of crashes and the fuel used/crash by roadway type.

Value of Travel Time

The added time spent by vehicle occupants stuck in or detouring around traffic at a crash site is an opportunity cost that represents a real cost to society. While the ability to travel is a valued asset that improves quality-of-life, consumers generally seek to minimize the time spent travelling because it reduces their opportunities to engage in more lucrative or enjoyable pursuits. Time spent travelling could instead be dedicated to production, which would yield monetary benefits to the travelers, their employers, or both. Alternately, it could be spent in recreation or other activities that the traveler would preferably choose to engage in. Finally, the conditions associated with traffic congestion and delay can cause frustration and tension that in themselves have a negative impact on vehicle occupants.

The U.S.DOT (2016) has issued general guidance regarding valuing travel time. This guidance lays out guidelines for valuing travel time under various surface modes, and for both business and personal travel. Generally, business travel is valued using wage rates while personal travel is valued using a variable percentage of wage rates, depending on mode and on whether travel is local or intercity. Based on this guidance and updated wage data from the BLS, FMCSA derived average values of travel time by roadway type for their commercial vehicle study. These values were weighted according to the prevalence of vehicle types on the roadway as well as average occupancy and are thus applicable for this study as well. These results were presented in 2010 values in the previous 2010 cost report. We used Average Hourly earnings data from BLS to express 2019 values for each roadway and injury severity category (Bureau of Labor Statistics, 2022). The results are shown in Table 4-2.

Table 4-2. Value of Travel Time/Crash, All Crash Types (2019 $)

	Urban Interstate/ Expressways	**Urban Arterials**	**Urban Other**	**Interstate/ Principal Rural Arterials**	**Rural Other**	**Average All Roadway Types**
VOT/ Vehicle Hour	$30.25	$29.79	$29.76	$32.46	$30.88	$24.34
Fatal Crashes						
Vehicle Hours/ Crash	4032.45	290.13	43.19	250.73	16.81	527.01
Total Cost/ Crash	$121,998	$8,644	$1,285	$8,139	$519	$16,018
Injury Crashes						
Vehicle Hours/ Crash	851.85	64.48	18.94	46.41	4.32	140.45

	Urban Interstate/ Expressways	Urban Arterials	Urban Other	Interstate/ Principal Rural Arterials	Rural Other	Average All Roadway Types
Total Cost/Crash	$25,772	$1,921	$564	$1,507	$134	$4,248
PDO Crashes						
Vehicle Hours/ Crash	724.71	39.05	11.38	47.13	3.57	138.77
Total Cost/Crash	$21,925	$1,163	$339	$1,530	$110	$4,207

Congestion Cost Summary

Table 4-3 summarizes the various costs that are estimated to result from congestion caused by police-reported motor vehicle crashes. Total costs range from $17,642 for fatal crashes to $4,587 for PDO crashes. The largest loss results from the opportunity cost of delay for vehicle occupants, but there are also significant impacts due to wasted fuel and greenhouse gases and criteria pollutants.

Table 4-3. Summary of Congestion Costs/Crash Due to Time Delay, Excess Fuel Burned, and Pollution Police-Reported Crashes (2019 $)

		Urban Interstate/ Expressways	Urban Arterial	Urban Other	Interstate/ Principal Rural Arterials	Rural Other	Average All Roadway Types
Fatal Crashes	CO2	$1,193	$308	$24	$179	$22	$230
	CO	$0	$0	$0	$0	$0	$0
	NOx	$298	$76	$6	$89	$9	$67
	PM10	$0	$0	$0	$0	$0	$0
	PM2.5	$2,031	$298	$20	$408	$40	$360
	SO2	$223	$57	$4	$32	$4	$43
	VOC	$5	$1	$0	$1	$0	$1
	Total Emissions	*$3,750*	*$740*	*$54*	*$709*	*$76*	*$700*
	Excess Fuel Burned	$4,796	$1,238	$95	$722	$90	$924
	Value of Time	$121,998	$8,644	$1,285	$8,139	$519	$16,018
	Total Congestion Costs	*$130,543*	*$10,621*	*$1,434*	*$9,570*	*$684*	*$17,642*
Injury Crashes	CO2	$252	$68	$10	$33	$6	$63
	CO	$0	$0	$0	$0	$0	$0
	NOx	$63	$17	$3	$16	$2	$17
	PM10	$0	$0	$0	$0	$0	$0
	PM2.5	$429	$65	$8	$75	$10	$90

		Urban Interstate/ Expressways	Urban Arterial	Urban Other	Interstate/ Principal Rural Arterials	Rural Other	Average All Roadway Types
Injury Crashes	SO2	$47	$13	$2	$6	$1	$12
	VOC	$1	$0	$0	$0	$0	$0
	Total Emissions	*$792*	*$163*	*$23*	*$131*	*$19*	*$182*
	Excess Fuel Burned	$1,013	$275	$42	$133	$23	$255
	Value of Time	$25,772	$1,921	$564	$1,507	$134	$4,248
	Total Congestion Costs	*$27,577*	*$2,358*	*$628*	*$1,771*	*$175*	*$4,686*
PDO Crashes	CO2	$214	$41	$6	$34	$5	$54
	CO	$0	$0	$0	$0	$0	$0
	NOx	$53	$10	$2	$17	$2	$15
	PM10	$0	$0	$0	$0	$0	$0
	PM2.5	$364	$41	$5	$76	$8	$85
	SO2	$40	$8	$1	$6	$1	$10
	VOC	$1	$0	$0	$0	$0	$0
	Total Emissions	*$673*	*$100*	*$14*	*$133*	*$16*	*$163*
	Excess Fuel Burned	$862	$166	$25	$135	$19	$217
	Value of Time	$21,925	$1,163	$339	$1,530	$110	$4,207
	Total Congestion Costs	*$23,460*	*$1,430*	*$378*	*$1,798*	*$145*	*$4,587*

Congestion costs have been estimated separately for fatal, injury, and PDO crashes. However, this report is primarily stratified according to injury severity for all injury crashes. As discussed previously, within injury crashes there are 5 nonfatal categories. For any given crash, congestion costs are a function of crash circumstances rather than injury severity. This implies an equal distribution of congestion costs among all crash involved parties, regardless of whether they died, were injured or were uninjured. To distribute costs among crash involved people for fatal crashes, the average cost/crash for fatal crash was divided by the average number of involved people per fatal crash. These data were obtained by examining FARS data for 2017 to 2019. From these data, the KABCO injury profile was obtained and run through an MAIS translator to reveal the average MAIS profile among fatal crashes. By definition, all fatalities occur in fatal crashes, so the average congestion cost per fatality was taken directly from the analysis of FARS crashes. The same approach was also applied to injury crashes. However, nonfatal injuries occur in both fatal and nonfatal injury crashes. The two nonfatal injury profiles were therefore weighted together based on the relative incidence of each injury severity in fatal or injury crashes. Since fatal crashes are relatively rare, the nonfatal injury crash estimate was heavily weighted toward the costs from injury crashes. Table 4-4 lists the weights, injuries per crash, and resulting congestion costs per injury for each injury severity for both fatal and injury crashes.

Table 4-4. Allocation of Congestion Costs Across Involved People in Fatal and Injury Crashes (2019 $)

	Fatal Crashes			Injury Crashes		
MAIS	**% of All Injuries**	**Injuries/Crash**	**Cost/Person**	**% of All Injuries**	**MAIS/Crash**	**Cost/Person**
0	0.0102	0.7279	$7,133	0.9898	1.2152	$1,684
1	0.0053	0.4135	$7,133	0.9947	1.3252	$1,684
2	0.0136	0.1287	$7,133	0.9864	0.1608	$1,684
3	0.0196	0.0795	$7,133	0.9804	0.0684	$1,684
4	0.0240	0.0143	$7,133	0.9760	0.0100	$1,684
5	0.0319	0.0071	$7,133	0.9681	0.0037	$1,684
Killed	1.0000	1.1022	$7,133	0.0000	0.0000	$1,684
Total	0.0151	2.4732	$17,642	0.9849	2.7833	$4,686

PDO crashes are expressed on a per damaged vehicle basis. Therefore, the unit cost for PDO crashes was divided by the average number of vehicles damaged in PDO crashes. Again, these data were derived from 20017-2019 CRSS records, which indicated an average of 1.77 vehicles/PDO crash. The results are summarized in Table 4-5. The nonfatal injury MAIS levels (MAIS0 to 5) are the weighted average of these costs from fatal and injury crashes noted in the previous table. Congestion costs for nonfatal injuries decline gradually as injury severity decreases because a larger portion of less severe injuries occur in injury crashes, resulting in more weight being given to the less costly injury crashes. Note that the PDO unit cost is higher than nonfatal injury costs, but they are not directly comparable because it is expressed on a per vehicle basis. If it were adjusted for vehicle occupants in PDOs (2.30 occupants per crash), it would decline to $2,019/person, still slightly more than all nonfatal injured/person costs. However, there are more people/crash in injury crashes 2.69 vs 2.30 for PDOs. Adjusting for this, injury crashes are more costly than PDO crashes.

Table 4-5. Final Congestion Cost/Severity Unit (2019 $), Police-Reported Crashes

MAIS	Cost/Crash
MAIS0	$1,739
MAIS1	$1,713
MAIS2	$1,758
MAIS3	$1,790
MAIS4	$1,814
MAIS5	$1,857
Fatal	$7,133
PDO	$2,591

Note: All injury costs are per person injured. PDO costs are per damaged vehicle.

Unreported Crashes

Most crashes that involve either serious injury or significant roadway blockage are reported to police, by either the involved parties or passing motorists. Police reports are filed in those cases where police respond to the crash and the crash severity passes a certain threshold, usually a specific amount of property damage, which varies by State. However, because they typically do not involve police or emergency vehicle presence, unreported crashes, even of the same nominal severity category, are unlikely to cause the same congestion impacts as police-reported crashes. Unfortunately, we were unable to find any research that directly addresses the issue of congestion caused by unreported crashes. To estimate these impacts, we assume that unreported crashes would have only half the probability of a lane being blocked and would be present on the roadway (crash duration) for only half as long as a police-reported crash. In addition, we assume that the proportion of roadway blockage and probability of opposite direction rubbernecking is only half that of police-reported crashes.[10] These assumptions are based on the likelihood that any formal lane closing would require police presence and any significant informal lane closing (due to vehicle obstruction) would draw police attention and thus could become a reported crash. Nonetheless, unreported crashes would likely involve at least some level of temporary lane blockage and would cause rubbernecking until the vehicles are removed or driven away. An example might be a low-speed crash in which one vehicle rear-ends another at a stoplight. If the damage is minor, the two drivers may contact their insurance companies, exchange insurance information and then drive away, but during the period they were examining their vehicles for damage and exchanging information the vehicles would have blocked the lane they were in. Alternately, this same crash might draw police attention, but, if the damage is minor, police may not file a formal report, and it would thus be an unreported crash. We note that all fatal and serious injury crashes are reported to the police. Therefore, only the minor injury and PDO congestion estimates are relevant to this estimate. The impact of these assumptions is noted in Table 4-6. These assumptions imply that on average, unreported injury crashes result in congestion impacts that are roughly 13 percent of the impacts that occur in police-reported injury crashes, and unreported PDO crashes produce congestion impacts that are roughly 18 percent of the impacts that occur in police-reported PDO crashes.

[10] We acknowledge that the selection of “half” as a factor to reflect the nature off unreported crashes is somewhat arbitrary. However, lacking specific data, we are hesitant to select values that imply that unreported crashes would have impacts that are more nearly like those of police-reported crashes or closer to zero. We view half as the best way to minimize potential error. Directionally, we only know unreported crashes would cause some level of congestion but that it is less than reported crashes.

Table 4-6. Summary of Congestion Costs/Crash Due to Time Delay, Excess Fuel Burned, and Pollution Unreported Crashes

		Urban Interstates/ Expressways	**Urban Arterials**	**Urban Other**	**Rural Interstate/ Principal Arterials**	**Rural Other**	**Average All Roadway Types**
Fatal Crashes	CO2	$98	$22	$1	$14	$2	$18
	CO	$0	$0	$0	$0	$0	$0
	NOx	$25	$5	$0	$7	$1	$5
	PM10	$0	$0	$0	$0	$0	$0
	PM2.5	$168	$21	$1	$31	$3	$28
	SO2	$18	$4	$0	$2	$0	$3
	VOC	$0	$0	$0	$0	$0	$0
	Total Emissions	*$309*	*$53*	*$3*	*$53*	*$5*	*$55*
	Excess Fuel Burned	$396	$89	$5	$54	$6	$72
	Value of Time	$10,065	$622	$73	$613	$37	$1,285
	Total Congestion Costs	*$10,770*	*$764*	*$82*	*$721*	*$49*	*$1,412*
Injury Crashes	CO2	$32	$10	$1	$5	$1	$9
	CO	$0	$0	$0	$0	$0	$0
	NOx	$8	$2	$0	$2	$0	$2
	PM10	$0	$0	$0	$0	$0	$0
	PM2.5	$54	$9	$1	$11	$1	$12
	SO2	$6	$2	$0	$1	$0	$2
	VOC	$0	$0	$0	$0	$0	$0
	Total Emissions	*$100*	*$24*	*$3*	*$19*	*$3*	*$25*
	Excess Fuel Burned	$127	$40	$6	$19	$3	$35
	Value of Time	$3,240	$281	$75	$217	$20	$553
	Total Congestion Costs	*$3,467*	*$345*	*$84*	*$255*	*$26*	*$612*
PDO Crashes	CO2	$39	$7	$1	$7	$1	$10
	CO	$0	$0	$0	$0	$0	$0
	NOx	$10	$2	$0	$3	$0	$3
	PM10	$0	$0	$0	$0	$0	$0
	PM2.5	$66	$7	$1	$16	$2	$16
	SO2	$7	$1	$0	$1	$0	$2
	VOC	$0	$0	$0	$0	$0	$0
	Total Emissions	*$123*	*$18*	*$2*	*$27*	*$3*	*$30*
	Excess Fuel Burned	$157	$29	$4	$28	$4	$40
	Value of Time	$3,996	$203	$59	$312	$20	$768
	Total Congestion Costs	*$4,276*	*$250*	*$66*	*$366*	*$27*	*$838*

The final MAIS distribution for unreported crashes, which is summarized in Table 4-7, is based on the average person involvement rates from police-reported crashes. As discussed, it is possible that unreported crashes have lower person involvement rates than reported crashes, since the presence of more than one driver is likely to increase the chances of the crash being reported. We do not have data on involvement rates for unreported crashes, but it is likely that basing these unit costs on police-reported rates produces a conservative estimate of these costs for unreported crashes. Note that there is no need to average congestion costs from both fatal and nonfatal crashes when allocating nonfatal injury costs because all fatal crashes are reported to police. Although costs are shown for each injury category, virtually all unreported crashes involve either minor injury or property damage only.

Table 4-7. Final Congestion Cost/Severity Unit (2019 $), Unreported Crashes

	Cost/Crash	MAIS/Crash	Cost/MAIS
MAIS0	$612	2.78	$220
MAIS1	$612	2.78	$220
MAIS2	$612	2.78	$220
MAIS3	$612	2.78	$220
MAIS4	$612	2.78	$220
MAIS5	$612	2.78	$220
Fatal	$1,412	2.47	$571
PDO	$838	1.77	$473

Average and Total Congestion Costs, Reported and Unreported Crashes

The average cost/crash across both police-reported and unreported crashes was calculated by weighting each category's costs according to the relative incidence within each severity category. For all injury categories this was based on the incidence of injured people. For PDOs, it is based on the incidence of damaged vehicles. These definitions are consistent with the stratification used throughout this report. Incidence was derived from the incidence chapter of this report. Table 4-8 summarizes this process and its results. Table 4-9 summarizes the total costs of congestion. In 2019, motor vehicle crashes are estimated to have caused $36 billion in travel delay, excess fuel consumption, and health and other economic impacts from added criteria pollutants and greenhouse gases.

Table 4-8. Average Congestion Costs for All Crashes, 2019

MAIS	Incidence			Unit Costs (2019 $)			
	Police-Reported	**Unreported**	**Total**	**% Police-Reported**	**Police-Reported**	**Unreported**	**Combined**
0	2,349,202	2,176,700	4,525,902	0.519057	$1,739	$220	$1,008
1	2,561,954	1,313,311	3,875,265	0.661104	$1,713	$220	$1,207
2	310,848	116,271	427,119	0.727778	$1,758	$220	$1,339
3	132,222	8,945	141,167	0.936635	$1,790	$220	$1,691
4	19,285	0	19,285	1	$1,814	$220	$1,814
5	7,187	0	7,187	1	$1,857	$220	$1,857
Fatal	36,500	0	36,500	1	$7,133	$571	$7,133
PDO	7,773,120	11,515,019	19,288,139	0.403	$2,591	$473	$1,327

Table 4-9. Total Congestion Costs, 2019

MAIS	Police-Reported	Unreported	Combined
0	$4,085,988,218	$478,959,072	$4,564,947,290
1	$4,389,407,738	$288,979,781	$4,678,387,518
2	$546,568,109	$25,584,091	$572,152,199
3	$236,720,194	$1,968,171	$238,688,365
4	$34,988,555	$0	$34,988,555
5	$13,349,262	$0	$13,349,262
Fatal	$260,400,806	$0	$260,400,806
PDO	$20,143,735,965	$5,447,572,678	$25,591,308,642
Total	$29,711,158,846	$6,243,063,791	$35,954,222,637

5. Lost Quality-of-Life

The human capital costs documented in the first chapter represent the tangible losses that result from motor vehicle crashes. They define the value of resources that are used or that would be required to restore crash victims, to the extent possible, to their pre-crash physical and financial status. These are resources have been diverted from other more productive uses to merely maintain the status quo. These costs, which can be estimated through empirical measurements, include medical care, lost productivity, legal and court costs, insurance administrative costs, workplace costs, congestion impacts (travel delay, excess fuel consumption and pollution), and property damage.

However, in cases of serious injury or death, medical care cannot fully restore victims to their pre-crash status and human capital costs fail to capture the intangible value of lost quality-of-life that results from these injuries. In the case of death, victims are deprived of their entire remaining lifespan. In the case of serious injury, the impact on the lives of crash victims can involve acute or extended physical pain or lifelong impairment, which can interfere with or prevent even the most basic living functions. These more intangible effects can be valued using studies that examine the willingness of consumers to pay to avoid risk of death or injury. Assessing the value of these impacts provides a more complete basis for quantifying the harmful impacts of motor vehicle crashes on society.

Value of a Statistical Life

The value of a statistical life (VSL) is a measure of consumer's implied willingness to pay to avoid the risk of death. A wide range of estimates of the value of VSL have been derived from numerous studies conducted over the past three decades. These "willingness to pay" studies (WTP) are most frequently based on wage rate differentials for risky jobs, or on studies of the prices consumers pay for products that reduce their risk of being fatally injured. The individual studies are too numerous to document here, but a number of authors have attempted to evaluate these studies as a group through systematic reviews or meta-analysis, which applies normalizing parameters and statistical weighting techniques to draw conclusions from related studies.

In 1990 Miller conducted a systematic review of 67 of these studies. In this study, Miller selected 47 studies that were the most methodologically sound, adjusted them to a common discount rate, and made adjustments for errors in perceived risk levels. The VSLs found in these 47 studies had both a mean and median value of $2.2 million in 1988 dollars with a standard deviation of $0.65 million. In 2000 Miller published another meta-analysis examining VSL estimates across differing countries. In this study he examined 68 studies, including the original 47 he had examined in 1990. Based on this study, Miller estimated the VSL in the United States to be $3.67 million in 1995 dollars.

Viscusi has also published a number of WTP reviews. In 1993 Viscusi found that most VSL estimates are clustered in the $3 million to $7 million range. In 2003 Viscusi and Aldy published a worldwide review of VSL studies and estimated a median value of $7 million in 2000 dollars. In 2004 Viscusi published his own estimate of WTP based on wage-risk premiums resulting in a $5 million VSL (using 2000 dollars). Other reviews include those by Mrozek and Taylor (2002), who found VSL estimates ranging from $1.5 million to $2.5 million in 1998 dollars, and a 2003 meta-analysis by Kochi et al. (2006), which produced a mean VSL estimate of $5.4 million in 2000 dollars.

It is apparent that there are a wide range of estimates regarding the implied VSL from WTP studies. This range is reflected in guidance supplied by the Office of Management and Budget in Circular A-4, issued on September 17, 2003, which recommended values between $1 million and $10 million be used by government agencies when evaluating the impacts of proposed regulations that affect fatality risk. In recent years, government agencies such as NHTSA, the FDA, EPA, the Consumer Product Safety Commission, the Department of Agriculture, and the Occupational Safety and Health Administration have used values ranging from $5 to $10 million in evaluating their regulations.

In February 2008, based on a review of the studies cited above, the Office of the Secretary of the Department of Transportation issued guidance setting a VSL of $5.8 million for use in Departmental regulatory programs (U.S. DOT, 2008). This value was subsequently updated for inflation twice, most recently in July 2011 to a value of $6.2 million (U.S. DOT, 2011).

In March 2013 U.S. DOT again updated its VSL guidance to a value of $9.1 million in 2012 dollars (U.S. DOT, 2013). The 2013 update was based exclusively on studies that used the Census of Fatal Occupational Injuries, a complete census of occupational fatalities conducted by the BLS (see Bureau of Labor Statistics, 2020, for an updated version of the earlier censuses). For a variety of reasons outlined in that guidance, U.S. DOT considered studies based on these data to be superior to those that used other sources.

Subsequent U.S. DOT VSL guidance updates based on the literature and methods established in the 2013 guidance memorandum, with the values being updated to reflect changes in income and prices (U.S. DOT, 2021a). This guidance found a 2021 value of $11.8 million. The corresponding values for other base years are shown in Table 5-1 below.

Table 5-1. Current and Prior Year VSL

Value (million $)	Base Year
11.8	2021
11.6	2020
10.9	2019
10.5	2018
10.2	2017
9.9	2016
9.6	2015
9.4	2014
9.2	2013
9.1	2012

This study adopts this current guidance for assessing the monetary value of fatalities caused by motor vehicle crashes. Since this study examines 2019 in detail, we adopt the 2019 VSL of $10.9 million for a fatality. This value will be used in this report. However, the literature on VSL estimates indicates a wide range of measured estimates of VSLs – some as low as a few million dollars, some as high as over $30 million. The U.S. DOT guidance memorandum (U.S. DOT, 2008), discusses a feasible range of VSLs for sensitivity analysis from $5.2 million to $12.9 million. The 2021 guidance memorandum (U.S. DOT, 2021b) recommends sensitivity analysis examining VSLs that are 40 percent above and below the central VSL value. Appendix A of this report provides a sensitivity analysis consistent with this range.

Lost Quality-of-Life for Nonfatal Injuries

While WTP studies can be used to value loss of life, nonfatal injuries, which are a far more prevalent occurrence in motor vehicle crashes, require a more complex examination to reflect the diversity of possible outcomes. When a life is lost prematurely in a motor vehicle crash, the victim loses all of his remaining life, and this can be quantified in terms of life years by comparing the victim's age at death to expected remaining lifespan. However, when the victim is injured but survives, the loss to the victim is a direct function of the extent to which the victim is disabled or made to suffer through physical pain or emotional distress, as well as the duration through which these impacts occur.

As noted previously, the metric commonly used to value these nonfatal injury losses is the quality adjusted life year or QALY, a health outcome measure that assigns a value of 1 to a year of perfect health and a value of 0 to death (Gold et al., 1996). QALY loss is determined by the duration and severity of the health problem, with a full year of QALY loss being equivalent to the loss of a full year of life in perfect health. QALYs are used in evaluating the outcomes of clinical trials of medical interventions, in approval of pharmaceuticals, and in studies of the return on investment in preventive health and safety measures (Miller, 2000). NHTSA routinely uses QALY based valuations to determine the relative value of nonfatal injuries when measuring the cost effectiveness of regulatory alternatives. The QALY valuations used by NHTSA were originally derived from work by Miller et al. (1995). These values were adopted for the report on the cost of crashes issued by NHTSA (Blincoe et al.) in 2002,and incorporated in subsequent regulatory evaluations conducted by NHTSA. Miller et al. (1995), based their QALY valuations on the Injury Impairment Index (III).

The III is based on physician estimates of impairment across six functional dimensions (cognitive, mobility, bending/grasping/lifting, sensory, pain, and cosmetic), originally developed for physician use by Hirsh et al. (1983), but subsequently enhanced to include permanent total and partial work-related disability by Miller et al. (1995). The physicians separately rated the average impairment for each injury diagnosis of AIS2 and above in the 1985 edition of the AIS. By diagnosis and broad age group, on each of the six dimensions functioning, their ratings showed the typical impairment level at hospital inpatient or ED discharge and its duration post-discharge. They then showed impairment changes by week/month in the first year post-injury, as well as the average impairment levels in years 2-5 and in years 6 to death on each of the six dimensions functioning. The III used the short-term work loss and permanent work-related disability data used in the productivity loss calculations described above.

The impairments were converted to QALY losses using weights from 0 percent to 100 percent on loss within dimension and on the relative contribution of the different dimensions to lifetime utility. Miller et al. (1995) derived those weights from a systematic review of the literature. When NHTSA conducted its last cost study (for 2010, published in 2015), it had been 15 years since the 1995 study. NHTSA was concerned that subsequent studies with better methods could have shifted the relative values of the functional losses within and between dimensions.

Therefore, NHTSA contracted with the Pacific Institute for Research and Evaluation to update the III injury preference weights based on a meta-analysis of literature. The resulting studies by Spicer and Miller (2010), and Spicer et al. (2011), provided the basis for the nonfatal injury QALY values used in the 2015 report. The report found slightly different QALY values for all injury levels, reflecting both the revised preference weights and the larger and more recent database examined.

Over the past decade, on projects for the Consumer Product Safety Commission (CPSC), PIRE further developed its III-based QALY estimates. It produced more detailed QALY estimates for hospital-admitted burns (Miller et al., 2013), for submersion and certain types of poisoning (Miller & Bhattacharya, 2013), and for electrical injuries, ED-treated burns, and methanol poisoning (Lawrence & Miller, 2020). The latter study also introduced a more precise mapping to ICD-9-CM from the 1980 revision of AIS, which was used by Hirsch et al. (1983). Lawrence and Miller (1988) provide a thorough, up-to-date description of the III-based QALY estimates that NHTSA has used heretofore.

However, the Hirsch impairment ratings at the heart of the III are now 40 years old. Therefore, PIRE investigated an alternative source of QALY estimates on a recent CDC project (2022). The Validating and Improving Injury Burden Estimates Study (VIBES) provides empirically derived disability ratings based on six relatively recent injury outcome studies in five countries with advanced healthcare systems, including the United States (Gabbe et al., 2016). At least two of the six studies that VIBES pooled included patients who were not hospital-admitted. Therefore, VIBES, which is based on recent patient data rather than the decades-old expert opinion of the III, and that differentiates between patient outcomes in ED and inpatient settings, can potentially serve as a basis for evaluating and updating the III estimates. The primary weakness of VIBES is its small sample sizes, particularly for ED-treated injuries, which allow for only limited differentiation by diagnosis and demographics.

While the VIBES estimates are broken into 97 ICD-10 diagnosis groups for inpatient injuries, they cover only 17 groups for non-admitted injuries, with roughly half of non-admitted injuries falling into just two diagnosis groups. PIRE concluded that the VIBES impairment estimates for non-admitted injuries would not meet the needs of this project because of the small sample size and lack of diagnosis detail, and therefore retained the III estimates as updated for CPSC for non-admitted cases. The VIBES inpatient estimates, although less problematic than the non-admitted estimates, are too coarse to support the breakdown by AIS, body part, and fracture involvement that is required to produce NHTSA's required estimates for crash injuries by AIS.

To solve that problem, PIRE used the VIBES estimates as control totals by diagnosis group for the III estimates. This preserved the detailed severity pattern of the III, while substituting the means of VIBES by diagnosis group. So, for example, if one III diagnosis within a VIBES diagnosis group has twice the impairment of a second, so will the imputed VIBES-III hybrid estimates.

Although the VIBES-III hybrid estimates are affected by the limitations each of their parent ratings, their complementary strengths weaken those limitations. VIBES is recent and is based on observed functional loss rather than physician judgement. The III adds the diagnostic detail that is lacking in the otherwise robust VIBES measurements. However, VIBES has data on too few non-admitted injuries to support construction of a hybrid non-admitted injury measure. In the future, it would be desirable to adapt the VIBES-III hybrid methodology to more recent hospital-admitted injury incidence data coded in ICD10-CM. Doing so will require mapping the III to ICD10-CM, which will be challenging. VIBES already is coded by ICD10 diagnosis group.

To estimate QALY based values for use in this report, we selected motor vehicle traffic injuries from the 2013-2014 HCUP NIS (the most recent data coded in the ICD9-CM diagnosis coding system that has been mapped to the III). We merged on both sets of impairment fractions—III and VIBES—by diagnosis and computed QALYs both ways for each case. Then, for each VIBES diagnosis group, we computed the ratio of the mean VIBES-based QALY to the mean III-based QALY. Next, we merged this ratio back onto the NIS and multiplied it times the III-based QALY to compute the final hybrid QALY. In a few instances, this process produced QALYs that exceeded remaining life expectancy – implying fates worse than death. While we acknowledge that some individuals might value the avoidance of severe, enduring impairment and pain more highly than avoiding mortality risk, we did not believe that the mechanics of this methodology were sufficient to apply such judgment to these estimates. To avoid assigning values that exceed complete loss of life, we constrained the maximum QALY loss to equal life expectancy. We performed all of these computations using discount rates of 0 percent, 2 percent, 3 percent, 4 percent, and 7 percent. Table 5-2 shows the QALY loss by discount rate for crashes by MAIS level.

Table 5-2. QALY Values for Injured Survivors by Discount Rate and MAIS (Percentage of QALY Lost per Fatality Lost per Person Injured)

Discount Rate	**0%**	**2%**	**3%**	**4%**	**7%**
Injury Severity					
MAIS1	0.35%	0.40%	0.43%	0.49%	0.54%
MAIS2	3.86%	4.09%	4.17%	4.34%	4.51%
MAIS3	16.79%	18.16%	18.28%	18.58%	18.72%
MAIS4	22.78%	30.32%	30.44%	30.44%	30.71%
MAIS5	54.99%	53.28%	52.52%	51.60%	50.10%

To monetize these QALY values—i.e., convert them from years to dollars—we used costs per QALY based on a value of statistical life of $10.9 million in 2019 dollars.

QALY values for the most serious injuries (MAIS5) are thus roughly 52 percent of a full remaining life, while minor injuries (MAIS1) are valued at less than 1 percent of a full remaining life. QALYs rise progressively with the severity of the injury. This reflects both the severity and longevity of injury consequences at each severity level. For example, serious brain injury, spinal cord injury, and other injuries likely to involve long term debilitation are typically classified in the higher MAIS categories while less debilitating injuries with shorter recovery times tend to be classified in the lower MAIS categories. Note that the impact of discount rates on QALY values is relatively limited. Shifts in discount rates affect both the MAIS levels and the full life values, which minimizes the relative impact on QALYs.

Although the impact of discount rates on QALYs is minor, a single value must still be adopted for this analysis. Ideally, QALY values would reflect the discount rate implicit in consumer valuations used to measure the VSL, which these QALYs will be applied to. Estimates of this rate vary as widely as estimates for the VSL. Aldy and Viscusi (2007) cite a range of implicit discount rates of from 1 to 17 percent across five different studies that examined VSLs or VSLYs.[11] Hartwick (2008) derived implicit discount rates of between 3 percent and 4 percent for people who die from ages 30 to 40 with a VSL of $6.3 million. Based on 2007-2009 FARS data, the median age of a person killed in a motor vehicle crash is 38. On this basis, either a 3-percent or a 4-percent discount rate appears to be appropriate, and the difference in QALYs between these two rates is extremely small. The U.S.DOT's VSL guidance provides scaling factors for value injuries from MAIS1 to MAIS5 based on QALYs estimated using a 4-percent discount rate as an intermediate value between the 3-percent and 7-percent rates recommended by OMB (2003) for use in regulatory analyses and evaluations (U.S. DOT, 2011b). Since this report is based on a 3-percent discount rate, we use the 3 percent values to retain consistency with the rest of the report. A separate table consistent with the U.S. DOT recommendation (i.e., with nonfatal injury QALYs based on a 4-percent discount rate), or with other discount rates can be derived using Table 5-2 above.

Comprehensive Costs

The VSL and QALY measures discussed in the previous section represent an average valuation of the lost quality-of-life that would be lost to crash victims. However, it does not include the economic costs that result from an unexpected event such as death or injury resulting from a motor vehicle crash. Those costs, which include medical care, legal costs, emergency services, insurance administrative costs, workplace costs, congestion impacts, and property damage, were previously estimated in Chapters 3 and 4 of this study. The full societal impact of crashes includes both the intangible impacts represented by VSL and QALY estimates, and the economic impacts that result directly from the crash. Combining these impacts – the direct economic costs that result from the crash and the value of lost quality-of-life experienced by injured crash victims, results in a measure of the comprehensive cost to society from death or injury.

The economic cost estimates developed previously include lost market and household productivity. WTP based valuations life, which encompass the entire expected life experience of consumers, theoretically encompass after-tax wages (the portion of wages actually received by the employee) and household productivity. Since these measures are hypothetically already included under WTP valuations, combining measures of economic costs and lost quality-of-life requires an adjustment to avoid double counting these components. In Table 5-2 below, the components that make up comprehensive costs are listed in the left column. These consist of the various economic cost components with an additional line for QALYs. Because lost after- tax market and household productivity are separate line items that are implicitly included in QALYs, the QALY values are reduced by these values so that the separate components can be added to produce the total comprehensive cost for each injury severity level.[12]

Comprehensive costs have been used by NHTSA and other agencies to evaluate regulatory programs for several decades. They provide a convenient basis for measuring the full societal benefits of regulations against their costs, and they are the appropriate basis for valuing benefits

[11] VSLY is the value of a statistical life year – a single year of remaining statistical life rather than the full value of all remaining life years as measured by VSL.

[12] After-tax market productivity is inherent to VSLs because it determines the individual's valuation of their potential material consumption. Household productivity is inherent to VSLs because it is a routine activity that is part of life experience. Both aspects are potentially threatened by behaviors that increase risk, and are thus inherently already reflected in the VSL.

in a cost-benefit context where societal impacts are the overriding concern. However, in some circumstances, users may wish to measure only the tangible economic value of goods and services lost and out of pocket expenses incurred that result of motor vehicle crashes. Economic impacts are commonly considered by policymakers and public interest groups when safety issues are being debated. These more tangible economic costs are both more easily understood and more reliably measured than lost quality-of-life, which, as noted previously, is subject to a wide range of estimates and the uncertainty implicit in this range. This report provides estimates of impacts under both bases to facilitate either approach.

Table 5-2 summarizes the total unit cost of crashes stratified by injury level and cost category, and Figure 5-A illustrates the relative contribution of economic costs and quality-of-life to the total comprehensive cost for each injury severity level. The total comprehensive cost for a fatality is $11.3 million. Roughly 82 percent of this is due to components that influence the VSL (QALY and lost productivity), with roughly 75 percent coming from lost quality-of-life alone. The portion of total comprehensive costs represented by economic costs decreases as the severity of the injury increases. Economic costs represent 14 percent of fatal comprehensive costs, 14-19 percent of the more serious nonfatal injury costs, 32 percent of minor injury costs, and 100 percent of MAIS0 and PDO costs. This reflects the relatively small values for lost quality-of-life found for less severe injuries. The “Subtotal” line represents components associated with injuries (both fatal and nonfatal). Costs on this line are thus useful in analyzing the economic cost savings of safety countermeasures that prevent injury in the event of a crash. The “Total” line is useful for estimating the economic benefits from countermeasures that prevent crashes from occurring. To examine the total societal harm prevented by either countermeasure type, the value on the QALY line should be added to the appropriate economic values, giving the comprehensive impacts of crashes on society.

Over half of all PDO crashes and about a quarter of all nonfatal injury crashes are not reported to police. However, analyses of safety countermeasures frequently rely only on police-reported incidence data. Crashes that get reported to police are likely to be more severe than unreported crashes because vehicles are more likely to require towing and occupants are more likely to require hospitalization or emergency services. These crashes are typically also likely to require more time to investigate and clear from roadways than unreported crashes. Analysis based solely on police-reported crashes should thus be based on unit costs that are specific to police-reported crashes. For injury-related costs, this is automatically accounted for by the shift in the injury severity profile. Unreported crashes have a lower average severity profile than do reported crashes. However, for non-injury-related cost components – property damage and congestion costs – there is no profile to shift. In addition, emergency services have higher involvement rates for police-reported crashes.

For this report, costs specific to police-reported and unreported crashes have been developed. The changes in unit costs are all due to economic cost factors and these are discussed in detail in the Human Capital chapter. The results of this analysis on comprehensive costs are presented in Tables 5-4 and 5-5. The differences seem negligible at the more severe injury levels due to the overwhelming costs of factors such as lost productivity and medical care that do not vary by reporting status, except through the shift in injury profiles. However, at lower severity levels the unit cost differences are significant. For PDO vehicles and MAIS0s, police-reported crashes have costs that are three times those of unreported crashes. For minor (MAIS1) injuries, reported crashes cost 24 percent more than unreported crashes. These ratios decline as injury severity increases. Note that for MAIS4s, MAIS5s, and Fatalities, property damage costs are identical under both reported and unreported cases. All injuries at these levels are believed to be reported to police, and the original property damage cost estimate is thus assumed to represent police-reported cases. These same costs are thus listed under both scenarios.

Table 5-3. Comprehensive Unit Costs, Reported and Unreported Crashes (2019 $)

	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$31	$24	$106	$228	$486	$976	$999	$1,060
Market	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$724	$380	$8,487	$60,464	$261,200	$653,348	$954,237	$1,584,326
Congestion	$1,327	$1,008	$1,207	$1,339	$1,691	$1,814	$1,857	$7,133
Prop. Damage	$3,200	$1,864	$9,650	$9,616	$17,835	$20,565	$23,234	$15,185
Subtotal	$4,527	$2,872	$10,857	$10,955	$19,526	$22,379	$25,091	$22,318
Total	$5,251	$3,252	$19,344	$71,419	$280,726	$675,727	$979,328	$1,606,644
QALYs	$0	$0	$41,112	$402,341	$1,763,881	$2,938,008	$5,068,923	$9,651,851
Comp.Total	$5,251	$3,252	$60,456	$473,760	$2,044,607	$3,613,735	$6,048,251	$11,258,495

Figure 5-A. Relative Distribution of Comprehensive Costs

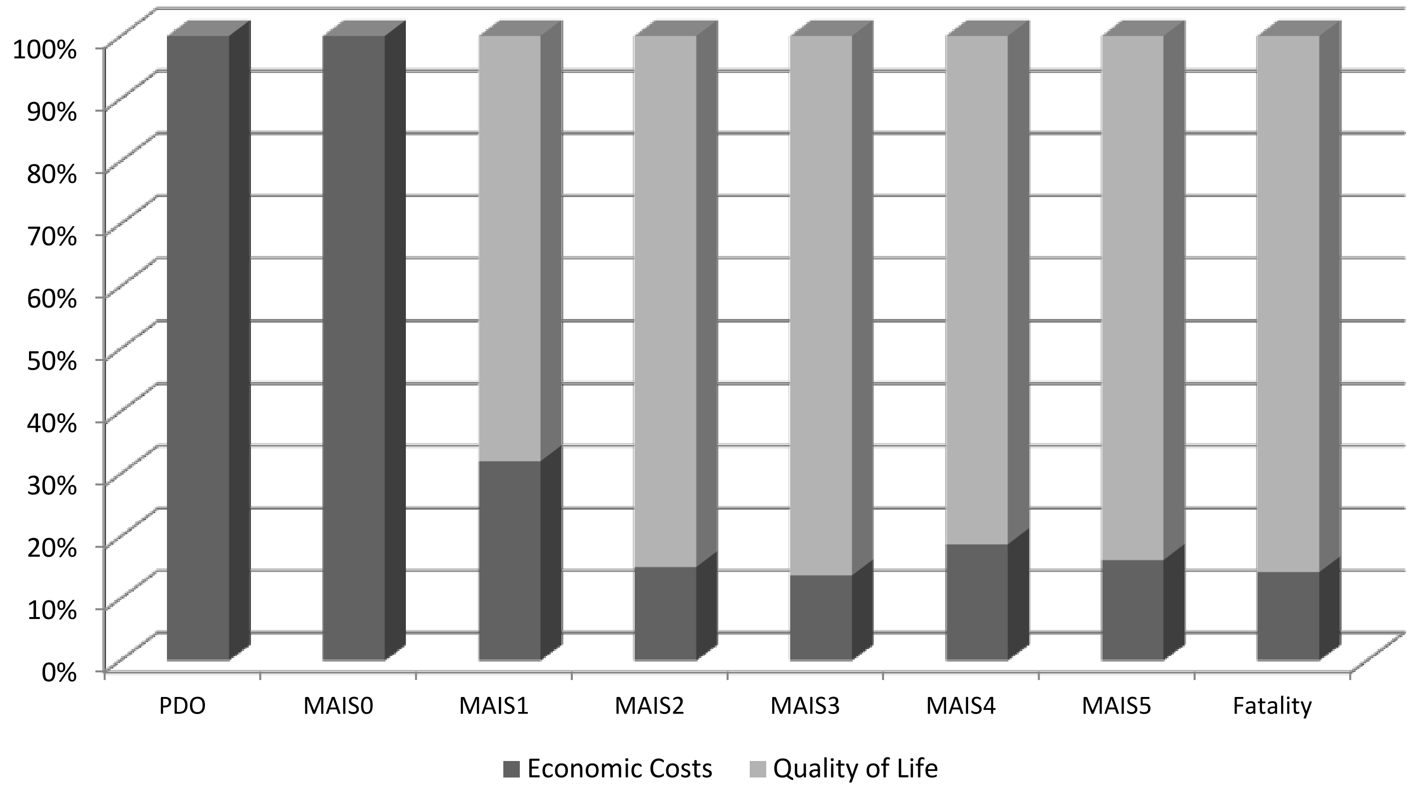


Table 5-4. Comprehensive Unit Costs, Police-Reported Crashes (2019 $)

	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$72	$40	$139	$274	$486	$976	$999	$1,060
Market	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$765	$396	$8,520	$60,510	$261,200	$653,348	$954,237	$1,584,326
Congestion	$2,591	$1,739	$1,713	$1,758	$1,790	$1,814	$1,857	$7,133
Prop. Damage	$4,556	$2,654	$13,741	$13,692	$25,395	$20,565	$23,234	$15,185
Subtotal	$7,147	$4,393	$15,454	$15,450	$27,185	$22,379	$25,091	$22,318
Total	$7,913	$4,789	$23,974	$75,961	$288,385	$675,727	$979,328	$1,606,644
QALYs	$0	$0	$41,112	$402,341	$1,763,881	$2,938,008	$5,068,923	$9,651,851
Total	$7,913	$4,789	$65,086	$478,302	$2,052,266	$3,613,735	$6,048,251	$11,258,495

Table 5-5. Comprehensive Unit Costs, Unreported Crashes (2019 $)

	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$8	$7	$41	$104	$486	$976	$999	$1,060
Market	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$701	$363	$8,422	$60,340	$261,200	$653,348	$954,237	$1,584,326
Congestion	$473	$220	$220	$220	$220	$220	$220	$571
Prop. Damage	$1,550	$903	$4,674	$4,657	$8,638	$20,565	$23,234	$15,185
Subtotal	$2,023	$1,123	$4,894	$4,877	$8,858	$20,785	$23,454	$15,756
Total	$2,724	$1,486	$13,315	$65,217	$270,058	$674,133	$977,691	$1,600,082
QALYs	$0	$0	$41,112	$402,341	$1,763,881	$2,938,008	$5,068,923	$9,651,851
Comp. Total	$2,724	$1,486	$54,427	$467,558	$2,033,939	$3,612,141	$6,046,614	$11,251,933

6. State Costs

States are directly involved in establishing and enforcing laws related to motor vehicle safety, such as seat belt laws, motorcycle helmet laws, speed limits, and impaired or distracted driving laws. In addition, they are directly involved in decisions to justify funding safety-related infrastructure expenditures. They are encouraged and assisted in this effort through Federal legislation enacted to promote highway safety such as The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) that was enacted in 2005 and that provided one- time grants to States that enacted and are enforcing a conforming primary seat belt law for all passenger motor vehicles. SAFETEA-LU authorized $770 million in grant money over a 6-year period to address roadway and driver behavioral safety activities, especially those designed to increase belt use. MAP-21, which was enacted in 2012, provided $1.3 billion for highway safety grant programs. MAP-21 restructured existing grant programs administered by NHTSA. It specified a single application deadline for all highway safety grants and required that all States have a performance-based highway safety program. In December 2015 the Fixing America's Surface Transportation Act, or "FAST Act," was signed into law. It was the first law enacted in more than 10 years that provided long-term funding certainty for surface transportation, meaning States and local governments could move forward with critical transportation projects, like new highways and transit lines, with the confidence that they will have a Federal partner over the long term. The FAST Act authorized $2.7 billion in funding for the Section 402 Highway Safety Programs and Section 405 National Priority Safety Programs for fiscal years 2016 to 2020. More recently, NHTSA announced the release of nearly $260 million in highway safety grants, part of the funding included in the Bipartisan Infrastructure Law, distributed to Highway Safety Offices in all 50 States, the District of Columbia, United States territories, and the Bureau of Indian Affairs. The funds will help address the traffic safety crisis on America's roads by helping States and territories support a broad array of traffic safety priorities. When full-year distributions are completed, the Bipartisan Infrastructure Law will increase the funding available for these vital life-saving programs by 31 percent over the previous fiscal year's levels.

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

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

The year 2019 fatalities were obtained by State from FARS. The portion of total national fatalities in each State was then applied directly to the total fatality cost ($58.6 billion). Crash incidence data were obtained from individual States for 2019. In cases where data were not available, a factor based on the trend in fatalities within the State was used to estimate crashes from the last years for which complete data were available. The portion of total national crashes in each State was applied to the total cost of all nonfatal injuries, PDOs, and uninjured occupants ($281.2 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 C2ER State Medical Cost Index (Council for Community and Economic

Research, n.d.) cited by Miller and Galbraith (1995) with updates provided by Miller (personal communication). Lost productivity, travel delay and workplace costs were adjusted based on 2019 per-capita income (Bureau of Economic Analysis, n.d.). 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 CCER (also provided by Miller).

These four adjustment factors were applied separately to the fatal and nonfatal costs for each State.

Weights to combine each factor were derived separately from the relative importance of each cost category to nationwide fatal and nonfatal total costs. The sum of fatal and nonfatal costs for each State was then adjusted to force the sum of all States' costs to equal the national total.

The results of this analysis are depicted in Table 6-1. There is considerable variation in costs among the States with New York, for example, having costs that are 17 times higher than those for Idaho. This is primarily due to the higher incidence of death and injury in New York (a function of population), but also to the higher cost levels in that State. However, as noted by Miller and Galbraith (1995), cost comparisons between States that are based on State injury totals can be misleading because injury totals do not capture differences in nonfatal injury severity between States. This would tend to understate costs in rural States relative to urban States, which typically have lower average speeds and consequently less severe injuries. Ideally, State costs would be based on individual State injury profiles, but these are not available for many States.

Differences between States may also result from different reporting practices that result in more or less complete recording of injuries from State to State. Differences in roadway characteristics and state of repair may account for some of this discrepancy, though it seems likely that variation in injury reporting is also a contributing factor. Finally, the impact of crash costs must be viewed in the context of each State's economy. Smaller, less populated States may have lower absolute costs, but they may also have fewer resources available to address these costs. A significant portion of these costs is borne by the general public through State and local revenue, or through private insurance plans. The per capita costs for each State vary from roughly $400 to $2,000 compared to the nationwide average of $1,035. These costs represent s 0.7 to 3.6 percent of the per-capita income for each State, with an overall average of 1.8 percent.

Table 6-1. Estimated 2019 Economic Costs Due to Motor Vehicle Crashes by State

State	(Millions 2019 $)	% Total	Cost Per Capita	% Per Capita Personal Income
Alabama	$6,437	1.9%	$1,313	3.0%
Alaska	$627	0.2%	$856	1.4%
Arizona	$5,946	1.7%	$817	1.8%
Arkansas	$3,142	0.9%	$1,041	2.3%
California	$29,098	8.6%	$736	1.1%
Colorado	$6,028	1.8%	$1,047	1.7%
Connecticut	$6,104	1.8%	$1,712	2.3%
Delaware	$1,478	0.4%	$1,518	2.8%
Dist. of Col.	$832	0.2%	$1,178	1.5%
Florida	$20,019	5.9%	$932	1.8%
Georgia	$18,697	5.5%	$1,761	3.6%
Hawaii	$580	0.2%	$410	0.7%
Idaho	$1,355	0.4%	$758	1.7%
Illinois	$13,977	4.1%	$1,103	1.9%
Indiana	$8,540	2.5%	$1,269	2.6%
Iowa	$2,794	0.8%	$885	1.8%
Kansas	$2,984	0.9%	$1,024	1.9%
Kentucky	$6,157	1.8%	$1,378	3.1%
Louisiana	$6,570	1.9%	$1,413	3.0%
Maine	$1,876	0.6%	$1,396	2.8%
Maryland	$5,910	1.7%	$977	1.6%
Massachusetts	$7,389	2.2%	$1,072	1.5%
Michigan	$12,305	3.6%	$1,232	2.5%
Minnesota	$3,803	1.1%	$674	1.2%
Mississippi	$2,533	0.7%	$851	2.2%
Missouri	$6,778	2.0%	$1,104	2.3%
Montana	$1,095	0.3%	$1,024	2.0%
Nebraska	$1,726	0.5%	$892	1.7%
Nevada	$2,645	0.8%	$859	1.7%
New Hampshire	$1,664	0.5%	$1,223	1.9%
New Jersey	$14,008	4.1%	$1,577	2.3%
New Mexico	$2,173	0.6%	$1,036	2.4%
New York	$23,616	6.9%	$1,214	1.7%
North Carolina	$12,039	3.5%	$1,148	2.4%

State	(Millions 2019 $)	% Total	Cost Per Capita	% Per Capita Personal Income
North Dakota	$735	0.2%	$965	1.7%
Ohio	$12,108	3.6%	$1,036	2.1%
Oklahoma	$3,420	1.0%	$864	1.8%
Oregon	$2,822	0.8%	$669	1.3%
Pennsylvania	$6,663	2.0%	$520	0.9%
Rhode Island	$2,105	0.6%	$1,987	3.5%
South Carolina	$6,269	1.8%	$1,218	2.7%
South Dakota	$941	0.3%	$1,063	1.9%
Tennessee	$10,050	3.0%	$1,472	3.0%
Texas	$28,939	8.5%	$998	1.9%
Utah	$2,803	0.8%	$874	1.8%
Vermont	$625	0.2%	$1,001	1.8%
Virginia	$6,455	1.9%	$756	1.3%
Washington	$6,337	1.9%	$832	1.3%
West Virginia	$1,460	0.4%	$815	1.9%
Wisconsin	$6,310	1.9%	$1,084	2.0%
Wyoming	$844	0.2%	$1,457	2.4%
Total	$339,809	100.0%	$1,035	1.8%

7. Alcohol-Involved Crash Costs

Alcohol consumption is a major cause of motor vehicle crashes and injury. In the 1980s and early 1990s alcohol was involved in more than 50 percent of all fatal crashes. Of these cases, about 85 percent involved a level of alcohol consumption that met the current typical legal definition for impairment, a BAC of .08 g/dL or higher. Over time, there has been an increased awareness of the problems caused by impaired driving. Many groups including NHTSA, Mothers Against Drunk Driving (MADD), Students Against Destructive Decisions (SADD), and State and local agencies, have promoted the enactment of laws and implemented public awareness campaigns to assist in combating this problem. Legal measures such as administrative license revocation/suspension have been enacted in numerous States. As a result, there has been a marked decrease in the number of fatalities resulting from alcohol-involved crashes. Over the past three decades, about 40 percent of all motor vehicle fatalities occurred in crashes in which a driver or nonoccupant had consumed alcohol prior to the crash. Table 7-1 displays the share of fatalities associated with various levels of alcohol involvement (BAC>.01 g/dL) and the current definition of legal impairment (.08 g/dL in all States except Utah) since 1982. Alcohol involvement in fatal crashes has declined from 60 percent of all fatalities in 1982 to roughly 39 percent in 2019, while legal intoxication (defined as a BAC of .08 g/dL or greater) has declined from 53 percent to 33 percent over the same period. While these declines are encouraging, alcohol still remains a significant factor in motor vehicle crashes.

All but one of the 50 States, the District of Columbia, and Puerto Rico define legal impairment, the level at which DWI convictions can be made, as having a BAC of .08 or higher. Utah sets a lower threshold of .05. FARS data indicates that fatalities involving legally impaired drivers or nonoccupants (defined as .08 g/dL or greater) account for 85 percent of the fatalities arising from all levels of alcohol involvement.

Fatalities

FARS provides detailed information about all traffic fatalities that occur within 30 days of a crash on a public road. Each case is investigated and documentation regarding alcohol involvement is included. Alcohol involvement can be indicated either by the judgment of the investigating police officers or by the results of administered BAC tests. Cases where either of these factors is positive are taken as alcohol-involved and any fatalities that result from these crashes are considered to be alcohol-involved fatalities. In addition, there are a large number of cases where alcohol involvement is unknown. In 1986 NHTSA's National Center for Statistics and Analysis (NCSA) developed an algorithm based on discriminant analysis of crash characteristics that estimates the BAC level for these cases (Klein, 1986). In 1998 NHTSA developed a more sophisticated technique to accomplish these estimates using imputation (Rubin et al., 1998), and substituted this method beginning with the 2001 FARS file. NHTSA has recomputed previous FARS files using this method and alcohol involvement rates based on the new method are routinely published by NHTSA and used in this report. The total number of alcohol-involved fatalities by BAC is shown in Table 7-1 from 1982 through 2019. In 2019 about 85 percent of all fatalities that occurred in alcohol-involved crashes were in cases where each had a driver or pedestrian with a BAC of .08 or higher.

Table 7-1. Alcohol-Involved Traffic Fatalities, Highest BAC in Crash

Year	Total		BAC=.00		BAC=.01-.07		BAC=.08+		BAC=.01+	
	Number	%	Number	%	Number	%	Number	%	Number	%
1982	43,945	100%	17,773	40%	2,927	7%	23,246	53%	26,173	60%
1983	42,589	100%	17,955	42%	2,594	6%	22,041	52%	24,635	58%
1984	44,257	100%	19,496	44%	3,046	7%	21,715	49%	24,762	56%
1985	43,825	100%	20,659	47%	3,081	7%	20,086	46%	23,167	53%
1986	46,087	100%	21,070	46%	3,546	8%	21,471	47%	25,017	54%
1987	46,390	100%	22,297	48%	3,398	7%	20,696	45%	24,094	52%
1988	47,087	100%	23,254	49%	3,234	7%	20,599	44%	23,833	51%
1989	45,582	100%	23,159	51%	2,893	6%	19,531	43%	22,424	49%
1990	44,599	100%	22,012	49%	2,980	7%	19,607	44%	22,587	51%
1991	41,508	100%	21,349	51%	2,560	6%	17,599	42%	20,159	49%
1992	39,250	100%	20,960	53%	2,443	6%	15,847	40%	18,290	47%
1993	40,150	100%	22,242	55%	2,361	6%	15,547	39%	17,908	45%
1994	40,716	100%	23,409	57%	2,322	6%	14,985	37%	17,308	43%
1995	41,817	100%	24,085	58%	2,490	6%	15,242	36%	17,732	42%
1996	42,065	100%	24,316	58%	2,486	6%	15,263	36%	17,749	42%
1997	42,013	100%	25,302	60%	2,290	5%	14,421	34%	16,711	40%
1998	41,501	100%	24,828	60%	2,465	6%	14,207	34%	16,673	40%
1999	41,717	100%	25,145	60%	2,321	6%	14,250	34%	16,572	40%
2000	41,945	100%	24,565	59%	2,511	6%	14,870	35%	17,380	41%
2001	42,196	100%	24,796	59%	2,542	6%	14,858	35%	17,400	41%
2002	43,005	100%	25,481	59%	2,432	6%	15,093	35%	17,524	41%
2003	42,884	100%	25,779	60%	2,427	6%	14,678	34%	17,105	40%
2004	42,836	100%	25,918	61%	2,325	5%	14,593	34%	16,919	39%
2005	43,510	100%	25,920	60%	2,489	6%	15,102	35%	17,590	40%
2006	42,708	100%	24,970	58%	2,594	6%	15,144	35%	17,738	42%
2007	41,259	100%	24,101	58%	2,554	6%	14,603	35%	17,158	42%
2008	37,423	100%	21,974	59%	2,191	6%	13,258	35%	15,449	41%
2009	33,883	100%	19,704	58%	2,031	6%	12,149	36%	14,179	42%
2010	32,999	100%	19,676	60%	1,861	6%	11,462	35%	13,323	40%
2011	32,367	100%	19,212	59%	1,758	5%	11,397	35%	13,155	41%
2012	33,782	100%	19,903	59%	1,920	6%	11,960	35%	13,879	41%
2013	32,893	100%	19,325	59%	1,938	6%	11,631	35%	13,569	41%
2014	32,744	100%	19,356	59%	1,873	6%	11,515	35%	13,388	41%
2015	35,484	100%	21,360	60%	2,044	6%	12,081	34%	14,125	40%
2016	37,806	100%	22,820	60%	2,113	6%	12,872	34%	14,986	40%
2017	37,473	100%	22,764	61%	2,046	5%	12,663	34%	14,709	39%
2018	36,835	100%	22,251	60%	2,035	6%	12,549	34%	14,584	40%
2019	36,355	100%	22,192	61%	2,054	6%	12,109	33%	14,163	39%

Alcohol use by drivers is the focus of most behavioral programs and State laws. Drivers are involved in the vast majority of alcohol-involved traffic crashes, but a significant number of crashes occur where pedestrians or bicyclist alcohol use was indicated, while driver alcohol use was not. Table 7-2 summarizes the incidence of alcohol-involved crashes based on driver BAC, while Table 7-3 shows the incidence of fatalities where pedestrians or bicyclists were using alcohol, but not drivers. In 2019 some 85 percent of all fatalities that occurred in alcohol-involved crashes were each in case where a driver had a BAC of .08 or higher. About 6 percent of all alcohol-related traffic fatalities involve alcohol use by pedestrians or bicyclists rather than motor vehicle drivers. Of these cases, 90 percent involve alcohol impairment (BAC = .08 or higher) on the part of the pedestrian or bicyclist.

Table 7-2. Alcohol-Involved Traffic Fatalities, Highest Driver BAC

Year	**Total***		**BAC=.00**		**BAC=.01-.07**		**BAC=.08+**		**BAC=.01+**	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
1982	43,945	100%	19,771	45%	2,912	7%	21,113	48%	24,025	55%
1983	42,589	100%	19,787	46%	2,588	6%	20,051	47%	22,639	53%
1984	44,257	100%	21,429	48%	3,007	7%	19,638	44%	22,645	51%
1985	43,825	100%	22,589	52%	2,974	7%	18,125	41%	21,098	48%
1986	46,087	100%	22,896	50%	3,487	8%	19,554	42%	23,041	50%
1987	46,390	100%	24,186	52%	3,238	7%	18,813	41%	22,051	48%
1988	47,087	100%	25,164	53%	3,156	7%	18,611	40%	21,767	46%
1989	45,582	100%	25,152	55%	2,793	6%	17,521	38%	20,314	45%
1990	44,599	100%	23,823	53%	2,901	7%	17,705	40%	20,607	46%
1991	41,508	100%	23,025	55%	2,480	6%	15,827	38%	18,307	44%
1992	39,250	100%	22,726	58%	2,352	6%	14,049	36%	16,401	42%
1993	40,150	100%	23,979	60%	2,300	6%	13,739	34%	16,039	40%
1994	40,716	100%	24,948	61%	2,236	5%	13,390	33%	15,626	38%
1995	41,817	100%	25,768	62%	2,416	6%	13,478	32%	15,893	38%
1996	42,065	100%	26,052	62%	2,415	6%	13,451	32%	15,866	38%
1997	42,013	100%	26,902	64%	2,216	5%	12,757	30%	14,973	36%
1998	41,501	100%	26,477	64%	2,353	6%	12,546	30%	14,899	36%
1999	41,717	100%	26,798	64%	2,235	5%	12,555	30%	14,790	35%
2000	41,945	100%	26,082	62%	2,422	6%	13,324	32%	15,746	38%
2001	42,196	100%	26,334	62%	2,441	6%	13,290	31%	15,731	37%
2002	43,005	100%	27,080	63%	2,321	5%	13,472	31%	15,793	37%
2003	42,884	100%	27,328	64%	2,327	5%	13,096	31%	15,423	36%
2004	42,836	100%	27,413	64%	2,212	5%	13,099	31%	15,311	36%
2005	43,510	100%	27,423	63%	2,404	6%	13,582	31%	15,985	37%
2006	42,708	100%	26,633	62%	2,479	6%	13,491	32%	15,970	37%
2007	41,259	100%	25,611	62%	2,494	6%	13,041	32%	15,534	38%
2008	37,423	100%	23,499	63%	2,115	6%	11,711	31%	13,826	37%
2009	33,883	100%	21,051	62%	1,972	6%	10,759	32%	12,731	38%
2010	32,999	100%	21,005	64%	1,771	5%	10,136	31%	11,906	36%
2011	32,367	100%	20,752	64%	1,633	5%	9,878	31%	11,510	36%
2012	33,782	100%	21,563	64%	1,782	5%	10,336	31%	12,118	36%
2013	32,893	100%	20,865	63%	1,834	6%	10,084	31%	11,918	36%
2014	32,744	100%	20,913	64%	1,800	5%	9,943	30%	11,743	36%
2015	35,484	100%	23,165	65%	1,930	5%	10,280	29%	12,210	34%
2016	37,806	100%	24,762	65%	1,984	5%	10,967	29%	12,951	34%

Year	Total*		BAC=.00		BAC=.01-.07		BAC=.08+		BAC=.01+	
	Number	%	Number	%	Number	%	Number	%	Number	%
2017	37,473	100%	24,589	66%	1,895	5%	10,880	29%	12,775	34%
2018	36,835	100%	24,186	66%	1,850	5%	10,710	29%	12,560	34%
2019	36,355	100%	24,251	67%	1,834	5%	10,196	28%	12,029	33%

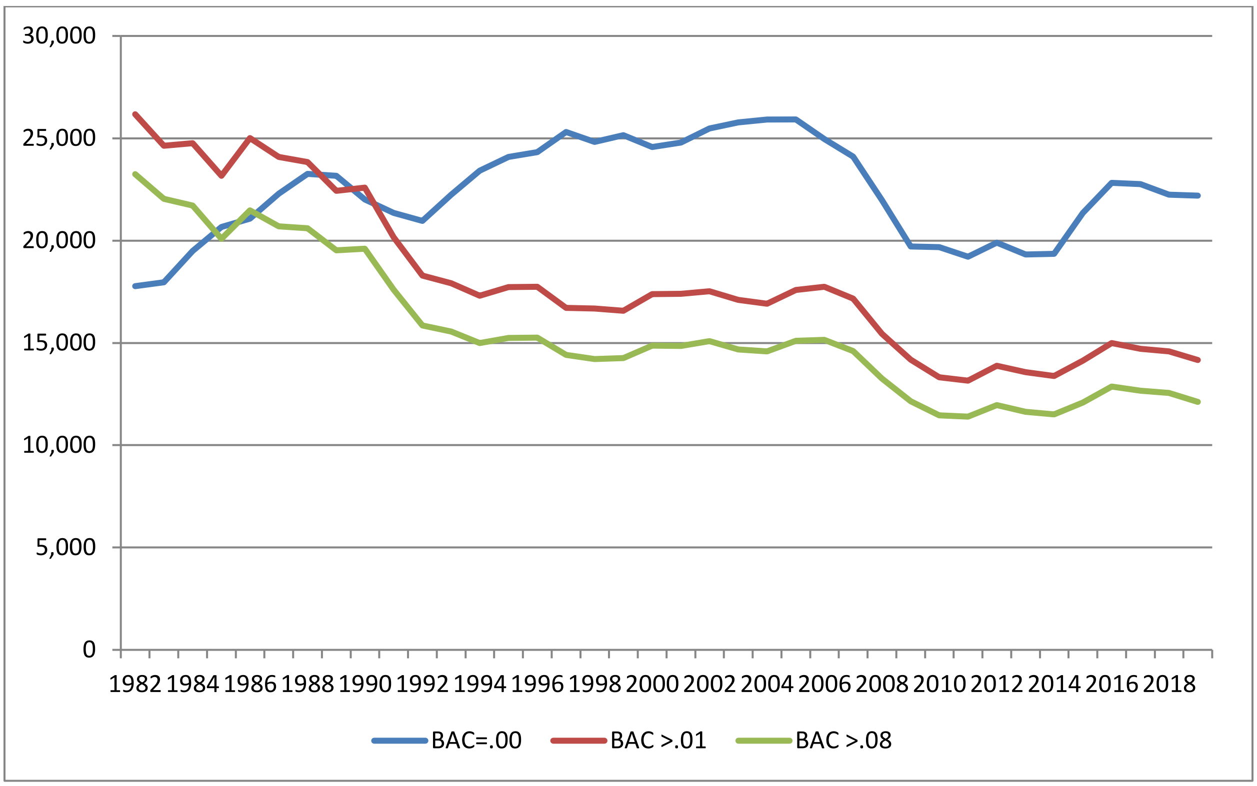
Table 7-3. Nonoccupant (Pedestrian and Bicyclist) Alcohol Use-Related Traffic Fatalities

Year	Total Including Occupants		Nonoccupant BAC=.01-.07		Nonoccupant BAC=.08+		Nonoccupant BAC=.01+	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1982	43,945	100%	15	0.0%	2,133	5%	2,148	5%
1983	42,589	100%	6	0.0%	1,990	5%	1,996	5%
1984	44,257	100%	39	0.1%	2,077	5%	2,117	5%
1985	43,825	100%	107	0.2%	1,961	4%	2,069	5%
1986	46,087	100%	59	0.1%	1,917	4%	1,976	4%
1987	46,390	100%	160	0.3%	1,883	4%	2,043	4%
1988	47,087	100%	78	0.2%	1,988	4%	2,066	4%
1989	45,582	100%	100	0.2%	2,010	4%	2,110	5%
1990	44,599	100%	79	0.2%	1,902	4%	1,980	4%
1991	41,508	100%	80	0.2%	1,772	4%	1,852	4%
1992	39,250	100%	91	0.2%	1,798	5%	1,889	5%
1993	40,150	100%	61	0.2%	1,808	5%	1,869	5%
1994	40,716	100%	86	0.2%	1,595	4%	1,682	4%
1995	41,817	100%	74	0.2%	1,764	4%	1,839	4%
1996	42,065	100%	71	0.2%	1,812	4%	1,883	4%
1997	42,013	100%	74	0.2%	1,664	4%	1,738	4%
1998	41,501	100%	112	0.3%	1,661	4%	1,774	4%
1999	41,717	100%	86	0.2%	1,695	4%	1,782	4%
2000	41,945	100%	89	0.2%	1,546	4%	1,634	4%
2001	42,196	100%	101	0.2%	1,568	4%	1,669	4%
2002	43,005	100%	111	0.3%	1,621	4%	1,731	4%
2003	42,884	100%	100	0.2%	1,582	4%	1,682	4%
2004	42,836	100%	113	0.3%	1,494	3%	1,608	4%
2005	43,510	100%	85	0.2%	1,520	3%	1,605	4%
2006	42,708	100%	115	0.3%	1,653	4%	1,768	4%
2007	41,259	100%	60	0.1%	1,562	4%	1,624	4%
2008	37,423	100%	76	0.2%	1,547	4%	1,623	4%
2009	33,883	100%	59	0.2%	1,390	4%	1,448	4%
2010	32,999	100%	90	0.3%	1,326	4%	1,417	4%
2011	32,367	100%	125	0.4%	1,519	5%	1,645	5%
2012	33,782	100%	138	0.4%	1,624	5%	1,761	5%
2013	32,893	100%	104	0.3%	1,547	5%	1,651	5%
2014	32,744	100%	73	0.2%	1,572	5%	1,645	5%
2015	35,484	100%	114	0.3%	1,801	5%	1,915	5%
2016	37,806	100%	129	0.3%	1,905	5%	2,035	5%

Year	Total Including Occupants		Nonoccupant BAC=.01-.07		Nonoccupant BAC=.08+		Nonoccupant BAC=.01+	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
2017	37,473	100%	151	0.4%	1,783	5%	1,934	5%
2018	36,835	100%	185	0.5%	1,839	5%	2,024	5%
2019	36,355	100%	220	0.6%	1,913	5%	2,134	6%

Figure 7-A illustrates the historical trend of overall fatalities plotted against alcohol-related and alcohol impaired fatalities. Their general trends are similar, but there was a noticeable decline in alcohol-related fatalities as a proportion of total fatalities during the 1990s. Overall alcohol-related fatalities declined from 60 percent of total fatalities in 1982 to about 40 percent by 1997. Since that time, the proportion has remained roughly constant. A similar trend is evident for fatalities in crashes involving alcohol impairment. Alcohol impaired fatalities declined from 48 percent of all fatalities in 1982 to about 30 percent in 1997, and have since declined to 28 percent in 2019.

Figure 7-A. Historical Trend of Fatalities, Alcohol-Involved Fatalities, and Alcohol-Impaired Fatalities



Nonfatal Injuries

NHTSA collects crash data though a two-tiered system redesigned in 1988 to replace the former NASS> The NASS Crashworthiness Data System and the General Estimates System comprise this new method.

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

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

The CRSS provides a sample of U.S. crashes by police-reported severity for all crash types. CRSS records injury severity by person on the KABCO scale (National Safety Council, 2015) from police crash reports as discussed at the beginning of Chapter 2.

KABCO ratings are coarse and inconsistently coded between States and over time. The codes are selected by police officers without medical training, typically without benefit of a hands-on examination. Some of the injured are transported from the scene before the police officer who completes the crash report even arrives. Miller, Viner, et al. (1991), and Blincoe and Faigin (1992) documented great diversity in KABCO coding across cases. O'Day (1993) more carefully quantified variability in use of the A-injury code between States. Viner and Conley (1994) probed how differing State definitions A-injury contributed to this variability. Miller, Whiting, et al. (1987), found police-reported injury counts by KABCO severity systematically varied between States because of differing State crash reporting thresholds (rules governing which crashes should be reported to the police). Miller and Blincoe (1994) found that State reporting thresholds often changed over time.

Thus police reports inaccurately describe injuries medically and crash databases inaccurately describe motor vehicle crash severity. We adopted a widely used method to refine crash and injury severity. Developed by Miller and Blincoe (1994), numerous studies have used this method, notably in impaired-driving cost estimates in Blincoe (1996); Miller, Lestina, and Spicer (1998); Blincoe et al. (2002); and Zaloshnja and Miller (2009).

To minimize the effects of variability in severity definitions by State, reporting threshold, and police perception of injury severity, this method uses NHTSA data sets that include both police-reported KABCO and medical descriptions injury in the Occupant Injury Coding system (OIC; AAAM, 1990, 1985). OIC codes include AIS severity score and body region, plus more detailed injury descriptors. We used both 2008–2010 CDS and 1984–1986 NASS data (NASS; NHTSA, 1987). CDS describes injuries to passenger vehicle occupants involved in tow-away crashes. The 1984–1986 NASS data provides the most recent medical description available of injuries to medium/heavy truck and bus occupants, nonoccupants, and others in non-CDS crashes. The

NASS data were coded with the 1980 version of AIS, which differs slightly from the 1985 version; but NHTSA made most AIS 85 changes well before their formal adoption. CDS data were coded in AIS 90/98 with coding shifting to AIS 2005 Update 2008 in 2011. We differentiated our analysis of the two versions AIS because AIS 90/98 scores and OIC codes differ greatly from codes and scores in AIS 85, especially for brain and severe lower limb injury. Garthe et al. (1996) find that AIS scores shifted for roughly 25 percent of all OICs between AIS 85 and AIS 90/98.

We used 2008–2010 CDS and GES non-CDS weights to weight the CDS and NASS data, respectively, so that they represent estimated counts of people injured in motor vehicle crashes during 2008–2010. In applying the GES weights to old NASS, we controlled for police-reported injury severity, restraint use, alcohol involvement, and occupant type (CDS occupant, non-CDS occupant, and nonoccupant). Weighting NASS data to GES restraint use and alcohol involvement levels updates the NASS injury profile to reflect contemporary belt use and alcohol-involvement levels, although it is imperfect in terms of its representation of airbag use in non-tow-away crashes. At completion of the weighting process, we had a hybrid CDS/NASS casualty-level file—that is, we had an appropriately reweighted NASS record for each injured survivor in each non-CDS crash. Similarly, we reweighted the 2008–2010 CDS file to match GES counts in order to get appropriately weighted unit records for CDS sample strata. From this file we obtained counts of alcohol cases based on all indicators of alcohol use to obtain an initial count of alcohol-involved crashes from police-reported crashes. The results are shown in the upper part of Table 7-4 below.

Table 7-4. Alcohol-Involvement Identified in Police-Reported Crashes

Alcohol-Involvement in Police-Reported Crashes Initially Derived From CDS/GES			
Injury Severity	**Total Incidence**	**Alcohol-involved**	**Percentage Alcohol-involved**
PDO	6,187,743	410,414	6.63%
MAIS0	1,782,823	118,235	6.63%
MAIS1	2,204,294	104,230	4.73%
MAIS2	220,982	17,783	8.05%
MAIS3	74,235	8,455	11.39%
MAIS4	13,131	1,574	11.99%
MAIS5	3,861	574	14.86%
Fatal	32,999	13,323	40.37%
Adjusted for GES Undercount and Unreported			
Injury Severity	**Total Incidence**	**Alcohol-involved**	**Percentage Alcohol-Involved**
PDO	17,007,212	1,128,037	6.63%
MAIS0	4,211,513	279,302	6.63%
MAIS1	3,273,070	154,767	4.73%
MAIS2	305,594	24,592	8.05%
MAIS3	85,883	9,781	11.39%
MAIS4	14,537	1,742	11.99%
MAIS5	4,274	635	14.86%
Fatal	32,999	13,323	40.37%

As previously noted, a significant portion of crashes are not reported to police. We assume that these underreporting rates apply to alcohol-involved crashes as well as to overall crashes. We thus divided by estimated fractions reported to the police: 1.0 for people with critical to fatal injuries, (1-.063) for people with MAIS3 injuries, (1-.272) for MAIS2, (1-.339) for MAIS1, (1-.481) for uninjured people in injury crashes, and (1-.597) for crashes without injuries.[13] The results of these adjustments are shown in the lower half of Table 7-4.

Underreported Alcohol-Involved Crashes

Although police crash reports typically include an indication of whether alcohol was involved, the nature of crash investigations ten precludes an accurate assessment of alcohol involvement at the crash site. Police underreporting of alcohol involvement has been well documented in numerous studies. Typically, studies on underreporting compare the results of BAC tests administered in medical care facilities to police reports of alcohol involvement. In a 1981 study of injured drivers, Terhune and Fell found that police correctly identified 42 percent of drivers who had been drinking. These rates of identification improved at higher BAC levels, ranging from only 18.5 percent of those with BACs of .01to .09, to 48.9 percent for those with BACs of .10 or greater. In a 1990 study Soderstrom et al. found that police correctly identified alcohol use in 71 percent of legally intoxicated, injured drivers. Earlier studies by Maull et al. in 1984 and Dischinger and Cowley in 1989, found that police correctly identified 57.1 percent and 51.7 percent of intoxicated drivers, respectively. The Dischinger and Cowley study also found a lower identification rate for "involved but not intoxicated" drivers of 28.6 percent. In a 1990 study of injured motorcycle drivers, Soderstrom et al. found that police correctly identified only half the drivers with positive alcohol measurements later identified by the hospital.

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

In several previous versions this report (Blincoe & Faigin, 1992; Blincoe, 1996) the studies cited above were used to estimate the impact of police underreporting of alcohol involvement. In a subsequent report (Blincoe et al., 2002), more updated information was used. However, those studies were over a decade old in 2015, and when applied to then-current data, they produced results that implied a higher rate of alcohol involvement in less severe injuries than in fatalities and more severe injuries. This is both counter-intuitive and at odds with historical alcohol involvement patterns. Moreover, over the last decade Federal, State and local governments had made concerted efforts to reduce alcohol-related crashes, and this may have improved the rate of alcohol reporting during crash investigations. Data that was more recent was therefore needed to make this adjustment for 2019 data.

The Crash Outcome Data Evaluation System (CODES) linked existing crash and injury data so that specific person, vehicle, and event characteristics could be matched to their medical and

[13] For incidence purposes, we used only the 2010 portion of the reweighted hybrid CDS/NASS casualty-level file and the 2010 FARS file

financial outcomes. At the time of the 2002 study 25 States participated in this program and 17 of these States are part of a data network supporting NHTSA highway safety programs. Effort was made to contact all States participating in NHTSA's CODES project to determine whether data were available that could be used to estimate current alcohol reporting rates. For a variety of reasons, only one State, Maryland, had data that was properly linked to allow a comparison between alcohol assessments in police reports and actual measured BACs. The Maryland data represented 2,070 cases admitted to the R Adams CowleyShock Trauma Center between 1997 and 1999. The basis for these data were thus similar to most of the studies cited above from the late 80s and early 90s.

An analysis of these data indicated that police were correctly identifying 74 percent of all alcohol-involved cases where BACs equaled or exceeded .10 g/dL, and 46 percent of all cases where BACs were positive, but less than .10. This represented a significant improvement from the corresponding rates of only 55 percent and 27 percent that were found in the earlier studies. This was consistent with the expectation that reporting rates had improved, and, when applied to police-reported rates in the NHTSA data bases, the more recent factors produce overall estimates that were consistent with FARS rates of involvement for fatal crashes. However, although these data produced logical results, they were gathered from only one State and there were no data to confirm whether the Maryland experience was typical of the Nation. These estimates were thus subject to the caveat that these results have not been verified by broader studies from more diverse regions. One of the previous studies (Soderstrom et al., 1990) was conducted at this same facility and found a higher rate of alcohol recognition than the other studies previously discussed. A second caveat was that, because these data were collected at a trauma unit, they may reflect the more serious cases rather than a sample of all injury levels. Two different, somewhat offsetting biases could result from this. Trauma unit cases are more likely to involve emergency transport and treatment that may occur before police are able to gain access to drivers to determine alcohol involvement. This could result in police missing a larger portion of trauma unit cases. On the other hand, the severity of the crash may prompt a more thorough investigation by the police, resulting in a higher rate of correct alcohol identification. It is not clear what the net effect of these biases would be.

Given these caveats, both the 2015 paper and this current report are based on a more recent study that analyzed what portion of U.S. nonfatal crashes are alcohol-involved and how well police and hospitals detect involvement (Miller et al., 2012). In that study, a capture recapture model estimated alcohol involvement from levels detected by police and hospitals and the extent of detection overlap. The authors analyzed 550,933 Crash Outcome Data Evaluation System driver records from 20062008 police crash report censuses probabilistically linked to hospital inpatient and emergency department (ED) discharge censuses for Connecticut, Kentucky (admissions only), Maryland, Nebraska, New York, South Carolina, and Utah. They then computed national estimates from NHTSA's General Estimates System.

Nationally an estimated 7.5 percent of drivers in nonfatal crashes and 12.9 percent of nonfatal crashes were alcohol-involved. (Crashes often involve several drivers but it is rare for several drivers to have positive BACs) Police correctly identified an estimated 32 percent of alcohol-involved drivers in nonfatal crashes including 48 percent in injury crashes. Excluding Kentucky, police in the six States reported 47 percent of alcohol involvement for cases treated in EDs and released and 39 percent for admitted cases. In contrast, hospitals reported 28 percent of involvement for ED cases and 51 percent for admitted cases. Underreporting varied widely between States. Police-reported alcohol involvement for 44 percent of those who hospitals reported were alcohol-involved, while hospitals reported alcohol involvement for 33 percent of those who police reported were alcohol-involved. Police alcohol reporting completeness rose with police-reported driver injury severity. At least one system reported 62 percent of alcohol involvement. Based on the combined results from the 6 States that had both admitted and ED data, police records account for 30 to45 percent of total actual alcohol involvement, depending on injury severity. These rates and the resulting estimates of alcohol involvement are summarized in Table 7-5. Note that although fatalities are listed in Table 7-5, they were not examined in the capture-recapture analysis. As noted previously fatal crashes are investigated much more thoroughly than nonfatal crashes and NHTSA's FARS, through both documentation of police and medical records and through modeling for unreported cases, is believed to account for all alcohol involvement in fatal crashes.

Table 7-5. Total Alcohol-involvement Adjusted for Unreported Cases

Injury Severity	Total Incidence	Percent Identified	Alcohol-involved	Percent Involved
PDO	18,508,632	42.90%	2,629,458	14.21%
MAIS0	4,583,265	42.90%	651,054	14.21%
MAIS1	3,459,200	45.40%	340,897	9.85%
MAIS2	338,730	42.60%	57,728	17.04%
MAIS3	100,740	39.70%	24,638	24.46%
MAIS4	17,086	40.60%	4,292	25.12%
MAIS5	5,749	30.10%	2,110	36.70%
Fatal	32,999	100.00%	13,323	40.37%

BAC Levels

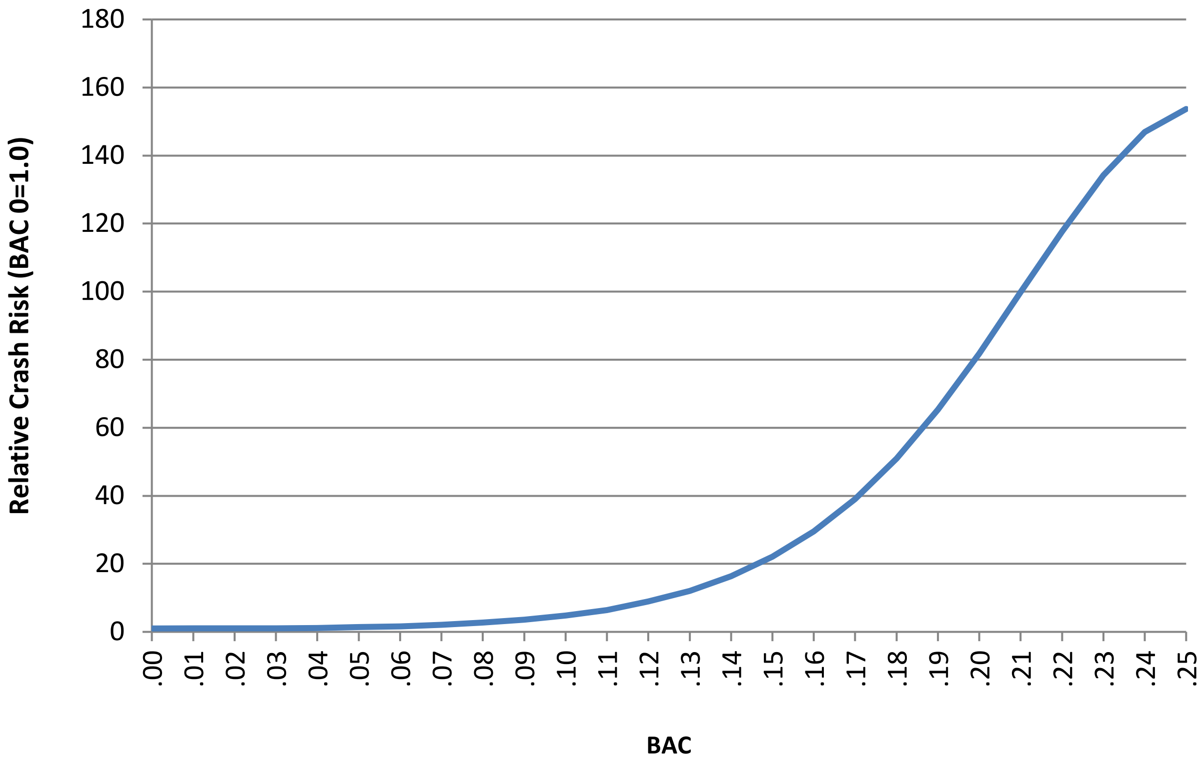
BAC levels are difficult to determine from injury data. Although there are some indications BAC included in CISS data, the CRSS has no such indicators. To determine BACs, an initial assessment was made that virtually all police-reported BACs for nonfatal crashes represent BACs that are at the .05 level or higher. It is illegal per se in every State to drive a motor vehicle with a BAC of .08 or higher. Some State laws establish lesser included offenses at lower BAC levels (most typically at .05 BAC). Unless a crash involves a fatality, police generally do not test or use the alcohol checkbox unless they suspect the driver might be near these levels. In fact, except for fatal crashes, some States do not even allow testing unless a BAC over .08 is suspected. Low BAC levels (especially below .05) are thus unlikely to be registered in police records. An examination of available data from NHTSA's CDS and NASS data systems bears this out. For nonfatal crashes, less than half of 1 percent of nonfatal injuries were recorded as BACS being between .01 and.04 g/dL. However, this primarily represents a limitation in data gathering rather than an indication of near complete absence of crashes at these lower BAC levels. An estimate of crashes at these BAC levels was thus derived from crash probabilities.

Subcategories of BAC levels were calculated as a function of odds ratios for crashes at each specific BAC level compared to exposure at those levels. Odds ratios were derived from a study of relative crash risk conducted by Dunlap and Associates (Blomberg et al., 2005).[14] In this study

[14] More recently, Lacey et al. (2016, see also Compton and Bering [2015] for a summary), conducted a similar study based on over 10,000 crash and control drivers. Their resulting odds ratios were similar to the Blomberg et al.

over 2,800 crashes and nearly 15,000 drivers in Long Beach, California, and Fort Lauderdale, Florida, were sampled to determine the relative risk of crashes at different BACs. Logistic regression techniques were used to create a relative risk model that indicated a notable dose-response relationship beginning at .04 BAC and increasing exponentially at >=.10 g/dL BAC. The results of this model are summarized in Figure 7-B below.

Figure 7-B. Relative Risk of Crash by Blood Alcohol Concentration



Source: Blomberg et al., 2005

(2005) study based solely on voluntary participants. However, Blomberg's group identified a significant number of cases where the drivers either refused to participate (7% of all crash-involved drivers), or left the scene entirely (hit-and-run or HR – 12% of all drivers). For the refusals, Lacey et al. based BAC estimates on passive alcohol sensors (PAS) for participants who refused to complete the study protocol. Forty-five percent of participants who refused had PAS scores >=3 (which indicated the potential for impairment), whereas only 10 percent of participants who completed the study protocol had such scores. Lacey et al. used these results to estimate the BACs of the refusal cases. For HR cases, the researchers based BAC on measured BACs taken for drivers who were apprehended by the police within 2 hours of the crash. Not surprisingly, they found that HR drivers had BACs that were very high. Hit-and-run drivers were especially important because they made up a sizeable portion of drivers involved in crashes in both studies, and because their results were much higher than other cases. In the Lacey et al. study about 63 percent of HR drivers had BACs of .08+, while only about 10 percent of other drivers had BACs this high. So, nearly 20 percent of all cases either refused or were HR, and these cases were the ones most likely to have high BACs. This indicates that results based on voluntary compliance alone will significantly undercount high BACs. For this reason, we based our estimates on the Blomberg et al. study.

The authors found some level of added crash risk beginning at roughly .04 g/dL BAC, but this risk rose noticeably at .08 g/dL BAC and rose exponentially from .10 g/dL BAC and beyond. For example, at .04 g/dL BAC the risk of a crash is 18 percent higher than at zero BAC, but at .08 g/dL BAC the risk of a crash is 2.69 times as high and at .10 g/dL BAC it is 4.79 times as high. To determine BAC distributions, the relative risk ratios of each individual BAC category were combined with exposure data from the same study to estimate the relative risk factor for each grouped BAC category (shown in Table 7-6). These grouped relative risk factors were then combined with national exposure data from Lacey et al. (2009) to determine the distribution of each grouped BAC category as follows.

$$r_n * e_n / r_y * e_y$$

where: r_n = relative risk ratio of specific BAC category

e_n = exposure of specific BAC category

r_y = relative risk of broader BAC category

e_y = exposure of broader BAC category

The broader categories are those derived above for nonfatal injuries, which were all assumed to be BAC>=.5 g/dL, and the difference between these and the total incidence, which represent .00- to .04 g/dL BAC. Essentially, this divides alcohol BAC cases into two broad categories at the .05 g/dL level. The .08 g/dL+BAC category was then derived using the above formula from the >=.05 g/dL BAC total and the .01-.04 g/dL BAC category was derived from the <.05 g/dL BAC category.

This process produced BAC distributions based on data first examined in the 2015 report. We note that these distributions have not materially changed for fatalities over this timeframe (see Table 7-1). We assumed that distributions for nonfatal crashes have been similarly static, and thus applied ratios derived from the 2015 report to 2019 incidence to estimate the 2019 BAC distributions. The inputs used for each category and the resulting BAC distributions are shown in Table 7-6.

Table 7-6. Incidence Stratified by Highest Driver or Nonoccupant BAC and Injury Severity

Injury Severity	BAC=.00	BAC=.01-.04	BAC=.05-.07	BAC≥.08	BAC≥.01	Total
PDO	16,547,940	355,746	169,431	2,215,022	2,740,199	19,288,139
MAIS0	3,882,996	83,476	39,751	519,678	642,905	4,525,901
MAIS1	3,493,366	75,100	21,799	285,000	381,899	3,875,265
MAIS2	354,328	7,617	4,630	60,544	72,791	427,119
MAIS3	106,641	2,293	2,290	29,943	34,526	141,167
MAIS4	14,441	310	323	4,211	4,844	19,285
MAIS5	4,549	98	180	2,360	2,638	7,187
Fatal	22,281	1,125	937	12,157	14,219	36,500
Total	24,426,542	525,765	239,341	3,128,915	3,894,021	28,320,563
% of Crash-Involved People	86.25%	1.86%	0.85%	11.05%	13.75%	100%
% of Miles Driven	97.18%	1.96%	0.39%	0.47%	2.82%	100%
Relative Risk	1.0000	1.0645	1.6581	17.9870	3.7568	

The results illustrate the disproportionate impact that high BACs have on crash incidence. Less than 1 percent of overall miles are driven by impaired drivers (.08+ g/dL BAC), but they account for over 11 percent of all vehicle crashes, and over 80 percent of all alcohol-involved crashes, including 86 percent of all alcohol-involved fatalities.

Figure 7-C illustrates the relative incidence of crashes with no alcohol, with alcohol below .08 g/dL BAC, and with alcohol above .08 g/dL BAC. Alcohol-involved crashes account for nearly 40 percent of all fatal crashes. There is a clear trend toward increased alcohol involvement as injury severity increases. This figure illustrates the fact that alcohol not only increases the likelihood of crashes, but their severity as well.

Figure 7-D illustrates the relative incidence of crashes at various BAC levels. The vast majority of all alcohol-related crashes occur at legally impaired BACs of .08 and above.

Figure 7-C. Relative Incidence in Crashes of Alcohol BAC Levels by Injury Severity

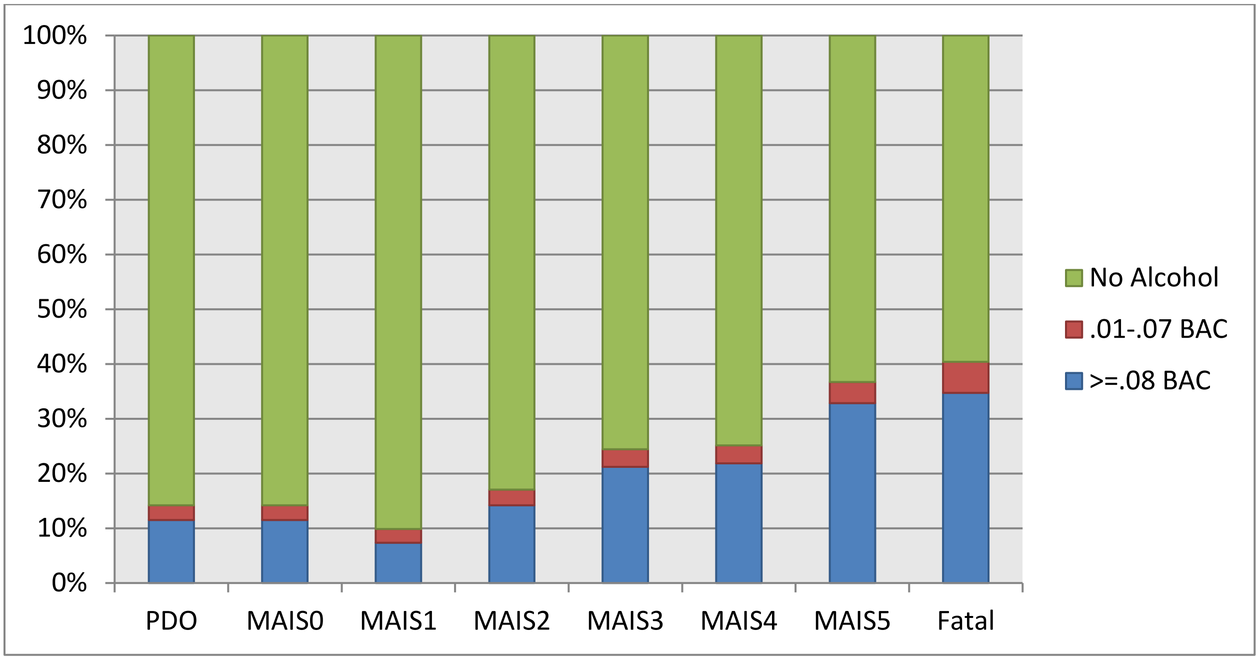
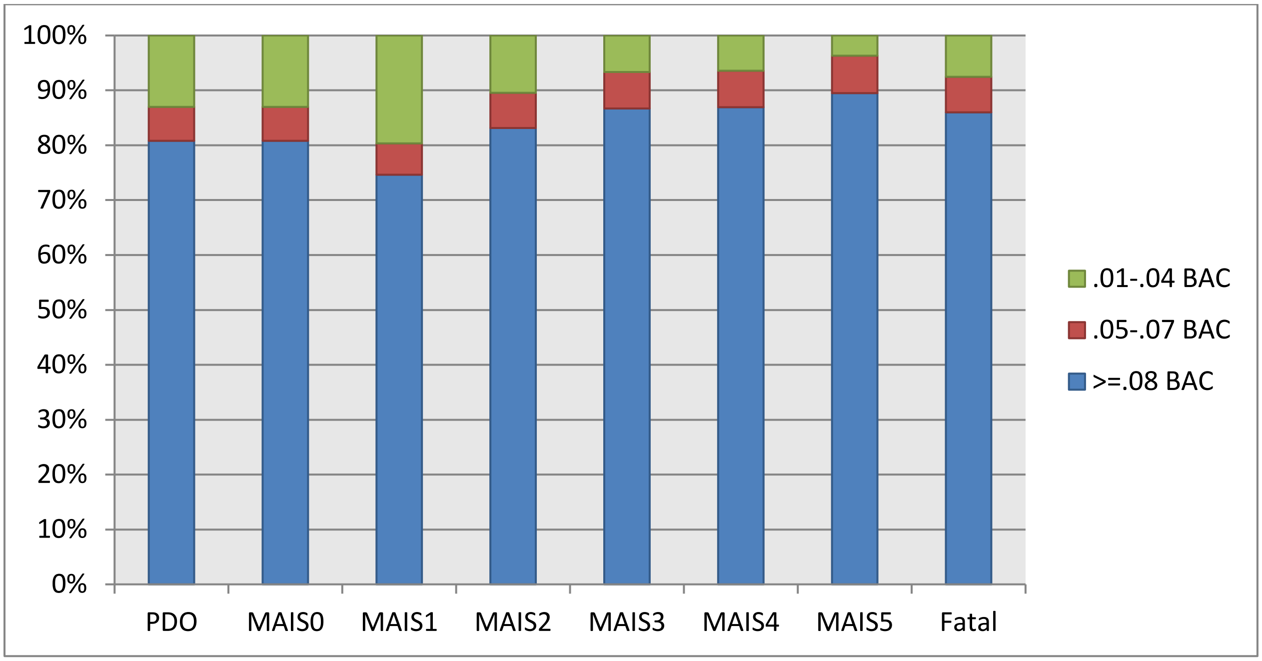


Figure 7-D. Relative Incidence of BAC Levels in Alcohol-Involved Crashes by Injury Severity



Alcohol-Involved Crash Costs

The costs of alcohol-involved crashes tend to exceed those of non-alcohol-involved crashes due to a variety of factors. The first is a general tendency toward greater relative severity of alcohol-involved crashes. For all crashes, fatalities are approximately 0.8 percent of injured survivors. This rate nearly quadruples for crashes involving alcohol. Similarly, the rate for critical injuries (MAIS5) triples for alcohol cases and for severe injuries (MAIS4) it more than doubles. The more severe and expensive injuries represent a much higher portion of alcohol-involved cases. A second factor is demographics. Men are disproportionately represented in alcohol-involved crashes and this makes the cost for each alcohol-involved case higher for men. This occurs because men have higher earnings and participation in the work force than women; thus, there is a higher lost productivity cost associated with these crashes. In non-alcohol-involved crashes, the gender distribution is more evenly distributed. In addition, the victims of alcohol-involved crashes tend to be of an age group where lost productivity is maximized by the discounting process.

Unit costs specific to alcohol-involved crashes were developed by extracting cases with police-reported alcohol from the previously discussed file based on 2008-2010 weights. As noted above, virtually all of these cases represent crashes with BACs of .05 or greater. Unit costs for these crashes were thus weighted by the relative incidence of .05 BAC+ cases within all positive BAC cases. The unit costs of cases with BACs of .00 to .04 were then derived as a function of the relative incidence and cost of the .05+BAC crashes and all crashes as follows:

$b=(cz-ax)/y$

where: b=unit cost in crashes with BAC<.05

c=average unit cost of all crashes

z=incidence of all crashes

a = unit cost of crashes with BAC≤.05

x=incidence of crashes with BAC≤.05

y = incidence of crashes with BAC<.05

As with incidence, this process produced BAC specific unit costs based on data first examined in the 2010 report. We adopted ratios of specific BAC costs to the average costs computed for 2019 to estimate specific unit costs for each BAC level. The results of this process are shown in Tables 7-7, 7-8, and 7-9.

Table 7-7. Average Unit Costs, BAC≥.05 Injuries, and BAC >.00 Fatalities (2019 $)

	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$0	$0	$2,409	$14,162	$73,434	$193,058	$370,687	$17,289
Emergency Services	$31	$24	$106	$228	$486	$976	$999	$1,060
Market Productivity	$0	$0	$2,547	$24,229	$98,032	$244,665	$314,591	$1,010,970
Household Productivity	$71	$55	$947	$9,358	$41,743	$121,459	$131,891	$367,148
Insurance Admin.	$523	$225	$2,679	$9,783	$30,535	$38,612	$38,959	$36,245
Workplace Costs	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$923	$7,593	$29,562	$78,478	$114,865	$138,025
Injury Subtotal	$724	$380	$9,667	$65,771	$277,031	$684,326	$979,786	$1,584,326
Congestion Costs	$1,327	$1,008	$1,207	$1,339	$1,691	$1,814	$1,857	$7,133
Property Damage	$3,200	$1,864	$9,650	$9,616	$17,835	$20,565	$23,234	$15,185
Economic Subtotal	$5,251	$3,252	$20,524	$76,726	$296,557	$706,705	$1,004,877	$1,606,644
QALYs	$0	$0	$43,679	$430,884	$1,904,629	$3,053,786	$5,529,606	$9,651,851
Comprehensive Total	$5,251	$3,252	$64,203	$507,610	$2,201,186	$3,760,490	$6,534,484	$11,258,495

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

Table 7-8. Average Unit Costs, BAC=.00-.04 Injuries, and BAC .00 Fatalities (2019 $)

	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$0	$0	$2,193	$13,108	$68,135	$187,264	$359,152	$17,289
Emergency Services	$31	$24	$106	$228	$486	$976	$999	$1,060
Market Productivity	$0	$0	$2,295	$22,892	$91,143	$225,366	$301,668	$1,010,970
Household Productivity	$71	$55	$839	$8,924	$38,190	$114,952	$125,697	$367,148
Insurance Admin.	$523	$225	$2,172	$7,938	$28,154	$35,831	$37,601	$36,245
Workplace Costs	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$724	$6,000	$27,167	$72,361	$107,359	$138,025
Injury Subtotal	$724	$380	$8,386	$59,508	$256,516	$643,827	$940,270	$1,584,326
Congestion Costs	$1,327	$1,008	$1,207	$1,339	$1,691	$1,814	$1,857	$7,133
Property Damage	$3,200	$1,864	$9,650	$9,616	$17,835	$20,565	$23,234	$15,185
Economic Subtotal	$5,251	$3,252	$19,243	$70,463	$276,042	$666,206	$965,361	$1,606,644
QALYs	$0	$0	$40,891	$397,201	$1,722,235	$2,902,425	$4,817,075	$9,651,851
Comprehensive Total	$5,251	$3,252	$60,134	$467,665	$1,998,276	$3,568,631	$5,782,435	$11,258,495

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

Table 7-9. Average Unit Costs, All Positive BAC Injuries and Fatalities (2019 $)

	PDO	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**
Medical	$0	$0	$2,409	$14,162	$73,434	$193,058	$370,687	$17,289
Emergency Services	$31	$24	$106	$228	$486	$976	$999	$1,060
Market Productivity	$0	$0	$2,547	$24,229	$98,032	$244,665	$314,591	$1,010,970
Household Productivity	$71	$55	$947	$9,358	$41,743	$121,459	$131,891	$367,148
Insurance Admin.	$523	$225	$2,679	$9,783	$30,535	$38,612	$38,959	$36,245
Workplace Costs	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$923	$7,593	$29,562	$78,478	$114,865	$138,025
Injury Subtotal	$724	$380	$9,667	$65,771	$277,031	$684,326	$979,786	$1,584,326
Congestion Costs	$1,327	$1,008	$1,207	$1,339	$1,691	$1,814	$1,857	$7,133
Property Damage	$3,200	$1,864	$9,650	$9,616	$17,835	$20,565	$23,234	$15,185
Economic Subtotal	$5,251	$3,252	$20,524	$76,726	$296,557	$706,705	$1,004,877	$1,606,644
QALYs	$0	$0	$43,679	$430,884	$1,904,629	$3,053,786	$5,529,606	$9,651,851
Comprehensive Total	$5,251	$3,252	$64,203	$507,610	$2,201,186	$3,760,490	$6,534,484	$11,258,495

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

Table 7-10 lists the aggregate 2019 economic costs of alcohol-involved crashes, and Table 7-11 lists the proportion of total economic crash costs that each BAC level represents. Alcohol is involved in crashes that account for 14 percent of the costs of PDO crashes, 18 percent of the costs that result from nonfatal injuries and 39 percent of the costs that result from fatalities. Overall, these crashes are responsible for 20 percent of total economic costs. The impact of alcohol-involved crashes on overall costs is thus higher than would be indicated by the alcohol-involved incidence rates across all crashes. Overall, alcohol-involved crashes cost $69 billion in economic costs in 2019, with 84 percent of this or $58 billion, occurring in crashes where the highest BAC was ≥.08.

Table 7-10. Summary of Total Economic Costs by BAC Level (Millions 2019 $)

	BAC=.00	**BAC=.01-.04**	**BAC=.05-.07**	**BAC≥.08**	**BAC≥.01+**	**Total**
PDO	$86,893	$1,868	$890	$11,631	$14,389	$101,282
MAIS0	$12,628	$271	$129	$1,690	$2,091	$14,718
MAIS1	$67,221	$1,445	$447	$5,849	$7,742	$74,963
MAIS2	$24,967	$537	$355	$4,645	$5,537	$30,504
MAIS3	$29,438	$633	$679	$8,880	$10,192	$39,629
MAIS4	$9,620	$207	$228	$2,976	$3,411	$13,031
MAIS5	$4,392	$94	$181	$2,372	$2,647	$7,039
Fatal	$35,797	$1,808	$1,505	$19,532	$22,846	$58,643
Total	$270,956	$6,863	$4,415	$57,576	$68,854	$339,809
% Total Alcohol Costs	NA	9.97%	6.41%	83.62%	100.00%	NA
% Total	79.74%	2.02%	1.30%	16.94%	20.26%	100.00%

Table 7-11. Percentage of Economic Injury Costs by BAC Level

	BAC= .00	**BAC=.01-.04**	**BAC=.05-.07**	**BAC≥.08**	**BAC≥.01+**	**Total**
PDO	85.79%	1.84%	0.88%	11.48%	14.21%	100.00%
MAIS0	85.79%	1.84%	0.88%	11.48%	14.21%	100.00%
MAIS1	89.67%	1.93%	0.60%	7.80%	10.33%	100.00%
MAIS2	81.85%	1.76%	1.16%	15.23%	18.15%	100.00%
MAIS3	74.28%	1.60%	1.71%	22.41%	25.72%	100.00%
MAIS4	73.82%	1.59%	1.75%	22.84%	26.18%	100.00%
MAIS5	62.40%	1.34%	2.57%	33.70%	37.60%	100.00%
Fatal	61.04%	3.08%	2.57%	33.31%	38.96%	100.00%
Total	79.74%	2.02%	1.30%	16.94%	20.26%	100.00%

Table 7-12 lists the aggregate 2019 comprehensive costs of alcohol-related crashes, and Table 7-13 lists the proportion of total comprehensive crash costs that each BAC level represents. Alcohol is involved in crashes that account for 14 percent of the societal harm of PDO crashes, 20 percent of the harm that result from nonfatal injuries, and 39 percent of the harm that result from fatalities. All alcohol-involved crashes are responsible for 26 percent of total societal harm from motor vehicle crashes, but crashes with BAC≥.08 are responsible for 85 percent of this or 22 percent of total harm. The impact of alcohol-involved crashes on overall costs is thus higher than would be indicated by the alcohol-involved incidence rates across all crashes. Overall, alcohol-involved crashes cost $348 billion in comprehensive societal costs in 2019, with 85 percent of this or $296 billion, occurring in crashes where the highest BAC was ≥.08.

Table 7-12. Total Comprehensive Costs by BAC Level (Millions 2019 $)

	BAC=.00	**BAC=.01-.04**	**BAC=.05-.07**	**BAC≥.08**	**BAC≥.01+**	**Total**
PDO	$86,893	$1,868	$890	$11,631	$14,389	$101,282
MAIS0	$12,628	$271	$129	$1,690	$2,091	$14,718
MAIS1	$210,070	$4,516	$1,400	$18,298	$24,213	$234,283
MAIS2	$165,706	$3,562	$2,350	$30,733	$36,645	$202,352
MAIS3	$213,100	$4,581	$5,040	$65,910	$75,531	$288,631
MAIS4	$51,532	$1,108	$1,214	$15,836	$18,157	$69,690
MAIS5	$26,307	$564	$1,176	$15,424	$17,164	$43,471
Fatal	$250,845	$12,671	$10,546	$136,873	$160,090	$410,935
Total	$1,017,080	$29,142	$22,745	$296,394	$348,281	$1,365,362
% Total Alcohol Costs	NA	8.37%	6.53%	85.10%	100.00%	NA
% Total	74.49%	2.13%	1.67%	21.71%	25.51%	100.00%

Table 7-13. Percentage of Comprehensive Injury Costs by BAC Level

	BAC=.00	**BAC=.01-.04**	**BAC=.05-.07**	**BAC≥.08**	**BAC≥.01+**	**Total**
PDO	85.79%	1.84%	0.88%	11.48%	14.21%	100.00%
MAIS0	85.79%	1.84%	0.88%	11.48%	14.21%	100.00%
MAIS1	89.66%	1.93%	0.60%	7.81%	10.34%	100.00%
MAIS2	81.89%	1.76%	1.16%	15.19%	18.11%	100.00%
MAIS3	73.83%	1.59%	1.75%	22.84%	26.17%	100.00%
MAIS4	73.95%	1.59%	1.74%	22.72%	26.05%	100.00%
MAIS5	60.52%	1.30%	2.71%	35.48%	39.48%	100.00%
Fatal	61.04%	3.08%	2.57%	33.31%	38.96%	100.00%
Total	74.49%	2.13%	1.67%	21.71%	25.51%	100.00%

Alcohol Crash Causation

Inebriated drivers often experience impaired perceptions that can lead to risky behavior such as speeding, reckless driving, and failure to wear seat belts. They also experience reduced reaction times, which can make it more difficult for them to perform defensive safety maneuvers. As a result, there is a general tendency to equate the presence of alcohol with crash causation. However, there are clearly some instances in which crashes would occur regardless of whether the driver had consumed alcohol. For example, if a distracted texting driver were to run into a driver with a positive BAC who was stopped at a red light, a police investigation or medical records might record that the struck driver had a positive BAC, even though that driver was not at fault. In this case, the crash would be recorded as alcohol-involved, even though alcohol was not a causative factor.

Miller, Spicer, and Levy (1999) estimated the percentages of alcohol-related crashes that are attributable to alcohol. In this study they examined the probability of crash involvement for drivers based on their BAC level and then removed the normal risk of crash involvement without alcohol from the overall risk found for drivers with positive BACs. Their study found that 94 percent of crashes at BACs of .10 g/dl or higher, and 31 percent of crashes with positive BACs less than .10 g/dL, were actually caused by alcohol. The remaining crashes were due to bad weather, poor road conditions, non-drinking drivers, etc. Currently a BAC of .08 g/dL is considered to be the definition of "illegal per se" for alcohol impairment rather than .10. More recently, Blomberg et al. (2005) examined the relative crash risk of drinking and non-drinking drivers. The methods and results of this study were discussed previously (see Figure 7-B above). Table 7-6 displayed the relative risk for various BAC categories that were derived from Blomberg and colleagues' BAC specific risk factors. These factors can be used to estimate the incidence of crashes where alcohol consumption actually contributed to the crash occurrence across the various BAC groupings examined in this report. These proportions were estimated as the ratio of the added risk in an alcohol-involved crash to the total risk in this crash. Specifically:

$y=(r-1)/r$

where: y = proportion of BAC + crashes that are attributable to alcohol.

r= relative risk ratio of specific BAC category

Table 7-14 and Figures 7-E and 7-F illustrate the results of this process. The second to the last row in Table 7-14 lists the relative risk calculated from data in Blomberg et al. (2005), while the last row lists the proportion of injuries in each BAC category that are attributable to alcohol. Roughly 6 percent of BAC = .01-.04 injuries, 40 percent of BAC = .05-.07 injuries, and 94 percent of BAC≥ .08 injuries are attributable to alcohol. The increasing proportions are expected since higher BAC levels cause more inebriation, with its associated reduction in awareness and motor skills. Overall, about 79 percent of injuries from crashes recorded as alcohol-involved can be attributed to alcohol as a causative factor. This is roughly the same percentage calculated in Blincoe et al., 2002 (80.8%), which was based on the earlier Miller, Spicer, and Levy analysis. Alcohol thus appears to be a causative factor in roughly 80 percent of cases coded as alcohol-involved but is irrelevant to crash causation in the other 20 percent of cases.

Table 7-14. Injuries Attributable to Alcohol Use by BAC Level

Injury Severity	**BAC=.01-.04**	**BAC=.05-.079**	**BAC≥.08**	**BAC≥.01+**
PDO	21,560	67,246	2,091,877	2,180,683
MAIS0	5,059	15,777	490,786	511,622
MAIS1	4,551	8,652	269,155	282,358
MAIS2	462	1,838	57,178	59,477
MAIS3	139	909	28,278	29,326
MAIS4	19	128	3,977	4,124
MAIS5	6	71	2,229	2,306
Fatal	68	372	11,481	11,921
Total	31,863	94,993	2,954,962	3,081,819
Relative Risk	1.0645	1.6581	17.9870	4.7477
% Attributable to Alcohol	6.06%	39.69%	94.44%	79.14%

Figure 7-E. Percentage of Positive BAC Crashes Attributable to Alcohol by BAC Level

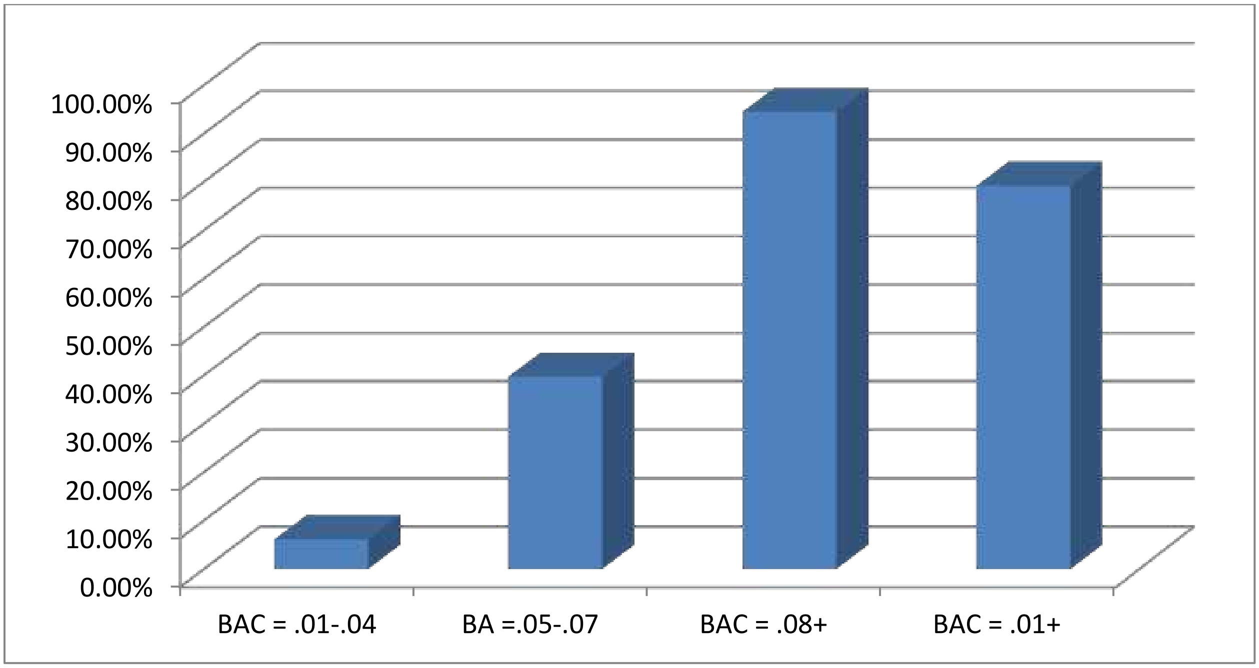
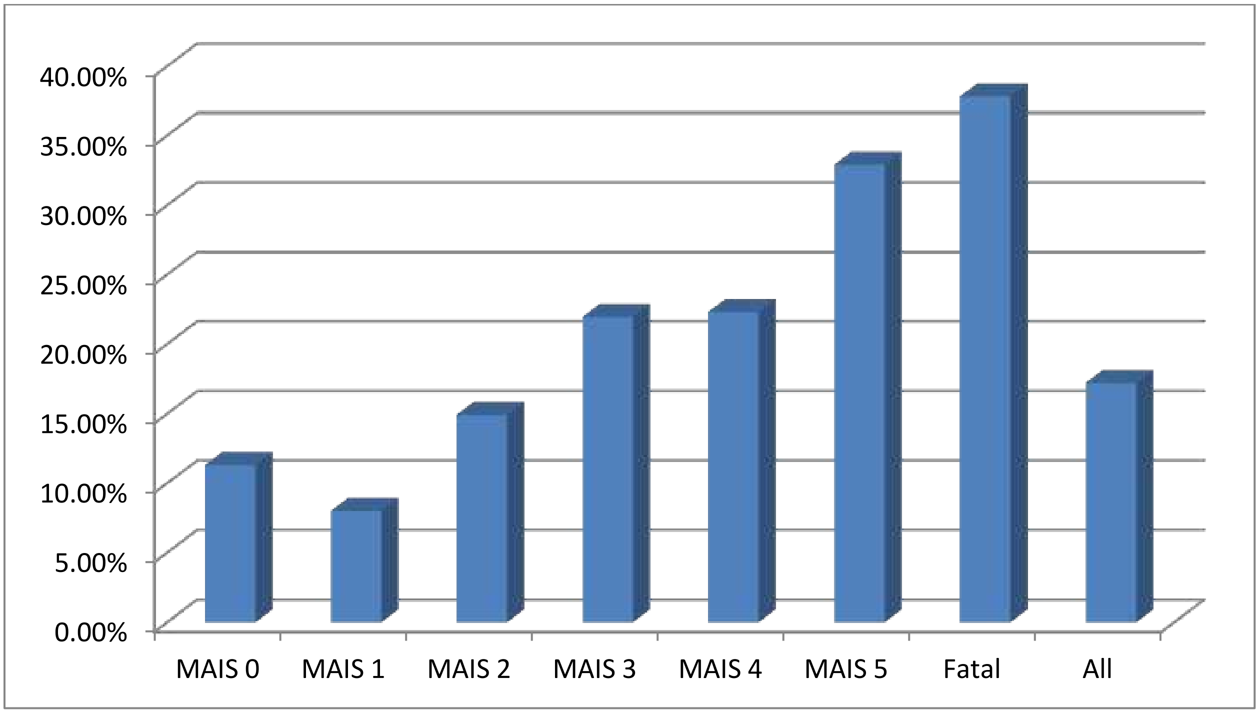


Figure 7-F. Percentage of Injuries Attributable to Alcohol by Injury Severity Level



To estimate the economic cost of crashes attributable to alcohol, the incidence from Table 7-14 was combined with the unit costs from Tables 7-7 and 7-8. The results, summarized in Table 7-15, indicate that alcohol causes crashes that result in roughly $57 billion in economic costs annually. This accounts for 82 percent of the crash costs associated with crashes that are considered alcohol-involved. It represents 17 percent of all crash costs (including those without alcohol involvement), accounting for 11 percent of PDO costs, 15 percent of nonfatal injury costs, and 33 percent of fatality costs.

Table 7-15. Economic Crash Costs (Millions 2019 $) Attributable to Alcohol Use by BAC Level and Injury Severity

Injury Severity	BAC=.01-.04	BAC=.05-.079	BAC≥.08	BAC≥.01+	Total
PDO	$113	$353	$10,984	$11,451	$101,282
MAIS0	$16	$51	$1,596	$1,664	$14,718
MAIS1	$88	$178	$5,524	$5,789	$74,963
MAIS2	$33	$141	$4,387	$4,561	$30,504
MAIS3	$38	$270	$8,386	$8,694	$39,629
MAIS4	$13	$91	$2,811	$2,914	$13,031
MAIS5	$6	$72	$2,240	$2,318	$7,039
Fatal	$110	$597	$18,447	$19,153	$58,643
Total	$416	$1,752	$54,375	$56,543	$339,809
% of Total Alcohol-Involved Costs Attributable to Alcohol	6.06%	39.69%	94.44%	82.12%	
% of Total Costs Attributable to Alcohol	0.12%	0.52%	16.00%	16.64%	

Table 7-16. Percentage of Total Economic Costs Attributable to Alcohol by BAC Level and Injury Severity

Injury Severity	BAC=.01-.04	BAC=.05-.079	BAC≥.08	BAC≥.01+
PDO	0.11%	0.35%	10.85%	11.31%
MAIS0	0.11%	0.35%	10.84%	11.30%
MAIS1	0.12%	0.24%	7.37%	7.72%
MAIS2	0.11%	0.46%	14.38%	14.95%
MAIS3	0.10%	0.68%	21.16%	21.94%
MAIS4	0.10%	0.69%	21.57%	22.36%
MAIS5	0.08%	1.02%	31.82%	32.92%
Fatal	0.19%	1.02%	31.46%	32.66%
Total	0.12%	0.52%	16.00%	16.64%

To estimate the comprehensive cost of crashes attributable to alcohol, the incidence from Table 7-14 was combined with the unit costs from Tables 7-7 and 7-8. The results, summarized in Table 7-17 and 7-18, indicate that alcohol causes crashes that result in roughly $287 billion in comprehensive societal costs annually. This accounts for 82 percent of the comprehensive crash costs associated with crashes that are considered alcohol-involved. It represents 21 percent of all crash costs (including those without alcohol involvement, accounting for 11 percent of societal harm from PDOs, 17 percent of harm from nonfatal injuries, and 32 percent of harm from fatalities.

Table 7-17. Comprehensive Crash Costs (Millions 2019 $) Attributable to Alcohol Use by BAC Level and Injury Severity

Injury Severity	BAC=.01-.04	BAC=.05-.079	BAC≥.08	BAC≥.01	Total
PDO	$113	$353	$10,984	$11,451	$101,282
MAIS0	$16	$51	$1,596	$1,664	$14,718
MAIS1	$274	$555	$17,281	$18,110	$234,283
MAIS2	$216	$933	$29,024	$30,173	$202,352
MAIS3	$278	$2,000	$62,246	$64,524	$288,631
MAIS4	$67	$482	$14,955	$15,504	$69,690
MAIS5	$34	$467	$14,566	$15,067	$43,471
Fatal	$768	$4	$129,263	$130,036	$410,935
Total	$1,766	$4,846	$279,916	$286,528	$1,365,362
% of Total Alcohol-Involved Costs Attributable to Alcohol	6.06%	21.31%	94.44%	82.27%	
% of Total Costs Attributable to Alcohol	0.13%	0.35%	20.50%	20.99%	

Table 7-18. Percentage of Total Comprehensive Costs Attributable to Alcohol by BAC Level and Injury Severity

Injury Severity	BAC=.01-.04	BAC=.05-.079	BAC≥.08	BAC≥.01
PDO	0.11%	0.35%	10.85%	11.31%
MAIS0	0.11%	0.35%	10.84%	11.30%
MAIS1	0.12%	0.24%	7.38%	7.73%
MAIS2	0.11%	0.46%	14.34%	14.91%
MAIS3	0.10%	0.69%	21.57%	22.36%
MAIS4	0.10%	0.69%	21.46%	22.25%
MAIS5	0.08%	1.07%	33.51%	34.66%
Fatal	0.19%	0.00%	31.46%	31.64%
Total	0.13%	0.35%	20.50%	20.99%

8. Speeding

Excess speed can contribute to both the frequency and severity of motor vehicle crashes. At higher speeds, additional time is required to stop a vehicle and more distance is traveled before corrective maneuvers can be implemented. Speeding reduces a driver's ability to react to an emergency created by driver inattention; by unsafe maneuvers of other vehicles; by roadway hazards; by vehicle system failures (such as tire blowouts); or by hazardous weather conditions. Further, if a crash does occur, higher impact speed increases the impact force and both the probability of, and severity of injury to both occupants and nonoccupants. The fact that a vehicle was speeding does not necessarily mean that this was the cause of the crash, but the probability of avoiding the crash would likely be greater had the driver been traveling at a slower speed.

A speed-related crash is defined as any crash in which the police indicate that one or more drivers involved were exceeding the posted speed limit, driving too fast for conditions, racing, or coded as speed-related conditions unknown. In 2019 a total of 10,192 fatalities, representing 27.9 percent of all motor vehicle fatalities, occurred in speed-related crashes. This estimate was derived by applying the portion of FARS fatalities with known speed status to total 2019 fatalities.

To estimate the cost of these crashes we examined the relative incidence of each injury severity level that was represented by crashes that were speed-related. These estimates reflect the relative proportions specific injury severities that occur under each scenario. CRSS was used for each nonfatal case while FARS was used for each fatal case. Each case in FARS contained information regarding speeding status, so the proportion of fatalities that occurred under each scenario was obtained directly from the 2019 FARS database. For nonfatal injuries and PDOs, 2017-2019 CRSS data were queried to determine whether the case fell under the scenario or not. However, CRSS data are only recorded using the KABCO severity system, whereas this report is based on the AIS. To translate CRSS data to an MAIS basis, we used a variety of KABCO/MAIS translators. For CISS equivalent crashes, we used a current translator derived from 2017-2019 CISS data. Since these data are relatively recent, they reflect roughly current levels of seat belt usage. For non-CISS cases, we apply newly developed translators derived from 2017-2019 CISS and 1982-1986 NASS files. Seat belt use has increased dramatically since this time. Observed belt use during this period ranged from roughly 10-37 percent as public awareness of the importance of belt use and belt use laws were just beginning to take hold in 1986. Belt use has since risen dramatically, and has been between 80 and 85 percent since 2004, and is currently roughly 90 percent. Belt use can influence injury reporting significantly in a number of ways. It changes the nature of injuries by preventing many more visible injuries (such as head/face contact with the windshield) but replaces them with often less visible (and also typically less serious) abdominal injuries such as bruising caused by pressure from the belt across the torso. This can influence the relationship between the KABCO reported injury severity and the corresponding MAIS injury level. For this reason, separate translators were developed from the 1982-86 NASS data for non-CDS cases where the victim was belted, unbelted, and for nonoccupants/motorcyclists. These translators are presented in Tables 1-5 in Appendix C.

The 2017-2019 CRSS KABCO incidence counts were obtained both for speed-involved and uninvolved cases. Consistent with NHTSA publication practice, cases where speed involvement was unknown were grouped with the uninvolved cases. Thus, one set of incidence counts was obtained for speed involved, and another for all other crashes. Each of these data sets was run through its corresponding translator to produce a set of MAIS based injury counts. These counts from each grouping (CISS equivalent cases, belted non-CDS cases, unbelted non-CDS cases, and nonoccupant/motorcycle cases) were added together to produce a total MAIS injury profile for each scenario. The percentage of each MAIS injury incidence that was appropriate to each scenario was then calculated as follows.

x=a/(a+b)

where x is the percentage of incidence attributable to speed-related crashes

a = the incidence of speed-related crashes

b = the incidence of crashes not related to speed, including those where the speed-related variable was coded unknown

The speed-attributable portion of each MAIS level was then multiplied by the total cost of all 2019 crashes for that MAIS level and the MAIS level results were summed to produce the total cost of each crash scenario. MAIS0 portions were calculated using the same procedure described elsewhere in this report for urban/rural crashes, based on the relative incidence of MAIS0 cases in injury crashes. The PDO portion was based on a direct count of PDO vehicles from each crash scenario compared to those not in that scenario.

The results of this process are summarized in Tables 8-1 and 8-2 for economic and comprehensive costs. Speed-related crashes resulted in 10,192 fatalities, nearly 500,000 nonfatal injuries, and 1.7 million PDO damaged vehicles in 2019. This represents 28 percent of all fatalities and roughly 11 percent of all nonfatal injury crashes, and 9 percent of all PDOs. Speed-related crashes caused $46 billion in economic costs and $225 billion in comprehensive costs, accounting for 14 percent of all economic costs and 16 percent of all societal harm (measured as comprehensive costs) from motor vehicle crashes.

Table 8-1. Economic Costs of Speed-Related Crashes (Millions 2019 $)

	% Speed-Related	Incidence		Total Economic Crash Costs		
		Total	Speed-Related	Total	Speed-Related	Other
PDO Vehicles	8.90%	19,288,139	1,717,134	$101,282	$9,017	$92,265
MAIS0	11.24%	4,525,901	508,842	$14,718	$1,655	$13,063
MAIS1	10.99%	3,875,265	425,991	$74,963	$8,240	$66,723
MAIS2	12.11%	427,119	51,705	$30,504	$3,693	$26,812
MAIS3	11.75%	141,167	16,584	$39,629	$4,656	$34,974
MAIS4	12.96%	19,285	2,499	$13,031	$1,688	$11,343
MAIS5	14.96%	7,187	1,075	$7,039	$1,053	$5,986
Fatalities	27.92%	36,500	10,192	$58,643	$16,376	$42,267
Total	9.65%	28,320,563	2,734,023	$339,809	$46,377	$293,432
Percentage of Total		100.00%	9.65%	100.00%	13.65%	86.35%

Table 8-2. Comprehensive Costs of Speed-Related Crashes (Millions 2019 $)

	% Speed-Related	Incidence		Total Comprehensive Crash Costs		
		Total	Speed-Related	Total	Speed-Related	Other
PDO Vehicles	8.90%	19,288,139	1,717,134	$101,282	$9,017	$92,265
MAIS0	11.24%	4,525,901	508,842	$14,718	$1,655	$13,063
MAIS1	10.99%	3,875,265	425,991	$234,283	$25,754	$208,529
MAIS2	12.11%	427,119	51,705	$202,352	$24,496	$177,856
MAIS3	11.75%	141,167	16,584	$288,631	$33,908	$254,723
MAIS4	12.96%	19,285	2,499	$69,690	$9,029	$60,660
MAIS5	14.96%	7,187	1,075	$43,471	$6,504	$36,967
Fatalities	27.92%	36,500	10,192	$410,935	$114,751	$296,184
Total	9.65%	28,320,563	2,734,023	$1,365,362	$225,113	$1,140,249
Percentage of Total		100.00%	9.65%	100.00%	16.49%	83.51%

One note of caution is in order when using these estimates – there is a significant overlap between alcohol involvement and speed. Many speed-related crashes involved alcohol and vice-versa. These two estimates should not be added together to account for the portion of costs that represent the combined factors of speed and alcohol. This same caveat applies to many of the other scenarios examined in this report, as several factors can be involved in any given crash.

9. Distracted Driving

Driver error has long been recognized as a principal cause of motor vehicle crashes. In a landmark 1979 Tri-Level study by the Indiana University (Teat et al., 1999), human factors such as speeding, inattention, distraction, and performance errors were found to be a contributing factor in 92.6 percent of all crashes. The Tri-Level study found that inattention was a crash cause in roughly 9.8 percent and a probable cause in 15.0 percent of crashes. It also found that “internal distraction” (distraction caused by factors within the vehicle) was a cause in 5.7 percent of crashes and a probable cause in 9.0 percent. The National Motor Vehicle Crash Causation Survey (NMVCCS, NHTSA, 2008) sponsored by NHTSA found that driver-related factors were a principal cause in 94 percent of crashes (NHTSA, 2018). Driver factors include both performance errors and errors related to non-driving activities, which typically involve distraction, inattention, inadequate surveillance, etc. Distraction, including interior distraction, exterior distraction, and inattention, was involved in about 17.7 percent of all cases where the critical pre-crash event was attributed to drivers. With vehicles traveling and interacting with other vehicles at high speeds, even momentary distraction can result in a crash.

Reported Distraction

For the national FARS and CRSS databases, NHTSA defines distraction to include both interior and exterior sources of distraction including inattentive driving. Types of distraction include talking on cell phones, texting, talking to other passengers, adjusting interior devices such as radios or mirrors, eating or drinking, diverting your attention to an exterior object, person, or event, or being lost in thought. All these activities can potentially distract drivers from the task of safely driving an automobile. Data from FARS and CRSS data systems (NHTSA, 2021) indicate that distracted driving plays a substantial role in motor vehicle crashes:

In 2019 about 9 percent of fatal crashes and 15 percent of injury crashes were reported as distraction-affected crashes.

In 2019, there were 3,142 people killed in crashes involving distracted drivers and an estimated additional 424,000 were injured in police-reported motor vehicle crashes involving distracted drivers.

Of those people killed in distraction-affected crashes, 422 occurred in crashes in which at least one of the drivers was using a cell phone (13 percent of fatalities in distraction-affected crashes) at the time of the crash. Use of a cell phone includes talking/listening to a cell phone, dialing/texting a cell phone, or other cell-phone-related activities.

Of those injured in distraction-affected crashes, an estimated 28,000 were injured in crashes that involved the use of cell phones at the time of the crashes (7% of injured people in distraction-affected crashes).

Nine percent of all drivers 15 to 20 years old involved in fatal crashes were reported as distracted at the time of the crashes. This age group has the largest proportion of drivers who were distracted (NHTSA, 2021).

For drivers under age 20 involved in fatal crashes, 19 percent of the distracted drivers were distracted by the use of cell phones (NHTSA, 2021).

To estimate the cost of distracted driving crashes, we examined the relative incidence of each injury severity level that was represented by distraction affected crashes. These incidence estimates reflect the relative proportions specific injury severities that occur in crashes involving distraction. FARS was used for each fatal case. For nonfatal injuries, the rate of distraction involvement is taken from CRSS and applied to the total incidence estimates previously derived. Application of these rates rather than direct counts is required to account for unreported crashes.

CRSS data are only recorded using the KABCO severity system, whereas this report is based on the AIS. To translate CRSS data to an MAIS basis, we used a variety of KABCO/MAIS translators. For CISS equivalent crashes, we used a new translator derived from 2017-2019 CISS data. Since these data are relatively recent, they reflect roughly current levels of seat belt usage. For non-CISS cases, the only available data from which to develop translators were contained in the 1982-1986 NASS files. Seat belt use has increased dramatically since this time. Observed belt use during this period ranged from roughly 10 to 37 percent as public awareness of the importance of belt use and belt use laws were just beginning to take hold in 1986. Belt use has since risen dramatically, reaching 91 percent in 2019. Belt use can influence injury reporting significantly in a number of ways. It changes the nature of injuries by preventing many more visible injuries (such as head/face contact with the windshield) but replaces them with often less visible (and also typically less serious) shoulder and abdominal injuries such as bruising caused by pressure from the belt across the torso. This can influence the relationship between the KABCO reported injury severity and the corresponding MAIS injury level. For this reason, separate translators were developed for non-CISS cases where the victim was belted, unbelted, and for nonoccupants/motorcyclists. These translators are presented in Tables 1-3 in Appendix C.

The 2019 CRSS KABCO incidence counts were obtained for each distraction status (distracted, not distracted). Cases with unknown belt use were distributed among known belt use cases proportionately. Each of these data sets was divided according to belt use and occupancy status and run through its corresponding translator to produce a set of MAIS based injury counts. These counts from each grouping (CISS equivalent cases, belted non-CISS cases, unbelted non-CISS cases, and nonoccupant/motorcycle cases) were added together to produce a total MAIS injury profile for each distraction scenario. The percentage of each MAIS injury incidence that resulted from a distraction-affected crash was then calculated as follows.

$x=a/(a+b)$

where x = the percentage of incidence attributable to a distraction-affected crash at each injury severity level

a = the incidence of distraction injuries

b = the incidence of injuries that were not specifically coded as being distraction-related (includes “not distracted” and Unknown).

The distraction-detected portion of each injury severity level was then multiplied by the total cost of all 2019 crashes for that severity level and the results were summed to produce the total cost of distraction-affected crashes. MAIS0 portions were calculated using the same procedure described previously for urban/rural crashes, based on the relative incidence of MAIS0 cases in injury crashes. The PDO portion was based on a direct count of PDO vehicles from the 2019 CRSS crashes involving distraction compared to those that did not.

The results of this analysis are summarized in Tables 9-1 and 9-2 for economic and comprehensive societal costs. Distracted driving is identified within NHTSA records as a factor for roughly 9 percent of all fatalities and 13 percent of all crashes overall. In 2019 distraction-affected crashes caused $46 billion in economic costs and are responsible for roughly 14 percent of all economic impacts from motor vehicle crashes. They caused $170 billion in societal harm (as measured by comprehensive costs), representing roughly 12 percent of total harm caused by motor vehicle crashes.

These estimates are almost certainly conservative because they are based only on identified distraction cases. Police records frequently fail to identify whether distraction was involved in the crash. Roughly 13 percent of all fatal crashes and 4 percent of all nonfatal crashes were coded in CRSS as "not reported" or "unknown if distracted."[15] Although it is likely that a portion of these cases could involve distraction, none of them are distributed to distraction in this analysis.

Table 9-1. Economic Cost of Police-Report-Identified Distraction Driving Crashes (Millions 2019 $)

	% Distracted	Incidence		Total Economic Crash Costs		
		Total	**Distracted**	**Total**	**Distracted**	**Other**
PDO Vehicles	15.23%	19,288,139	2,936,833	$101,282	$15,421	$85,861
MAIS0	14.98%	4,525,901	678,162	$14,718	$2,205	$12,513
MAIS1	15.21%	3,875,265	589,546	$74,963	$11,404	$63,559
MAIS2	13.84%	427,119	59,131	$30,504	$4,223	$26,281
MAIS3	13.45%	141,167	18,982	$39,629	$5,329	$34,300
MAIS4	12.80%	19,285	2,469	$13,031	$1,668	$11,363
MAIS5	11.75%	7,187	845	$7,039	$827	$6,212
Fatalities	8.70%	36,500	3,177	$58,643	$5,105	$53,538
Total	15.14%	28,320,563	4,289,145	$339,809	$46,183	$293,627
Percentage of Total		100.00%	15.14%	100.00%	13.59%	86.41%

[15] The discrepancy between the rates for fatal and nonfatal crashes may be a function of police inability to interview survivors in fatal crashes where drivers or occupants are deceased.

Table 9-2. Comprehensive Costs of Police-Report-Identified Distraction Crashes (Millions 2019 $)

	% Distracted	Incidence		Total Comprehensive Crash Costs		
		Total	Distracted	Total	Distracted	Other
PDO Vehicles	15.23%	19,288,139	2,936,833	$101,282	$15,421	$85,861
MAIS0	14.98%	4,525,901	678,162	$14,718	$2,205	$12,513
MAIS1	15.21%	3,875,265	589,546	$234,283	$35,642	$198,641
MAIS2	13.84%	427,119	59,131	$202,352	$28,014	$174,338
MAIS3	13.45%	141,167	18,982	$288,631	$38,811	$249,820
MAIS4	12.80%	19,285	2,469	$69,690	$8,921	$60,768
MAIS5	11.75%	7,187	845	$43,471	$5,108	$38,363
Fatalities	8.70%	36,500	3,177	$410,935	$35,770	$375,165
Total	15.14%	28,320,563	4,289,145	$1,365,362	$169,892	$1,195,469
Percentage of Total		100.00%	15.14%	100.00%	12.44%	87.56%

Underreported Distraction

In previous publications NHTSA has noted that there are limitations to the collection and reporting of FARS and CRSS data regarding driver distraction (NHTSA, 2021). Mynatt and Radja (2013) found that police reported distraction rates understated distraction by a factor of 2.5 compared to more in-depth review that focused on pre-crash elements found in the NMVCCS. The data for FARS and GES are based on PCRs and investigations conducted after the crash has occurred. One significant challenge for collection of distracted driving data are the PCR itself. Police crash reports vary across jurisdictions, thus creating potential inconsistencies in reporting. Many variables on the police crash report are nearly universal, but distraction is not one of those variables. Some police crash reports identify distraction as a distinct reporting field, while others do not have such a field and identification of distraction is based upon the narrative portion of the report. The variation in reporting forms contributes to variation in the reported number of distraction-affected crashes. Any national or State count of distraction-affected crashes should be interpreted with this limitation in mind due to potential under-reporting in some States/primary sampling units and over-reporting in others.[16]

There are several potential reasons for underreporting of distraction-affected crashes. There are negative implications associated with distracted driving—especially in conjunction with a crash. Survey research shows that self-reporting of negative behavior is lower than actual occurrence of that negative behavior. There is no reason to believe that self-reporting of distracted driving to a law enforcement officer would differ. The inference is that the reported driver distraction during crashes is lower than the actual occurrence.

[16] Note that in the reporting of distraction-affected crashes, sometimes external distractions are identified as a distinct type of distraction. Some of the scenarios captured under external distractions might actually be related to the task of driving (e.g., looking at a street sign). However, the crash reports may not differentiate these driving-related tasks from other external distractions (looking at previous crash or billboard). Currently, the category of external distractions is included in the counts of distraction-affected crashes reported in NHTSA crash databases.

If a driver fatality occurs in the crash, law enforcement must rely on the crash investigation to determine whether driver distraction was involved. Law enforcement may not have information to indicate distraction. For example, some forms of distraction such as cognitive distraction (lost in thought) are impossible to identify. These investigations ten rely on witness account and these accounts are often not available, especially in fatal crashes.

Another concern is the speed at which technologies are changing and the difficulty in updating the PCR to accommodate these changes. Without broad-sweeping changes to the PCR to incorporate new technologies and features of technologies, it is difficult to capture the data that involve interaction with these devices.

The prevalence of distraction as a factor in crashes was examined by Dingus et al. (2016), which used results from the SHRP 2 Naturalistic Driving Study data base[17] to measure access the incidence of various distraction categories as well as impairment and driver error in crashes that resulted in injury or property damage. Naturalistic driving studies (NDS) use in-vehicle cameras and sensors to document driver behavior and other risk factors, enabling researchers to document the prevalence of these factors at the time of crashes or near crash events. The Dingus study was the first to access distraction from a NDS based solely on actual crashes rather than near crashes, which was enabled by the large sample size collected in SHRP 2, which included 905 crash events involving injury or damage.

Dingus found rates of driver distraction that exceeded those documented in police reports by a large margin, with observable distraction occurring in 68.3 percent of all crashes (compared to the much lower 15% found in 2019 CRSS or the 9% found in 2019 FARS). 54.5% of these crashes involved distraction as well as driver error. Table 9-3, taken from Dingus (2016), summarizes the findings.

Table 9-3. Prevalence of Distraction, Driver Error, and Impairment

Distracted	**Error**	**Impaired**	**Prevalence (%)**
Yes	Yes	Yes	3.4
		No	51.1
	No	Yes	0.1
		No	13.7
No	Yes	Yes	2.7
		No	16.5
	No	Yes	0.3
		No	12.3
		Total	100.0

NDS give researchers a unique perspective into pre-crash environments and driver behavior that is not available to police or post-crash crash investigators. It is thus expected that NDS-based results would capture a more complete picture of human factors associated with crashes. In fact, from Table 9-3, distraction was detected in 68.3 percent of all crashes, a far higher rate than the roughly 9 to 15 percent documented in police reports.

[17] See Antin, 2011 and 2019 for further details of SHRP2 design.

Note from Table 9-3 that this includes overlap with the other two elements measured in SHRP2 – driver performance or judgment error and impairment. As with other causation estimates in this report such as speeding and alcohol, there can be significant overlap among these elements. Thus, it is difficult to assign sole causation to any one of these factors. Did the crash occur because the driver was speeding? Was he speeding because he was impaired? If he hadn't been distracted, might he have avoided the crash despite being impaired? If he hadn't been speeding, might he have avoided the crash if he hadn't been distracted? The relevant observation about distraction is that it may prevent the driver from detecting a safety hazard altogether, or, at a minimum, it would reduce the time available for the driver to avoid the safety hazard. Importantly though, these data indicate that distraction significantly increases the chance of driver error.

Dingus et al. found significant overlap between distraction and driver error. This complicates the question of crash causation, making it difficult to attribute the cause of the crash to either error or distraction. However, in many cases, driver error would occur because of distraction. To examine this issue, we referred to the results in Table 9-3 above, which establishes an overlap matrix for distraction, driver error, and impairment. Table 9-4 summarizes the prevalence of driver error for distraction crashes, crashes without distraction, and baseline driving from Dingus et al. These results indicate that:

- Driver error is 6.0 times more likely to occur in crashes where driver distraction is observed than in baseline (non-crash) driving;
- Driver error is 2.1 times more likely to occur in crashes where there is no observable distraction than in baseline (non-crash) driving; and
- Driver error is 2.8 times as likely to occur in crashes where driver distraction is observed than in crashes where there is no observable distraction.

Table 9-4. Prevalence of Driver Error

	% Cases Driver Error Observed
Distraction Crashes	54.50%
No Distraction Crashes	19.20%
Baseline Prevalence	9.03%

From Table 9-3, of the 68.3 percent of cases where drivers were visibly distracted, 54.5 percent also involved some form of driver error and 3.6 percent were also impaired. Only 13.7 percent had distraction without impairment or driver error. This is coincidently similar to the 15 percent found in CRSS files, but a substantial portion of the 15 percent that were distracted also had overlapping driver error or impairment as well.

Overall, this indicates that driver error is linked to distraction, implying that distraction may lead to increased probability of driver error.

Distraction Crash Causation

Dingus et al. (2016) calculated odds ratios to determine the relative risk of a crash caused by distraction. They found that distraction doubles the risk of a crash occurring compared to model driving, which is defined as driving alert, attentive, and sober. Dingus notes that given the 68.3 percent prevalence of distraction in crashes, this 2.0 odds ratio implies that 36 percent of all crashes could be avoided if distraction were eliminated.

There are several features of the Dingus results that limit their applicability to nationwide crash estimates. The first is that crashes from both old and young drivers were oversampled. This was done because crash risk is higher among these age groups. This was confirmed by Guo et al., who found differences in the odds ratios for crash risk caused by distraction among different age groups. The results are thus not representative of driver age prevalence on U.S. roadways. A second concern is that the odds ratios were developed against a baseline of “model driving.” It thus represents a maximum impact of distraction compared to perfect driving behavior. However, Dingus et al. found distraction and driver error were common even in non-crash circumstances.

To establish estimates that were applicable to nationwide crash data, we contacted the Virginia Tech Transportation Institute and discussed revising its approach to measure risk against all characteristics found in on-road driving rather than against model driving. The authors agreed to this proposal and conducted a revised analysis based on the most current SHRP2 database that included 1,100 crashes that involved property damage or injury. The revised analysis was designed to establish specific values for a number of different metrics.

Specific age groups to enable adjustment of results to be nationally representative of driving ages on U.S. roadways. Separate results were derived for teens (16-19), young adults (20-29), middle-aged adults (30-64), and seniors (65+).

Categories of distraction, to examine whether general types of distraction were more harmful than others. These categories were cell phone use, interaction with others, interaction with in-vehicle features (other than cell phones), and all other driver distraction. The types of distraction included under each category are listed in Table 9-5.

Crash severity, to determine whether there were significant differences in distraction impacts across crashes of differing severity. The study analyzed three separate categories of crash severity. Level 1 crashes involved injury, air bag deployment, rollover, high delta V (>20 mph), or enough vehicle damage to require towing. Level 2 crashes involved a minimum of $1,500 property damage, or moderate crash loads (acceleration on any axis greater than +/-1.3 g, excluding curb strikes). Level 3 crashes involved physical contact with another object or roadway departure, with only minimal or no damage.

Table 9-5. Distraction Categories

In Vehicle Controls, Non-Cell Phone:	**Other Driver Distraction, Non-Cell Phone**
Adjusting/monitoring radio	Reading
Adjusting/monitoring climate control	Writing
Adjusting/monitoring other devices integral to vehicle	Tablet device, operating
Inserting/retrieving CD (or similar)	Tablet device, viewing
	Eating without utensils
	Eating with utensils
Cell Phone Use:	Drinking from open container
Cell phone, talking/listening, hand-held	Drinking with lid, no straw
Cell phone, texting	Drinking with lid and straw
Cell phone, dialing hand-held	Drinking with straw no lid
Cell phone, dialing hand-held using quick keys	Make up
Cell phone, locating/reaching/answering	Combing/brushing/fixing hair
Cell phone, browsing	Brushing teeth
Cell phone, dialing hands-free using voice-activated software	Biting nails/cuticles
Cell phone, holding	Shaving
Cell phone, other	Other personal hygiene
	Removing/adjusting clothing
	Removing/adjusting jewelry
Interaction With Others:	Removing/inserting/ adjusting contact lenses or glasses
Child in rear seat - interaction	Reaching for cigar/cigarette
Passenger in adjacent seat - interaction	Reaching for food-related or drink-related item
Passenger in rear seat - interaction	Reaching for object, other (leave a note)
Child in adjacent seat - interaction	Reaching for personal body-related item
Insect in vehicle	Dancing
Pet in vehicle	Looking at an object external to the vehicle
	Looking at pedestrian
	Looking at animal
	Looking at previous crash or incident
	Distracted by construction
	Other external distraction
	Talking/singing, audience unknown
	Moving object in vehicle
	Lighting cigar/cigarette
	Smoking cigar/cigarette
	Extinguishing cigar/cigarette
	Object dropped by driver
	Object in vehicle, other
	Other known secondary task
	Other non-specific internal eye glance
	Tablet device, other
	Unknown
	Unknown type (secondary task present)

The prevalence of distraction varied significantly among the four sub-categories, and by age groups within each category. For example, cell phone use was quite common among teenagers and young adults, but rare among middle-aged adults and seniors. Cell phone distraction was higher across all age categories in crashes than in baseline driving. This later finding applies to almost all categories, the exception being interaction with others, where the reverse occurred among three of the four age groups. The most common type of distraction was non-cell driver-only distraction, which includes the largest number of potentially distracting activities. Note that while distraction occurred in 68.9 percent of all crashes, it was also present in 52.8 percent of baseline (non-crash) driving. Prevalence is summarized in Table 9-6 below.

Table 9-6. Prevalence of Distraction by Category and Driver Age

Distraction Type	Outcome	Age Group	Percentage of Distracted Events
All distraction	Baseline	1Teen	59
	Crash	1Teen	73.6
	Baseline	2Young	58.3
	Crash	2Young	77.8
	Baseline	3Middle	52.4
	Crash	3Middle	63.9
	Baseline	4Senior	41.3
	Crash	4Senior	54.5
Cell phone use	Baseline	1Teen	11.6
	Crash	1Teen	20.7
	Baseline	2Young	14.9
	Crash	2Young	26.3
	Baseline	3Middle	6.8
	Crash	3Middle	11.7
	Baseline	4Senior	1
	Crash	4Senior	3.2
Interaction with others	Baseline	1Teen	18.5
	Crash	1Teen	19.9
	Baseline	2Young	15
	Crash	2Young	14.3
	Baseline	3Middle	15.2
	Crash	3Middle	13.2
	Baseline	4Senior	15.2
	Crash	4Senior	12.2
Driver only non-cell	Baseline	1Teen	33
	Crash	1Teen	42
	Baseline	2Young	32
	Crash	2Young	42
	Baseline	3Middle	32.4

Distraction Type	Outcome	Age Group	Percentage of Distracted Events
	Crash	3Middle	47.3
	Baseline	4Senior	25.7
	Crash	4Senior	39.6
In-vehicle_device	Baseline	1Teen	5.4
	Crash	1Teen	7.4
	Baseline	2Young	4.6
	Crash	2Young	6.1
	Baseline	3Middle	3.7
	Crash	3Middle	5.9
	Baseline	4Senior	3.4
	Crash	4Senior	4.5
All distractions	Baseline	all	52.8
	Crash	all	68.9

The impact of distraction on odds ratios varied noticeable among the 4 subcategories, as well as across the 4 age groups. Teens, young adults, and seniors were most distracted by cellphones (when present), whereas middle aged adults were most distracted by other non-cell phone distraction. Table 9-7 summarizes the odds ratios, lower limits, upper limits, and p-values for each category and age group.

Table 9-7. Odds Ratio Results by Age group and Distraction Category

Age	Type	OR	LL	UL	p-value
Teens	cell_Teen	2.05	1.54	2.74	<.001
	vehicle_Teen	1.41	0.91	2.17	0.125
	interaction_Teen	1.06	0.8	1.41	0.663
	other distraction_Teen	1.48	1.18	1.85	0.001
	distraction_overall_Teen	1.93	1.51	2.48	<.001
Young Adults	cell_Young	2.01	1.5	2.68	<.001
	vehicle_Young	1.39	0.83	2.34	0.212
	interaction_Young	0.96	0.68	1.36	0.815
	otherdistraction_Young	1.53	1.19	1.96	0.001
	distraction_overall_Young	2.5	1.87	3.34	<.001
Middle-age	cell_Middle	1.59	0.99	2.56	0.055
	vehicle_Middle	1.74	0.92	3.29	0.087
	interaction_Middle	0.85	0.55	1.3	0.446
	other distraction_Middle	1.97	1.47	2.66	<.001
	distraction_overall_Middle	1.61	1.19	2.18	0.002
Senior	cell_Senior	3.04	1.23	7.54	0.016
	vehicle_Senior	1.32	0.66	2.63	0.432
	interaction_Senior	0.8	0.52	1.23	0.302
	other distraction_Senior	1.96	1.46	2.64	<.001
	distraction_overall_Senior	1.77	1.33	2.36	<.001

To create a relative crash risk value that is representative of drivers in the United States, we accessed the odds ratios for the four age groups examined in this study and recalculated the overall odds ratio across all age groups by applying nationwide driver age prevalence weights derived from FHWA data on licensed drivers and average VMT by driver age to the four age category odds ratios. The product of licensed drivers and VMT per driver gives average annual VMT per driver by age group, which is the proper measure of relative risk exposure. This process that produced an average risk ratio of 1.79 for all distraction causes, is illustrated in Table 9-8. Observable distraction is estimated to increase crash risk by 79 percent compared to normal driving. Corresponding odds ratios were 1.82 for cellphones, 1.63 for in-vehicle devices, .87 for interaction with others, and 1.88 for driver non-cell distraction. Two of these categories, in-vehicle devices and interaction with others, produced results that were not statistically significant.

Table 9-8. Recalculation of Distraction Odds Ratio to Reflect Nationwide Age Distribution

	Total Annual VMT by Driver Age	**All Distraction**	**Cell Phones**	**In-Vehicle Device***	**Interaction w/Others***	**Driver Non-cell**
Driver Age	**Percentage**	**Odds Ratio**				
16-19	0.0241	1.93	2.05	1.41	1.06	1.48
20-29	0.1726	2.5	2.01	1.39	0.96	1.53
30-64	0.7036	1.61	1.59	1.74	0.85	1.97
65+	0.0998	1.77	3.04	1.32	0.8	1.96
Wtd Total	1.0000	1.7873	1.8182	1.6298	0.8691	1.8813

*= Results not statistically significant

As shown in Table 9-9, risk varied only slightly across the three crash severity categories, with central values for each category well within the confidence intervals of the other categories. We therefore conclude that there is not sufficient information to discriminate the impacts of distraction across crashes of different severity.

Table 9-9. Odds Ratios by Crash Severity

Type	**OR**	**95th CI (lower limit**	**95th CI (lower limit)**	**p_value**
Crash L1	2	1.25	3.19	0.004
Crash L2	2.2	1.51	3.19	<.001
Crash L3	1.97	1.68	2.31	<.001
Crash All	1.98	1.73	2.27	<.001

To estimate the impact of distraction on existing crash incidence we combine the rate of distraction prevalence from Table 9-6 and the distraction odds ratio from Table 9-8. However, as with the odds ratios, the raw distraction prevalence rates must be adjusted to eliminate the sampling bias built into the SHRP2 sample. The results (Table 9-10) indicate distraction was prevalent in 66 percent of crashes.

Table 9-10. Recalculation of Prevalence to Reflect National Age Distribution

Driver Age	2017-2019 CRSS Drivers Percent	Distraction Prevalence
16-20	0.0241	73.60%
21-29	0.1726	77.80%
30-64	0.7036	63.90%
65-98	0.0998	54.50%
Total		65.59%

Using these data, we estimate the impact of distraction as follows.

x=1-((p/r)+1-p))

Where:

x= percent of current crashes attributable to distraction

p =prevalence of distraction in crashes

r = odds ratio for distraction

x = 1-(.66/1.79)+(1-.66)

x=.289

We thus estimate that 29 percent of crashes are attributable to distraction.

Because cell phones are of special interest, we repeated this process for cell phone distraction. Cell phones had an odds ratio of 1.82 and cell phone distraction was observed in 13.59 percent of crashes. Applying these inputs to the above formula, we find that 6.1 percent of crashes are attributable to cell phone distraction, implying that roughly one-fifth of distraction-caused crashes are related to cell phone use.

We note that this estimate assumes that the SHRP2 sample adjusted for national driving age prevalence is representative of driving experience in real world crashes. We caution that as a voluntary sample it is subject to selection bias on the part of its participants. Nonetheless, the high incidence of driver error and distraction seems to indicate that the participants did settle into natural driving habits that are likely indicative of real-world driving. We also note that the SHRP2 study was conducted from October 2010 to November 2013, and thus represents levels of distraction experienced by drivers in vehicles on the road during that timeframe.[18] Over time newer vehicles have become more frequently equipped with in-vehicle systems (such as entertainment systems) that allow or encourage driver attention and could lead to more distraction due to interaction with in-vehicle devices. Potentially offsetting the impact of added distraction, newer vehicles are more likely to be equipped with automated safety devices that alert drivers or even intervene to prevent crashes. Neither of these technologies were on most vehicles in the on-road fleet in 2019, but drivers of more modern fleets of vehicles may thus

[18] NHTSA data from FARS and GES indicate similar rates of distraction during 2010 to 2013 as was measured in 2019, with 10 percent of fatalities and roughly 16 percent of nonfatal crashes involving distraction, versus 9 percent for fatalities and 13 percent for nonfatal crashes in 2019. It's not clear whether these small changes represent a trend or sample variation related to the redesign of NHTSA's crash databases.

experience somewhat different effects from distraction, which argues for periodic updating of naturalistic studies.

To address uncertainty regarding distraction impacts, we examined the confidence intervals derived for each age group and reproduced the above analysis to determine a range of outcomes for the three distraction categories with statistically significant outcomes. Tables 9-11 and 9-12 summarize these results for the lower and upper confidence bounds respectively. Recalculating the above formula substituting the lower and upper odds ratios indicates a possible range of distraction attribution of between 16.2 percent and 38.3 percent, with a central value of 28.9 percent.

Table 9-11. Recalculation of Distraction Odds Ratio to Reflect Nationwide Age Distribution, Lower Bound Odds Ratio

	Total Annual VMT	**All Distraction**	**Cell Phones**	**Driver Non-Cell**
Driver Age	**Percentage**	**Odds Ratio**		
16-19	0.0241	1.51	1.54	1.18
20-29	0.1726	1.87	1.5	1.19
30-64	0.7036	1.19	0.99	1.47
65+	0.0998	1.33	2.3	1.46
Wtd Total	1.0000	1.3290	1.2219	1.4137

Table 9-12. Recalculation of Distraction Odds Ratio to Reflect Nationwide Age Distribution, Upper Bound Odds Ratio

	Total Annual VMT	**All Distraction**	**Cell Phones**	**Driver Non-Cell**	
Driver Age	**Percentage**	**Odds Ratio**			
16-19	0.0241	2.48	2.74	1.85	
20-29	0.1726	3.34	2.68	1.96	
30-64	0.7036	2.18	2.56	2.66	
65+	0.0998	2.36	7.54	2.64	
Wtd Total	1.0000	2.4054	3.0819	2.5177	

To estimate the societal impacts attributable to distraction, we apply the central estimate that 29 percent of all crashes are attributable to distraction. The results are summarized in Tables 9-13 and 9-14 below. These data indicate that distracted driving likely causes $98 billion in economic impacts annually, and produces total societal harm, including lost quality-of-life, valued at $395 billion annually.

Table 9-13. Economic Costs Attributable to Distracted Driving (Millions 2019 $)

	% Distracted	Incidence		Total Economic Crash Costs		
		Total	Distracted	Total	Distracted	Other
PDO Vehicles	28.89%	19,288,139	5,573,010	$101,282	$29,264	$72,018
MAIS0	28.89%	4,525,901	1,307,689	$14,718	$4,253	$10,466
MAIS1	28.89%	3,875,265	1,119,698	$74,963	$21,659	$53,304
MAIS2	28.89%	427,119	123,409	$30,504	$8,814	$21,691
MAIS3	28.89%	141,167	40,788	$39,629	$11,450	$28,179
MAIS4	28.89%	19,285	5,572	$13,031	$3,765	$9,266
MAIS5	28.89%	7,187	2,077	$7,039	$2,034	$5,005
Fatalities	28.89%	36,500	10,546	$58,643	$16,944	$41,699
Total	28.89%	28,320,563	8,182,789	$339,809	$98,183	$241,627
Percentage of Total		100.00%	28.89%	100.00%	28.89%	71.11%

Table 9-14. Comprehensive Costs Attributable to Distracted Driving (Millions 2019 $)

	% Distracted	Incidence		Total Comprehensive Crash Costs		
		Total	Distracted	Total	Distracted	Other
PDO Vehicles	28.89%	19,288,139	5,573,010	$101,282	$29,264	$72,018
MAIS0	28.89%	4,525,901	1,307,689	$14,718	$4,253	$10,466
MAIS1	28.89%	3,875,265	1,119,698	$234,283	$67,692	$166,591
MAIS2	28.89%	427,119	123,409	$202,352	$58,466	$143,885
MAIS3	28.89%	141,167	40,788	$288,631	$83,396	$205,236
MAIS4	28.89%	19,285	5,572	$69,690	$20,136	$49,554
MAIS5	28.89%	7,187	2,077	$43,471	$12,560	$30,911
Fatalities	28.89%	36,500	10,546	$410,935	$118,733	$292,202
Total	28.89%	28,320,563	8,182,789	$1,365,362	$394,500	$970,861
Percentage of Total		100.00%	28.89%	100.00%	28.89%	71.11%

10. Seat Belt Use

Seat belts provide significant protection to vehicle occupants involved in a crash. The simple act of buckling a seat belt can improve an occupant's chance of surviving a potentially fatal crash by from 44 to 73 percent, depending on the type of vehicle and seating position involved (Kahane, 2000). They are also highly effective against serious nonfatal injuries. Belts reduce the chance of receiving an MAIS2-5 injury (moderate to critical) by 49 to 78 percent.

The effectiveness of seat belts is a function of vehicle type, restraint type, and seat position. Table 10-1 shows the estimated effectiveness of seat belts for various seating positions for passenger cars and for light trucks, vans, and sports utility vehicles (LTVs).

Table 10-1. Effectiveness of Seat Belts Against Fatalities and Serious Injuries

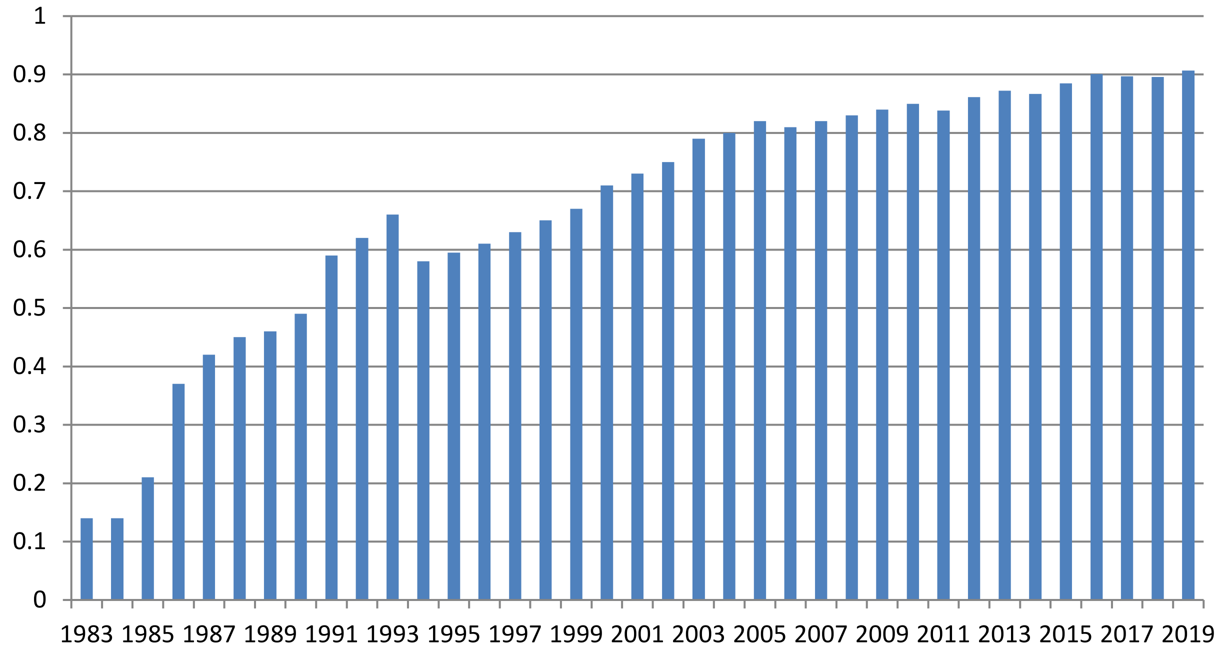
	Lap Belts	Lap/Shoulder Belts
Passenger Cars, Front Seat		
Fatalities	35	45
MAIS2-5 Injuries	30	50
Passenger Cars, Rear Seat		
Fatalities	32	44
MAIS2-5 Injuries	37	49
LTVs, Front Seat		
Fatalities	50	60
MAIS2-5 Injuries	55	65
LTVs, Rear Seat		
Fatalities	63	73
MAIS2-5 Injuries	68	78

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

Although all passenger vehicles have been equipped with seat belts since 1968, a sizable minority of vehicle occupants still neglect to use these devices. As of 2019 about 91 percent of occupants wear their seat belts. Usage has risen steadily throughout the last three decades, largely in response to public education programs sponsored by State and Federal safety agencies, as well as private consumer and safety advocacy groups. A major factor in this increase has been the passage of seat belt use laws. As of 2001, all States except New Hampshire had some form of adult usage law. These laws can take the form of either primary enforcement laws, under which police can stop drivers specifically for failing to wear seat belts, or secondary laws, under which fines can only be levied if a driver is stopped for some other offense. Primary enforcement laws are far more effective in increasing seat belt use. Experience in a number of States indicates that usage rates rise from 10- to 15 percentage points when primary laws are passed. For example, usage in California jumped from 70 percent to 82 percent when a primary law was passed in

1993. Similar impacts occurred in Louisiana where usage rose 18 points, in Georgia where usage rose 17 points, in Maryland where usage rose 13 points, and in the District of Columbia where usage rose 24 points when they combined a new primary enforcement law with penalty points. Overall, States with primary belt use laws have an average belt use rate that is 12 percentage points higher than States with only secondary enforcement (Pickrell & Ye, 2012). Figure 10-A illustrates the nationwide trend in seat belt use rates from 1983 through 2019.

Figure 10-A. Observed Daytime Seat Belt Use Rate



By combining seat belt use rates with effectiveness rates and national injury counts, an estimate can be made of the impact of seat belts on fatality and casualty rates. The basic methods for these calculations are well documented (Partyka & Womble, 1989; Blincoe, 1994; Wang & Blincoe, 2001; Wang & Blincoe, 2003; Glassbrenner & Starnes, 2009). The effect of increases in seat belt use on fatalities is curvilinear, i.e., the more the observed usage rate in the general population approaches 100 percent, the more lives are saved for each incremental point increase. This occurs because those who are most resistant to buckling up tend to be in high-risk groups such as impaired drivers or people who are risk takers in general. These people are more likely to be involved in serious crashes and are thus more likely to actually benefit from wearing their belts. Belt use by people involved in potentially fatal crashes ("restraint) use in potentially fatal crashes," UPFC) tends to be lower than observed use for these same reasons. Figure 10-B illustrates the relationship between use in potentially fatal crashes as well as lives saved and increasing rates of observed seat belt usage.

Figure 10-B. UPFC and Percent Lives Saved as a Function of Observed Belt Use

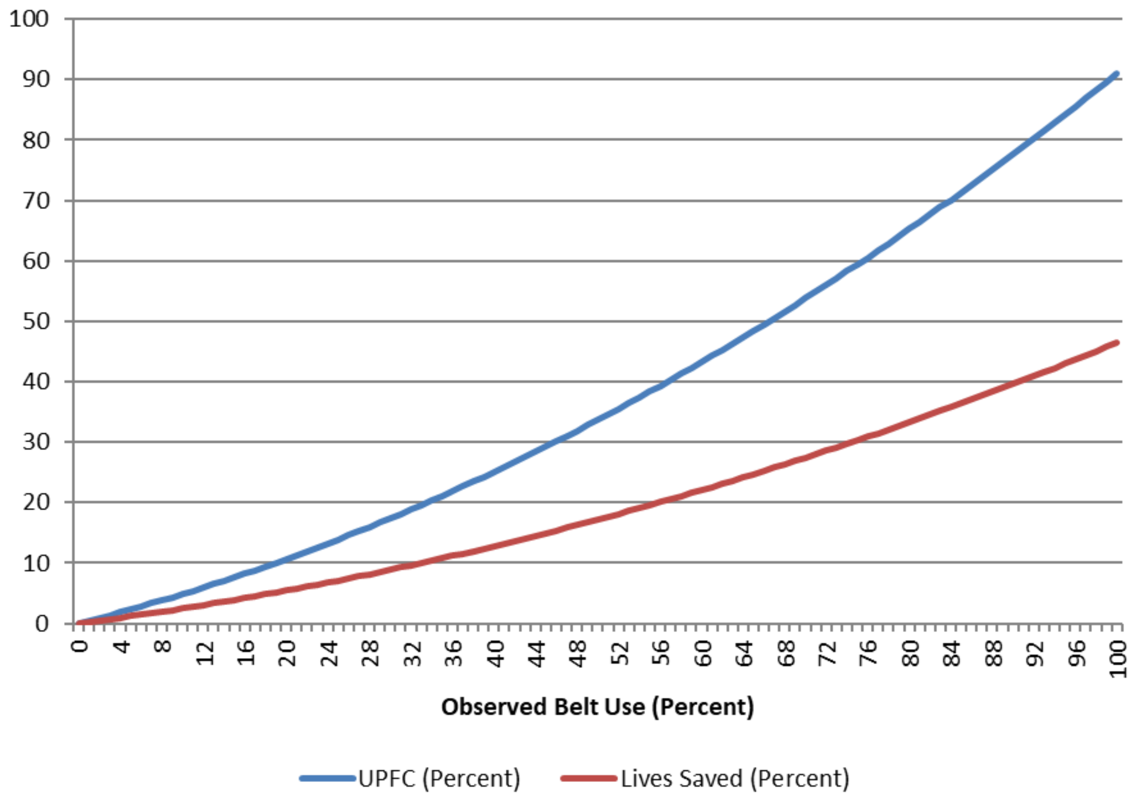


Table 10-2 lists the historical and cumulative impact of seat belt use on motor vehicle casualties. Through 2019, seat belts have saved 404,000 lives and prevented 11.88 million serious nonfatal police reported injuries.19 At current (2019) use rates, they are preventing 14,600 fatalities and 450,000 serious (MAIS2 to MAIS5) police-reported nonfatal injuries annually. The failure of a large segment of the driving population to wear their belts also has significant safety implications. If all occupants had used seat belts properly, many more lives would have been saved. Table 10-2 also lists the potential safety benefits that could have been realized since 1975 had all occupants worn their seat belts. Over this period, passenger vehicles were equipped with devices that could have saved over 390,000 additional lives and prevented 7.1 million additional serious police reported injuries if all vehicle occupants had taken a few seconds to buckle their seat belts. At current (2019) belt use rates, an additional 2,400 fatalities and 46,000 serious injuries could be prevented every year if all passengers were to wear their seat belts. This represents an enormous lost opportunity for injury prevention.

[19] This analysis includes only police-reported injuries. About 27 percent of MAIS2 injuries and 6 percent of MAIS3 injuries are estimated to be unreported. Belt use rates are unknown for unreported crashes. If belt use rates for unreported crashes are similar to reported crashes, benefits for each of these two categories would increase proportionally. All MAIS4, MAIS5, and fatal injuries are estimated to be reported to police.

Table 10-2. Achieved and Potential Impact of Seat Belt Use on Fatalities and Serious Injuries, 1975-2019

Year	Lives Saved by Seat Belts	Fatalities Preventable @100% Usage*	Lives Lost Due to Belt Nonuse	MAIS2-5 PR Injuries Prevented	MAIS2-5 PR Injuries Preventable @ 100% Usage	PR MAIS2-5 Benefits Lost to Nonuse
1975	978	14,279	13,301	39,704	293,620	253,916
1976	796	14,647	13,851	32,509	296,745	264,236
1977	682	15,142	14,460	28,616	310,084	281,468
1978	679	16,220	15,541	24,891	286,351	261,461
1979	594	16,320	15,726	25,159	332,589	307,430
1980	575	16,305	15,730	24,422	330,587	306,165
1981	548	15,770	15,222	23,285	317,738	294,452
1982	678	13,928	13,250	28,691	286,244	257,553
1983	809	13,722	12,913	40,076	286,257	246,181
1984	1,197	14,424	13,227	41,524	296,601	255,077
1985	2,435	14,943	12,508	64,192	305,676	241,484
1986	4,094	16,822	12,728	135,444	366,065	230,621
1987	5,141	17,819	12,678	165,616	394,323	228,708
1988	5,959	18,633	12,674	181,756	403,902	222,146
1989	6,333	18,589	12,256	189,704	412,400	222,696
1990	6,592	18,353	11,761	202,762	413,799	211,038
1991	6,838	17,650	10,812	244,783	414,887	170,104
1992	7,020	17,215	10,195	263,532	425,051	161,519
1993	7,773	17,985	10,212	301,851	457,350	155,499
1994	9,219	18,726	9,507	321,860	480,389	158,528
1995	9,882	19,663	9,781	355,170	522,308	167,139
1996	10,710	20,169	9,459	360,192	529,694	169,502
1997	11,259	20,355	9,096	354,161	513,277	159,116
1998	11,680	20,370	8,690	327,913	475,237	147,323
1999	11,941	20,750	8,809	358,627	512,324	153,697
2000	12,882	21,127	8,245	388,306	531,927	143,620
2001	13,295	21,311	8,016	349,369	478,587	129,219
2002	14,264	21,101	6,837	372,236	496,314	124,079
2003	15,095	21,246	6,151	385,191	487,584	102,393
2004	15,548	21,422	5,874	383,624	479,530	95,906
2005	15,688	21,355	5,667	393,745	480,177	86,432
2006	15,458	20,926	5,468	360,664	445,264	84,600
2007	15,223	20,271	5,048	359,775	438,750	78,975
2008	13,312	17,483	4,171	342,591	412,760	70,169
2009	12,763	16,463	3,700	339,700	404,405	64,705
2010	12,546	15,902	3,356	348,798	410,350	61,553
2011	12,071	15,467	3,396	341,067	407,002	65,934
2012	12,386	15,416	3,030	370,881	430,757	59,875
2013	12,644	15,415	2,771	375,317	430,409	55,092

Year	Lives Saved by Seat Belts	Fatalities Preventable @100% Usage*	Lives Lost Due to Belt Nonuse	MAIS2-5 PR Injuries Prevented	MAIS2-5 PR Injuries Preventable @ 100% Usage	PR MAIS2-5 Benefits Lost to Nonuse
2014	12,801	15,678	2,877	379,295	437,480	58,185
2015	14,062	16,777	2,715	413,830	467,605	53,775
2016	14,753	17,224	2,471	485,696	539,063	53,367
2017	14,955	17,504	2,549	435,243	485,221	49,978
2018	14,871	17,263	2,392	428,422	478,150	49,728
2019	14,653	17,051	2,398	449,988	496,127	46,140
Total	403,682	795,201	391,519	11,840,178	18,900,958	7,060,781

Seat belt use has also had a significant economic impact. Table 10-3 lists the economic savings that have resulted from seat belt use over the past 45 years. Since 1975 nearly $2.5 trillion in economic costs (2019 $) have been saved due to seat belt use. At 2019 usage rates, seat belts saved society an estimated $93 billion annually in medical care, lost productivity, and other injury-related costs. Table 10-4 lists the potential economic savings that were lost due to nonuse. These lost savings could be viewed as costs of seat belt nonuse. Since 1975 over $1.7 trillion in unnecessary economic costs (2019 $) have been incurred due to seat belt nonuse. At current usage rates, the needless deaths and injuries that result from nonuse continue to cost society an estimated $11. billion annually in medical care, lost productivity, and other injury-related costs.[20]

Table 10-3. Impact of Seat Belt Use on Economic Costs, 1975-2019

					Total Cost Savings (Millions)	
Year	Lives Saved by Seat Belts	Cost/Fatality Current $	MAIS2-5 Injuries Prevented	MAIS2-5 Cost/Injury Current $	Current $	2019$
1975	978	$333,403	39,704	$32,623	$1,621	$7,704
1976	796	$352,614	32,509	$34,502	$1,402	$6,301
1977	682	$375,543	28,616	$36,746	$1,308	$5,517
1978	679	$404,049	24,891	$39,535	$1,258	$4,934
1979	594	$449,908	25,159	$44,022	$1,375	$4,841
1980	575	$510,639	24,422	$49,965	$1,514	$4,697
1981	548	$563,314	23,285	$55,119	$1,592	$4,478
1982	678	$598,018	28,691	$58,515	$2,084	$5,522
1983	809	$617,229	40,076	$60,394	$2,920	$7,494
1984	1,197	$643,876	41,524	$63,002	$3,387	$8,334
1985	2,435	$666,805	64,192	$65,245	$5,812	$13,809
1986	4,094	$679,200	135,444	$66,458	$11,782	$27,483
1987	5,141	$703,988	165,616	$68,883	$15,027	$33,819
1988	5,959	$733,114	181,756	$71,733	$17,407	$37,617

[20] Prior years' unit costs were estimated by deflating the 2019 unit costs using the CPI annual average All Items index.

					Total Cost Savings (Millions)	
Year	**Lives Saved by Seat Belts**	**Cost/Fatality Current $**	**MAIS2-5 Injuries Prevented**	**MAIS2-5 Cost/Injury Current $**	**Current $**	**2019$**
1989	6,333	$768,437	189,704	$75,190	$19,130	$39,442
1990	6,592	$809,958	202,762	$79,252	$21,409	$41,876
1991	6,838	$844,042	244,783	$82,587	$25,988	$48,781
1992	7,020	$869,450	263,532	$85,074	$28,523	$51,975
1993	7,773	$895,478	301,851	$87,620	$33,409	$59,109
1994	9,219	$918,407	321,860	$89,864	$37,390	$64,501
1995	9,882	$944,434	355,170	$92,411	$42,154	$70,716
1996	10,710	$972,321	360,192	$95,139	$44,682	$72,806
1997	11,259	$994,631	354,161	$97,322	$45,666	$72,741
1998	11,680	$1,010,123	327,913	$98,838	$44,209	$69,339
1999	11,941	$1,032,433	358,627	$101,021	$48,557	$74,514
2000	12,882	$1,067,137	388,306	$104,417	$54,293	$80,606
2001	13,295	$1,097,502	349,369	$107,388	$52,109	$75,224
2002	14,264	$1,114,854	372,236	$109,086	$56,508	$80,304
2003	15,095	$1,140,262	385,191	$111,572	$60,189	$83,629
2004	15,548	$1,170,628	383,624	$114,543	$62,142	$84,103
2005	15,688	$1,210,289	393,745	$118,424	$65,616	$85,894
2006	15,458	$1,249,331	360,664	$122,244	$63,401	$80,402
2007	15,223	$1,284,914	359,775	$125,726	$64,793	$79,891
2008	13,312	$1,334,249	342,591	$130,553	$62,488	$74,200
2009	12,763	$1,329,502	339,700	$130,089	$61,160	$72,882
2010	12,546	$1,351,310	348,798	$132,222	$63,072	$73,948
2011	12,071	$1,393,964	341,067	$136,396	$63,347	$71,997
2012	12,386	$1,422,812	370,881	$139,219	$69,257	$77,118
2013	12,644	$1,443,652	375,317	$141,258	$71,270	$78,215
2014	12,801	$1,467,071	379,295	$143,549	$73,228	$79,080
2015	14,062	$1,468,812	413,830	$143,720	$80,130	$86,432
2016	14,753	$1,487,342	485,696	$145,533	$92,627	$98,667
2017	14,955	$1,519,027	435,243	$148,633	$87,409	$91,166
2018	14,871	$1,556,129	428,422	$152,263	$88,374	$89,976
2019	14,653	$1,584,326	449,988	$155,022	$92,973	$92,973
Total	403,682		11,840,178		$1,843,991	$2,475,057

Table 10-4. Unrealized Impact of Potential Seat Belt Use on Economic Costs, 1975-2019

					Cost Savings Forgone (Millions)	
Year	**Lives Lost Due to Belt Nonuse**	**Cost/Fatality Current $**	**MAIS2-5 Injury Benefits Lost Due to Belt Nonuse**	**MAIS2-5 Cost/Injury Current $**	**Current $**	**2019 $**
1975	13,301	$333,403	253,916	$32,623	$12,718	$60,436
1976	13,851	$352,614	264,236	$34,502	$14,001	$62,907
1977	14,460	$375,543	281,468	$36,746	$15,773	$66,543
1978	15,541	$404,049	261,461	$39,535	$16,616	$65,154
1979	15,726	$449,908	307,430	$44,022	$20,609	$72,574
1980	15,730	$510,639	306,165	$49,965	$23,330	$72,384
1981	15,222	$563,314	294,452	$55,119	$24,805	$69,763
1982	13,250	$598,018	257,553	$58,515	$22,994	$60,919
1983	12,913	$617,229	246,181	$60,394	$22,838	$58,622
1984	13,227	$643,876	255,077	$63,002	$24,587	$60,498
1985	12,508	$666,805	241,484	$65,245	$24,096	$57,252
1986	12,728	$679,200	230,621	$66,458	$23,971	$55,917
1987	12,678	$703,988	228,708	$68,883	$24,679	$55,541
1988	12,674	$733,114	222,146	$71,733	$25,227	$54,517
1989	12,256	$768,437	222,696	$75,190	$26,162	$53,940
1990	11,761	$809,958	211,038	$79,252	$26,251	$51,349
1991	10,812	$844,042	170,104	$82,587	$23,174	$43,500
1992	10,195	$869,450	161,519	$85,074	$22,605	$41,191
1993	10,212	$895,478	155,499	$87,620	$22,769	$40,285
1994	9,507	$918,407	158,528	$89,864	$22,977	$39,638
1995	9,781	$944,434	167,139	$92,411	$24,683	$41,407
1996	9,459	$972,321	169,502	$95,139	$25,323	$41,263
1997	9,096	$994,631	159,116	$97,322	$24,533	$39,078
1998	8,690	$1,010,123	147,323	$98,838	$23,339	$36,606
1999	8,809	$1,032,433	153,697	$101,021	$24,621	$37,783
2000	8,245	$1,067,137	143,620	$104,417	$23,795	$35,327
2001	8,016	$1,097,502	129,219	$107,388	$22,674	$32,732
2002	6,837	$1,114,854	124,079	$109,086	$21,157	$30,067
2003	6,151	$1,140,262	102,393	$111,572	$18,438	$25,618
2004	5,874	$1,170,628	95,906	$114,543	$17,862	$24,174
2005	5,667	$1,210,289	86,432	$118,424	$17,094	$22,377
2006	5,468	$1,249,331	84,600	$122,244	$17,173	$21,778
2007	5,048	$1,284,914	78,975	$125,726	$16,415	$20,241
2008	4,171	$1,334,249	70,169	$130,553	$14,726	$17,486
2009	3,700	$1,329,502	64,705	$130,089	$13,337	$15,893
2010	3,356	$1,351,310	61,553	$132,222	$12,674	$14,859
2011	3,396	$1,393,964	65,934	$136,396	$13,727	$15,602

					Cost Savings Forgone (Millions)	
Year	**Lives Lost Due to Belt Nonuse**	**Cost/Fatality Current $**	**MAIS2-5 Injury Benefits Lost Due to Belt Nonuse**	**MAIS2-5 Cost/Injury Current $**	**Current $**	**2019 $**
2012	3,030	$1,422,812	59,875	$139,219	$12,647	$14,083
2013	2,771	$1,443,652	55,092	$141,258	$11,783	$12,931
2014	2,877	$1,467,071	58,185	$143,549	$12,573	$13,578
2015	2,715	$1,468,812	53,775	$143,720	$11,716	$12,638
2016	2,471	$1,487,342	53,367	$145,533	$11,442	$12,188
2017	2,549	$1,519,027	49,978	$148,633	$11,300	$11,786
2018	2,392	$1,556,129	49,728	$152,263	$11,294	$11,499
2019	2,398	$1,584,326	46,140	$155,022	$10,952	$10,952
Total	391,519		7,060,781		$865,463	$1,714,873

Figure 10-C compares the portion of potential seat belt fatality benefits to those that could be achieved if observed belt use rose to 100 percent. For nearly 2 decades, between 1975 and 1985, belt use was so low that less than 10 percent of potential safety benefits were actually achieved. However, belt use and its corresponding life-saving benefits increased dramatically over the past 35 years, and by 2019, 86 percent of potential safety benefits were being realized.

Figure 10-C. Realized and Unrealized Fatality Benefits From Seat Belt Use

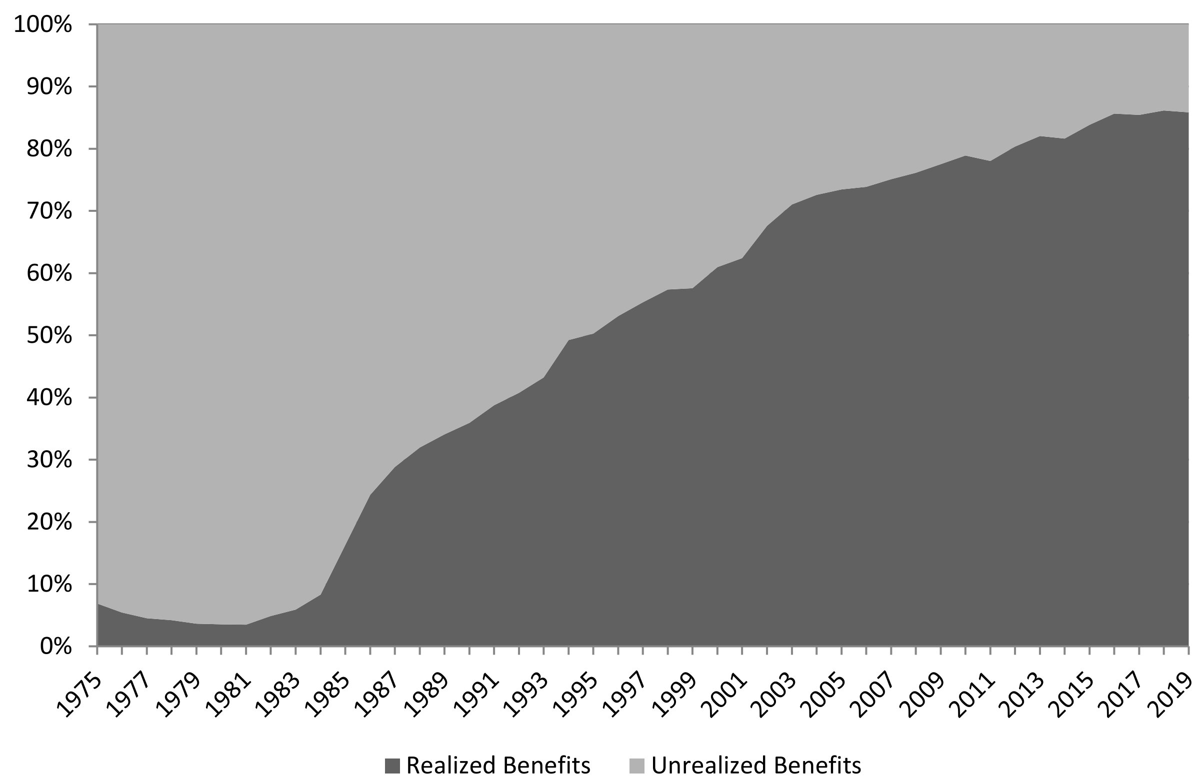


Figure 10-D compares the achieved economic benefits from seat belt use to those that could have been achieved if observed belt use was 100 percent. Cost impacts (which include impacts to both fatalities and nonfatal injuries) roughly parallel the pattern seen for fatalities, with less than 10 percent of potential economic benefits being realized between 1975 and 1985, but with significant growth in later years due to increases in belt use. By 2019 some 89 percent of potential economic benefits were being realized.

Figure 10-D. Realized and Unrealized Economic Benefits From Seat Belt Use

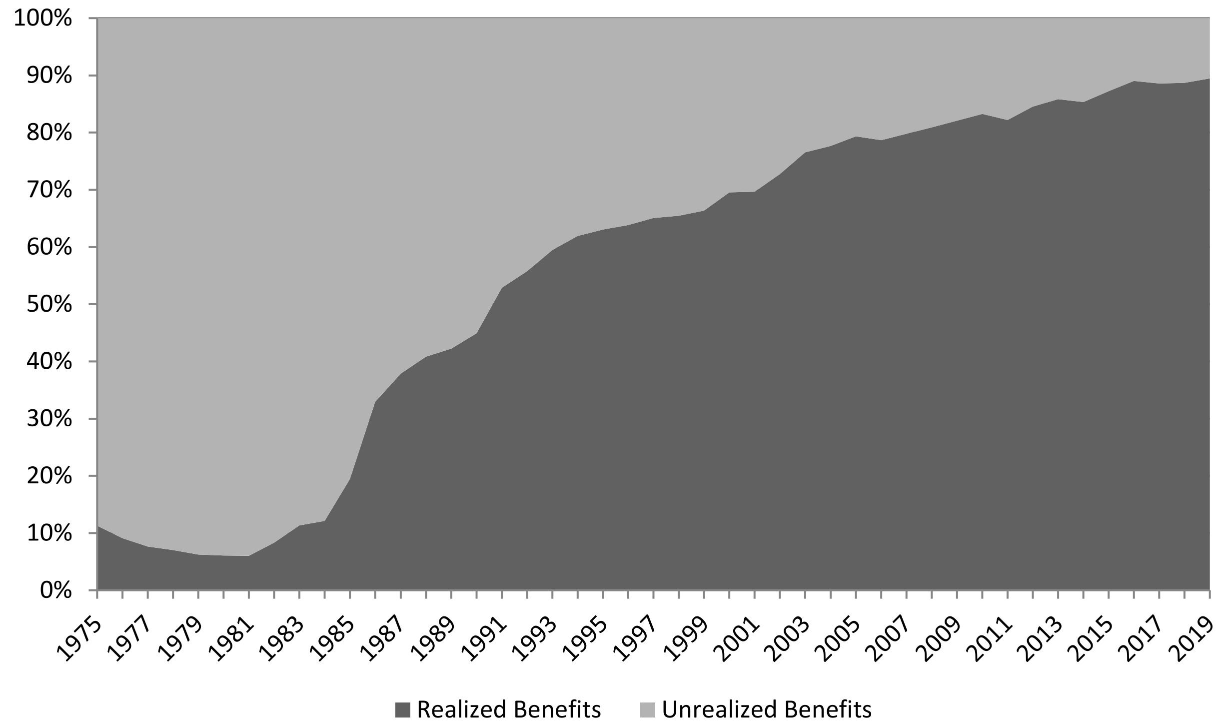


Table 10-5 lists the comprehensive cost impact of seat belt use. This table reflects the combined impact of both economic cost savings and valuations for lost quality-of-life (see Chapter 5). The comprehensive societal benefits from seat belt use are enormous. From 1975 to 2019 seat belts have prevented $17.8 trillion (2019 $) in societal harm as measured by comprehensive costs, and they are currently preventing $667 billion in societal harm annually.

Table 10-5. Impact of Seat Belt Use on Comprehensive Costs, 1975-2019

					Total Cost Savings (millions)	
Year	**Lives Saved by Seat Belts**	**Cost/Fatality Current $**	**MAIS2-5 Injuries Prevented**	**MAIS2-5 Cost/Injury Current $**	**Current $**	**2019 $**
1975	978	$2,364,521	39,704	$234,922	$11,640	$55,312
1976	796	$2,500,767	32,509	$248,458	$10,068	$45,235
1977	682	$2,663,382	28,616	$264,614	$9,389	$39,609
1978	679	$2,865,553	24,891	$284,701	$9,032	$35,416
1979	594	$3,190,785	25,159	$317,013	$9,871	$34,761
1980	575	$3,621,497	24,422	$359,806	$10,870	$33,725
1981	548	$3,995,073	23,285	$396,922	$11,432	$32,152
1982	678	$4,241,195	28,691	$421,375	$14,965	$39,647
1983	809	$4,377,440	40,076	$434,911	$20,971	$53,829
1984	1,197	$4,566,426	41,524	$453,687	$24,305	$59,805
1985	2,435	$4,729,042	64,192	$469,843	$41,675	$99,020
1986	4,094	$4,816,942	135,444	$478,577	$84,541	$197,203
1987	5,141	$4,992,743	165,616	$496,043	$107,820	$242,650
1988	5,959	$5,199,309	181,756	$516,566	$124,872	$269,859
1989	6,333	$5,449,825	189,704	$541,455	$137,230	$282,934
1990	6,592	$5,744,292	202,762	$570,711	$153,585	$300,421
1991	6,838	$5,986,018	244,783	$594,728	$186,512	$350,096
1992	7,020	$6,166,213	263,532	$612,630	$204,734	$373,070
1993	7,773	$6,350,804	301,851	$630,970	$239,824	$424,309
1994	9,219	$6,513,420	321,860	$647,126	$268,332	$462,894
1995	9,882	$6,698,011	355,170	$665,466	$302,543	$507,528
1996	10,710	$6,895,787	360,192	$685,116	$320,627	$522,438
1997	11,259	$7,054,008	354,161	$700,835	$327,630	$521,874
1998	11,680	$7,163,883	327,913	$711,752	$317,067	$497,303
1999	11,941	$7,322,104	358,627	$727,471	$348,324	$534,523
2000	12,882	$7,568,225	388,306	$751,924	$389,471	$578,229
2001	13,295	$7,783,581	349,369	$773,320	$373,657	$539,401
2002	14,264	$7,906,641	372,236	$785,547	$405,189	$575,816
2003	15,095	$8,086,837	385,191	$803,450	$431,553	$599,616
2004	15,548	$8,302,193	383,624	$824,846	$445,513	$602,957
2005	15,688	$8,583,475	393,745	$852,792	$470,440	$615,829
2006	15,458	$8,860,361	360,664	$880,302	$454,456	$576,314
2007	15,223	$9,112,723	359,775	$905,374	$464,454	$572,682
2008	13,312	$9,462,611	342,591	$940,137	$448,049	$532,026
2009	12,763	$9,428,945	339,700	$936,792	$438,570	$522,630
2010	12,546	$9,583,605	348,798	$952,158	$452,346	$530,348
2011	12,071	$9,886,115	341,067	$982,213	$454,336	$516,381
2012	12,386	$10,090,703	370,881	$1,002,539	$496,807	$553,203

					Total Cost Savings (millions)	
Year	**Lives Saved by Seat Belts**	**Cost/Fatality Current $**	**MAIS2-5 Injuries Prevented**	**MAIS2-5 Cost/Injury Current $**	**Current $**	**2019 $**
2013	12,644	$10,238,507	375,317	$1,017,224	$511,237	$561,053
2014	12,801	$10,404,595	379,295	$1,033,726	$525,276	$567,259
2015	14,062	$10,416,945	413,830	$1,034,953	$574,778	$619,980
2016	14,753	$10,548,356	485,696	$1,048,009	$664,633	$707,972
2017	14,955	$10,773,074	435,243	$1,070,335	$626,967	$653,919
2018	14,871	$11,036,204	428,422	$1,096,478	$633,875	$645,360
2019	14,653	$11,236,177	449,988	$1,116,346	$666,985	$666,985
Total	403,682		11,840,178		$13,226,449	$17,753,572

Table 10-6 lists the unnecessary societal harm (as measured by comprehensive costs) that resulted from failure of occupants to wear seat belts. These lost potential savings can be viewed as the societal cost of seat belt nonuse. Since 1975 some $12.3 trillion in unnecessary societal harm (2019 $) has been incurred due to seat belt nonuse. At current usage rates, the needless deaths and injuries that result from nonuse continue to cost society an estimated $78.5 billion annually in lost quality-of-life, medical care, lost productivity, and other injury-related costs.

Table 10-6. Impact of Potential Seat Belt Use on Societal Harm

					Cost Savings Forgone (millions)	
Year	**Lives Lost Due to Belt Nonuse**	**Cost/Fatality Current $**	**MAIS2-5 Injury Benefits Lost Due to Belt Nonuse**	**MAIS2-5 Cost/Injury Current $**	**Current $**	**2019 $**
1975	13,301	$2,364,521	253,916	$234,922	$91,101	$432,910
1976	13,851	$2,500,767	264,236	$248,458	$100,290	$450,611
1977	14,460	$2,663,382	281,468	$264,614	$112,993	$476,691
1978	15,541	$2,865,553	261,461	$284,701	$118,972	$466,502
1979	15,726	$3,190,785	307,430	$317,013	$147,638	$519,898
1980	15,730	$3,621,497	306,165	$359,806	$167,126	$518,531
1981	15,222	$3,995,073	294,452	$396,922	$177,688	$499,748
1982	13,250	$4,241,195	257,553	$421,375	$164,722	$436,397
1983	12,913	$4,377,440	246,181	$434,911	$163,593	$419,916
1984	13,227	$4,566,426	255,077	$453,687	$176,125	$433,374
1985	12,508	$4,729,042	241,484	$469,843	$172,611	$410,122
1986	12,728	$4,816,942	230,621	$478,577	$171,680	$400,467
1987	12,678	$4,992,743	228,708	$496,043	$176,747	$397,769
1988	12,674	$5,199,309	222,146	$516,566	$180,649	$390,399
1989	12,256	$5,449,825	222,696	$541,455	$187,373	$386,316

					Cost Savings Forgone (millions)	
Year	**Lives Lost Due to Belt Nonuse**	**Cost/Fatality Current $**	**MAIS2-5 Injury Benefits Lost Due to Belt Nonuse**	**MAIS2-5 Cost/Injury Current $**	**Current $**	**2019 $**
1990	11,761	$5,744,292	211,038	$570,711	$188,000	$367,740
1991	10,812	$5,986,018	170,104	$594,728	$165,886	$311,380
1992	10,195	$6,166,213	161,519	$612,630	$161,816	$294,864
1993	10,212	$6,350,804	155,499	$630,970	$162,970	$288,334
1994	9,507	$6,513,420	158,528	$647,126	$164,511	$283,795
1995	9,781	$6,698,011	167,139	$665,466	$176,738	$296,486
1996	9,459	$6,895,787	169,502	$685,116	$181,356	$295,506
1997	9,096	$7,054,008	159,116	$700,835	$175,677	$279,832
1998	8,690	$7,163,883	147,323	$711,752	$167,112	$262,106
1999	8,809	$7,322,104	153,697	$727,471	$176,311	$270,559
2000	8,245	$7,568,225	143,620	$751,924	$170,392	$252,972
2001	8,016	$7,783,581	129,219	$773,320	$162,321	$234,322
2002	6,837	$7,906,641	124,079	$785,547	$151,527	$215,336
2003	6,151	$8,086,837	102,393	$803,450	$132,009	$183,419
2004	5,874	$8,302,193	95,906	$824,846	$127,875	$173,066
2005	5,667	$8,583,475	86,432	$852,792	$122,351	$160,163
2006	5,468	$8,860,361	84,600	$880,302	$122,922	$155,882
2007	5,048	$9,112,723	78,975	$905,374	$117,503	$144,884
2008	4,171	$9,462,611	70,169	$940,137	$105,437	$125,199
2009	3,700	$9,428,945	64,705	$936,792	$95,502	$113,807
2010	3,356	$9,583,605	61,553	$952,158	$90,770	$106,422
2011	3,396	$9,886,115	65,934	$982,213	$98,335	$111,763
2012	3,030	$10,090,703	59,875	$1,002,539	$90,602	$100,887
2013	2,771	$10,238,507	55,092	$1,017,224	$84,412	$92,638
2014	2,877	$10,404,595	58,185	$1,033,726	$90,081	$97,281
2015	2,715	$10,416,945	53,775	$1,034,953	$83,936	$90,537
2016	2,471	$10,548,356	53,367	$1,048,009	$81,994	$87,341
2017	2,549	$10,773,074	49,978	$1,070,335	$80,953	$84,433
2018	2,392	$11,036,204	49,728	$1,096,478	$80,924	$82,390
2019	2,398	$11,236,177	46,140	$1,116,346	$78,452	$78,452
Total	391,519		7,060,781		$6,197,982	$12,281,447

11. Motorcycle Crashes

Motorcycles are the most hazardous form of motor vehicle transportation. The lack of external protection provided by vehicle structure, the lack of internal protection provided by seat belts and air bags, their speed capability, the propensity for riders to become airborne through ejection, and the relative instability inherent with riding a two-wheeled vehicle all contribute to making the motorcycle the highest risk passenger vehicle. In 2019 there were 5,044 motorcyclists killed and 88,000[21] were injured in police-reported crashes on our Nation's roadways. This represents 14 percent of all traffic fatalities and 3 percent of all police-reported injuries. Motorcycles accounted for only 0.6 percent of all vehicle miles traveled in 2019. Per vehicle mile traveled in 2019, a motorcyclist was nearly 30 times more likely than a passenger car occupant to die in a motor vehicle traffic crash and 4 times more likely to be injured.[22] The difference in these proportions reflects the more severe injury profile that results from motorcycle crashes.

Over the past several decades motorcycle rider fatalities and injuries have generally increased relative to those of occupants of other vehicle types. Figure 11-A shows the fatality rate per 100,000 registered vehicles by vehicle type.[23] The rates for passenger cars, light trucks, and heavy trucks declined steadily from 1995 through 2006.[24] The recession that occurred in 2007 caused a dramatic decline in fatality rates for heavy trucks, and a less severe but still noticeable decline in the rates for passenger cars and light trucks. The heavy truck rate began increasing in 2010 as the economy began to recover. By contrast, the motorcycle fatality rate climbed steadily from the mid-1990s through 2006 as middle-aged baby boomers showed increased interest in motorcycle riding (Blincoe & Shankar, 2007). Motorcycle fatality rates were also affected by the recession and declined sharply from 2007 through 2009, but then stabilized for several years before beginning a gradual increase. Although the 2019 rate (58.3/100,000 vehicles) increased from the 2013 low of 54.9/100,000 vehicles, it is still well below the pre-recession rate of 73.5. What is most apparent from Figure 11-A though, is the magnitude of the fatality rate for motorcycles when compared with other vehicles.

Figure 11-B illustrates the percentage of occupant fatalities by vehicle type. The portions fatalities represented by motorcycles and light trucks have been increasing since 1995, while the portions represented by passenger cars has declined. The light truck increase is explained by the increasing sales of these vehicles relative to other types. However, as shown in Table 11-1, the fatality rate for these vehicles has declined while for motorcycles it has increased. Light trucks have benefitted from a variety of occupant protection safety standards such as air bags, increased seat belt use, and side door beams that cannot be installed in motorcycles. The increase in the portion of fatalities represented by motorcycles thus represents both their increased popularity

[21] There were 85,906 annual injuries estimated from the 2017-2019 CRSS files. These represent the sum of all A, B, C and "injured severity unknown" injuries. Further adjustment to reflect the more accurate MAIS coding structure through the motorcycle specific KABCO/MAIS translator indicates over 88,000 nonfatal police-reported injuries. See further discussion in this section.

[22] Fatality rates in 2019 for motorcyclists and passenger cars were 25.47/100 million VMT and 0.89 per 100 million VMT respectively. Sources are NHTSA 2019 FARS for fatalities and FHWA for VMT.

[23] Although VMT is the preferable basis for fatality rates, motorcycle fatality VMT was not recorded reliably until 2007, therefore rate comparisons are based on vehicle registrations.

[24] The heavy-truck fatality rate per registered vehicle is much higher than the passenger car and light-truck rates because heavy trucks drive many more miles per year.

and the relative safety improvements made in other vehicle types, but not in motorcycles. If these trends continue, motorcycle riders will make up an increasing share of occupant fatalities.

Figure 11-A. Fatality Rates per 100,000 Registered Vehicles by Vehicle Type

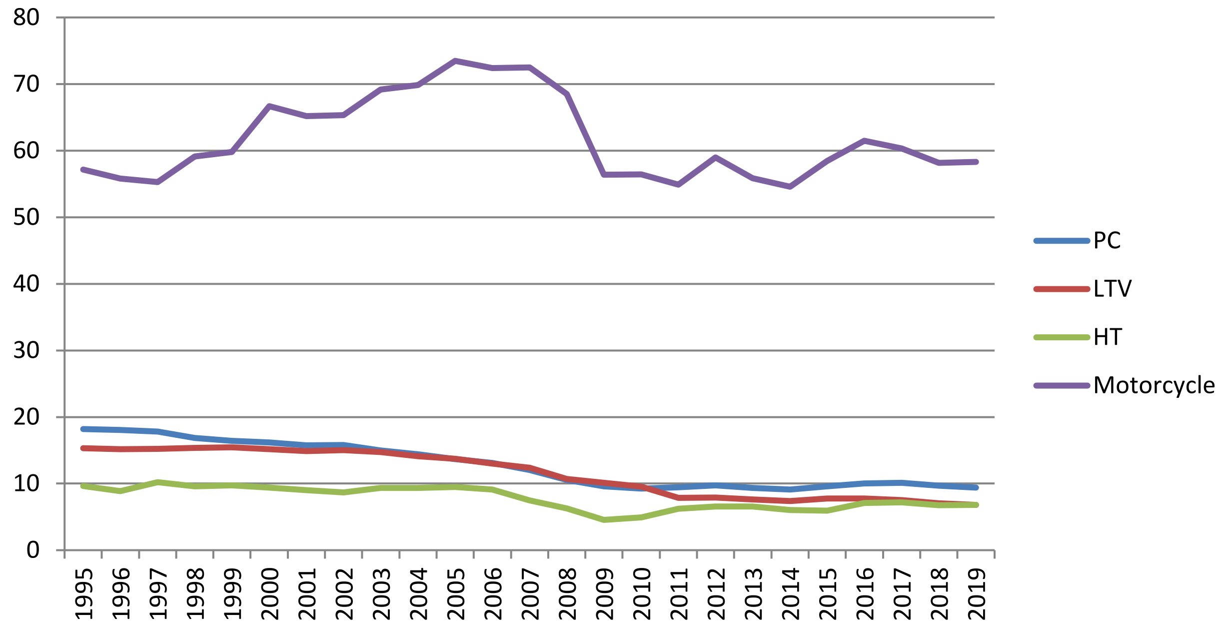


Figure 11-B. Portions Occupant Fatalities Represented by Vehicle Type

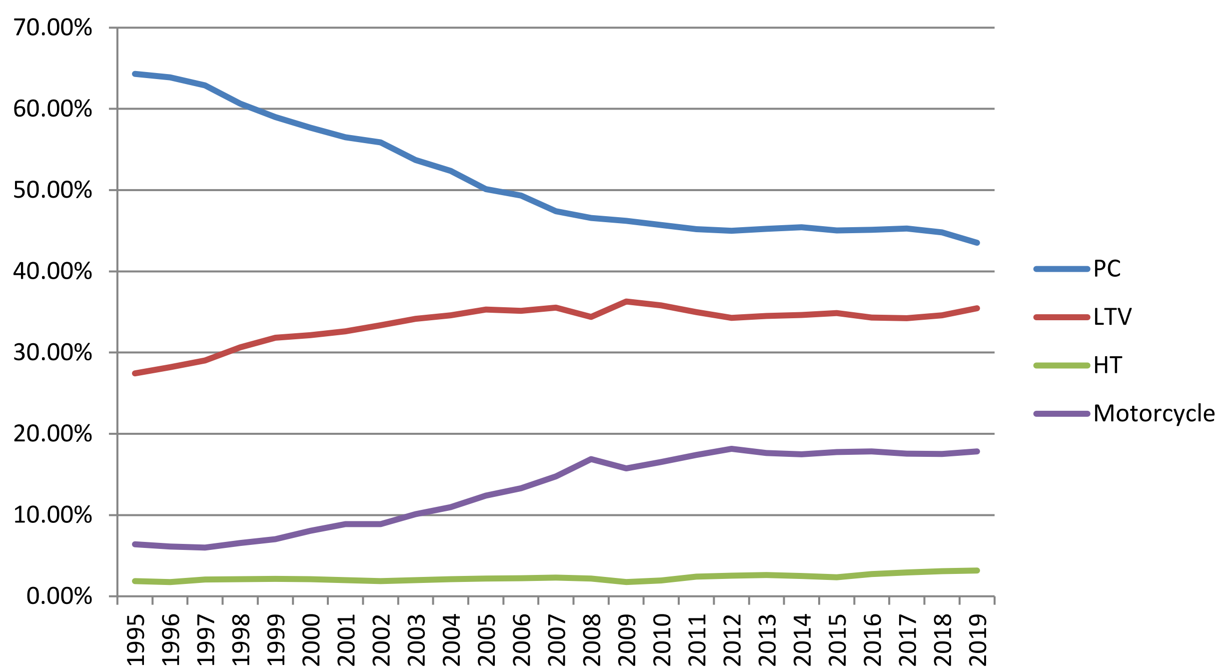


Table 11-1 lists a history of motorcycle fatalities and injuries along with fatality and injury rates from 1975 through 2019. Fatalities are taken directly from NHTSA's FARS database while injury totals represent the sum of all A, B, and C injuries from NHTSA's GES system. As noted in Chapter 2, Incidence, these KABCO based injury counts are not consistent with the AIS used to stratify injury in this report. They must therefore be adjusted using a KABCO/MAIS translator. This motorcycle specific translator was derived from the 1982-1986 NASS, the only database containing both KABCO and MAIS information that has motorcycle crashes. Table 11-2 illustrates this translator, which indicates roughly 36 percent of all uninjured KABCO cases had actually sustained minor or moderate injuries. As with other nonfatal injury categories in this report, we apply this translator to the three-year average from 2017-2019 CRSS files to minimize the impact of year-to-year sample variation.

A final adjustment was made to nonfatal injuries to represent unreported crashes. We know of no studies that indicate the extent to which motorcycle crashes go unreported, but we have no reason to believe that there is no underreporting for this vehicle type.[25] It's possible that the rates are different due to post-crash vehicle drivability, insurance coverage rates, the prevalence of single-vehicle crashes, or the different nature of motorcycle injuries, but we have no data to quantify how any such differences would impact police reporting for motorcycle crashes. For this study, we assume that underreporting rates are the same for motorcycles as for all vehicles.

The results of this process are summarized in Table 11-3. In 2019 it is estimated that there were 5044 motorcycle riders killed in crashes. An additional 93,000 were injured in police-reported crashes while 39,000 were injured in unreported crashes. Overall, an estimated 132,500 motorcyclists were injured in crashes, roughly 40,000 of them seriously (MAIS2-5).

Table 11-1. Motorcyclist Fatalities, Injuries, and Casualty Rates, 1975-2019

Year	Registered Motor-cycles	Vehicle Miles Traveled -millions	Motor-cycle Rider Fatalities	Fatality Rate per 100,000 Regis-trations	Fatality Rate per 100 Million VMT	Motorcycle Riders Injured	Injury Rate per 100,000 Regis-trations	Injury Rate per 100 Million VMT
1975	4,964,070	5,629	3,189	64.24	56.65	*	*	*
1976	4,933,332	6,003	3,312	67.14	55.17	*	*	*
1977	4,933,256	6,349	4,104	83.19	64.64	*	*	*
1978	4,867,855	7,158	4,577	94.02	63.94	*	*	*
1979	5,422,132	8,637	4,894	90.26	56.66	*	*	*
1980	5,693,940	10,214	5,144	90.34	50.36	*	*	*
1981	5,831,132	10,690	4,906	84.13	45.89	*	*	*
1982	5,753,858	9,910	4,453	77.39	44.93	*	*	*
1983	5,585,112	8,760	4,265	76.36	48.69	*	*	*
1984	5,479,822	8,784	4,608	84.09	52.46	*	*	*
1985	5,444,404	9,086	4,564	83.83	50.23	*	*	*
1986	5,198,993	9,397	4,566	87.82	48.59	*	*	*
1987	4,885,772	9,506	4,036	82.61	42.46	*	*	*
1988	4,584,284	10,024	3,662	79.88	36.53	105,168	2,294	1,049
1989	4,420,420	10,371	3,141	71.06	30.29	83,435	1,888	805

[25] Motorcycles were included in the M. Davis survey discussed in the Incidence chapter. However, the survey only contained 6 motorcycle cases. The weighted police reporting rate for those cases (53%) was almost identical to the overall rate for all crashes (54%), but these are too few cases to rely on for a separate motorcycle reporting rate.

Year	Registered Motor-cycles	Vehicle Miles Traveled -millions	Motor-cycle Rider Fatalities	Fatality Rate per 100,000 Regis-trations	Fatality Rate per 100 Million VMT	Motorcycle Riders Injured	Injury Rate per 100,000 Regis-trations	Injury Rate per 100 Million VMT
1990	4,259,462	9,557	3,244	76.16	33.94	84,285	1,979	882
1991	4,177,365	9,178	2,806	67.17	30.57	80,435	1,925	876
1992	4,065,118	9,557	2,395	58.92	25.06	65,099	1,601	681
1993	3,977,856	9,906	2,449	61.57	24.72	59,436	1,494	600
1994	3,756,555	10,240	2,320	61.76	22.66	57,405	1,528	561
1995	3,897,191	9,797	2,227	57.14	22.73	57,480	1,475	587
1996	3,871,599	9,920	2,161	55.82	21.78	55,281	1,428	557
1997	3,826,373	10,081	2,116	55.3	20.99	52,574	1,374	522
1998	3,879,450	10,283	2,294	59.13	22.31	48,974	1,262	476
1999	4,152,433	10,584	2,483	59.8	23.46	49,986	1,204	472
2000	4,346,068	10,469	2,897	66.66	27.67	57,723	1,328	551
2001	4,903,056	9,633	3,197	65.2	33.19	60,236	1,229	625
2002	5,004,156	9,552	3,270	65.35	34.23	64,713	1,293	677
2003	5,370,035	9,576	3,714	69.16	38.78	67,103	1,250	701
2004	5,767,934	10,122	4,028	69.83	39.79	76,379	1,324	755
2005	6,227,146	10,454	4,576	73.48	43.77	87,335	1,402	835
2006	6,678,958	12,049	4,837	72.42	40.14	87,652	1,312	727
2007	7,138,476	21,396	5,174	72.48	24.18	102,994	1,443	481
2008	7,752,926	20,811	5,312	68.52	25.52	95,986	1,238	461
2009	7,929,724	20,822	4,469	56.36	21.46	89,607	1,130	430
2010	8,009,503	18,513	4,518	56.41	24.4	81,979	1,024	443
2011	8,437,502	18,500	4,612	54.66	24.93	81,399	965	440
2012	8,454,939	21,385	4,986	58.97	23.32	93,000	1,103	436
2013	8,404,687	20,366	4,692	55.83	23.04	89,000	1,056	436
2014	8,417,718	19,970	4,594	54.58	23.00	92,000	1,093	461
2015	8,600,936	19,606	5,029	58.47	25.65	89,000	1,032	453
2016	8,679,380	20,445	5,337	61.49	26.10	104,000	1,203	511
2017	8,664,108	20,149	5,226	60.32	25.94	89,000	1,023	440
2018	8,659,741	20,076	5,038	58.18	25.09	82,000	945	408
2019	8,596,314	19,688	5,044	58.33	25.47	84,000	975	426

Sources: National Center for Statistics and Analysis, 2021, Table 10. Note that 2019 fatalities were revised to 5,044 in March 2022. This revised number is used throughout this analysis.

FARS 1975-2018 Final, 2019 ARF; NASS GES 1988-2015; CRSS 2016-2019; Registered Motorcycles and Vehicle Miles Traveled-Federal Highway Administration.

* Injury data not available before 1988.

Table 11-2. Motorcyclist KABCO/MAIS Translator

	O	C	B	A	K	ISU
0	0.643066055	0.052205624	0.025686451	0.005539356	NA	0.054279749
1	0.309204773	0.69708257	0.71882592	0.330751238	NA	0.725585711
2	0.04369182	0.199188736	0.183424819	0.304692632	NA	0.141846439
3	0.003527217	0.048393073	0.068954122	0.296501754	NA	0.070749246
4	0.000510135	0.001452865	0.002469204	0.027276223	NA	0.007538854
5	0	0.001677132	0.000397765	0.028842303	NA	0
Fatality			0.000241719	0.006396495	NA	0
Total	**1**	**1**	**1**	**1**	NA	**1**

Table 11-3. Motorcycle Riders, Incidence Summary, 2019

	CRSS Translated	% Unreported	# Unreported	Total
MAIS0	3,475	48.09%	3,220	6,695
MAIS1	61,060	33.89%	31,301	92,361
MAIS2	19,882	27.22%	7,437	27,318
MAIS3	10,613	6.34%	718	11,331
MAIS4	766	0.00%	0	766
MAIS5	700	0.00%	0	700
Nonfatal Injury Total	93,021	29.78%	39,455	132,476
Fatal	5,044	0.00%	0	5,044
PDO Vehicle	16,553	59.70%	24,522	41,075

The crash environment faced by motorcyclists results in an injury profile skewed more toward serious injuries than the typical crash in a passenger car or light truck. Minor injuries (MAIS1) represent over 84 percent of police-reported injuries for the general crash population, but they represent only 70 percent of police-reported motorcyclist injuries. The more serious MAIS2-5 injuries represent 30 percent of motorcyclist injuries, compared to only 16 percent for the general crash population. In addition, within each MAIS category, the type of injuries typically received is different for motorcyclists. For example, motorcyclists, especially those who do not wear helmets, are more likely to receive head injuries than are their counterparts in regular passenger vehicles. Lower extremity injuries are also more likely since a crashed motorcycle is likely to fall over and crush lower limbs. These differences produce different average injury costs within each MAIS category. In the 2015 NHTSA cost report to assess these injuries, we isolated crash records for motorcycle occupants on the crash file described in the Incidence chapter of that report. For this current report, we adopted the 2015 ratios of motorcycle crash costs, both helmeted and unhelmeted, to average crash costs for all crash victims by each severity level. We applied those ratios to the revised 2019 unit costs derived in Chapter 3 of this report. The resulting average unit costs are shown in Table 11-4. Also in Table 11-4, these motorcycle occupant specific costs are combined with injury incidence from Table 11-2 to estimate the total costs associated with motorcycle rider crashes.[26]

In 2019, motorcycle rider crashes cost $16.9 billion in economic impacts, and $107.1 billion in societal harm as measured by comprehensive costs. Compared to other motor vehicle crashes, these costs are disproportionately caused by fatalities and serious injuries.

Table 11-4. Motorcycle Rider Unit Costs and Total Costs (2019 $)

	Incidence	**Unit Economic Costs**	**Total Economic Costs (Millions)**	**Unit Comprehensive Costs**	**Total Comprehensive Costs (Millions)**
MAIS0	6,017	$2,430	$15	$2,430	$15
MAIS1	92,361	$14,871	$1,373	$68,068	$6,287
MAIS2	27,318	$69,194	$1,890	$413,400	$11,293
MAIS3	11,331	$295,580	$3,349	$2,116,134	$23,977
MAIS4	766	$744,369	$570	$3,942,317	$3,021
MAIS5	700	$820,357	$574	$5,572,556	$3,902
Fatal	5,044	$1,781,477	$8,986	$11,602,884	$58,525
PDO	37,815	$3,183	$120	$3,183	$120
Total			$16,879		$107,141

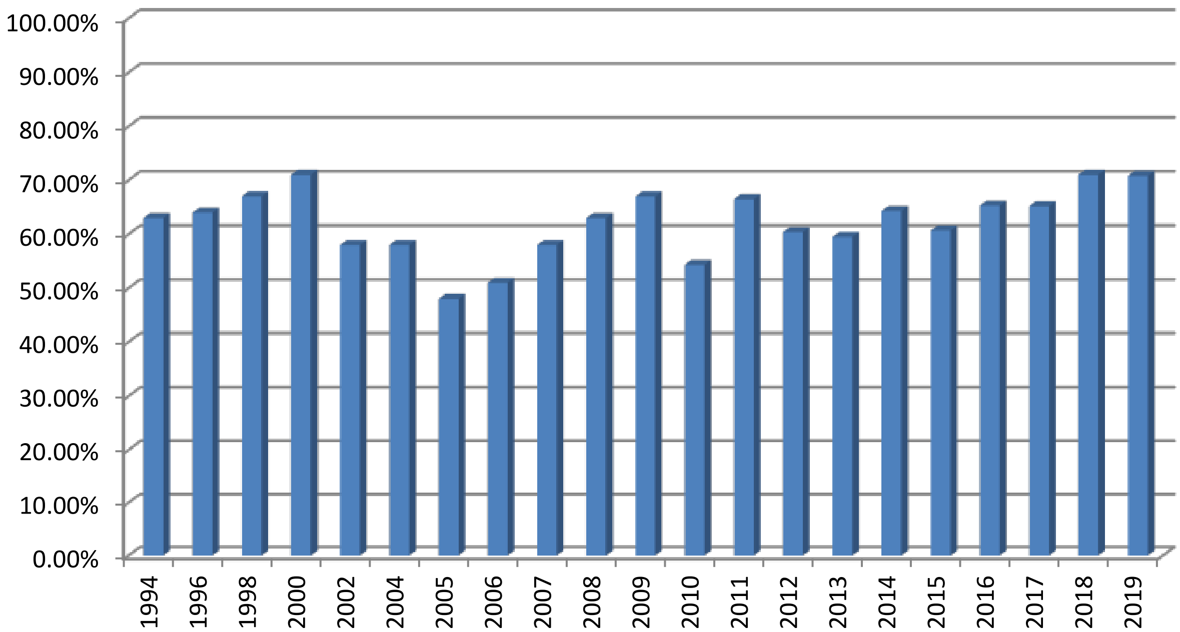
Impacts of Helmet Use

Motorcycle helmet usage is the most important action that motorcycle riders can take to protect themselves in the event of a crash. Helmets reduce the chance of fatal injury by 37 percent for motorcycle operators and by 41 percent for passengers (Deutermann, 2004). They reduce the chance of nonfatal serious injury by 13 percent and minor injury by 8 percent (Blincoe, 1988). Unfortunately, only about 70 percent of motorcycle riders currently wear helmets. This causes unnecessary loss of life and critical injury, as well as considerable preventable economic loss to society. Figure 11-C illustrates the historical trend in motorcycle rider helmet use from 1994 through 2019 from NOPUS.

Helmet use peaked in 2000, but then declined after several States repealed their helmet use laws. It reached a nadir in 2005, but has since slowly increased due to a number of factors including public awareness and possibly shifting attitudes associated with the age of riders. Note that there was a noticeable decline in observed use in 2010, but this was followed by a return to 2009 levels in 2011. The 2010 drop was not mirrored by a similar drop in use in crash data, raising the possibility that the observation survey recorded a less representative sample that year. Use declined again in 2012, but then began to gradually improve. By 2019, use had returned to its historical peak of roughly 70 percent. Note, however, that calculations used in this analysis are based on police-reported use in crashes, not the NOPUS survey.

[26] Note that these represent costs for motorcycle riders. They do not include costs for other vehicle occupants or pedestrians in crashes with motorcyclists, which are not examined here.

Figure 11-C. Observed Helmet Use



Source: National Occupant Protection Use Survey (NOPUS), 1994-2019 data

NHTSA has published historical estimates of lives that have been saved by helmets, as well as those that could have been saved, but were instead lost due to helmet nonuse. To determine the cost impact of these savings, similar estimates must be derived for nonfatal injuries. The methods used to estimate savings from helmet use have been established in several studies.[27] Different approaches apply depending on the type of data available. For this study we based our calculations on methods used in the NHTSA 2011 Research Note because we were able to develop separate incidence for helmeted and unhelmeted riders, and it contains the most up to date effectiveness estimates. Helmets are estimated to be 37 percent effective against fatalities, 13 percent effective against nonfatal MAIS2 through5 injuries, and 8 percent effective against minor injuries.

A first step in this process was to develop separate helmeted and unhelmeted incidence profiles using the same methods and translators as were used for the overall incidence estimate, but specific to cases with known helmet status. We then distributed cases with Unknown helmet status according to the known cases. The results are shown in Tables 11-5 and 11-6.

[27] See NHTSA, 1988, Blincoe, 1994, and NHTSA, 2011b.

Table 11-5. Helmeted Motorcycle Injured Riders, Incidence Summary, 2019

	Police-Reported	% Unreported	# Unreported	Total
MAIS0	1,907	48.09%	1,767	3,674
MAIS1	41,020	33.89%	21,028	62,047
MAIS2	13,238	27.22%	4,952	18,190
MAIS3	6,912	6.34%	468	7,379
MAIS4	491	0.00%	0	491
MAIS5	447	0.00%	0	447
Nonfatal Injury Total	62,108	29.78%	26,447	88,555
Fatal	2,998	0.00%	0	2,998
PDO	10,437	59.70%	15,461	25,897

Table 11-6 Unhelmeted Motorcycle Injured Riders, Incidence Summary, 2019

	Police-Reported	% Unreported	# Unreported	Total
MAIS0	1,543	48.09%	1,430	2,973
MAIS1	22,453	33.89%	11,510	33,963
MAIS2	7,252	27.22%	2,712	9,964
MAIS3	3,947	6.34%	267	4,213
MAIS4	293	0.00%	0	293
MAIS5	268	0.00%	0	268
Nonfatal Injury Total	34,212	29.78%	14,489	48,701
Fatal	2,046	0.00%	0	2,046
PDO	8,445	59.70%	12,510	20,955

Unhelmeted motorcycle crash victims have more severe injuries than do those who wear helmets. These injuries are also more expensive to treat and result in more lost quality-of-life. To determine benefits from helmet use, we isolated crash records separately for helmeted and unhelmeted motorcycle occupants on the crash file described in section 2. The resulting average unit costs are shown in Tables 11-7 and 11-8. Also in these tables, these motorcycle occupant helmet status specific costs are combined with injury incidence from Tables 11-5 and 11-6 to estimate the total costs associated with helmeted and unhelmeted motorcycle riders. Unhelmeted riders make up 36 percent of all motorcycle injuries, but, due to their more serious injury profile, account for 39 percent of total economic and total comprehensive costs caused by these crashes.

Table 11-7. Helmeted Motorcycle Rider Unit Costs and Total Costs (2019 $)

	Incidence	**Unit Economic Costs**	**Total Economic Costs (millions)**	**Unit Comprehensive Costs**	**Total Comprehensive Costs (millions)**
MAIS0	3,674	$2,200	$8	$2,200	$8
MAIS1	62,047	$14,068	$873	$64,007	$3,971
MAIS2	18,190	$66,617	$1,212	$396,874	$7,219
MAIS3	7,379	$289,065	$2,133	$2,063,750	$15,229
MAIS4	491	$708,534	$348	$3,730,078	$1,832
MAIS5	447	$708,408	$317	$4,539,645	$2,030
Fatal	2,998	$1,781,477	$5,341	$11,602,884	$34,785
PDO Vehicle	25,897	$2,569	$67	$2,569	$67
Total			$10,298		$65,142

Table 11-8. Unhelmeted Motorcycle Rider Unit Costs and Total Costs (2019 $)

	Incidence	**Unit Economic Costs**	**Total Economic Costs (millions)**	**Unit Comprehensive Costs**	**Total Comprehensive Costs (millions)**
MAIS0	2,973	$2,200	$7	$2,200	$7
MAIS1	33,963	$14,739	$501	$68,171	$2,315
MAIS2	9,964	$68,098	$679	$408,914	$4,074
MAIS3	4,213	$288,593	$1,216	$2,076,164	$8,748
MAIS4	293	$759,626	$222	$4,060,781	$1,189
MAIS5	268	$962,761	$258	$6,995,100	$1,872
Fatal	2,046	$1,781,477	$3,645	$11,602,884	$23,740
PDO Vehicle	20,955	$2,569	$54	$2,569	$54
Total			$6,580		$41,999

Using methods described in NHTSA (2011b), the lives saved, serious (MAIS2-5) injuries and minor (MAIS1) injuries avoided due to helmet use and non-use were calculated and combined with the unit costs from Table 11-8 to derive estimates of the economic impact of helmet use and non-use from 1975 through 2019. The results are summarized in Tables 11-9 and 11-10. Over this 45-year period, motorcycle helmets have saved over $92 billion in economic costs (2019 $). However, another $65 billion in potential economic savings was lost due to the refusal of some riders to wear helmets. Helmets are currently saving $3.2 billion in economic costs annually, but another $1.4 billion in potential savings is lost to helmet nonuse. As shown in Figures 11-D and 11-E, the gap between potential benefits and achieved benefits has grown smaller over time, but there is still considerable progress to be made if all motorcycle riders can be persuaded to wear helmets.

Table 11-9. Economic Benefits of Helmet Use, 1975-2019

Year	Lives Saved by Helmets	Cost/Fatality Current $	MAIS 2-5 Injuries Prevented	MAIS2-5 Cost/Injury Current $	MAIS 1 Injuries Prevented	MAIS1 Cost/Injury Current $	Current $ (millions)	2019 $ (millions)
1975	823	$371,603	2,660	$32,183	3,623	$1,786	$398	$1,613
1976	788	$393,015	2,546	$34,037	3,468	$1,889	$403	$1,544
1977	970	$418,571	3,142	$36,251	4,280	$2,012	$529	$1,902
1978	900	$450,344	2,913	$39,002	3,968	$2,164	$528	$1,764
1979	885	$501,457	2,858	$43,429	3,893	$2,410	$577	$1,734
1980	871	$569,146	2,833	$49,291	3,859	$2,735	$646	$1,709
1981	843	$627,857	2,731	$54,376	3,720	$3,017	$689	$1,653
1982	816	$666,537	2,645	$57,726	3,603	$3,203	$708	$1,600
1983	735	$687,949	2,381	$59,580	3,244	$3,306	$658	$1,441
1984	813	$717,649	2,640	$62,153	3,597	$3,449	$760	$1,595
1985	788	$743,206	2,550	$64,366	3,473	$3,572	$762	$1,545
1986	807	$757,020	2,632	$65,562	3,586	$3,638	$797	$1,585
1987	667	$784,648	2,171	$67,955	2,958	$3,771	$682	$1,309
1988	622	$817,112	1,967	$70,767	2,679	$3,927	$658	$1,213
1989	561	$856,482	1,727	$74,176	2,353	$4,116	$618	$1,087
1990	655	$902,760	1,956	$78,184	2,665	$4,338	$756	$1,261
1991	595	$940,749	1,739	$81,474	2,368	$4,521	$712	$1,140
1992	641	$969,068	1,824	$83,927	2,485	$4,657	$786	$1,221
1993	671	$998,078	1,857	$86,439	2,530	$4,796	$842	$1,271
1994	625	$1,023,634	1,689	$88,653	2,300	$4,919	$801	$1,178
1995	624	$1,052,644	1,648	$91,165	2,245	$5,059	$818	$1,171
1996	617	$1,083,726	1,590	$93,857	2,166	$5,208	$829	$1,152
1997	627	$1,108,592	1,582	$96,010	2,155	$5,328	$858	$1,166
1998	660	$1,125,860	1,627	$97,506	2,216	$5,411	$914	$1,222
1999	745	$1,150,725	1,800	$99,659	2,452	$5,530	$1,050	$1,375

Year	Lives Saved by Helmets	Cost/Fatality Current $	MAIS 2-5 Injuries Prevented	MAIS2-5 Cost/Injury Current $	MAIS 1 Injuries Prevented	MAIS1 Cost/Injury Current $	Current $ (millions)	2019 $ (millions)
2000	872	$1,189,405	2,058	$103,009	2,804	$5,716	$1,265	$1,602
2001	947	$1,223,250	2,193	$105,940	2,988	$5,879	$1,408	$1,734
2002	992	$1,242,590	2,253	$107,615	3,068	$5,972	$1,493	$1,810
2003	1,173	$1,270,909	2,603	$110,068	3,546	$6,108	$1,799	$2,132
2004	1,324	$1,304,754	2,942	$112,999	4,007	$6,270	$2,085	$2,407
2005	1,554	$1,348,959	3,457	$116,828	4,709	$6,483	$2,531	$2,826
2006	1,667	$1,392,474	3,715	$120,596	5,061	$6,692	$2,803	$3,032
2007	1,788	$1,432,135	3,985	$124,031	5,429	$6,882	$3,092	$3,252
2008	1,836	$1,487,122	4,089	$128,793	5,571	$7,147	$3,297	$3,339
2009	1,486	$1,481,832	3,311	$128,335	4,510	$7,121	$2,659	$2,703
2010	1,551	$1,506,138	3,454	$130,440	4,705	$7,238	$2,821	$2,821
2011	1,622	$1,553,679	3,603	$134,558	4,907	$7,467	$3,041	$2,948
2012	1,715	$1,585,832	3,819	$137,342	5,202	$7,621	$3,284	$3,119
2013	1,640	$1,609,061	3,658	$139,354	4,983	$7,733	$3,187	$2,983
2014	1,673	$1,635,163	3,727	$141,614	5,077	$7,858	$3,303	$3,043
2015	1,800	$1,637,104	4,015	$141,783	5,469	$7,867	$3,559	$3,274
2016	1,885	$1,657,756	4,203	$143,571	5,725	$7,967	$3,774	$3,429
2017	1,872	$1,693,072	4,239	$146,630	5,774	$8,136	$3,838	$3,414
2018	1,832	$1,734,425	4,122	$150,211	5,615	$8,335	$3,844	$3,338
2019	1,761	$1,765,852	3,961	$152,933	5,395	$8,486	$3,761	$3,208
Total	49,339		125,116		170,429		$74,625	$91,865

Table 11-10. Economic Benefits Forgone by Helmet Nonuse

Year	Lives Lost Due to Helmet Nonuse	Cost/Fatality Current $	MAIS 2-5 Injuries Caused by Helmet Nonuse	MAIS2-5 Cost/Injury Current $	MAIS 1 Injuries Caused by Helmet Nonuse	MAIS1 Cost/Injury Current $	Current $ (millions)	2019 $ (millions)
1975	1,164	$371,603	1,101	$32,183	1,561	$1,786	$471	$1,908
1976	1,189	$393,015	1,297	$34,037	1,840	$1,889	$515	$1,973
1977	1,472	$418,571	1,616	$36,251	2,292	$2,012	$679	$2,444
1978	1,588	$450,344	2,221	$39,002	3,150	$2,164	$809	$2,704
1979	1,676	$501,457	2,557	$43,429	3,626	$2,410	$960	$2,884
1980	1,744	$569,146	2,809	$49,291	3,984	$2,735	$1,142	$3,022
1981	1,667	$627,857	2,658	$54,376	3,770	$3,017	$1,203	$2,885
1982	1,528	$666,537	2,295	$57,726	3,255	$3,203	$1,161	$2,624
1983	1,450	$687,949	2,306	$59,580	3,270	$3,306	$1,146	$2,508
1984	759	$717,649	2,444	$62,153	3,465	$3,449	$709	$1,487
1985	764	$743,206	2,467	$64,366	3,498	$3,572	$739	$1,498
1986	751	$757,020	2,410	$65,562	3,418	$3,638	$739	$1,470
1987	697	$784,648	2,240	$67,955	3,177	$3,771	$711	$1,365
1988	644	$817,112	2,035	$70,767	2,886	$3,927	$682	$1,256
1989	553	$856,482	1,717	$74,176	2,435	$4,116	$611	$1,074
1990	541	$902,760	1,651	$78,184	2,342	$4,338	$628	$1,047
1991	467	$940,749	1,395	$81,474	1,979	$4,521	$562	$900
1992	323	$969,068	950	$83,927	1,347	$4,657	$399	$620
1993	336	$998,078	977	$86,439	1,385	$4,796	$426	$644
1994	339	$1,023,634	976	$88,653	1,384	$4,919	$440	$648
1995	326	$1,052,644	917	$91,165	1,301	$5,059	$433	$620
1996	324	$1,083,726	897	$93,857	1,272	$5,208	$442	$614
1997	315	$1,108,592	860	$96,010	1,220	$5,328	$438	$595
1998	369	$1,125,860	995	$97,506	1,411	$5,411	$520	$696
1999	396	$1,150,725	1,049	$99,659	1,488	$5,530	$568	$744

Year	Lives Lost Due to Helmet Nonuse	Cost/Fatality Current $	MAIS 2-5 Injuries Caused by Helmet Nonuse	MAIS2-5 Cost/Injury Current $	MAIS 1 Injuries Caused by Helmet Nonuse	MAIS1 Cost/Injury Current $	Current $ (millions)	2019 $ (millions)
2000	478	$1,189,405	1,254	$103,009	1,778	$5,716	$708	$896
2001	558	$1,223,250	1,439	$105,940	2,041	$5,879	$847	$1,043
2002	576	$1,242,590	1,466	$107,615	2,078	$5,972	$886	$1,074
2003	651	$1,270,909	1,633	$110,068	2,315	$6,108	$1,021	$1,210
2004	673	$1,304,754	1,687	$112,999	2,392	$6,270	$1,084	$1,251
2005	731	$1,348,959	1,835	$116,828	2,602	$6,483	$1,217	$1,359
2006	756	$1,392,474	1,896	$120,596	2,689	$6,692	$1,299	$1,405
2007	805	$1,432,135	2,020	$124,031	2,865	$6,882	$1,423	$1,497
2008	827	$1,487,122	2,076	$128,793	2,944	$7,147	$1,518	$1,538
2009	733	$1,481,832	1,838	$128,335	2,607	$7,121	$1,341	$1,363
2010	711	$1,506,138	1,783	$130,440	2,528	$7,238	$1,322	$1,322
2011	707	$1,553,679	1,765	$134,558	2,504	$7,467	$1,355	$1,313
2012	782	$1,585,832	1,962	$137,342	2,783	$7,621	$1,531	$1,454
2013	717	$1,609,061	1,801	$139,354	2,554	$7,733	$1,424	$1,333
2014	661	$1,635,163	1,660	$141,614	2,355	$7,858	$1,334	$1,229
2015	742	$1,637,104	1,863	$141,783	2,643	$7,867	$1,500	$1,380
2016	805	$1,657,756	2,019	$143,571	2,863	$7,967	$1,647	$1,496
2017	749	$1,693,072	1,889	$146,630	2,679	$8,136	$1,567	$1,394
2018	710	$1,734,425	1,796	$150,211	2,547	$8,335	$1,522	$1,321
2019	757	$1,765,852	1,916	$152,933	2,717	$8,486	$1,653	$1,410
Total	35,511		78,440		111,241		$43,332	$64,521

Figure 11-D. Realized and Unrealized Fatality Benefits From Motorcycle Helmet Use

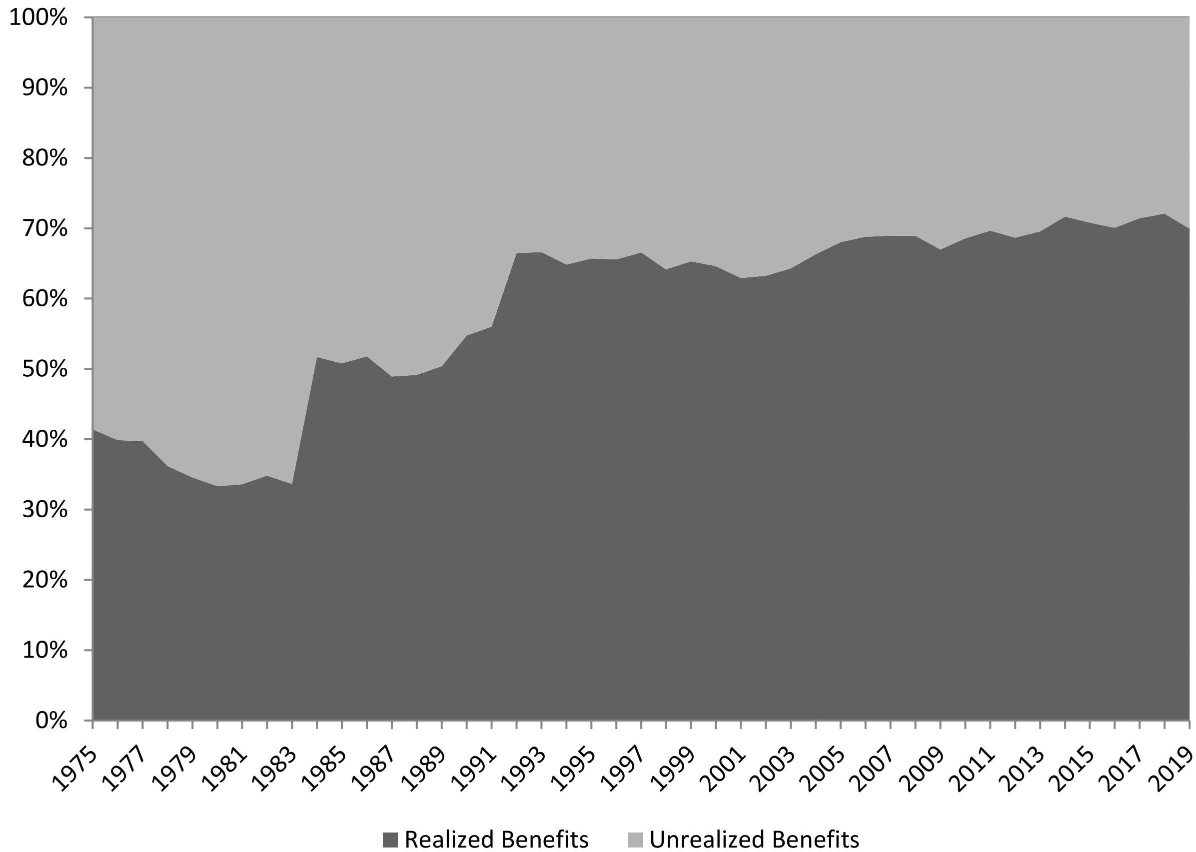
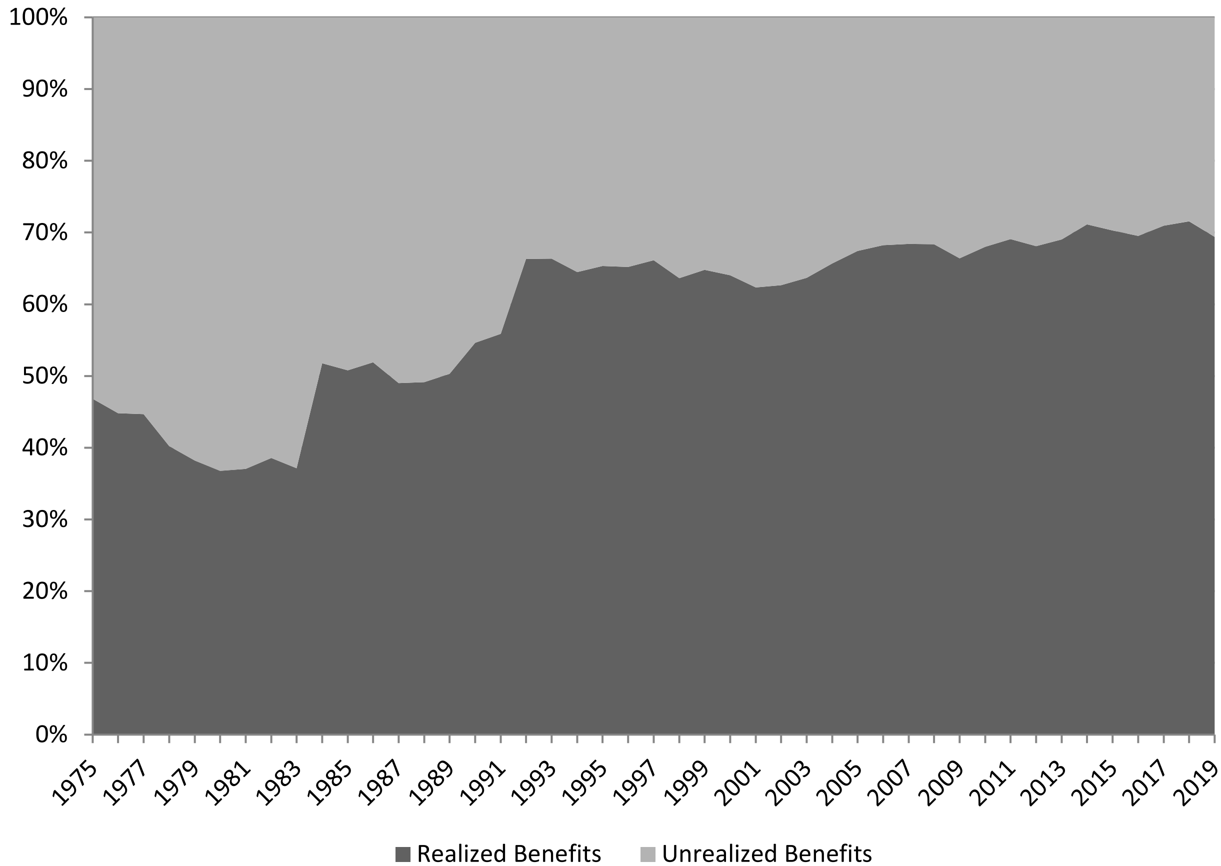


Figure 11-E. Realized and Unrealized Economic Benefits From Motorcycle Helmet Use



In Table 11-9, the societal impact of helmet use over this same time period is shown. Over $607 billion in societal harm, as measured by comprehensive costs, has been averted over the past 45 years due to motorcycle helmet use. Over this same period, an additional $346 billion in societal harm could have been prevented had all motorcycle riders worn helmets. Motorcycle helmets are currently preventing $21.2 billion in societal harm annually, but another $9.4 billion in harm could be prevented if all riders were to wear their helmets.

Table 11-11. Comprehensive Societal Benefits of Helmet Use, 1975-2019

Year	Lives Saved by Helmets	Cost/Fatality Current $	MAIS 2-5 Injuries Prevented	MAIS2-5 Cost/Injury Current $	MAIS 1 Injuries Prevented	MAIS1 Cost/Injury Current $	Current $ (millions)	2019 $ (millions)
1975	823	$2,438,402	2,660	$225,075	3,623	$8,260	$2,635	$10,681
1976	788	$2,578,905	2,546	$238,044	3,468	$8,736	$2,668	$10,226
1977	970	$2,746,602	3,142	$253,523	4,280	$9,304	$3,501	$12,596
1978	900	$2,955,089	2,913	$272,767	3,968	$10,010	$3,494	$11,685
1979	885	$3,290,483	2,858	$303,725	3,893	$11,146	$3,824	$11,484
1980	871	$3,734,653	2,833	$344,724	3,859	$12,651	$4,278	$11,322
1981	843	$4,119,902	2,731	$380,284	3,720	$13,956	$4,564	$10,947
1982	816	$4,373,714	2,645	$403,712	3,603	$14,815	$4,690	$10,598
1983	735	$4,514,216	2,381	$416,681	3,244	$15,291	$4,360	$9,545
1984	813	$4,709,107	2,640	$434,670	3,597	$15,951	$5,034	$10,564
1985	788	$4,876,804	2,550	$450,149	3,473	$16,520	$5,048	$10,230
1986	807	$4,967,451	2,632	$458,516	3,586	$16,827	$5,276	$10,497
1987	667	$5,148,745	2,171	$475,250	2,958	$17,441	$4,518	$8,672
1988	622	$5,361,765	1,967	$494,913	2,679	$18,162	$4,357	$8,031
1989	561	$5,620,109	1,727	$518,759	2,353	$19,037	$4,094	$7,199
1990	655	$5,923,776	1,956	$546,789	2,665	$20,066	$5,003	$8,347
1991	595	$6,173,055	1,739	$569,799	2,368	$20,910	$4,713	$7,546
1992	641	$6,358,881	1,824	$586,951	2,485	$21,540	$5,200	$8,082
1993	671	$6,549,240	1,857	$604,522	2,530	$22,185	$5,573	$8,411
1994	625	$6,716,936	1,689	$620,001	2,300	$22,753	$5,297	$7,794
1995	624	$6,907,295	1,648	$637,572	2,245	$23,398	$5,413	$7,746
1996	617	$7,111,250	1,590	$656,398	2,166	$24,088	$5,483	$7,621
1997	627	$7,274,415	1,582	$671,459	2,155	$24,641	$5,676	$7,712
1998	660	$7,387,724	1,627	$681,917	2,216	$25,025	$6,041	$8,081
1999	745	$7,550,888	1,800	$696,978	2,452	$25,578	$6,943	$9,087

Year	Lives Saved by Helmets	Cost/Fatality Current $	MAIS 2-5 Injuries Prevented	MAIS2-5 Cost/Injury Current $	MAIS 1 Injuries Prevented	MAIS1 Cost/Injury Current $	Current $ (millions)	2019 $ (millions)
2000	872	$7,804,699	2,058	$720,406	2,804	$26,437	$8,363	$10,589
2001	947	$8,026,784	2,193	$740,905	2,988	$27,190	$9,308	$11,460
2002	992	$8,153,690	2,253	$752,619	3,068	$27,620	$9,869	$11,962
2003	1,173	$8,339,516	2,603	$769,772	3,546	$28,249	$11,886	$14,086
2004	1,324	$8,561,601	2,942	$790,271	4,007	$29,001	$13,777	$15,903
2005	1,554	$8,851,671	3,457	$817,046	4,709	$29,984	$16,721	$18,669
2006	1,667	$9,137,209	3,715	$843,402	5,061	$30,951	$18,522	$20,033
2007	1,788	$9,397,456	3,985	$867,424	5,429	$31,833	$20,432	$21,488
2008	1,836	$9,758,276	4,089	$900,729	5,571	$33,055	$21,784	$22,062
2009	1,486	$9,723,559	3,311	$897,525	4,510	$32,937	$17,569	$17,858
2010	1,551	$9,883,052	3,454	$912,247	4,705	$33,478	$18,637	$18,637
2011	1,622	$10,195,013	3,603	$941,042	4,907	$34,534	$20,096	$19,481
2012	1,715	$10,405,994	3,819	$960,516	5,202	$35,249	$21,698	$20,608
2013	1,640	$10,558,417	3,658	$974,586	4,983	$35,765	$21,059	$19,712
2014	1,673	$10,729,694	3,727	$990,395	5,077	$36,345	$21,826	$20,104
2015	1,800	$10,742,430	4,015	$991,571	5,469	$36,389	$23,517	$21,635
2016	1,885	$10,877,947	4,203	$1,004,080	5,725	$36,848	$24,936	$22,656
2017	1,872	$11,109,686	4,239	$1,025,470	5,774	$37,633	$25,362	$22,561
2018	1,832	$11,381,037	4,122	$1,050,517	5,615	$38,552	$25,402	$22,059
2019	1,761	$11,587,259	3,961	$1,069,552	5,395	$39,250	$24,850	$21,195
Total	49,339		125,116		170,429		$493,296	$607,463

Table 11-12. Comprehensive Benefits Forgone by Helmet Nonuse

Year	Lives Lost Due to Helmet Nonuse	Cost/Fatality Current $	MAIS2-5 Injuries Caused by Helmet Nonuse	MAIS2-5 Cost/Injury Current $	MAIS1 Injuries Caused by Helmet Nonuse	MAIS1 Cost/Injury Current $	Current $ (millions)	2019 $ (millions)
1975	1,164	$2,438,402	1,101	$225,075	3,623	$8,260	$3,116	$12,630
1976	1,189	$2,578,905	1,297	$238,044	3,468	$8,736	$3,405	$13,050
1977	1,472	$2,746,602	1,616	$253,523	4,280	$9,304	$4,493	$16,165
1978	1,588	$2,955,089	2,221	$272,767	3,968	$10,010	$5,338	$17,853
1979	1,676	$3,290,483	2,557	$303,725	3,893	$11,146	$6,335	$19,027
1980	1,744	$3,734,653	2,809	$344,724	3,859	$12,651	$7,530	$19,928
1981	1,667	$4,119,902	2,658	$380,284	3,720	$13,956	$7,931	$19,025
1982	1,528	$4,373,714	2,295	$403,712	3,603	$14,815	$7,663	$17,316
1983	1,450	$4,514,216	2,306	$416,681	3,244	$15,291	$7,556	$16,543
1984	759	$4,709,107	2,444	$434,670	3,597	$15,951	$4,694	$9,851
1985	764	$4,876,804	2,467	$450,149	3,473	$16,520	$4,894	$9,917
1986	751	$4,967,451	2,410	$458,516	3,586	$16,827	$4,896	$9,741
1987	697	$5,148,745	2,240	$475,250	2,958	$17,441	$4,705	$9,031
1988	644	$5,361,765	2,035	$494,913	2,679	$18,162	$4,509	$8,311
1989	553	$5,620,109	1,717	$518,759	2,353	$19,037	$4,043	$7,110
1990	541	$5,923,776	1,651	$546,789	2,665	$20,066	$4,161	$6,942
1991	467	$6,173,055	1,395	$569,799	2,368	$20,910	$3,727	$5,968
1992	323	$6,358,881	950	$586,951	2,485	$21,540	$2,665	$4,142
1993	336	$6,549,240	977	$604,522	2,530	$22,185	$2,847	$4,297
1994	339	$6,716,936	976	$620,001	2,300	$22,753	$2,934	$4,317
1995	326	$6,907,295	917	$637,572	2,245	$23,398	$2,889	$4,134
1996	324	$7,111,250	897	$656,398	2,166	$24,088	$2,945	$4,093
1997	315	$7,274,415	860	$671,459	2,155	$24,641	$2,922	$3,970
1998	369	$7,387,724	995	$681,917	2,216	$25,025	$3,460	$4,629
1999	396	$7,550,888	1,049	$696,978	2,452	$25,578	$3,784	$4,953

Year	Lives Lost Due to Helmet Nonuse	Cost/Fatality Current $	MAIS2-5 Injuries Caused by Helmet Nonuse	MAIS2-5 Cost/Injury Current $	MAIS1 Injuries Caused by Helmet Nonuse	MAIS1 Cost/Injury Current $	Current $ (millions)	2019 $ (millions)
2000	478	$7,804,699	1,254	$720,406	2,804	$26,437	$4,708	$5,962
2001	558	$8,026,784	1,439	$740,905	2,988	$27,190	$5,626	$6,928
2002	576	$8,153,690	1,466	$752,619	3,068	$27,620	$5,884	$7,132
2003	651	$8,339,516	1,633	$769,772	3,546	$28,249	$6,786	$8,042
2004	673	$8,561,601	1,687	$790,271	4,007	$29,001	$7,211	$8,324
2005	731	$8,851,671	1,835	$817,046	4,709	$29,984	$8,111	$9,056
2006	756	$9,137,209	1,896	$843,402	5,061	$30,951	$8,664	$9,371
2007	805	$9,397,456	2,020	$867,424	5,429	$31,833	$9,490	$9,981
2008	827	$9,758,276	2,076	$900,729	5,571	$33,055	$10,124	$10,253
2009	733	$9,723,559	1,838	$897,525	4,510	$32,937	$8,926	$9,072
2010	711	$9,883,052	1,783	$912,247	4,705	$33,478	$8,811	$8,811
2011	707	$10,195,013	1,765	$941,042	4,907	$34,534	$9,039	$8,762
2012	782	$10,405,994	1,962	$960,516	5,202	$35,249	$10,205	$9,693
2013	717	$10,558,417	1,801	$974,586	4,983	$35,765	$9,504	$8,896
2014	661	$10,729,694	1,660	$990,395	5,077	$36,345	$8,921	$8,217
2015	742	$10,742,430	1,863	$991,571	5,469	$36,389	$10,018	$9,216
2016	805	$10,877,947	2,019	$1,004,080	5,725	$36,848	$10,995	$9,989
2017	749	$11,109,686	1,889	$1,025,470	5,774	$37,633	$10,476	$9,319
2018	710	$11,381,037	1,796	$1,050,517	5,615	$38,552	$10,179	$8,840
2019	757	$11,587,259	1,916	$1,069,552	5,395	$39,250	$11,033	$9,410
Total	28,881		61,768		122,281		$197,785	$345,874

12. Pedestrian and Bicyclist Crashes

Pedestrian Crashes

Pedestrian crashes are defined to include all crashes where a pedestrian was involved. This includes cases where a driver swerves to avoid a pedestrian and crashes his vehicle, causing property damage or injury to the vehicle occupants. It thus includes counts of all fatalities, injuries, or property damage that occur in crashes where a pedestrian was involved, regardless of whether the pedestrian was struck or injured. Calculations pedestrian crash frequencies and costs were developed using the same proportional distribution techniques described in previous chapters (see, for example, Chapter 14).

Pedestrian crashes resulted in 6,351 fatalities, 122,000 injuries, and 6,500 PDO damaged vehicles in 2019. This represents 17 percent of all fatalities, 3 percent of all nonfatal injuries and roughly 1 percent of all nonfatal crashes (including both nonfatal injury and PDO). Pedestrian fatalities have been steadily increasing for the last decade, rising from 4,302 (13% of all motor vehicle fatalities) in 2010 to 6,351 (17%) in 2019 (NCSA, 2021b, with update to 2019 fatality count effective June 2022). These crashes caused $17.6 billion in economic costs and $112.5 billion in comprehensive costs, accounting for 5 percent of all economic costs, and 8 percent of all societal harm (measured as comprehensive costs). These costs are summarized in Tables 12-1 and 12-2 below.

Table 12-1. Economic Costs of Pedestrian Crashes

	%	Incidence		Total Economic Crash Costs (millions 2019 $)		
	% Pedestrian	**Total**	**Pedestrian**	**Total**	**Pedestrian**	**Other**
PDO Vehicles	0.03%	19,288,139	6,505	$101,282	$34	$101,248
MAIS0	2.79%	4,525,901	126,357	$14,718	$411	$14,307
MAIS1	2.32%	3,875,265	90,061	$74,963	$1,742	$73,221
MAIS2	4.97%	427,119	21,236	$30,504	$1,517	$28,988
MAIS3	6.31%	141,167	8,910	$39,629	$2,501	$37,128
MAIS4	4.66%	19,285	899	$13,031	$608	$12,424
MAIS5	8.32%	7,187	598	$7,039	$586	$6,453
Fatalities	17.40%	36,500	6,351	$58,643	$10,204	$48,438
Total	0.92%	28,320,563	260,918	$339,809	$17,603	$322,206
Percentage of Total		100.00%	0.92%	100.00%	5.18%	94.82%

Table 12-2. Comprehensive Costs of Pedestrian Crashes

	% Pedestrian	Incidence		Total Comprehensive Crash Costs (millions 2019 $)		
		Total	**Pedestrian**	**Total**	**Pedestrian**	**Other**
PDO Vehicles	0.03%	19,288,139	6,505	$101,282	$34	$101,248
MAIS0	2.79%	4,525,901	126,357	$14,718	$411	$14,307
MAIS1	2.32%	3,875,265	90,061	$234,283	$5,445	$228,838
MAIS2	4.97%	427,119	21,236	$202,352	$10,061	$192,291
MAIS3	6.31%	141,167	8,910	$288,631	$18,218	$270,413
MAIS4	4.66%	19,285	899	$69,690	$3,250	$66,440
MAIS5	8.32%	7,187	598	$43,471	$3,618	$39,853
Fatalities	17.40%	36,500	6,351	$410,935	$71,506	$339,429
Total	0.92%	28,320,563	260,918	$1,365,362	$112,543	$1,252,819
Percentage of Total		100.00%	0.92%	100.00%	8.24%	91.76%

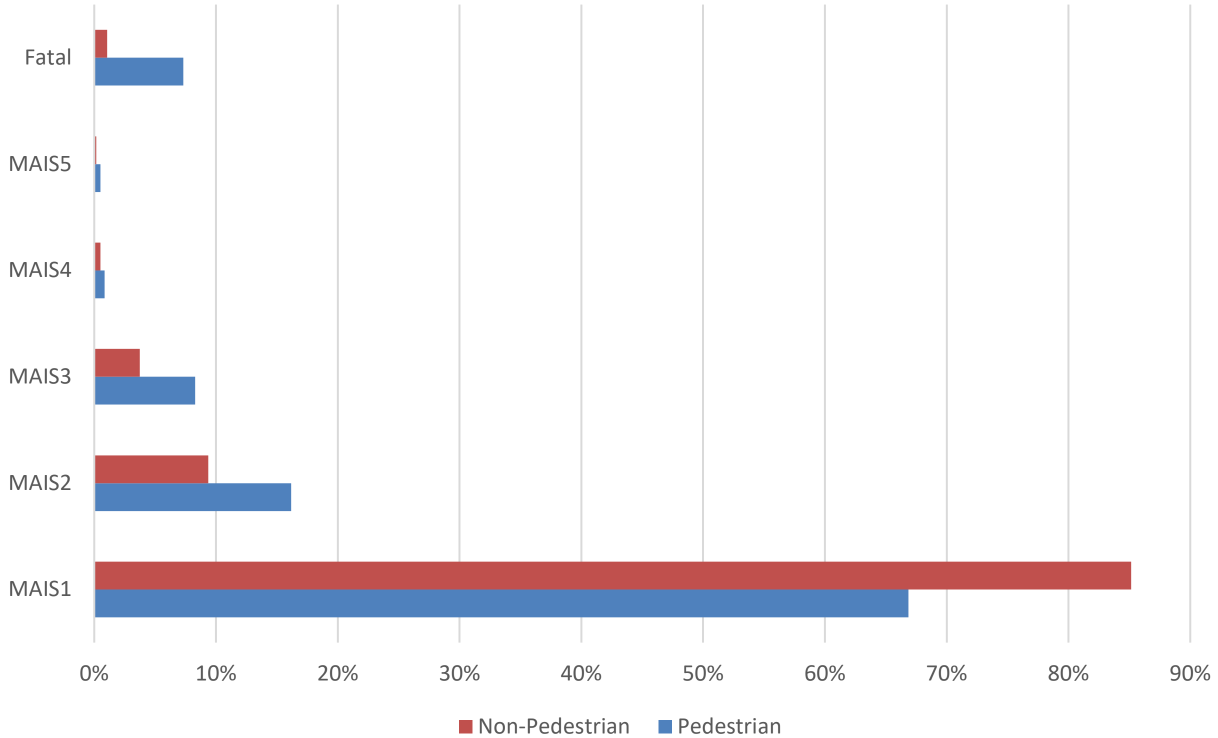
Pedestrian Injury Severity

With no surrounding vehicle structure to protect them, pedestrians are particularly vulnerable in the event of a crash. This is reflected in the more severe injury profile that pedestrians experience. Table 12-3 and Figure 12-A illustrate the average injury profile for pedestrians compared to that for all crash injuries. Relative to non-pedestrian injuries, the pedestrian injury profile is skewed toward the more serious injuries. The portion of pedestrian injuries that are MAIS2-5 ranges from 1.6 to 3.0 times the respective portions for non-pedestrian injuries, while the fatality portion is nearly 7 times the portion for non-pedestrian injuries. By contrast, the portion of injuries that are considered minor is much higher for non-pedestrian injuries.

Table 12-3. Injury Severity Distribution by Pedestrian Status

Injury Severity	Pedestrian	Non-Pedestrian	Ratio/Non-Pedestrian
MAIS1	66.85%	85.15%	0.79
MAIS2	16.18%	9.37%	1.73
MAIS3	8.30%	3.73%	2.22
MAIS4	0.84%	0.52%	1.61
MAIS5	0.50%	0.17%	3.00
Fatal	7.32%	1.05%	6.95

Figure 12-A. Relative Injury Distribution for Pedestrian and Non-Pedestrian Injuries



Pedestrians also experience different types of injuries within each injury severity category. For example, pedestrians have a high incidence of head, spine, and lower extremity injuries. Because costs of specific injuries differ, the average unit cost of a pedestrian injury of a specific MAIS level also differs from that of an occupant injury of the same MAIS severity. Table 12-4 summarizes these different unit costs for injured occupants and three categories of non-occupants. Note that these totals represent medical care, work loss, household productivity, insurance administration, legal costs, and lost quality-of-life. These are the primary categories that would vary with injury profiles. Note that costs are also influenced by the age and sex of injury victims, with a significant portion of pedestrian injuries occurring among the elderly.

Table 12-4. Unit Costs by Injured Person Crash Status Injury Severity Categories Only (2019 $)*

	Occupants	Motorcyclists	Pedestrians	Bicyclists
MAIS1	$45,824	$60,605	$70,814	$62,254
MAIS2	$472,974	$405,189	$627,462	$407,199
MAIS3	$1,928,170	$2,099,109	$2,527,135	$2,197,556
MAIS4	$3,513,643	$3,918,571	$3,588,751	$3,664,678
MAIS5	$6,246,959	$5,546,713	$5,721,875	$7,223,795
Fatal	$10,992,940	$11,571,204	$10,522,895	$10,505,421

*Includes medical care, work loss, household productivity, insurance administration, legal costs, and lost quality-of-life.

A significant portion of these differences are associated with medical care and lost productivity. This in turn is to some extent a function of varying hospitalization rates for each injury category. Table 12-5 shows hospitalization rates for these same injury categories. Nonoccupants experiencing MAIS1 injuries are admitted to the hospital for treatment at rates that are roughly 3- to 5 times those of motor vehicle occupants. This likely reflects the frequency of lower limb injuries experienced by pedestrians in encounters with vehicle bumper systems. Nonoccupants also experience higher hospitalization rates for MAIS2 and 3 injuries.

Table 12-5. Hospital Admittance Rates by Injury Category

	Occupants	Motorcyclists	Pedestrians	Bicyclists
MAIS1	0.56%	2.65%	1.99%	1.45%
MAIS2	21.45%	30.82%	34.74%	15.11%
MAIS3	78.30%	87.73%	87.50%	82.55%
MAIS4	100.00%	100.00%	100.00%	100.00%
MAIS5/6	100.00%	100.00%	100.00%	100.00%
Fatal	0.00%	0.00%	0.00%	0.00%

Table 12-6 summarizes costs associated with pedestrian injury in pedestrian crashes. Overall, injury to pedestrians accounts for 79 percent of all economic costs in these crashes, and 89 percent of all comprehensive costs. These costs do not include property damage, travel delay, or injury to vehicle occupants. This reflects the fact that property damage and congestion costs are not directly attributed to the pedestrian injury per-se. These are a small portion of comprehensive costs, but a significant portion of economic costs.

Table 12-6. Pedestrian Crash Costs Due to Injury of Pedestrian

Injury Severity	Incidence	Economic Unit Cost	Total Economic Cost	Comprehensive Unit Cost	Total Comprehensive Cost
MAIS1	49269	$6,446	$317,601,192	$70,991	$3,497,668,336
MAIS2	13138	$82,786	$1,087,641,443	$628,232	$8,253,742,794
MAIS3	6786	$359,398	$2,438,839,430	$2,531,131	$17,176,011,762
MAIS4	674	$726,167	$489,413,352	$3,597,135	$2,424,354,258
MAIS5	416	$906,156	$376,530,719	$5,730,975	$2,381,365,918
Fatalities	6,272	$1,477,572	$9,267,331,082	$10,537,544	$66,091,475,466
Pedestrian Injury Total			$13,977,357,218		$99,824,618,533
Pedestrian Crash Total			$17,603,027,990		$112,542,819,128
% Due to Pedestrian Injury			79.40%		88.70%

Bicyclist Crashes

Bicyclist crashes are defined to include all crashes where a pedalcyclist (bicyclist or other pedal driven vehicle) was involved. This includes cases where a driver swerves to avoid a bicyclist and crashes his vehicle, causing property damage or injury to the vehicle occupants. It thus includes counts of all fatalities, injuries, or property damage that occur in crashes where a bicyclist was involved, regardless of whether the bicyclist was struck or injured. Bicyclist crashes resulted in 865 fatalities, 78,700 nonfatal injuries, and 8,400 PDO damaged vehicles in 2019.[28] This represents 2.4 percent of all fatalities and 0.6 percent of all nonfatal crashes (including both nonfatal injury and PDO). These crashes caused $5.6 billion in economic costs and $32.2 billion in comprehensive costs, accounting for 1.7 percent of all economic costs, and 2.4 percent of all societal harm (measured as comprehensive costs). These costs are summarized in Tables 12-7 and 12-8 below.

[28] Bicyclist crashes include crashes of all types of pedal-cycled vehicles, such as tricycles and monocycles. However, the vast majority are bicycles.

Table 12-7. Economic Costs of Bicyclist Crashes

	% Bicyclist	Incidence		Total Economic Crash Costs (millions 2019 $)		
		Total	**Bicyclist**	**Total**	**Bicyclist**	**Other**
PDO Vehicles	0.04%	19,288,139	8,387	$101,282	$44	$101,238
MAIS0	1.75%	4,525,901	79,151	$14,718	$257	$14,461
MAIS1	1.56%	3,875,265	60,643	$74,963	$1,173	$73,790
MAIS2	2.99%	427,119	12,761	$30,504	$911	$29,593
MAIS3	3.29%	141,167	4,643	$39,629	$1,303	$38,326
MAIS4	2.15%	19,285	414	$13,031	$280	$12,751
MAIS5	3.44%	7,187	247	$7,039	$242	$6,797
Fatalities	2.37%	36,500	865	$58,643	$1,389	$57,253
Total	0.59%	28,320,563	167,110	$339,809	$5,600	$334,209
Percentage of Total		100.00%	0.59%	100.00%	1.65%	98.35%

Table 12-8. Comprehensive Costs of Bicyclist Crashes

	% Bicyclist	Incidence		Total Comprehensive Crash Costs (Millions 2019 $)		
		Total	**Bicyclist**	**Total**	**Bicyclist**	**Other**
PDO Vehicles	0.04%	19,288,139	8,387	$101,282	$44	$101,238
MAIS0	1.75%	4,525,901	79,151	$14,718	$257	$14,461
MAIS1	1.56%	3,875,265	60,643	$234,283	$3,666	$230,617
MAIS2	2.99%	427,119	12,761	$202,352	$6,046	$196,306
MAIS3	3.29%	141,167	4,643	$288,631	$9,492	$279,139
MAIS4	2.15%	19,285	414	$69,690	$1,496	$68,194
MAIS5	3.44%	7,187	247	$43,471	$1,495	$41,976
Fatalities	2.37%	36,500	865	$410,935	$9,734	$401,201
Total	0.59%	28,320,563	167,110	$1,365,362	$32,230	$1,333,131
Percentage of Total		100.00%	0.59%	100.00%	2.36%	97.64%

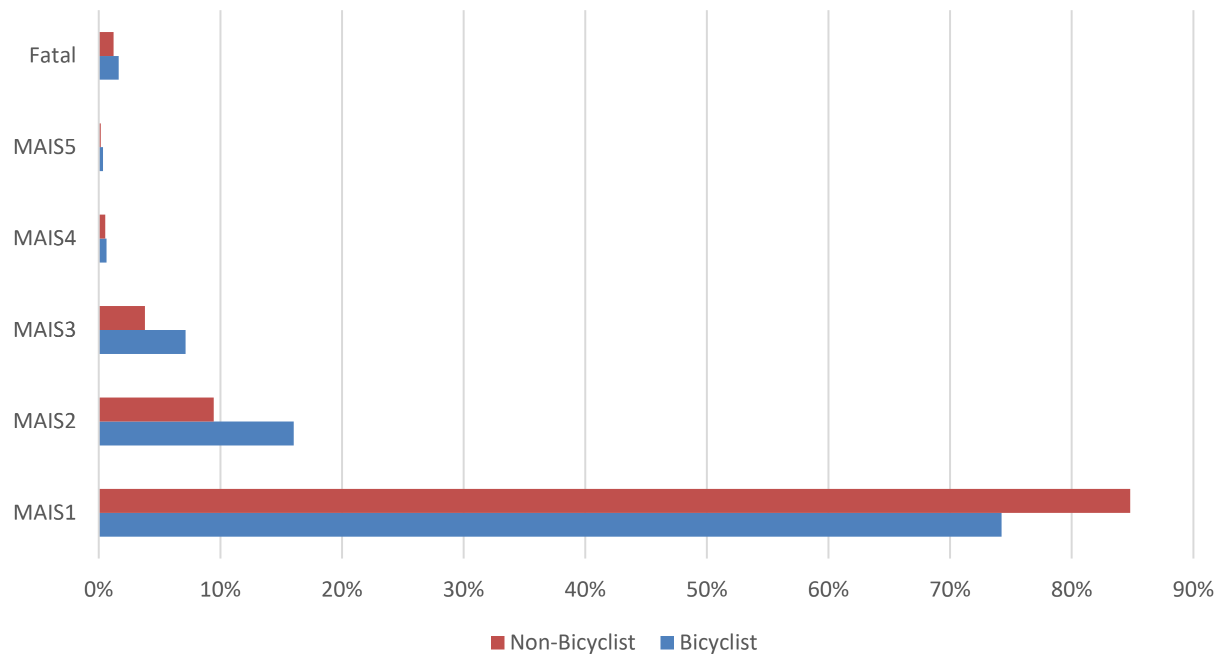
Bicyclist Injury Severity

As with pedestrians, bicyclists have no surrounding vehicle structure to protect them, and are thus particularly vulnerable in the event of a crash. This is reflected in the more severe injury profile that bicyclists experience. Table 12-9 and Figure 12-B illustrate the average injury profile for bicyclists compared to that for all crash injuries. Relative to non-bicyclist injuries, the bicyclist injury profile is skewed toward the more serious injuries. The portion of bicyclist injuries that are MAIS2-5 or fatal ranges from 1.2 to nearly double the respective portions for non-bicyclist injuries. By contrast, the portion of injuries that are considered minor is much higher for non-bicyclist injuries.

Table 12-9. Injury Severity Distribution by Bicyclist Status

Injury Severity	Bicyclist	Non-Bicyclist	Ratio/Non-Bicyclist
MAIS1	74.23%	84.81%	0.88
MAIS2	16.02%	9.45%	1.70
MAIS3	7.13%	3.81%	1.87
MAIS4	0.64%	0.53%	1.21
MAIS5/6	0.34%	0.18%	1.96
Fatal	1.64%	1.23%	1.34

Figure 12-B. Relative Injury Distribution, Bicyclist and Non-Bicyclist Crashes



Bicyclists also experience different types of injuries within each injury severity category. For example, bicyclists have a high incidence of both head and extremity injuries. Because costs of specific injuries differ, the average unit cost of a bicyclist injury of a specific MAIS level also differs from that of an occupant injury of the same MAIS severity. Table 12-10 summarizes these different unit costs for injured occupants and three categories of non-occupants. Note that these totals represent medical care, work loss, household productivity, insurance administration, legal costs, and lost quality-of-life. These are the primary categories that would vary with injury profiles. Note that costs are also influenced by the age and sex of injury victims, with a significant portion of bicyclist injuries occurring among the elderly.

Table 12-10. Unit Costs by Injured Person Crash Status, Injury Severity Categories Only (2019 $)*

	Occupants	**Motorcyclists**	**Pedestrians**	**Bicyclists**
MAIS1	$45,824	$60,605	$70,814	$62,254
MAIS2	$472,974	$405,189	$627,462	$407,199
MAIS3	$1,928,170	$2,099,109	$2,527,135	$2,197,556
MAIS4	$3,513,643	$3,918,571	$3,588,751	$3,664,678
MAIS5/6	$6,246,959	$5,546,713	$5,721,875	$7,223,795
Fatal	$10,992,940	$11,571,204	$10,522,895	$10,505,421

*Includes medical care, work loss, household productivity, insurance administration, legal costs, and lost quality-of-life.

A significant portion of these differences are associated with medical care and lost productivity. This in turn is to some extent a function of varying hospitalization rates for each injury category. Table 12-11 shows hospitalization rates for these same injury categories. Nonoccupants experiencing MAIS1 injuries are admitted to the hospital for treatment at rates that are roughly 3- to 5 times those of motor vehicle occupants. This likely reflects the frequency of lower limb injuries experienced by pedestrians and bicyclists in encounters with vehicle bumper systems. Nonoccupants also experience higher hospitalization rates for MAIS2 and 3 injuries, although bicyclists hospitalization for MAIS2s are lower.

Table 12-11. Hospital Admittance Rates by Injury Category

	Occupants	**Motorcyclists**	**Pedestrians**	**Bicyclists**
MAIS1	0.56%	2.65%	1.99%	1.45%
MAIS2	21.45%	30.82%	34.74%	15.11%
MAIS3	78.30%	87.73%	87.50%	82.55%
MAIS4	100.00%	100.00%	100.00%	100.00%
MAIS5/6	100.00%	100.00%	100.00%	100.00%
Fatal	0.00%	0.00%	0.00%	0.00%

Table 12-12 summarizes costs associated with bicyclist injury in bicyclist crashes. Overall, injury to bicyclists accounts for roughly 79 percent of all economic and comprehensive costs in these crashes. These costs do not include property damage, congestion impacts, or injury to vehicle occupants. This reflects the fact that property damage and congestion costs are not directly attributed to the bicyclist injury per-se, but are associated with the crash. These are a small portion of comprehensive costs, but a significant portion of economic costs.

Table 12-12. Bicyclist Crash Costs Due to Injury of Bicyclist

Injury Severity	Incidence	Economic Unit Cost	Total Economic Cost	Comprehensive Unit Cost	Total Comprehensive Cost
MAIS1	34663	$8,511	$295,025,045	$64,382	$2,231,703,979
MAIS2	8100	$77,133	$624,778,351	$426,337	$3,453,319,334
MAIS3	3604	$428,057	$1,542,671,657	$2,302,725	$8,298,781,938
MAIS4	320	$894,400	$286,004,573	$3,891,200	$1,244,298,551
MAIS5/6	174	$1,576,241	$274,546,848	$7,537,127	$1,312,803,222
Fatalities	859	$1,605,615	$1,379,223,285	$10,529,526	$9,044,862,834
Bicyclist Injury Total			$4,402,249,759		$25,585,769,859
Bicycle Crash Total			$5,600,057,911		$32,230,438,043
% Due to Bicyclist Injury			78.61%		79.38%

13. Crashes by Roadway Location

Urban roadway environments are characterized by high population densities. This typically produces higher traffic volumes and, on average, lower average travel speeds than are found in more rural areas. These conditions affect crash impacts in a variety of ways. Slower travel speeds can reduce the severity of crashes when they occur, but higher traffic volume creates more opportunities for exposure to distracted or alcohol impaired drivers, as well as more complex driving interactions in general. Higher traffic volume also means that when crashes do occur, they will have more impact on uninvolved drivers and cause more aggregate travel delay and pollution. By contrast, the higher speeds typically encountered on less congested rural roadways can lead to more serious injury outcomes in the event of a crash.

The categorization of any specific crash locale as urban or rural is a function of the definition that is assumed for these designations. Within the U.S. Government there are at least 15 different official definitions of the word "rural" (Fahrenthold, 2013). The Department of Agriculture alone has 11 different definitions depending on the specific program that the definition relates to. Most definitions seem to be based on absolute population size: for example, "fewer than 50,000 inhabitants and not located next to an urban area," "20,000 or fewer inhabitants," "10,000 or fewer inhabitants," or "5,000 or fewer inhabitants." In some cases these definitions are based on area as well, such as "less than 20 people per square mile." The FHWA is a primary user of crash cost information related to roadway systems. FHWA uses these data to allocate resources toward improving safety on the U.S. roadways. The definition adopted for this study is that used by the FHWA to define the Nation's roadway system. FHWA's roadway designations were designed to be consistent with designations used by the U.S. Census Bureau. Urban areas are defined in the Federal aid highway law (Section 101 of Title 23, U.S. Code) as follows.

> The term "urban area" means an urbanized area or, in the case of an urbanized area encompassing more than one State, that part of the urbanized area in each such State, or an urban place as designated by the Bureau of the Census having a population of five thousand or more and not within any urbanized area, within boundaries to be fixed by responsible State and local officials in cooperation with each other, subject to approval by the Secretary. Such boundaries shall, as a minimum, encompass the entire urban place designated by the Bureau of the Census… .
>
> Small urban areas are those urban places, as designated by the Bureau of the Census having a population of five thousand (5,000) or more and not within any urbanized area.
>
> Rural areas comprise the areas outside the boundaries of small urban and urbanized areas, as defined above."

FARS collects geospatial coordinates that permit the exact identification of crashes and allow for the overlay of theses crashes on the roadway land use designation map defined by FHWA. The urban/rural breakout of fatal crashes can thus be derived directly from the FARS database. Table 13-1 below lists this profile over the past 22 years. Over this period, there has been a very gradual decline in the portion of fatalities that occur in rural jurisdictions, from roughly 61 percent in 1998 to 44 percent in 2019.

Table 13-1. Traffic Fatalities With Known Urban/Rural Designation

	Urban	%Urban	Rural	%Rural
1998	16,219	39.2%	25185	60.8%
1999	16,058	38.6%	25548	61.4%
2000	16,113	39.3%	24838	60.7%
2001	16,988	40.3%	25150	59.7%
2002	17,013	39.6%	25896	60.4%
2003	17,783	41.6%	24957	58.4%
2004	17,581	41.1%	25179	58.9%
2005	18,627	43.1%	24587	56.9%
2006	18,791	44.3%	23646	55.7%
2007	17,908	43.5%	23254	56.5%
2008	16,218	43.6%	20987	56.4%
2009	13,504	43.8%	17,303	56.2%
2010	13,713	45.6%	16,347	54.4%
2011	13,685	46.0%	16,062	54.0%
2012	14,347	46.3%	16,616	53.7%
2013	14,147	46.9%	16,023	53.1%
2014	14,914	49.7%	15,108	50.3%
2015	16,494	51.0%	15,860	49.0%
2016	18,166	52.5%	16,462	47.5%
2017	18,730	54.3%	15,745	45.7%
2018	19,388	57.3%	14,433	42.7%
2019	18,753	56.2%	14,626	43.8%

* Known designations only

Urban/rural designations for nonfatal crashes are more elusive. There are no definitive sources or surveys designed specifically to produce a nationally representative break out of urban and rural crashes. Until it was discontinued in 1997 the General Estimates System (GES) included a specific urban/rural variable. However, this variable was not directly linked to the crash itself. Rather, it represented the pre-determined urban/rural proportion of the general population that was covered by the primary sampling unit (PSU) from which each case was drawn. Thus, use of this variable assumes that crashes occur proportionally according to the population spread. Given the shift in urban and rural crash proportions noted in FARS, these data would likely no longer be representative in any case.

A second possible indicator of urban/rural status is the Land Use Variable that has been collected in GES since 1988 (except 2009). This variable categorizes land use based on population size within the specific police jurisdictions from which crash records are drawn. Each PSU has several police jurisdictions. Therefore, this variable represents a finer definition than the Urban/Rural variable that reflected populations at the PSU level. The categories included under land use are:

Within an area of population 25,000-50,000;
Within an area of population 50,000-100,000;
Within an area of population 100,000 +;

Other area; and
Unknown area.

This variable quantifies populations, but fails to define urban/rural. A small area with a population of 25,000 might be considered urban whereas a large area with the same population might be considered rural. Generally, since these areas are all specific police jurisdictions, the size of the area is somewhat limited and, although there would be exceptions, we might expect that most police jurisdictions with 25,000 or more population would be considered urban. By the same logic, the “Other Area” category is more likely to represent rural roadways, but may also include some urban areas as defined by FHWA.

A third possible source for insight into the urban/rural breakdown of nonfatal crashes is the National Highway System variable collected in GES from 1995 to 1998. This variable has 20 possible selections based on the type of roadway on which the crash occurred and whether that roadway was urban or rural. The urban/rural designation for these roadways reflects the characteristics of the surrounding land use area. The selections for this variable for roadways with known urban/rural characteristics are as follows.

National Highway System Variables
Urban
1 = Eisenhower Interstate (EIS)
2= Congressional High Priority Route
3 = STRAHNET Route
4 = STRAHNET Major Connector
5 = Other NHS Route
9 = Unknown Urban Route
Rural
11 = Eisenhower Interstate (EIS)
12 = Congressional High Priority Route
13 = STRAHNET Route
14 = STRAHNET Major Connector
15 = Other NHS Route
19 = Unknown Rural Route

Only about 15 percent of the crashes in the 1994-1998 GES occurred on roadways in the NHS, so these data represents only a sample of all crashes and use of these variables to represent nationwide distributions assumes that the urban/rural distribution for crashes on all roadways is similar to that on NHS roadways. Again, due to their age, these data are not likely to be useful in estimating current urban/rural splits.

A fourth possible source of urban/rural designations is State data files collected in NHTSA’s State Data System (SDS). Many States do not collect urban/rural information, but a subsample of the 34 States in the SDS system do have urban/rural indicators. NHTSA found 8 States with urban/rural indicators within their data sets in 2014 or later. Table 13-2 summarizes the average rural portion of crashes in each State by injury severity based on the designations found in State files for all available years within each State from 2014-2018. Table 13-3 presents the relative rates of rural proportions according to injury severity for each State and the average across all States.

Table 13-2. Portion of Injuries Occurring in Rural Jurisdictions, by Injury Severity

State	Injury Severity					Total
	K	A	B	C	O	
Arkansas	60.89%	53.56%	28.68%	16.87%	12.84%	15.04%
Florida	59.09%	61.95%	48.45%	45.32%	43.48%	44.59%
Illinois	48.08%	38.36%	29.95%	22.92%	26.91%	27.19%
Minnesota	80.99%	71.00%	63.37%	55.45%	55.96%	56.92%
Nebraska	72.61%	50.63%	31.73%	22.59%	24.64%	25.55%
Texas	48.24%	60.79%	72.86%	81.31%	75.65%	75.90%
Washington	35.62%	37.17%	30.58%	15.56%	16.82%	17.63%
Wisconsin	68.07%	53.40%	39.26%	26.85%	36.53%	36.18%
Average	59.20%	53.36%	43.11%	35.86%	36.60%	37.38%

Table 13-3. Rural Proportions Relative to Fatal Proportions by Injury Severity

State	Injury Severity					Total
	K	A	B	C	O	
Arkansas	1.0000	0.8797	0.4711	0.2771	0.2108	0.2471
Florida	1.0000	1.0484	0.8200	0.7670	0.7358	0.7547
Illinois	1.0000	0.7979	0.6228	0.4766	0.5597	0.5656
Minnesota	1.0000	0.8766	0.7824	0.6846	0.6910	0.7028
Nebraska	1.0000	0.6973	0.4369	0.3111	0.3393	0.3518
Texas	1.0000	1.2601	1.5103	1.6855	1.5681	1.5734
Washington	1.0000	1.0436	0.8585	0.4368	0.4722	0.4950
Wisconsin	1.0000	0.7846	0.5768	0.3945	0.5367	0.5315
Average	100.00%	92.35%	75.98%	62.92%	63.92%	65.27%

A final source for urban/rural definitions for injuries is the National Motor Vehicle Crash Causation Survey (NMVCSS). In 2008 NHTSA’s National Center for Statistics and Analysis completed a nationwide survey of crashes involving light passenger vehicles, with a focus on the factors related to pre-crash events. This nationally representative sample of crashes was investigated from 2005 to 2007. NMVCCS investigated a total of 6,950 crashes during the 3-year period from January 2005 to December 2007. However, the final report was based on a nationally representative sample of 5,471 crashes that were investigated during a 2 ½- year period from July 3, 2005, to December 31, 2007. The remaining 1,479 crashes were investigated but were not used because (1) these crashes were investigated during the transition period from January 1, 2005, to July 2, 2005, when the data collection effort was being phased in, or (2) these crashes were investigated after the phase-in period, but ultimately determined not to meet the requisite sample selection criteria. Each investigated crash involved at least one light passenger vehicle that was towed due to damage. Data were collected on at least 600 data elements to capture information related to the drivers, vehicles, roadways, and environment. In addition, the NMVCCS database includes crash narratives, photographs, schematic diagrams, vehicle information, as well as event data recorder (EDR) data, when available. An important feature of NMVCCS relevant to this study is the fact that each crash location was recorded using geo-spatial devices. For this study, these coordinates were overlain on the previously discussed roadway land use designation map developed by FHWA to produce urban and rural designations for each crash.

As noted above, the higher average speeds encountered in less congested rural areas result in generally more severe crash outcomes. Based on this, we would expect to see a higher rural proportion of more serious crashes. To estimate the urban/rural portions for nonfatal crashes, we examined the relative proportions these factors by injury severity level across the 5 sources cited above. As expected, the rural proportion of crashes was highest in the most serious crashes and declined fairly steadily as crash severity diminished. However, the absolute portions fatal crashes that were rural in these databases differed significantly from the rural rates that were found in FARS. It is uncertain why these differences occur, but it is possible that whatever is biasing the fatality number in these sources is also biasing the nonfatal injuries as well. This would seem to be the case given that the value of all nonfatal injury severity levels seems consistent with the absolute value of the fatal injury proportions measured in each data source. Generally speaking, the sources with rural fatality portion that are higher also have nonfatal injury rural portions that are higher. For this analysis we adopted this assumption (that both fatal and injury biases are similar) and normalize the results of each source to the known rural portion from FARS. That is, we assume the FARS urban/rural distribution is correct, but accept the relative ratios among injury severity from the 3 sources. The results are displayed in Table 13- 4.

Table 13-4. Derivation of Estimated Urban/Rural Proportions Crashes by Injury Severity

	No Injury (O)	**Possible Injury (C)**	**Non-incapacitating Injury (B)**	**Incapacitating Injury (A)**	**Fatal Injury (K)**
Estimated Percentage Rural					
2017-2019 CRSS Urban/Rural	21.4%	20.5%	24.2%	29.1%	39.5%
2014-2015 GES Land Use	30.9%	31.1%	40.4%	42.8%	48.3%
SDS States w/Urban Rural (8 States)	36.6%	35.9%	43.1%	53.4%	59.2%
Average	29.6%	29.2%	35.9%	41.8%	49.0%

	No Injury (O)	Possible Injury (C)	Non-incapacitating Injury (B)	Incapacitating Injury (A)	Fatal Injury (K)
Ratio/Fatal					
2017-2019 CRSS Urban/Rural	0.5432	0.5198	0.6139	0.7374	1.0000
2014-2015 GES Land Use	0.6393	0.6442	0.8362	0.8856	1.0000
SDS States w/Urban Rural (8 States)	0.6392	0.6292	0.7598	0.9235	1.0000
Normalized to 2019 FARS					
2017-2019 CRSS Urban/Rural	23.8%	22.8%	26.9%	32.3%	43.8%
2014-2015 GES Land Use	28.0%	28.2%	36.6%	38.8%	43.8%
SDS States w/Urban Rural (8 States)	27.1%	26.5%	31.9%	39.5%	43.8%
Average of 3 Methods	26.3%	25.8%	31.8%	36.9%	43.8%

A limitation common to all 3 sources is that injury severity is only coded in the KABCO system. As previously noted in Chapter 2, this report stratifies injury severity using the more precise MAIS basis. Previously the derivation and use of KABCO-MAIS translators was discussed. In order to derive urban/rural proportions under MAIS, a reverse translator was applied to the urban and rural KABCO injury distributions (see Table 13-5 below). This translator was derived from the same historical data bases as the previously discussed translators. However, since it will be applied to known nonfatal injuries only, it was normalized to remove categories of Unknowns and fatalities. Table13- 6 shows the resulting KABCO/MAIS matrix. Table 13-7 shows the estimated rural incidence counts for each MAIS level derived by applying the KABCO injury-severity- specific rural percentage (from Table 13-4 above) to the corresponding incidence counts in Table 13-6. The resulting MAIS totals were then used to obtain rates for urban and rural crashes for each MAIS severity level, and these rates were applied to the nationwide 2019 incidence data previously derived in the Incidence chapter to estimate total nationwide urban and rural crash incidence.

Table 13-5. Reverse Translator for MAIS to KABCO Application to Injured Survivors

MAIS	O No Injury	C Possible Injury	B Non- Incapacitating	A Incapacitating	Total
0	0.94016	0.04930	0.00902	0.00152	1.00000
1	0.36721	0.35833	0.24290	0.03156	1.00000
2	0.08281	0.27770	0.37597	0.26352	1.00000
3	0.01262	0.26106	0.25883	0.46749	1.00000
4	0.00000	0.16816	0.22708	0.60476	1.00000
5	0.00000	0.08046	0.02536	0.89418	1.00000

Table 13-6. KABCO Incidence Counts From MAIS Injured Survivors

MAIS	O No Injury	C Possible Injury	B Non-Incapacitating	A Incapacitating	Total
0	4,255,066	223,142	40,828	6,864	4,525,901
1	1,423,048	1,388,609	941,297	122,311	3,875,265
2	35,371	118,609	160,583	112,556	427,119
3	1,782	36,853	36,538	65,994	141,167
4	0	3,243	4,379	11,663	19,285
5	0	578	182	6,426	7,187

Table 13-7. Rural KABCO Incidence Counts From MAIS Injured Survivors

MAIS	O No Injury	C Possible Injury	B Non-Incapacitating	A Incapacitating	Total Rural	% Rural
0	1,205,360	62,122	13,990	2,726	1,284,198	28.37%
1	374,296	358,945	299,483	45,099	1,077,823	27.81%
2	9,303	30,660	51,091	41,502	132,556	31.03%
3	469	9,526	11,625	24,333	45,953	32.55%
4	0	838	1,393	4,300	6,532	33.87%
5	0	149	58	2,370	2,577	35.86%

Cases designated as O-Uninjured in KABCO records are likely to be predominately PDO crashes. In addition, they would include cases where uninjured people were involved in crashes that did produce injury, which are categorized as MAIS0 in this study. Since PDOs are counted separately, the rural portion for MAIS0 injuries should equal the weighted average rural portion of MAIS0 incidence in injury crashes. To estimate rural MAIS0 incidence we examined the frequency of uninjured occupants in injury crashes by MAIS level. Data from the 2013-2015 CDS and 2017-2019 CISS were examined to determine ratios of uninjured occupant frequencies. These are the only two current databases with MAIS stratification. Neither database is ideal because both represent tow-away crashes for light vehicles. However, the previous version of this report (Blincoe et al., 2015) found very close agreement between older CDS data and 1982-86 NASS data, which included all injury types. Both of the more current data bases also show very similar frequencies. These are shown in Table 13-8. Using these frequencies, we calculated a weighted average rural portion across all injury severity categories. We then assumed that the frequency of PDOs versus MAIS0 was similar to the relative frequency of these cases nationwide. This would imply that 82.1 percent of these cases were PDOs and 17.9 percent were MAIS0s. Using these weights, we derived the rural portion of MAIS0s. We then imputed the PDO portion. The results, which are shown in the lower half of Table 13-8, are nearly identical for either data source. We chose to base our estimate on the CISS data because it is more recent and based on the more current MAIS definitions but the difference if we used CDS would be insignificant.

Table 13-8. Derivation of Rural Incidence Percentage for MAIS0 and PDO

	2009-11 CDS	1982-86 NASS
Distribution of MAIS0 by Crash Severity		
MAIS1	0.8322	0.8500
MAIS2	0.1424	0.1032
MAIS3	0.0159	0.0351
MAIS4	0.0078	0.0037
MAIS5	0.0003	0.0007
Fatal	0.0013	0.0074
Imputed % Rural		
All KABCO O Injuries	26.30%	26.30%
MAIS0 in Injury Crashes	28.42%	28.46%
PDO	25.84%	25.83%

As noted previously, for fatalities, the urban/rural designation contained in the FARS files is used directly. The resulting urban/rural incidence counts are illustrated in Figure 13-A and shown in Table 13-9 for each injury severity category.

Figure 13-A. Rural Percentage of Motor Vehicle Injury by Injury Severity

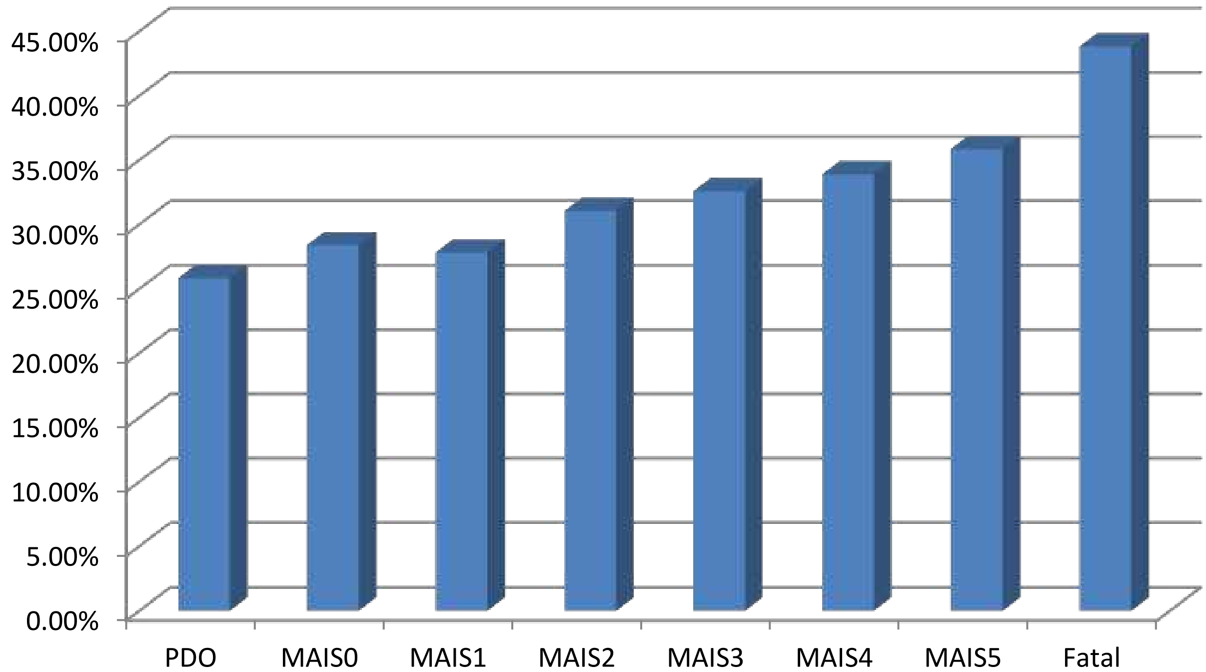


Table 13-9. Urban/Rural Incidence Summary

	Urban	% Urban	Rural	% Rural	Total
MAIS0	3,241,703	71.63%	1,284,198	28.37%	4,525,901
MAIS1	2,797,442	72.19%	1,077,823	27.81%	3,875,265
MAIS2	294,563	68.97%	132,556	31.03%	427,119
MAIS3	95,214	67.45%	45,953	32.55%	141,167
MAIS4	12,753	66.13%	6,532	33.87%	19,285
MAIS5	4,610	64.14%	2,577	35.86%	7,187
Fatal	20,506	56.18%	15,994	43.82%	36,500
PDO	14,308,670	74.18%	4,979,469	25.82%	19,288,139

In Table 13-10, the incidence from Table 13-9 is combined with the per-unit economic costs of crashes from Table 3-13 in chapter 3. In Table 13-11, incidence is combined with the per-unit comprehensive costs from Table 5-2 in chapter 5. The results indicate that urban crashes cost an estimated $234 billion and rural crashes cost $106 billion in economic costs in 2019. Roughly 69 percent of all economic crash costs thus occur in urban areas while 31 percent occur in rural areas. Urban crashes result in $894 billion in societal harm as measured by comprehensive costs, while rural crashes produce $471 billion in societal harm. Comparing Tables 9, 10, and 11, the rural portion of incidence was 27 percent, but the rural portion rises to 31 percent for economic costs and 35 percent for comprehensive costs. This reflects the more severe injury profile associated with rural crashes, which have larger proportions more costly and debilitating injuries. Nonetheless, the higher frequency of crashes in urban areas results in urban crashes causing the majority of all injury incidence, economic costs, and comprehensive costs. As noted in Table 13-1, there has been a steady shift of traffic fatalities toward urban and away from rural areas of the past several decades. This primarily reflects concurrent population shifts favoring urban environments and the growth of suburbs.

Table 13-10. Urban/Rural Economic Cost Summary (Millions 2019 $)

	Urban	% Urban	Rural	% Rural	Total
MAIS0	$10,542	71.63%	$4,176	28.37%	$14,718
MAIS1	$54,114	72.19%	$20,849	27.81%	$74,963
MAIS2	$21,037	68.97%	$9,467	31.03%	$30,504
MAIS3	$26,729	67.45%	$12,900	32.55%	$39,629
MAIS4	$8,617	66.13%	$4,414	33.87%	$13,031
MAIS5	$4,515	64.14%	$2,524	35.86%	$7,039
Fatal	$32,947	56.18%	$25,696	43.82%	$58,643
PDO	$75,135	74.18%	$26,147	25.82%	$101,282
Total Economic Costs	$233,636	68.75%	$106,174	31.25%	$339,809

Table 13-11. Urban/Rural Comprehensive Cost Summary (Millions 2019 $)

	Urban	% Urban	Rural	% Rural	Total
MAIS0	$10,542	71.63%	$4,176	28.37%	$14,718
MAIS1	$169,122	72.19%	$65,161	27.81%	$234,283
MAIS2	$139,552	68.97%	$62,800	31.03%	$202,352
MAIS3	$194,675	67.45%	$93,956	32.55%	$288,631
MAIS4	$46,085	66.13%	$23,604	33.87%	$69,690
MAIS5	$27,884	64.14%	$15,587	35.86%	$43,471
Fatal	$230,872	56.18%	$180,063	43.82%	$410,935
PDO	$75,135	74.18%	$26,147	25.82%	$101,282
Total Comprehensive Costs	$893,866	65.47%	$471,495	34.53%	$1,365,362

Roadway Classification

A further breakdown of these crash cost estimates was made by roadway classification. Data on roadway crash costs is useful for highway safety planning and allocation of limited roadway construction funds. For this analysis, roadways were divided into the following five classifications.

- 4-lane divided roadways
- Greater than 4-lane divided roadways
- 2-lane undivided roadways
- Multi-lane undivided roadways
- All other roadways

The lane count designations in the above categories include lanes in both directions. Thus, for example, four lane divided roadways would include two lanes in each direction. These categories and designations were selected based on discussions with FHWA staff regarding the most useful categories for planning purposes.

As previously noted, NHTSA’s FARS system collects geospatial coordinates that permit the exact identification of crashes and allow for the overlay of these crashes on the roadway land use designation maps defined by FHWA, or, for some roadway designations, individual States. The urban/rural and roadway designation breakout of fatal crashes can thus be derived directly from the FARS database.

For nonfatal injuries and PDOs, roadway designations are available within NHTSA's GES data system, but as noted earlier, urban and rural designations for these roadways are not collected in GES. To stratify these nonfatal impacts by roadway category, we first examined the roadway designation proportions within GES under the five categories discussed above. All cases were stratified by their coded roadway type and lumped under the appropriate category. The approach we used involved determining proportions cases that occurred under each roadway type from the data files and then applying these proportions to the total urban and rural costs already derived. Cases where the roadway designation was unknown were thus ignored, because redistributing these cases across known roadway cases would not alter the proportions assigned to that roadway type. In other words, we used the police-reported cases with known roadway types to determine the proportions crashes that occurred on each roadway type, and then applied that proportion to the total costs of urban and rural crashes.

Because GES is stratified only by KABCO, data were organized into the same five categories noted in previous sections this report to be run through KABCO/MAIS translators to produce an MAIS based injury profile. Those categories are CDS equivalent cases, unbelted non-CDS cases, belted non-CDS cases, unknown belt use non-CDS cases, and motorcycle/nonoccupant cases. The MAIS injury totals from each of these cases were then combined to form a full MAIS injury profile representing all five translator scenarios. This was done separately for each of the five roadway types.

Because GES records do not include an urban/rural designation, this feature was derived from the database we created from NMVCCS discussed above. NMVCCS cases were stratified within one of the five roadway designations for both urban and rural crashes. The proportions each Roadway Type that were urban and rural were calculated within each KABCO injury severity level. Table 13-12 lists the NMVCCS case distributions that resulted from this process. These proportions were then applied to each translated MAIS case total that was derived from the corresponding KABCO distribution.

Table 13-12. NMVCCS Cases, Percentages Urban Versus Rural by Roadway Type

A Injuries	**Rural**	**Urban**	**Total**
Greater than four lanes divided	13.11%	86.89%	100.00%
Multi-lane undivided	26.63%	73.37%	100.00%
Four lanes divided	64.59%	35.41%	100.00%
Two-lane undivided	67.79%	32.21%	100.00%
Other	37.20%	62.80%	100.00%
Total	42.88%	57.12%	100.00%
B Injuries			
Greater than four lanes divided	14.14%	85.86%	100.00%
Multi-lane undivided	13.14%	86.86%	100.00%
Four lanes divided	43.27%	56.73%	100.00%
Two-lane undivided	43.67%	56.33%	100.00%
Other	14.30%	85.70%	100.00%
Total	27.82%	72.18%	100.00%
C Injuries			
Greater than four lanes divided	9.42%	90.58%	100.00%
Multi-lane undivided	12.70%	87.30%	100.00%
Four lanes divided	24.34%	75.66%	100.00%
Two-lane undivided	30.74%	69.26%	100.00%
Other	10.11%	89.89%	100.00%
Total	18.77%	81.23%	100.00%
Uninjured			
Greater than four lanes divided	23.14%	76.86%	100.00%
Multi-lane undivided	14.82%	85.18%	100.00%
Four lanes divided	67.71%	32.29%	100.00%
Two-lane undivided	34.91%	65.09%	100.00%
Other	20.19%	79.81%	100.00%
Total	29.90%	70.10%	100.00%
Injured Severity Unknown			
Greater than four lanes divided	4.98%	95.02%	100.00%
Multi-lane undivided	5.11%	94.89%	100.00%
Four lanes divided	31.20%	68.80%	100.00%
Two-lane undivided	0.79%	99.21%	100.00%
Other	0.00%	100.00%	100.00%
Total	4.72%	95.28%	100.00%

This process produced separate tables that define the proportions all crashes that occur on different roadway types by injury severity for urban and rural locations. Tables 13 and 14 summarize these results.

Table 13-13. Proportions Fatalities, Injuries and PDOV by Roadway Designation in Rural Crashes

	Divided Roadways		Undivided Roadways			
	4 Lanes	**>4 Lanes**	**2 Lanes**	**>2 Lanes**	**All Other**	**Total**
MAIS0	26.35%	22.16%	37.16%	12.79%	1.54%	100.00%
MAIS1	20.09%	14.09%	52.72%	11.99%	1.11%	100.00%
MAIS2	18.77%	10.00%	59.81%	10.32%	1.10%	100.00%
MAIS3	18.15%	8.53%	61.63%	10.40%	1.29%	100.00%
MAIS4	18.30%	7.51%	63.48%	9.49%	1.22%	100.00%
MAIS5	17.65%	5.95%	65.48%	9.52%	1.40%	100.00%
Fatal	17.17%	4.56%	72.30%	5.05%	0.93%	100.00%
PDOV	26.56%	18.72%	40.77%	12.10%	1.84%	100.00%

Table 13-14. Proportions Fatalities, Injuries and PDOV by Roadway Designation in Urban Crashes

	Divided Roadways		Undivided Roadways			
	4 Lanes	**>4 Lanes**	**2 Lanes**	**>2 Lanes**	**All Other**	**Total**
MAIS0	7.52%	33.89%	26.85%	29.00%	2.73%	100.00%
MAIS1	10.98%	31.75%	29.16%	25.72%	2.40%	100.00%
MAIS2	11.09%	31.08%	30.95%	24.70%	2.18%	100.00%
MAIS3	10.74%	31.99%	29.91%	24.95%	2.41%	100.00%
MAIS4	10.58%	32.38%	30.76%	24.14%	2.14%	100.00%
MAIS5	9.67%	33.74%	29.97%	24.36%	2.26%	100.00%
Fatal	15.64%	25.18%	32.38%	24.24%	2.56%	100.00%
PDOV	7.86%	29.72%	30.57%	28.47%	3.39%	100.00%

The resulting estimates indicate significant differences in the proportions crashes that occur on various roadway types in rural versus urban settings. In rural settings over half of all injuries and 40 percent of PDOs occur on tw0-lane undivided roadways, and over 20 percent of injuries and 30 percent of PDOs occur on four-lane divided roadways. These two roadway types account for roughly 80 percent of all injuries and over 70 percent of all PDOs in rural settings. By contrast, in urban settings injury incidence is spread more evenly, with over 30 percent occurring on two-lane undivided roadways, about 24 percent on undivided roadways with more than two lanes, about 20 percent on divided roadways with more than four lanes, and about 14 percent on four-lane divided roadways. This might be expected given that the roadway infrastructure in rural areas is typically designed for a lower population density. Rural occupants travel exposure is more likely to occur on roadways with fewer lanes.

The proportions in Table 13-13 were then applied to the total economic costs of rural crashes from Table 13-10, and the proportions in Table 13-14 were applied to the total economic costs of urban crashes in Table 13-10 to distribute these costs by roadway type. This same process was then repeated for the comprehensive costs in Table 13-11. The results are shown in Tables 13-15 and 13-16 for economic costs, and Tables 17 - 18 for comprehensive costs. Figures 13-B through 13-G illustrate the distribution of costs across roadways.

Table 13-15. Estimated Economic Cost of Crashes in Rural Areas by Roadway Designation (Millions 2019 $)

	Divided Highways		**Undivided Highways**			
	4 Lanes	**>4 Lanes**	**2 Lanes**	**>2 Lanes**	**All Other**	**Total**
MAIS0	$1,101	$925	$1,552	$534	$64	$4,176
MAIS1	$4,189	$2,938	$10,991	$2,501	$231	$20,849
MAIS2	$1,777	$947	$5,662	$977	$104	$9,467
MAIS3	$2,342	$1,101	$7,950	$1,342	$166	$12,900
MAIS4	$808	$332	$2,802	$419	$54	$4,414
MAIS5	$446	$150	$1,653	$240	$35	$2,524
Fatal	$4,411	$1,172	$18,578	$1,297	$239	$25,696
PDOV	$6,945	$4,896	$10,660	$3,164	$482	$26,147
Total	$22,018	$12,460	$59,847	$10,473	$1,375	$106,174
% Rural	20.74%	11.74%	56.37%	9.86%	1.30%	100.00%
% All	6.48%	3.67%	17.61%	3.08%	0.40%	31.25%

Table 13-16. Estimated Economic Cost of Crashes in Urban Areas by Roadway Designation (Millions 2019 $)

	Divided Highways		**Undivided Highways**			
	4 Lanes	**>4 Lanes**	**2 Lanes**	**>2 Lanes**	**All Other**	**Total**
MAIS0	$792	$3,573	$2,831	$3,058	$288	$10,542
MAIS1	$5,941	$17,178	$15,781	$13,917	$1,297	$54,114
MAIS2	$2,334	$6,538	$6,510	$5,196	$459	$21,037
MAIS3	$2,871	$8,551	$7,995	$6,668	$643	$26,729
MAIS4	$912	$2,790	$2,651	$2,080	$184	$8,617
MAIS5	$437	$1,523	$1,353	$1,100	$102	$4,515
Fatal	$5,152	$8,295	$10,669	$7,988	$844	$32,947
PDOV	$5,905	$22,327	$22,969	$21,389	$2,545	$75,135
Total	$24,343	$70,777	$70,759	$61,395	$6,363	$233,636
% Rural	10.42%	30.29%	30.29%	26.28%	2.72%	100.00%
% All	7.16%	20.83%	20.82%	18.07%	1.87%	68.75%

Table 13-17. Estimated Comprehensive Cost of Crashes in Rural Areas by Roadway Designation (Millions 2019 $)

	Divided Highways		**Undivided Highways**			
	4 Lanes	**>4 Lanes**	**2 Lanes**	**>2 Lanes**	**All Other**	**Total**
MAIS0	$1,101	$925	$1,552	$534	$64	$4,176
MAIS1	$13,092	$9,182	$34,350	$7,816	$721	$65,161
MAIS2	$11,789	$6,283	$37,559	$6,478	$691	$62,800
MAIS3	$17,057	$8,016	$57,903	$9,773	$1,208	$93,956
MAIS4	$4,319	$1,773	$14,985	$2,239	$288	$23,604
MAIS5	$2,752	$927	$10,207	$1,483	$218	$15,587
Fatal	$30,909	$8,210	$130,184	$9,086	$1,673	$180,063
PDOV	$6,945	$4,896	$10,660	$3,164	$482	$26,147
Total	$87,964	$40,212	$297,399	$40,574	$5,346	$471,495
% Rural	18.66%	8.53%	63.08%	8.61%	1.13%	100.00%
% All	6.44%	2.95%	21.78%	2.97%	0.39%	34.53%

Table 13-18. Estimated Comprehensive Cost of Crashes in Urban Areas by Roadway Designation (Millions 2019 $)

	Divided Highways		**Undivided Highways**			
	4 Lanes	**>4 Lanes**	**2 Lanes**	**>2 Lanes**	**All Other**	**Total**
MAIS0	$792	$3,573	$2,831	$3,058	$288	$10,542
MAIS1	$18,568	$53,688	$49,320	$43,494	$4,052	$169,122
MAIS2	$15,480	$43,373	$43,185	$34,467	$3,047	$139,552
MAIS3	$20,908	$62,283	$58,229	$48,569	$4,686	$194,675
MAIS4	$4,876	$14,921	$14,178	$11,125	$986	$46,085
MAIS5	$2,698	$9,408	$8,355	$6,793	$630	$27,884
Fatal	$36,102	$58,124	$74,760	$55,974	$5,912	$230,872
PDOV	$5,905	$22,327	$22,969	$21,389	$2,545	$75,135
Total	$105,328	$267,697	$273,827	$224,869	$22,147	$893,866
% Rural	11.78%	29.95%	30.63%	25.16%	2.48%	100.00%
% All	7.71%	19.61%	20.06%	16.47%	1.62%	65.47%

Figure 13-B. Distribution of Economic Costs, Rural Roadway Crashes

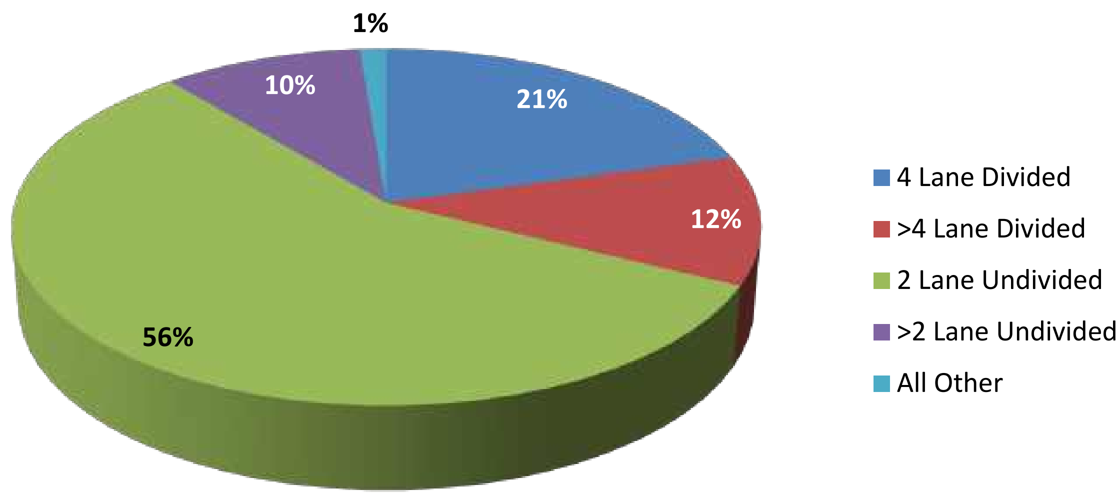


Figure 13-C. Distribution of Economic Costs, Urban Roadway Crashes

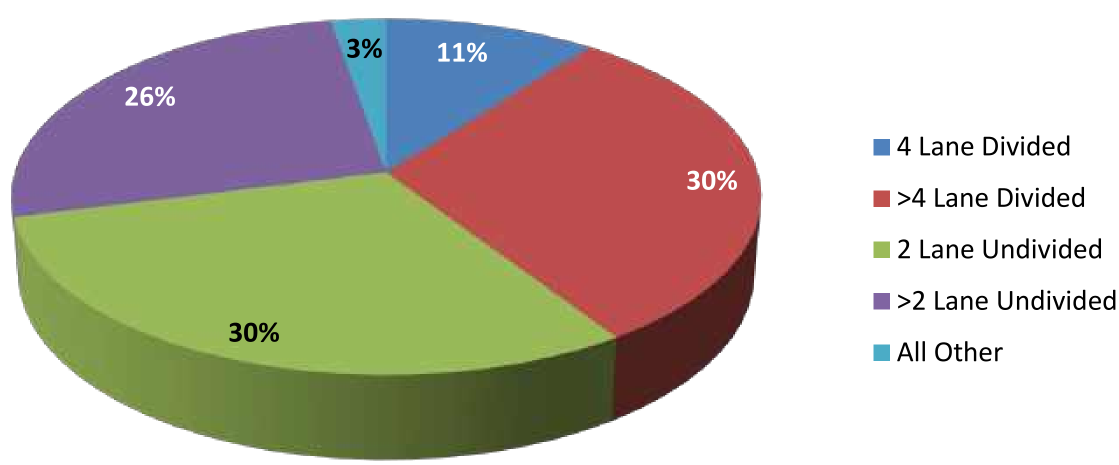


Figure 13-D. Distribution of Economic Costs by Roadway Type

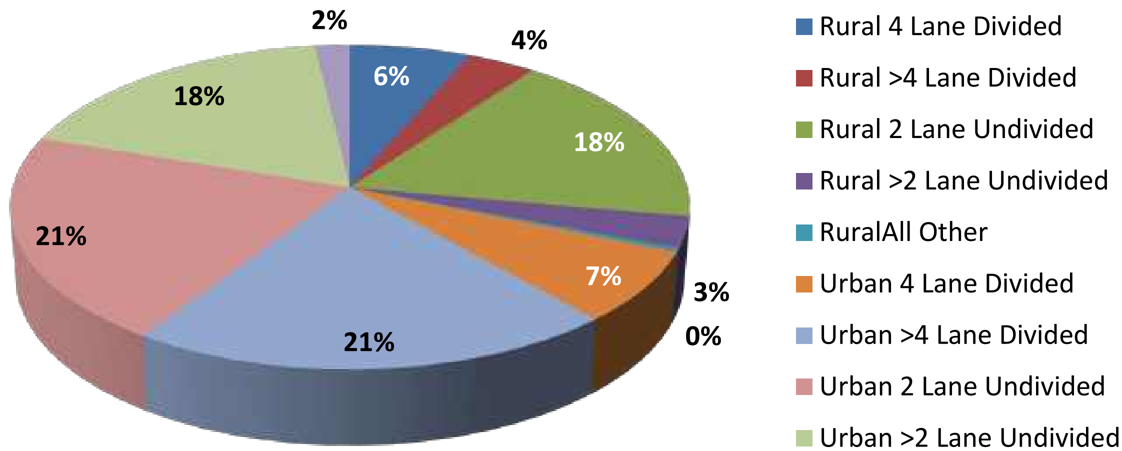


Figure 13-E. Distribution of Comprehensive Costs, Rural Roadway Crashes

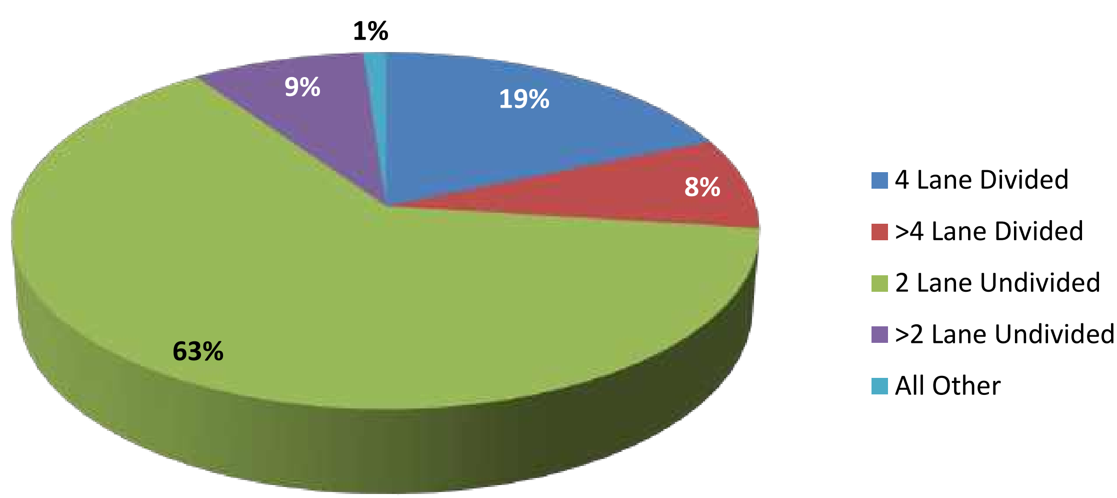


Figure 13-F. Distribution of Comprehensive Costs, Urban Roadway Crashes

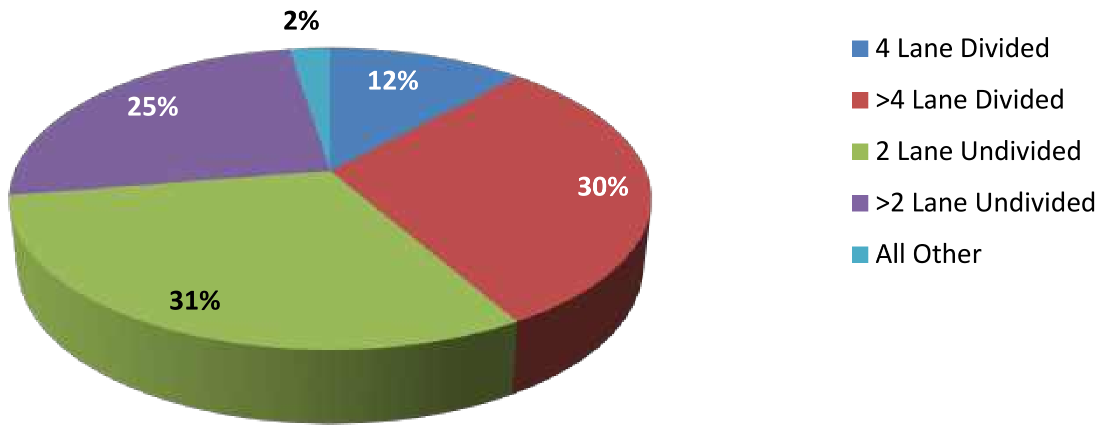
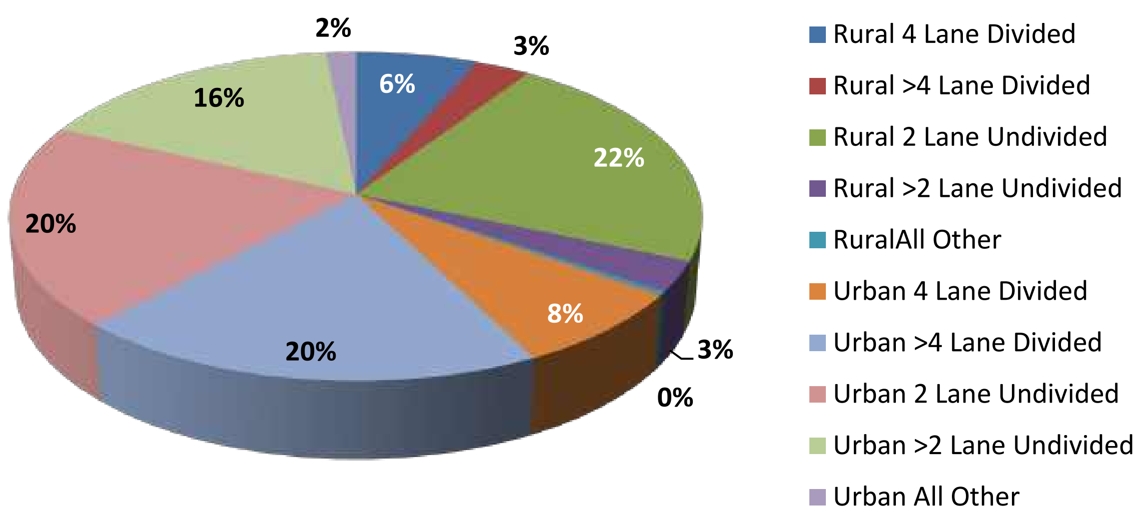


Figure 13-G. Distribution of Comprehensive Costs by Roadway Type



These data indicates that the largest impact on society from motor vehicle crashes, whether measured by economic costs or by the societal harm implied in comprehensive costs, occurs on 2-lane undivided roadways in both rural and urban settings. In rural areas, this is likely a function of both exposure, since these roadways are the most common type, and the relatively serious injury profile that occurs on rural 2-lane undivided roadways, which lack dividers to separate vehicles traveling at relatively high speeds compared to those in urban areas where congestion slows down traffic. In urban areas, exposure is the primary cause of this disproportionate impact. Figures H and I show the relative portion of all motor vehicle injuries that are in the most serious injury categories – MAIS3, MAIS4, MAIS5, and Fatal. In rural crashes, this portion is significantly higher on 2-Lane undivided roadways than on other types, and it is higher for most rural roadways than for corresponding urban roadways – an indication of the impact that higher travel speeds have on injury profiles.

Significant economic impact also occurs on urban divided highways (both lane count categories), and in urban undivided highways with more than two lanes. These impacts are primarily exposure driven, although high speed travel on urban divided roadways does contribute to a relatively severe injury profile as well.

Figure 13-H. Portion of Rural Injuries MAIS3+

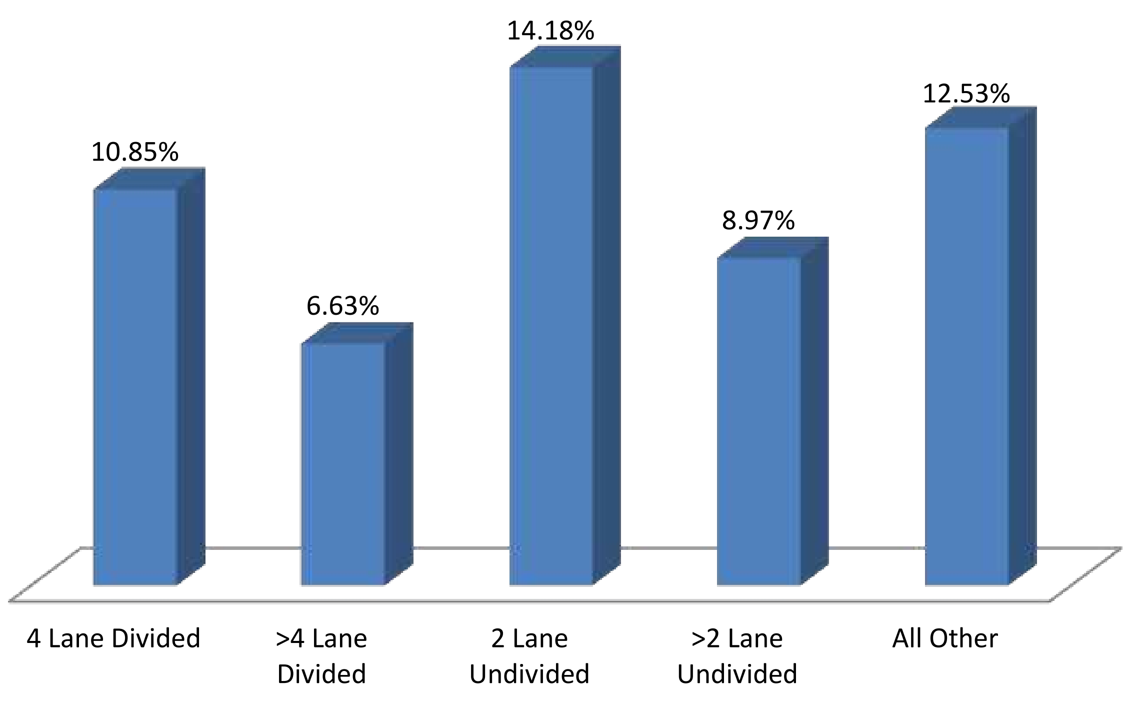
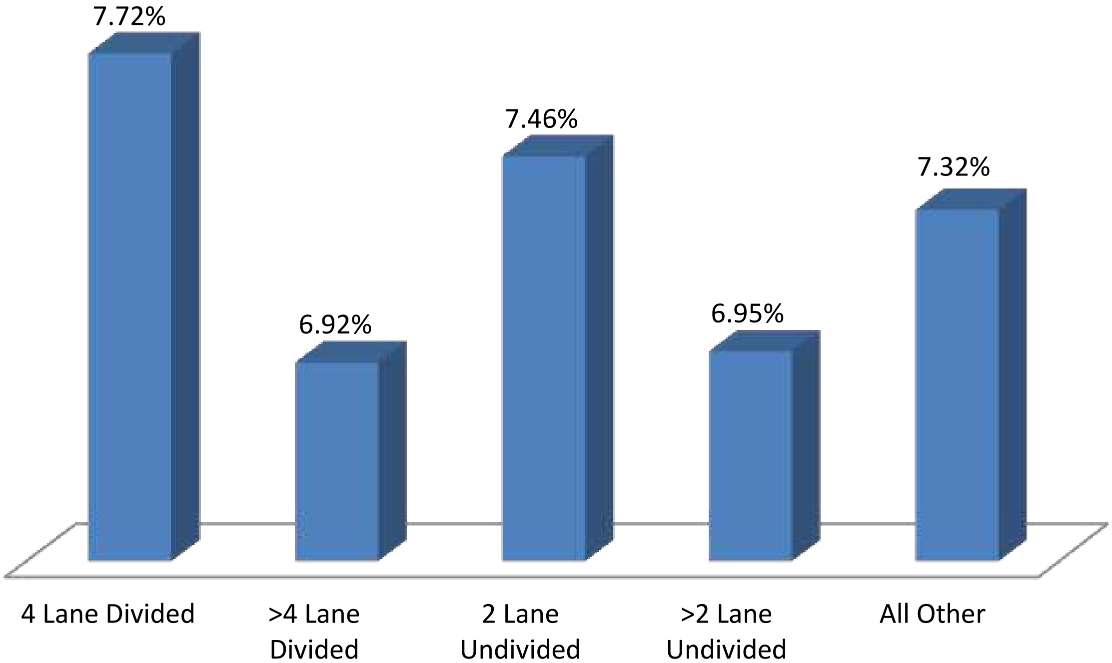


Figure 13-I. Portion of Urban Injuries MAIS3+



14. Other Special Interest Crash Scenarios

Motor vehicle crashes cost society hundreds of billions dollars in medical care, lost productivity, legal costs, congestion, and other economic impacts. The cost of crashes is even higher when pain, suffering, and lost quality-of-life are taken into account. Federal, State, local, and private organizations are constantly striving to reduce these impacts through motor vehicle safety regulations, behavioral programs such as alcohol and seat belt laws, roadway improvements, traffic control measures, and public information and educational programs. Efforts to address the impacts of motor vehicle crashes are normally focused on specific types of crashes, based on locality, roadway type, crash causation, or victim characteristics. For this report we have estimated crash costs for a number of specific crash scenarios that are commonly of interest to organizations interested in improving vehicle safety. These include seat belt use, impaired driving, speeding, and distracted driving, urban/rural crashes, and State-specific costs, each of which is examined in a separate chapter due to the complexity of the methodology required. However, a number of additional crash scenarios were estimated based on a fairly straightforward examination of the data in NHTSA's two primary databases, FARS and CRSS. These include, crashes on interstate highways, crashes at intersections, single-vehicle crashes, and roadway departure crashes.

To estimate the cost of these crashes, we examined the relative incidence of each injury severity level that was represented by crashes that matched each scenario. These estimates reflect the relative proportions specific injury severities that occur under each scenario. The 2017-2019 CRSS data were used for each nonfatal case, while 2019 FARS was used for each fatal case. Each case in FARS contained information regarding the status of the specific scenario, so the proportion of fatalities that occurred under each scenario was obtained directly from the FARS database. For nonfatal injuries and PDOs, CRSS data were queried to determine whether the case fell under the scenario or not. However, CRSS data are only recorded using the KABCO severity system, whereas this report is based on the AIS. To translate CRSS data to an MAIS basis, we used a variety of KABCO/MAIS translators. For CISS equivalent crashes, we used a current translator derived from 2017-2019 CISS data. Since these data are relatively recent, it reflects roughly current levels of seat belt usage. For non-CISS cases, the only available data from which to develop translators were contained in the 1982-1986 NASS files. Seat belt use has increased dramatically since this time. Observed belt use during this period ranged from roughly 10-37 percent as public awareness of the importance of belt use and belt use laws were just beginning to take hold in 1986. Belt use has since risen dramatically, and crossed 90 percent for the first time in 2019. Belt use can influence injury reporting significantly in a number of ways. It changes the nature of injuries by preventing many more visible injuries (such as head/face contact with the windshield) but replaces them with often less visible (and also typically less serious) abdominal injuries such as bruising caused by pressure from the belt across the torso. This can influence the relationship between the KABCO reported injury severity and the corresponding MAIS injury level. For this reason, separate translators were developed from the 1982-86 NASS data for non-CDS cases where the victim was belted or unbelted, and for nonoccupants/motorcyclists. Cases with unknown belted status were distributed proportionately among cases with known status prior to translation. These translators are presented in Tables 14-1 through 14-4.

Annual average 2017-2019 CRSS KABCO incidence counts were obtained for each scenario, both for the cases that met the scenario definition, and for all other cases. So, for example, one set of incidence counts was obtained for intersection crashes, and another for all other crashes. Each of these data sets was run through its corresponding translator to produce a set of MAIS based injury counts. These counts from each grouping (CDS equivalent cases, belted non-CDS cases, unbelted non-CDS cases, and nonoccupant/motorcycle cases) were added together to produce a total MAIS injury profile for each scenario. The process was repeated for each “Other” category (e.g., all non-intersection crashes). The percentage of each MAIS injury incidence that was appropriate to each scenario was then calculated as:

x=a/(a+b) where x is the percentage of incidence attributable to the specific crash scenario

a = the incidence of the specific crash scenario

b = the incidence of each case not attributable to the specific crash scenario.

The attributable portion of each MAIS level was then multiplied by the total cost of all 2010 crashes for that MAIS level and the MAIS level results were summed to produce the total cost of each crash scenario. MAIS0 portions were calculated using the same procedure described previously for Urban/Rural crashes, based on the relative incidence of MAIS0 cases in injury crashes. The PDO portion was based on a direct count of PDO vehicles from each crash scenario compared to those not in that scenario. For the interstate highway crash scenario, congestion costs were modified based on data in Chapter 4 to reflect congestion impacts specific to interstate highways, which have far more serious congestion impacts. These data indicates that crashes on interstates cause roughly three times the average congestion costs across all roadways.

The results of this process are summarized for each scenario in Tables 14-5 through 14-12 for both economic costs and comprehensive costs. Note that these categories are not exclusive or additive, since some crashes qualify under more than one category.

Intersection Crashes

Intersection crashes resulted in 10,326 fatalities, over 2.8 million injuries, and nearly 10.7million PDO damaged vehicles in 2019.29 This represents 28 percent of all fatalities and roughly 58 percent of all nonfatal crashes (including both nonfatal injury and PDO). Intersection crashes caused $179 billion in economic costs and $639 billion in comprehensive costs, accounting for 53 percent of all economic costs and 48 percent of all societal harm (measured as comprehensive costs) from motor vehicle crashes.

Interstate Highway Crashes

Crashes on interstate highways resulted in 4,712 fatalities, over 550,000 injuries, and 1.47 million PDO damaged vehicles in 2019. This represents 13 percent of all fatalities and roughly 9 percent of all nonfatal crashes (including both nonfatal injury and PDO). Interstate highway crashes caused $42 billion in economic costs and $159 billion in comprehensive costs, accounting for roughly 12 percent of both economic costs and societal harm (measured as comprehensive costs).

[29] Intersection crashes includes crashes that occur at normal roadway intersections, at driveway or alleyway intersections, and at some highway interchanges.

Single-Vehicle Crashes

Single-vehicle crashes resulted in 19,954fatalities, roughly 1 million injuries, and nearly 3.1 million PDO damaged vehicles in 2019. This represents 55 percent of all fatalities and roughly 18 percent of all nonfatal crashes (including both nonfatal injuries and PDO). Single-vehicle crashes caused $97 billion in economic costs and $486 billion in comprehensive costs, accounting for 29 percent of all economic costs, and 37 percent of all societal harm (measured as comprehensive costs).

Roadway Departure Crashes

Roadway departure crashes resulted in 11,501 fatalities, 808,000 injuries, and over 3.5 million PDO damaged vehicles in 2019. This represents 32 percent of all fatalities and roughly 18 percent of all nonfatal crashes (including both nonfatal injury and PDO). Roadway departure crashes caused $72 billion in economic costs and $314 billion in comprehensive costs, accounting for 21 percent of all economic costs, and 24 percent of all societal harm (measured as comprehensive costs).

Table 14-1. KABCO/MAIS Translator for CDS Equivalent Cases

	O	C	B	A	K	Injured Severity Unknown	Unknown if Injured
MAIS	No Injury	Possible Injury	Non-incapacitating	Incapacitating	Killed		
0	0.86231	0.33909	0.1156	0.05592	0	0.42682	0
1	0.13249	0.5705	0.69558	0.32145	0	0.46843	0
2	0.00484	0.06677	0.14142	0.30823	0	0.06976	0
3	0.00037	0.02093	0.04018	0.23048	0	0.02921	0
4	0	0.00223	0.00599	0.05073	0	0.00579	0
5	0	0.00041	0.00027	0.02581	0	0	0
Fatal	0	0.00007	0.00097	0.00739	0	0	0
Total	1.000	1.000	1.000	1.000	0.000	1.000	0.000

Table 14-2. KABCO/MAIS Translator for Non-CDS Equivalent Cases, Unbelted

	O	C	B	A	Injured Severity Unknown	Unknown if Injured
MAIS	No Injury	Possible Injury	Non-incapacitating	Incapacitating		
0	0.96925	0.49704	0.19194	0.16511	0.54331	0.96925
1	0.02964	0.44883	0.70931	0.42861	0.42957	0.02964
2	0.00110	0.04580	0.08734	0.23952	0.02712	0.00110
3	0.00001	0.00821	0.00719	0.11951	0.00000	0.00001
4	0.00000	0.00000	0.00183	0.02870	0.00000	0.00000
5	0.00000	0.00012	0.00000	0.01395	0.00000	0.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fatality	0.00000	0.00000	0.00240	0.00461	0.00000	0.00000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 14-3. KABCO/MAIS Translator for Non-CDS Equivalent Cases, Belted

AIS	O No Injury	C Possible Injury	B Non-incapacitating	A Incapacitating	Injured Severity Unknown	Unknown if Injured
0	0.96179	0.53844	0.34551	0.34111	0.91429	0.96179
1	0.03764	0.42662	0.61614	0.33491	0.06423	0.03764
2	0.00054	0.01537	0.02322	0.22534	0.01553	0.00054
3	0.00003	0.01923	0.01273	0.08557	0.00594	0.00003
4	0.00000	0.00034	0.00240	0.01307	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fatality	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 14-4. KABCO/MAIS Translator for Nonoccupants and Motorcyclists

MAIS	O No Injury	C Possible Injury	B Non-incapacitating	A Incapacitating	Injured Severity Unknown	Unknown if Injured
0	0.73701	0.10573	0.02212	0.00595	0.02535	0.73701
1	0.23585	0.73969	0.74557	0.31959	0.67881	0.23585
2	0.02201	0.11848	0.16845	0.31442	0.21665	0.02201
3	0.00477	0.03187	0.05979	0.28611	0.05717	0.00477
4	0.00035	0.00324	0.00274	0.03490	0.00290	0.00035
5	0.00000	0.00099	0.00053	0.02588	0.00262	0.00000
7	0.00000	0.00000	0.00080	0.01316	0.01651	0.00000
Fatality	0.99999	1.00000	1.00000	1.00001	1.00001	0.99999
Total	0.99999	1.00000	1.00002	1.00000	1.00001	0.99999

Table 14-5. Economic Costs of Intersection Crashes (Millions 2019 $)

	% Intersection	Incidence		Total Economic Crash Costs		
		Total	**Intersection**	**Total**	**Intersection**	**Other**
PDO Vehicles	55.44%	19,288,139	10,694,078	$101,282	$56,155	$45,127
MAIS0	62.68%	4,525,901	2,836,761	$14,718	$9,225	$5,493
MAIS1	63.65%	3,875,265	2,466,781	$74,963	$47,717	$27,246
MAIS2	58.90%	427,119	251,560	$30,504	$17,966	$12,538
MAIS3	54.98%	141,167	77,612	$39,629	$21,788	$17,842
MAIS4	52.70%	19,285	10,162	$13,031	$6,867	$6,164
MAIS5	45.12%	7,187	3,243	$7,039	$3,176	$3,863
Fatalities	28.29%	36,500	10,326	$58,643	$16,590	$42,052
Total	57.73%	28,320,563	16,350,523	$339,809	$179,484	$160,326
Percentage of Total		100.00%	57.73%	100.00%	52.82%	47.18%

Table 14-6. Comprehensive Costs of Intersection Crashes (Millions 2019 $)

	% Intersection	Incidence		Total Comprehensive Crash Costs		
		Total	**Intersection**	**Total**	**Intersection**	**Other**
PDO Vehicles	55.44%	19,288,139	10,694,078	$101,282	$56,155	$45,127
MAIS0	62.68%	4,525,901	2,836,761	$14,718	$9,225	$5,493
MAIS1	63.65%	3,875,265	2,466,781	$234,283	$149,132	$85,151
MAIS2	58.90%	427,119	251,560	$202,352	$119,179	$83,173
MAIS3	54.98%	141,167	77,612	$288,631	$158,686	$129,945
MAIS4	52.70%	19,285	10,162	$69,690	$36,724	$32,966
MAIS5	45.12%	7,187	3,243	$43,471	$19,613	$23,858
Fatalities	28.29%	36,500	10,326	$410,935	$116,255	$294,680
Total	57.73%	28,320,563	16,350,523	$1,365,362	$664,968	$700,394
Percentage of Total		100.00%	57.73%	100.00%	48.70%	51.30%

Table 14-7. Economic Costs of Interstate Highway Crashes (Millions 2019 $)

	% Interstate	Incidence		Interstate Unit Costs	Total Economic Crash Costs		
		Total	**Interstate**		**Total**	**Interstate**	**Other**
PDO Vehicles	7.62%	19,288,139	1,470,506	$7,291	$101,282	$10,722	$90,560
MAIS0	12.34%	4,525,901	558,471	$5,379	$14,718	$3,004	$11,714
MAIS1	12.49%	3,875,265	484,124	$22,012	$74,963	$10,657	$64,306
MAIS2	11.38%	427,119	48,612	$74,434	$30,504	$3,618	$26,886
MAIS3	10.70%	141,167	15,105	$284,676	$39,629	$4,300	$35,329
MAIS4	11.17%	19,285	2,154	$680,001	$13,031	$1,465	$11,566
MAIS5	10.18%	7,187	732	$983,704	$7,039	$720	$6,319
Fatalities	12.91%	36,500	4,712	$1,620,828	$58,643	$7,638	$51,005
Total	9.13%	28,320,563	2,584,417		$339,809	$42,124	$297,686
Percentage of Total		100.00%	9.13%		100.00%	12.40%	87.60%

Table 14-8. Comprehensive Costs of Interstate Highway Crashes (Millions 2019 $)

	% Interstate	Incidence		Interstate Unit Costs	Total Comprehensive Crash Costs		
		Total	**Interstate**		**Total**	**Interstate**	**Other**
PDO Vehicles	7.62%	19,288,139	1,470,506	$7,291	$101,282	$10,722	$90,560
MAIS0	12.34%	4,525,901	558,471	$5,379	$14,718	$3,004	$11,714
MAIS1	12.49%	3,875,265	484,124	$63,124	$234,283	$30,560	$203,723
MAIS2	11.38%	427,119	48,612	$476,775	$202,352	$23,177	$179,175
MAIS3	10.70%	141,167	15,105	$2,048,557	$288,631	$30,944	$257,687
MAIS4	11.17%	19,285	2,154	$3,618,009	$69,690	$7,795	$61,895
MAIS5	10.18%	7,187	732	$6,052,627	$43,471	$4,429	$39,042
Fatalities	12.91%	36,500	4,712	$11,272,679	$410,935	$53,120	$357,815
Total	9.13%	28,320,563	2,584,417		$1,365,362	$163,751	$1,201,611
Percentage of Total		100.00%	9.13%		100.00%	11.99%	88.01%

Table 14-9. Economic Costs of Single-Vehicle Crashes (Millions 2019 $)

	% Single-Vehicle	Incidence		Total Economic Crash Costs		
		Total	Single-Vehicle	Total	Single-Vehicle	Other
PDO Vehicles	15.99%	19,288,139	3,083,657	$101,282	$16,192	$85,090
MAIS0	22.69%	4,525,901	1,026,905	$14,718	$3,339	$11,379
MAIS1	21.21%	3,875,265	821,777	$74,963	$15,896	$59,067
MAIS2	30.60%	427,119	130,683	$30,504	$9,333	$21,171
MAIS3	33.50%	141,167	47,291	$39,629	$13,276	$26,353
MAIS4	34.67%	19,285	6,687	$13,031	$4,519	$8,513
MAIS5	42.61%	7,187	3,063	$7,039	$2,999	$4,040
Fatalities	54.67%	36,500	19,954	$58,643	$32,059	$26,584
Total	18.15%	28,320,563	5,140,015	$339,809	$97,614	$242,196
Percentage of Total		100.00%	18.15%	100.00%	28.73%	71.27%

Table 14-10. Comprehensive Costs of Single-Vehicle Crashes (Millions 2019 $)

	% Single-Vehicle	Incidence		Total Comprehensive Crash Costs		
		Total	Single-Vehicle	Total	Single-Vehicle	Other
PDO Vehicles	15.99%	19,288,139	3,083,657	$101,282	$16,192	$85,090
MAIS0	22.69%	4,525,901	1,026,905	$14,718	$3,339	$11,379
MAIS1	21.21%	3,875,265	821,777	$234,283	$49,681	$184,602
MAIS2	30.60%	427,119	130,683	$202,352	$61,912	$140,440
MAIS3	33.50%	141,167	47,291	$288,631	$96,692	$191,940
MAIS4	34.67%	19,285	6,687	$69,690	$24,165	$45,525
MAIS5	42.61%	7,187	3,063	$43,471	$18,523	$24,948
Fatalities	54.67%	36,500	19,954	$410,935	$224,650	$186,285
Total	18.15%	28,320,563	5,140,015	$1,365,362	$495,155	$870,207
Percentage of Total		100.00%	18.15%	100.00%	36.27%	63.73%

Table 14-11. Economic Costs of Roadway Departure Crashes (Millions 2010 Dollars)

	% Roadway Departure	Incidence		Total Economic Crash Costs		
		Total	**Roadway Departure**	**Total**	**Roadway Departure**	**Other**
PDO Vehicles	18.50%	19,288,139	3,569,126	$101,282	$18,741	$82,541
MAIS0	18.15%	4,525,901	821,315	$14,718	$2,671	$12,047
MAIS1	17.78%	3,875,265	688,959	$74,963	$13,327	$61,636
MAIS2	19.29%	427,119	82,405	$30,504	$5,885	$24,619
MAIS3	21.64%	141,167	30,548	$39,629	$8,576	$31,054
MAIS4	23.55%	19,285	4,542	$13,031	$3,069	$9,962
MAIS5	24.72%	7,187	1,777	$7,039	$1,740	$5,299
Fatalities	31.51%	36,500	11,501	$58,643	$18,478	$40,164
Total	18.40%	28,320,563	5,210,173	$339,809	$72,488	$267,321
Percentage of Total		100.00%	18.40%	100.00%	21.33%	78.67%

Table 14-12. Comprehensive Costs of Roadway Departure Crashes (Millions 2019 $)

	% Roadway Departure	Incidence		Total Comprehensive Crash Costs		
		Total	**Roadway Departure**	**Total**	**Roadway Departure**	**Other**
PDO Vehicles	18.50%	19,288,139	3,569,126	$101,282	$18,741	$82,541
MAIS0	18.15%	4,525,901	821,315	$14,718	$2,671	$12,047
MAIS1	17.78%	3,875,265	688,959	$234,283	$41,652	$192,631
MAIS2	19.29%	427,119	82,405	$202,352	$39,040	$163,311
MAIS3	21.64%	141,167	30,548	$288,631	$62,459	$226,172
MAIS4	23.55%	19,285	4,542	$69,690	$16,415	$53,275
MAIS5	24.72%	7,187	1,777	$43,471	$10,745	$32,725
Fatalities	31.51%	36,500	11,501	$410,935	$129,487	$281,448
Total	18.40%	28,320,563	5,210,173	$1,365,362	$321,211	$1,044,151
Percentage of Total		100.00%	18.40%	100.00%	23.53%	76.47%

15. Source of Payment

The economic toll of motor vehicle crashes is borne by society through a variety of payment mechanisms. The most common of these are private insurance plans such as Blue Cross-Blue Shield, HMOs, commercial insurance policies, or worker's compensation. Medicare is the primary payer for people over the age of 65. When these sources are not available, government programs such as Obamacare or Medicaid may provide coverage for those who meet eligibility requirements. A host of other Federal, State, and local programs such as CHAMPVA, Tricare, Title 5, and Indian Health Services also provide health care coverage for specific groups. Expenses not covered by private or governmental sources must be paid out-of-pocket by individuals, or, absorbed as losses by health care providers.

Blincoe (1996) provided estimates of sources of payment for motor vehicle crashes that combined analysis of CODES data with previous estimates developed by the Urban Institute (Miller et al., 1991). These data were also used in a previous version of this current study (Blincoe et al., 2002). For the most recent report, (Blincoe et al., 2015), data from Blincoe (1996) were carried forward for insurance administration, workplace costs, legal costs, and congestion while new estimates of source of payment were developed for medical care, lost productivity, workplace costs, and property damage. Blincoe also estimated values for emergency services. However, in that study ambulance costs were included under emergency services, while for both the 2015 study and this current study, ambulance costs are included under medical care. Ambulance costs had been distributed across all payer categories in the same proportion as medical care. To adjust for this, the impact of ambulance costs was removed from the EMS distribution. This results in 100 percent of emergency service costs being born by States and localities (primarily localities).

In this study "unspecified government" represents programs that are funded primarily by government revenues, but that are lumped together in HCUP data and that therefore cannot be individually identified as belonging to either State or Federal categories. In addition, some of these programs are partially funded by participants through subsidized premium charges. Programs in these categories include Veterans Administration, Tricare, Title 5, Indian Health Services, and State and local health care programs. These are programs that cover medical care for service personal and their families, veterans, Native Americans, and State and local employees. In previous studies, these costs were lumped under the "Other" category. We have categorized them with government programs because they are either entirely supported by, or heavily subsidized by, tax dollars, but some unknown portion of these costs are paid by individual insurance premiums.

For property damage, we adopt the same method used for the 2015 report. We derived total 2019 insurance claim payments for property damage in motor vehicle crashes from industry data. We then divided it by the sum of property damage and roadside furniture calculated in this report, yielding an estimate of 76.24 percent of property damage covered by commercial insurance. The rest was paid out of pocket by involved vehicle owners.

Workplace costs are borne by employers, who are generally categorized as "Other" sources in this study. However, Federal, State, and local governments employ a substantial portion of the U.S. workforce. BLS data indicate that the Federal Government employs 1.8 percent of the U.S. workforce, and State and local governments employee 12.1 percent (www.bls.gov/emp/tables/employment-by-major-industry-sector.htm). We distribute workplace costs to government sources in these proportions, with the remainder allocated to private employers categorized under “Other”.

Following are discussions the derivation of revised source of payment estimates for medical care and lost productivity.

The distribution of payment varies among the components of crash cost. State and local government pay almost all costs of police, fire, emergency medical, vocational rehabilitation, victim assistance, and coroner services; incident management; and roadside furniture damage. They share foregone taxes, welfare, and public medical payments. As employers, they bear their share of costs that fall on employers, including private medical care, disability compensation, property damage, auto liability insurance payments, insurance claims processing expenses, and workplace disruption/rehiring expenses. In Table 3-8, we estimated that 84.4 percent of property damage costs ($83.15 billion out of $98.5 billion) are covered by insurance. All insured drivers split the auto insurance costs and all motor vehicle travelers split crash-related congestion costs. The following two sections detail who pays for medical costs and work losses.

Medical Costs

Miller et al. (2011) provide factors for computing the percentage of crash costs paid by State/local and Federal Governments. Table 15-1, drawn in part from that paper, updates the medical cost split using 2018 data from HCUP NIS. Medical costs were estimated using hospital charges, as recorded in the NIS, converted to costs using hospital-specific cost-to-charge ratios supplied by HCUP. The NIS also records the expected payer for each hospital stay, which allowed estimation of the amount paid by payer. Medicaid paid an estimated 19.3 percent of hospital costs for motor vehicle crashes and Medicare paid 13.6 percent. That is roughly a ten percentage point rise in share of the medical costs paid by Federal and State governments from 2010 to 2018. Factors driving that rise include the graying of the American population and Medicaid expansion in many States under the Affordable Care Act.

Zaloshnja and Miller (2012) analyzed Medicaid claims and HCUP data from 14 States. They estimated that 22 percent of adults aged 19–64 with hospital-admitted crash injuries covered by Medicaid (2.85 percent of all those admitted) became Medicaid-eligible because earnings losses and medical bills resulting from crash injury left them indigent or disabled. The crash resulted in Medicaid paying all their medical bills, not just their injury bill. Zaloshnja and Miller further estimated that 35 percent of those who converted to Medicaid to pay hospital bills stayed on Medicaid indefinitely. The present value of their lifetime Medicaid health care costs averaged $316,000 (computed following the article’s methods but substituting Fiscal Year 2019 Medicaid spending of $15,840 per disabled recipient (KFF, n.d.-b). Thus, government pays an estimated $3,152 ($316,000×0.0285×0.35) in Medicaid costs for other medical care per hospital-admitted non-elderly crash survivor. With roughly 5.4 percent of medically treated crash survivors admitted, government spending due to Medicaid conversion is $170 per injured crash survivor.

The division of Medicaid costs between the Federal and State levels varies by State. On average, States paid 43.8 percent in fiscal year 2021 (KFF, n.d.-a).

Among the elderly, HCUP data show private insurance paid 41.7 percent of the medical cost of crash injuries but only 7.5 percent of the cost of other injuries. The 34.2 percent differential presumably is due to medical costs borne by or recovered from auto insurers. Assuming this percentage applies to injuries not requiring hospital admission is aggressive. Health insurers are less likely to pursue recovery through subrogation for smaller medical bills. Even if we apply this percentage to non-admitted injuries, at most $11.4 billion in medical costs would be compensated by auto insurance. Thus our modelling from auto insurance data that suggested $25.4 billion in compensation for medical costs may be overestimating that compensation but underestimating work loss compensation or implicit compensation of legal fees on 30 percent contingency by a like amount.

Productivity (Work) Losses

Estimated productivity losses in 2019 were $106.3 billion, of which 71 percent were wages and fringe benefits. The remainder was lost household productivity. As shown in Table 3-10, estimated auto insurance compensation for productivity losses, net of fraud, was $34.6 billion in 2019, which equates to 33 percent of those losses.

Following methods in Miller et al. (2011), from 2019 data on personal income (Bureau of Economic Analysis, Table 2.1, Personal Income and its Distribution, https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey, 2021), State income and sales tax revenues (Bureau of the Census. Annual Census of Government Finances, Table 1. State and Local Government Finances by Level of Government and by State: 2019, www.census.gov/data/datasets/2019/econ/local/public-use-datasets.html, 2021.) and Federal income tax revenues (Congressional Budget Office. The Distribution of Household Income, 2018, www.cbo.gov/system/files/2021-08/57061-Distribution-Household-Income.pdf, 2021.), we estimate that 5.8 percent of market productivity losses[30] (7.25% of wage losses) are State tax losses and 7.61 percent (9.4% of wage loss) are Federal tax losses. From old survey data, following Miller et al. (2011) we estimate that the safety net compensates another 1.3 percent (1.65% of market work loss) Some employer-paid crash costs result from crashes involving government employees. Following Miller et al. (2011) we estimate the Federal Government pays 2.0 percent of the sick leave and Worker's Compensation costs, while State and local governments pay 12.3 percent.

Miller & McKnight (2021) estimated the costs of crashes to employers. As shown in Table 15-2, in 2019 dollars and updated with the crash costs reported here, workers' compensation covered $2.74 billion in medical costs (8.9%) and $2.263 billion in nonfatal market work losses (5.9%), disability insurance covered $0.85 billion (2.2%), and sick leave $10.61 billion (27.5%). In addition, social security payments covered an average of $484 per person aged 18-64 who is killed or injured, $1.85 billion in total (4.8% of nonfatal work losses).

The American Council of Life Insurers (2020) provides data on life insurance policies in force by type. Table 15-3 starts from those data. (In this table, group policies generally are employment-related.) Dividing the amount of coverage by policies in force yields the average payment per premium. Multiplying coverage per policy times the percentage of the U.S. population with policies of the given type yields expected payout per policy. The average death at ages 16 and older in 2019 generated $19,873 in life insurance payments. With 34,870 crash deaths at ages 16 and over, life insurance payments totaled $0.69 billion (0.9% of market work loss).

[30] Market productivity loss includes wages and fringe benefits.

Together, these sources absorb an estimated 69 percent of the market productivity losses (Table 15-4). The remaining portion is paid by people injured in crashes and their families.

Following Blincoe et al. (2010, 2015), from Miller et al. (1991), we adopted administrative cost percentages for claims processing and payment of 1.76 percent for sick leave, 3.61 percent for Social Security disability and survivor payments, and 9.0 percent for life insurance claims administration. Multiplying the mean market productivity loss by MAIS times the percentage compensated by each of these sources times the administrative cost percentages yielded the administrative cost estimates for these programs. We summed those costs with the motor vehicle insurance claims adjustment costs developed above to arrive at total insurance administrative costs.

Table 15-1. Primary Payer for Medical Costs of Hospital-Admitted Road Crash Injuries, by Age, United States, per 2018 HCUP-NIS

Payer*	**Ages 0–18**	**Ages 19–64**	**Ages ≥65**	**All Ages**
Medicare	0.1%	4.2%	48.0%	13.6%
Medicaid	39.4%	35.0%	1.3%	19.3%
Private	49.3%	42.0%	41.7%	48.3%
Self	5.8%	11.2%	2.5%	10.5%
Charity	0.1%	0.7%	0.1%	0.7%
Other Government	5.0%	6.6%	6.2%	7.3%
Unknown	0.3%	0.3%	0.3%	0.3%

*Private includes auto insurance, private health insurance, HMO/managed care, and workers' compensation. Self-pay and charity care ultimately may shift to Medicare or Medicaid. Other Government includes VA, CHAMPUS/ TRICARE, and State and local government health care programs.

Table 15-2. Employer Health-Related Fringe Benefit Costs From Motor Vehicle Crashes, United States, 2019 (Millions 2019 $)

	On-the-Job	**Off-the-Job**	**All**
Workers' Compensation	5,370	0	5,370
Medical	2,740	0	2,740
Disability	2,630	0	2,630
Health Insurance	70	13,430	13,500
Disability Insurance	0	850	850
Life Insurance	70	1,010	1,080
Insurance Administration	750	2,010	2,760
Insurance Overhead	40	250	290
Social Security	180	1,670	1,850
Sick Leave	1,030	9,580	10,610
TOTAL	7,510	28,800	36,310

Source: Miller & McKnight, 2021. Updated to incorporate the national crash cost estimates in the present report.

Table 15-3. Life Insurance Coverage and Policy Amounts, United States, 2019

	Policies	Amount per Policy	Deaths Paid	Paid per Paid Claim	% With Policy	Paid per Death, Ages 16 & Over
Individual	137,213,000	$90,285	2,843,000	$20,217	52.6%	$10,644
Group	108,495,000	$67,823	1,016,000	$20,298	41.6%	$8,450
Credit	13,038,000	$6,699	84,000	$3,071	5.0%	$154
All	*258,746,000*	*$76,655*	*3,943,000*	*$19,873*	*99.3%*	*$19,729*

Source: Computed from data in American Council of Life Insurers (2020), Tables 5.9 and 7.1.

Results Table 15-4 shows the distribution of the portion of crash-related costs that are borne by private insurers, governmental sources, individual crash victims, and other sources. These distributions are quite variable depending on the nature of the cost category. Private Insurers are the primary source of payment for medical care, insurance administration, legal costs, and property damage, but tax revenues cover a significant portion of medical care, emergency services, workplace costs and lost market productivity. Third parties absorb most workplace costs and all congestion costs, as well as a portion of lost productivity through sick leave. Individual crash victims pay a modest portion of medical care and absorb significant portions both market and household productivity losses, as well as property damage.

Table 15-4. Distribution of Source of Payment for Economic Costs by Cost Category, 2019

	Federal	State/ Locality	Unspecified Govt.	Total Government	Insurer	Other	Self	Total
Medical	23.25%	9.65%	7.30%	40.20%	48.30%	1.00%	10.50%	100.00%
Emergency Services	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Market Prod.	11.70%	7.96%	0.00%	19.66%	37.66%	12.04%	30.64%	100.00%
Household Prod.	0.00%	0.00%	0.00%	0.00%	33.00%	0.00%	67.00%	100.00%
Insurance Admin.	0.89%	0.51%	0.00%	1.40%	98.60%	0.00%	0.00%	100.00%
Workplace Costs	1.82%	12.09%	0.00%	13.92%	0.00%	86.08%	0.00%	100.00%
Legal Costs	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Congestion Costs	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Property Damage	0.00%	0.00%	0.00%	0.00%	72.12%	0.00%	27.88%	100.00%

In Table 15-5, total economic costs are distributed according to the proportions listed in Table 15-4. The results indicate that approximately $29.5 billion, or 8.7 percent of all costs are borne by public sources, with Federal revenues accounting for 4.8 percent and States/Localities accounting for 3.2 percent, with another 0.7 percent borne by a number of State and Federal programs that could not be broken out by government source. Public expenditures for economic harm caused by motor vehicle crashes are the equivalent of $230 in added taxes for every household in the United States (U.S. Census Bureau, 2022).[31] State and local government pay almost all costs of police, fire, emergency medical, vocational rehabilitation, victim assistance, and coroner services; incident management; and roadside furniture damage. They share foregone taxes, welfare, and public medical payments. As employers, they bear their share of costs that fall on employers, including private medical care, disability compensation, property damage, auto liability insurance payments, insurance claims processing expenses, and workplace disruption/rehiring expenses. Private insurers paid $182 billion, or 53.7 percent, while individual crash victims absorbed $79 billion or 23.3 percent. Other sources, including third parties impacted by traffic congestion from crashes, employers who pay for sick leave and workplace disruption, and health care providers and charities who absorb unpaid charges for medical care, absorbed $49 billion (14.5%) of the total economic cost.

Table 15-5. Source of Payment of Economic Costs by Cost Category, 2019 Motor Vehicle Crash Costs (Millions 2019 $)

	Federal	**State/ Locality**	**Unspecified Govt.**	**Total Government**	**Insurer**	**Other**	**Self**	**Total**
Medical	$7,184	$2,982	$2,256	$12,422	$14,925	$309	$3,245	$30,900
Emergency Services	$0	$1,348	$0	$1,348	$0	$0	$0	$1,348
Market Prod.	$8,826	$6,009	$0	$14,834	$28,416	$9,087	$23,122	$75,459
Household Prod.	$0	$0	$0	$0	$10,170	$0	$20,646	$30,816
Insurance Admin.	$263	$151	$0	$414	$29,127	$0	$0	$29,540
Workplace Costs	$69	$459	$0	$528	$0	$3,267	$0	$3,795
Legal Costs	$0	$0	$0	$0	$16,698	$0	$0	$16,698
Congestion Costs	$0	$0	$0	$0	$0	$35,954	$0	$35,954
Property Damage	$0	$0	$0	$0	$83,153	$0	$32,144	$115,297
Total	$16,342	$10,948	$2,256	$29,546	$182,489	$48,617	$79,157	$339,809
% Total	4.81%	3.22%	0.66%	8.69%	53.70%	14.31%	23.29%	100.00%

[31] Based on 128,579,000 households in the U.S. in 2019

Figure 15-A. Source of Payment for Motor Vehicle Crash Costs

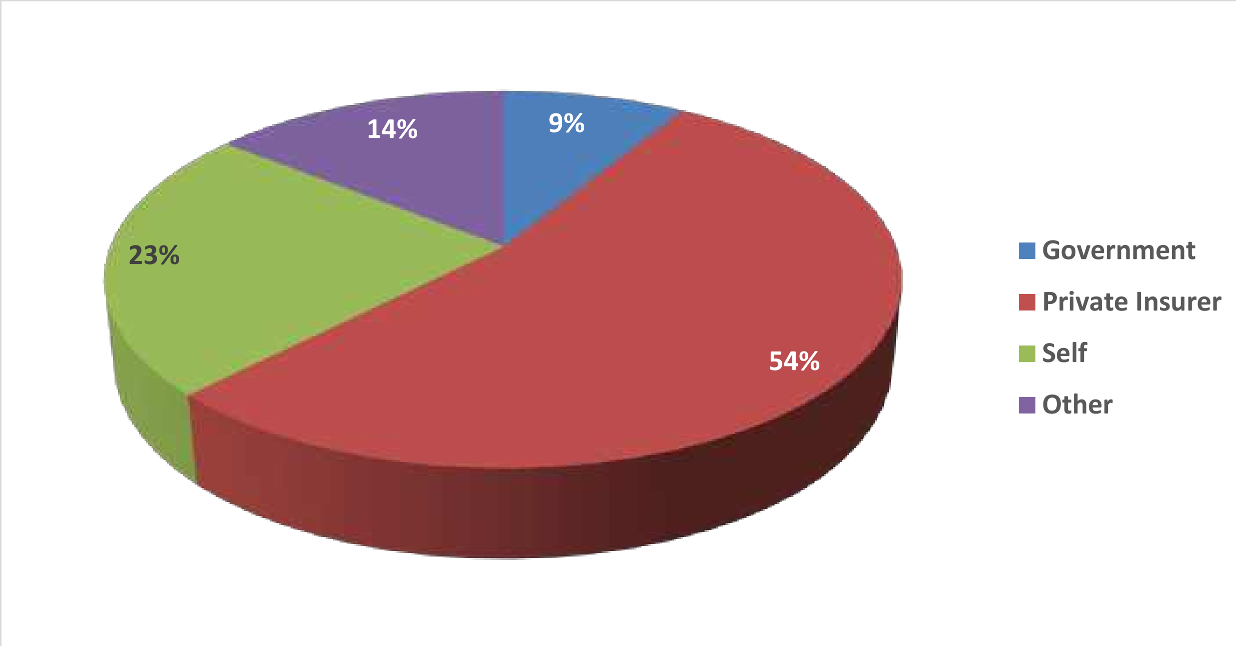


Figure 15-A illustrates overall distribution of payment for motor vehicle crash costs. To some extent it is illusory to disaggregate costs across payment categories because ultimately, it is individuals who pay for these costs through insurance premiums, taxes, direct out-of-pocket cost, or higher charges for medical care. A real distinction can be made, however, between costs borne by those directly involved in the crashes and costs that are absorbed by the rest of society. Costs paid out of Federal or State revenues are funded by taxes from the general public. Similarly, costs borne by private insurance companies are funded by insurance premiums paid by policyholders, most of whom are not involved in crashes. Even unpaid charges, which are absorbed by health care providers, are ultimately translated into higher costs that are borne by a smaller segment of the general public – users of health care facilities. From this perspective, perhaps the most significant point from Figure15-A is that society at large absorbs over three-quarters of all the economic crash costs that are incurred by individual motor vehicle crash victims.

Appendix A: Sensitivity Analysis, Value of a Statistical Life

Much of this report focuses on the economic impact of motor vehicle crashes – the societal losses that can be directly measured in economic terms. However, these costs do not represent the more intangible consequences of these events and should not, therefore, be used alone to produce cost-benefit ratios. Measurement of the dollar value of intangible consequences such as pain and suffering has been undertaken in numerous studies. These studies have estimated values based on wages for high-risk occupations and prices paid in the marketplace for safety products, among other measurement techniques. These “willingness to pay” based estimates of how society values risk reduction capture valuations not associated with direct monetary consequences. In this study, comprehensive costs, which include both the economic impacts of crashes and valuation of lost quality-of-life, are also examined. Comprehensive costs represent the value of the total societal harm that results from traffic crashes. The basis for these estimates is the most recent guidance issued by the U.S. Department of Transportation for valuing mortality risk reduction at $10.9 million for 2019 (U.S. DOT, 2021b). Additionally, this study establishes new relative disutility factors stratified by injury severity level to estimate the lost quality-of-life for nonfatal injuries. These factors were derived in a research contract designed specifically for this current cost study. More detailed discussion of comprehensive costs is included in Chapter 5 of this report.

From Table 8 in chapter 1, the total societal harm from motor vehicle crashes in 2019 is estimated to have been $1.3 trillion, roughly four times the value measured by economic impacts alone. Of this total, 75 percent represents lost quality-of-life, dwarfing the contribution of all other cost categories. This highlights the importance of accounting for all societal impacts when measuring costs and benefits from motor vehicle safety countermeasures. However, the literature on VSL estimates indicates a wide range of measured estimates of VSLs – some as low as a few million dollars, some as high as over $30 million. The 2013 U. S. DOT guidance memorandum, which established a central VSL of $9.1 million, discusses a plausible range of VSLs for sensitivity analysis in 2012 dollars from $5.2 million to $12.9 million. Current U.S.DOT guidance recommends sensitivity analyses using values that are +-40 percent of the central VSL. There is thus far more uncertainty regarding the accuracy of estimates of lost quality-of-life than there is regarding economic costs. In this appendix, comprehensive costs are estimated based on this range adjusted to the 2019 basis of an $10.9 million VSL ($6.54 million and $15.26 million, computed by applying the +-40 percent factor to the 2019 VSL. The results indicate a plausible range of societal harm from motor vehicle crashes of from $869 billion to $1.8 trillion in 2019, with lost quality-of-life accounting for between 62 and 81 percent of all societal harm respectively. The central value used in this report, $1.37 trillion, should thus be viewed with this range in mind. Although the U.S.DOT values were not selected statistically, they imply a central value with the equivalent of a confidence interval of approximately +-40 percent.

Appendix Table A-1. Total Comprehensive Costs, $6.5 Million VSL (Millions 2019 $)

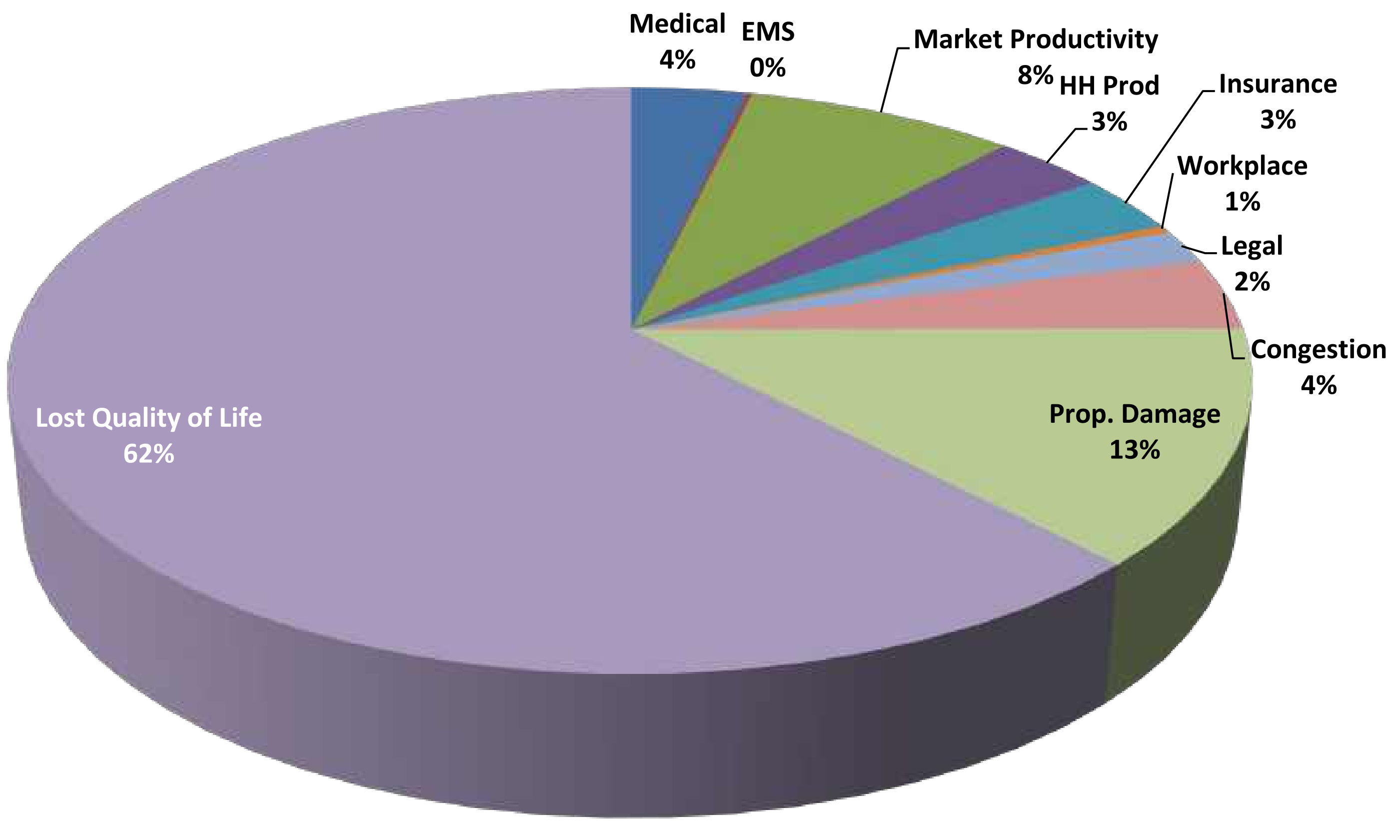
	PDO	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**	**Total**	**% Total**
Medical	$0	$0	$8,564	$5,667	$9,789	$3,638	$2,611	$571	$30,840	3.6%
EMS	$571	$109	$411	$97	$69	$19	$7	$35	$1,318	0.2%
Market	$0	$0	$8,971	$9,865	$13,088	$4,434	$2,201	$33,361	$71,920	8.3%
Household	$1,309	$249	$3,286	$3,840	$5,506	$2,246	$919	$12,116	$29,470	3.4%
Insurance	$9,639	$1,018	$8,572	$3,511	$4,051	$704	$274	$1,196	$28,965	3.3%
Workplace	$1,825	$344	$217	$179	$457	$136	$56	$448	$3,662	0.4%
Legal Costs	$0	$0	$2,868	$2,667	$3,912	$1,423	$791	$4,555	$16,215	1.9%
Subtotal	$13,343	$1,720	$32,889	$25,825	$36,873	$12,600	$6,858	$52,281	$182,390	21.0%
Congestion	$24,457	$4,562	$4,677	$572	$239	$35	$13	$235	$34,790	4.0%
Prop. Damage	$58,976	$8,436	$37,396	$4,107	$2,518	$397	$167	$501	$112,498	12.9%
Subtotal	$83,432	$12,998	$42,074	$4,679	$2,756	$432	$180	$736	$147,289	17.0%
Economic Total	$96,776	$14,718	$74,963	$30,504	$39,629	$13,031	$7,038	$53,018	$329,678	38.0%
QALYs	$0	$0	$82,043	$92,235	$135,372	$30,880	$24,228	$174,278	$539,037	62.0%
Comp.Total	$96,776	$14,718	$157,006	$122,740	$175,001	$43,911	$31,267	$227,296	$868,715	100.0%
% Total	11.1%	1.7%	18.1%	14.1%	20.1%	5.1%	3.6%	26.2%	100.0%	0.0%

Appendix Table A-2. Comprehensive Unit Costs, $6.5 Million VSL (2019 $)

	PDO	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**Fatal**
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$31	$24	$106	$228	$486	$976	$999	$1,060
Market	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$724	$380	$8,487	$60,464	$261,200	$653,348	$954,237	$1,584,326
Congestion	$1,327	$1,008	$1,207	$1,339	$1,691	$1,814	$1,857	$7,133
Prop. Damage	$3,200	$1,864	$9,650	$9,616	$17,835	$20,565	$23,234	$15,185
Subtotal	$4,527	$2,872	$10,857	$10,955	$19,526	$22,379	$25,091	$22,318
Economic Total	$5,251	$3,252	$19,344	$71,419	$280,726	$675,727	$979,328	$1,606,644
QALYs	$0	$0	$21,171	$215,948	$958,950	$1,601,221	$3,371,145	$5,281,316
Comp.Total	$5,251	$3,252	$40,515	$287,367	$1,239,676	$2,276,948	$4,350,473	$6,887,960

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

Appendix Figure A-A. Components of Comprehensive Costs, $6.5 Million VSL



Appendix Table A-3. Total Comprehensive Costs, $15.3 Million VSL (Millions 2019 $)

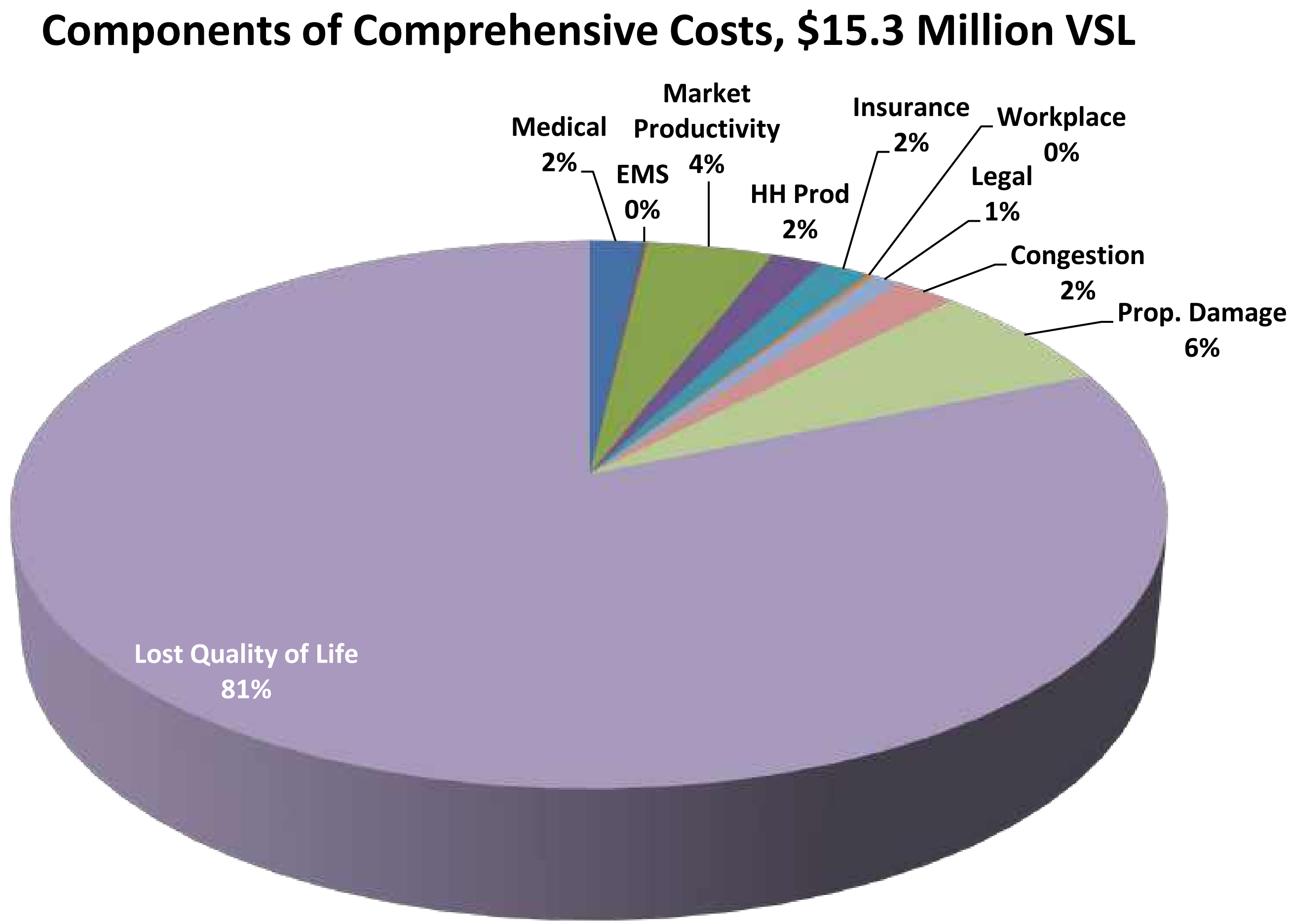
	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal	Total	% Total
Medical	$0	$0	$8,564	$5,667	$9,789	$3,638	$2,611	$571	$30,840	1.8%
EMS	$571	$109	$411	$97	$69	$19	$7	$35	$1,318	0.1%
Market	$0	$0	$8,971	$9,865	$13,088	$4,434	$2,201	$33,361	$71,920	4.1%
Household	$1,309	$249	$3,286	$3,840	$5,506	$2,246	$919	$12,116	$29,470	1.7%
Insurance	$9,639	$1,018	$8,572	$3,511	$4,051	$704	$274	$1,196	$28,965	1.6%
Workplace	$1,825	$344	$217	$179	$457	$136	$56	$448	$3,662	0.2%
Legal Costs	$0	$0	$2,868	$2,667	$3,912	$1,423	$791	$4,555	$16,215	0.9%
Subtotal	$13,343	$1,720	$32,889	$25,825	$36,873	$12,600	$6,858	$52,281	$182,390	10.4%
Congestion	$24,457	$4,562	$4,677	$572	$239	$35	$13	$235	$34,790	2.0%
Prop. Damage	$58,976	$8,436	$37,396	$4,107	$2,518	$397	$167	$501	$112,498	6.4%
Subtotal	$83,432	$12,998	$42,074	$4,679	$2,756	$432	$180	$736	$147,289	8.4%
Economic Total	$96,776	$14,718	$74,963	$30,504	$39,629	$13,031	$7,038	$53,018	$329,678	18.7%
QALYs	$0	$0	$217,507	$244,525	$358,885	$81,865	$64,232	$462,029	$1,429,044	81.3%
Comp.Total	$96,776	$14,718	$292,470	$275,030	$398,515	$94,896	$71,270	$515,047	$1,758,722	100.0%
% Total	5.5%	0.8%	16.6%	15.6%	22.7%	5.4%	4.1%	29.3%	100.0%	0.0%

Appendix Table A-4. Comprehensive Unit Costs, $15.3 Million VSL (2019 $)

	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$0	$0	$2,210	$13,269	$69,345	$188,626	$363,229	$17,289
EMS	$31	$24	$106	$228	$486	$976	$999	$1,060
Market	$0	$0	$2,315	$23,096	$92,716	$229,903	$306,236	$1,010,970
Household	$71	$55	$848	$8,990	$39,001	$116,482	$127,886	$367,148
Insurance	$523	$225	$2,212	$8,220	$28,698	$36,485	$38,081	$36,245
Workplace	$99	$76	$56	$418	$3,240	$7,077	$7,794	$13,589
Legal Costs	$0	$0	$740	$6,243	$27,714	$73,799	$110,012	$138,025
Subtotal	$724	$380	$8,487	$60,464	$261,200	$653,348	$954,237	$1,584,326
Congestion	$1,327	$1,008	$1,207	$1,339	$1,691	$1,814	$1,857	$7,133
Prop. Damage	$3,200	$1,864	$9,650	$9,616	$17,835	$20,565	$23,234	$15,185
Subtotal	$4,527	$2,872	$10,857	$10,955	$19,526	$22,379	$25,091	$22,318
Economic Total	$5,251	$3,252	$19,344	$71,419	$280,726	$675,727	$979,328	$1,606,644
QALYs	$0	$0	$56,127	$572,499	$2,542,276	$4,245,003	$8,937,254	$14,001,316
Comp.Total	$5,251	$3,252	$75,471	$643,918	$2,823,002	$4,920,730	$9,916,582	$15,607,960

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

Appendix Figure A-B. Components of Comprehensive Costs, $15.3 Million VSL



Appendix B: Costs by Body Region

Appendix Table B-1. Economic Unit Costs by Body Region (2019 $)

Fracture Status	**MAIS**	**Medical**	**Emerg.**	**Wage**	**House-hold Brain**	**Work-place**	**Legal**	**Ins.**	**Cong.**	**Property Damage**	**Total**
N/A	1	2,625	106	4,269	1,503	56	1,157	1,603	1,210	9,624	22,153
N/A	2	14,948	228	42,945	16,060	418	10,190	11,355	1,343	9,590	107,078
N/A	3	119,734	486	215,375	90,576	3,240	58,718	55,145	1,690	17,809	562,772
N/A	4	190,091	976	262,931	134,196	7,077	81,005	35,796	1,810	20,539	734,422
N/A	5 or 6	500,438	999	426,387	181,832	7,794	138,025	45,349	1,853	23,208	1,325,885
Spinal Cord											
N/A	1										
N/A	2										
N/A	3	428,095	486	339,997	134,675	3,240	124,567	116,987	1,690	17,809	1,167,545
N/A	4	614,745	976	319,932	170,150	7,077	138,025	67,366	1,810	20,539	1,340,620
N/A	5 or 6	738,984	999	550,891	209,305	7,794	138,025	61,328	1,853	23,208	1,732,387
Other Head											
No	1	2,703	106	3,481	1,150	56	1,010	1,400	1,210	9,624	20,740
No	2	5,019	228	10,071	3,426	418	2,538	2,829	1,343	9,590	35,461
No	3	15,443	486	46,676	17,726	3,240	10,983	10,315	1,690	17,809	124,369
No	4	75,921	976	151,061	59,726	7,077	39,527	17,467	1,810	20,539	374,105
No	5 or 6					7,794					
Yes	1	6,072	106	5,583	1,838	56	1,860	2,578	1,210	9,624	28,927
Yes	2	15,529	228	22,538	7,961	418	6,336	7,060	1,343	9,590	71,004
Yes	3	27,833	486	61,889	22,918	3,240	15,510	14,566	1,690	17,809	165,941
Yes	4	54,034	976	128,966	58,244	7,077	33,252	14,694	1,810	20,539	319,592
Yes	5 or 6										
Trunk											
No	1	2,500	106	3,601	1,356	56	1,027	1,423	1,210	9,624	20,903
No	2	17,548	228	16,865	6,620	418	5,647	6,292	1,343	9,590	64,551
No	3	41,033	486	39,323	17,691	3,240	13,496	12,675	1,690	17,809	147,443

Fracture Status	MAIS	Medical	Emerg.	Wage	House-hold Brain	Work-place	Legal	Ins.	Cong.	Property Damage	Total
No	4	102,420	976	71,434	35,362	7,077	28,831	12,740	1,810	20,539	281,190
No	5 or 6	90,098	999	97,043	48,479	7,794	32,479	9,628	1,853	23,208	311,581
Yes	1	3,935	106	4,227	1,724	56	1,363	1,888	1,210	9,624	24,133
Yes	2	18,041	228	29,231	12,766	418	8,270	9,215	1,343	9,590	89,102
Yes	3	35,564	486	41,242	19,289	3,240	13,226	12,421	1,690	17,809	144,967
Yes	4	105,249	976	102,981	46,242	7,077	35,078	15,501	1,810	20,539	335,454
Yes	5 or 6	115,673	999	156,201	83,791	7,794	49,048	14,540	1,853	23,208	453,106
Upper Extremity											
No	1	3,681	106	2,962	1,059	56	1,061	1,470	1,210	9,624	21,229
No	2	4,785	228	5,584	1,813	418	1,664	1,855	1,343	9,590	27,281
No	3	37,884	486	58,793	25,162	3,240	16,780	15,759	1,690	17,809	177,603
No	4	96,417	976	250,230	91,191	7,077	60,387	26,685	1,810	20,539	555,311
No	5 or 6	119,147	999	138,896	112,738	7,794	51,135	15,158	1,853	23,208	470,929
Yes	1	2,655	106	5,920	2,079	56	1,468	2,034	1,210	9,624	25,152
Yes	2	9,891	228	19,466	7,284	418	5,040	5,617	1,343	9,590	58,876
Yes	3	54,601	486	92,252	37,336	3,240	25,385	23,841	1,690	17,809	256,641
Yes	4			,							
Yes	5 or 6										
Lower extremity											
No	1	1,736	106	2,199	786	56	650	900	1,210	9,624	17,267
No	2	6,614	228	7,810	2,757	418	2,354	2,624	1,343	9,590	33,739
No	3	79,135	486	92,117	34,132	3,240	28,311	26,588	1,690	17,809	283,507
No	4										
No	5 or 6										
Yes	1	2,135	106	3,337	1,170	56	915	1,267	1,210	9,624	19,819
Yes	2	21,703	228	36,993	14,121	418	10,033	11,181	1,343	9,590	105,610
Yes	3	81,281	486	68,533	27,105	3,240	24,382	22,898	1,690	17,809	247,424
Yes	4	167,619	976	100,998	51,375	7,077	44,121	19,497	1,810	20,539	414,012
Yes	5 or 6	151,417	999	140,854	81,849	7,794	51,595	15,295	1,853	23,208	474,864
Burn											
N/A	1	1,827	106	3,058	1,144	56	830	1,150	1,210	9,624	19,005
N/A	2	6,645	228	7,468	2,586	418	2,288	2,549	1,343	9,590	33,116

Fracture Status	MAIS	Medical	Emerg.	Wage	House-hold Brain	Work-place	Legal	Ins.	Cong.	Property Damage	Total
N/A	3										
N/A	4										
N/A	5 or 6	276,728	999	49,372	23,000	7,794	48,142	14,271	1,853	23,208	445,368
Minor Injury											
N/A	1	1,665	106	820	333	56	387	536	1,210	9,624	14,737

*MAIS5 injury costs include a very small number of MAIS 6 survivor costs.

Appendix Table B-2. QALY Values by MAIS, Body Region, and Injury Status (2019$)

Body Region	Fracture	MAIS	ED Mean	Hospitalized Mean	All Cases Mean
Brain	N/A	1	$493,860	$2,220,856	$374,341
Brain	N/A	2	$803,026	$1,401,896	$1,059,531
Brain	N/A	3	$1,588,184	$2,201,533	$2,094,243
Brain	N/A	4	$1,709,414	$2,898,648	$2,891,812
Brain	N/A	5 or 6		$4,556,832	$4,556,852
Spinal Column	N/A	1			
Spinal Column	N/A	2			
Spinal Column	N/A	3	$663,972	$3,291,946	$3,172,873
Spinal Column	N/A	4	$763,326	$5,104,758	$4,939,227
Spinal Column	N/A	5 or 6		$6,257,838	$6,257,861
Upper Extremity	Yes	1	$8,801	$32,688	$7,204
Upper Extremity	Yes	2	$43,451	$672,241	$147,899
Upper Extremity	Yes	3	$165,691	$1,483,459	$1,301,715
Upper Extremity	Yes	4		$2,273,997	$2,273,997
Upper Extremity	Yes	5 or 6		$3,102,598	$3,102,584
Upper Extremity	No	1	$43,267	$482,519	$34,564
Upper Extremity	No	2	$94,961	$866,841	$139,319
Upper Extremity	No	3	$122,930	$1,630,897	$1,110,624
Upper Extremity	No	4			
Upper Extremity	No	5 or 6			
Lower Extremity	Yes	1	$11,747	$915,591	$30,088
Lower Extremity	Yes	2	$49,691	$981,970	$422,416
Lower Extremity	Yes	3	$1,124,283	$2,005,510	$1,946,586
Lower Extremity	Yes	4	$137,691	$3,995,258	$3,971,024
Lower Extremity	Yes	5 or 6		$6,282,067	$6,282,050
Lower Extremity	No	1	$73,591	$1,810,298	$66,107
Lower Extremity	No	2	$204,899	$1,345,101	$354,405
Lower Extremity	No	3	$378,918	$5,141,484	$4,266,241
Lower Extremity	No	4	$6,232,280	$8,748,225	$8,579,503
Lower Extremity	No	5 or 6		$5,255,943	$5,255,918
Trunk	Yes	1	$6,399	$562,861	$34,855
Trunk	Yes	2	$35,468	$1,299,056	$619,761
Trunk	Yes	3	$66,240	$1,723,375	$1,317,470
Trunk	Yes	4	$49,412	$2,479,974	$2,342,244
Trunk	Yes	5 or 6		$5,829,549	$5,829,530
Trunk	No	1	$20,406	$801,383	$25,213
Trunk	No	2	$203,156	$1,463,429	$915,268
Trunk	No	3	$2,278,298	$1,811,391	$1,891,130
Trunk	No	4	$1,819,788	$2,459,274	$2,430,179

Body Region	Fracture	MAIS	ED Mean	Hospitalized Mean	All Cases Mean
Trunk	No	5 or 6		$3,860,733	$3,860,742
Other Head/Neck	Yes	1	$9,573	$322,475	$28,488
Other Head/Neck	Yes	2	$141,152	$1,177,344	$502,595
Other Head/Neck	Yes	3	$107,755	$2,110,084	$1,134,329
Other Head/Neck	Yes	4	$26,314	$3,717,413	$2,879,548
Other Head/Neck	Yes	5 or 6			
Other Head/Neck	No	1	$275,678	$891,889	$215,931
Other Head/Neck	No	2	$180,052	$933,851	$251,346
Other Head/Neck	No	3	$136,694	$1,871,294	$709,053
Other Head/Neck	No	4	$203,509	$5,503,029	$2,511,327
Other Head/Neck	No	5 or 6			
Burn	N/A	1	$13,514	$898,029	$22,266
Burn	N/A	2	$9,315	$916,714	$118,426
Burn	N/A	3			
Burn	N/A	4			
Burn	N/A	5 or 6		$1,098,598	$1,098,603
Minor Injury	N/A	1	$3,363	$400,342	$6,258

Appendix C: KABCO/MAIS Translators

Throughout this analysis translators developed from historical data are used to translate nonfatal injury severity estimates based on police records using a KABCO scale, into the more precise AIS measure. Injuries are categorized according to the MAIS, the highest AIS level injury experienced by an injured person. For towaway crashes, MAIS can be determined directly from the CISS data base. However, for non-towaway injuries and PDOs the only source is CRSS. CRSS data are only recorded using the KABCO severity system, whereas this report is based on the Abbreviated Injury Scale. To translate CRSS data to a MAIS basis, we used a variety of KABCO/MAIS translators. For non-CISS cases, we have previously relied on translators derived from 1982-1986 NASS files, which are of uncertain relevance to current crash data bases.

Since the last version of this report, published in 2015 (Blincoe et al., 2015), there have been notable changes in NHTSA's databases involving a significant redesign of the systems, with CISS and CRSS replacing CDS and GES, and a shift to the newest version of the AIS. Due to these changes, revised translators have been developed based on the CISS data bases. Wang (in press) examined alternate methods of developing KABCO-to-MAIS translators based on 2000-2015 CDS and on 2017-2019 CISS. These translators were designed to control for significant changes in CDS over the years and for changes in design from CDS to CISS.[32] These changes included revisions to the AIS and changes to the scope of injury reporting. These hybrid translators were designed to reflect current CISS relationships while linking relationships between non-CISS cases to those found in the previous data bases. This approach was established for vehicle occupants, but an exception was made for non-occupants such as motorcyclists, pedestrians, and bicyclists. There are no nonoccupants in CISS. Therefore, the only available translator estimates were the original translators based on 1982-1986 NASS data.

Seat belt use can influence injury reporting significantly in a number of ways. It changes the nature of injuries by preventing many more visible injuries (such as head/face contact with the windshield) but replaces them with often less visible (and also typically less serious) abdominal injuries such as bruising caused by pressure from the belt across the torso. This can influence the relationship between the KABCO reported injury severity and the corresponding MAIS injury level. For this reason, separate translators were developed for occupants based on belt use status.

The translators used in this report are presented in Tables C-1-3 below. In addition, Tables C-4 and C-5 provide translators that can be used when addressing all CISS equivalent cases as a group, and all crashes, regardless of their relationship to CISS respectively. The translator in Table C-5 would be applicable to universal KABCO crash counts that don't discriminate by occupant status or belt use.

[32] For further discussion of the development of these translators see Chapter 2 Nonfatal Police-Reported Injuries. Translators. Table C-1, C-2, C-4, and C-5 were derived from Translator 5 described in Table 2-3. Translator C-3 is derived from the Current translator basis noted in Table 2-3

Appendix Table C-.1 Non-CISS Occupants, Unbelted

MAIS	O No Injury	C Possible Injury	B Non-Incapacitating Injury	A Incapacitating Injury	Injured Severity Unk
0	0.9693	0.4970	0.1919	0.1651	0.5433
1	0.0296	0.4488	0.7093	0.4286	0.4296
2	0.0011	0.0458	0.0873	0.2395	0.0271
3	0.0000	0.0082	0.0072	0.1195	0.0000
4	0.0000	0.0000	0.0018	0.0287	0.0000
5	0.0000	0.0001	0.0000	0.0140	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000
Fatality	0.0000	0.0000	0.0024	0.0046	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000

Appendix Table C-2. Non-CISS Occupants, Belted

MAIS	O No Injury	C Possible Injury	B Non-Incapacitating Injury	A Incapacitating Injury	Injured Severity Unk
0	0.9618	0.5384	0.3455	0.3411	0.9143
1	0.0376	0.4266	0.6161	0.3349	0.0642
2	0.0005	0.0154	0.0232	0.2253	0.0155
3	0.0000	0.0192	0.0127	0.0856	0.0059
4	0.0000	0.0003	0.0024	0.0131	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000
Fatality	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000

Appendix Table C-3. Non-CISS, Nonoccupants/Motorcyclists

MAIS	O No Injury	C Possible Injury	B Non-Incapacitating Injury	A Incapacitating Injury	Injured Severity Unknown
0	0.7370	0.1057	0.0221	0.0060	0.0254
1	0.2359	0.7397	0.7456	0.3196	0.6788
2	0.0220	0.1185	0.1685	0.3144	0.2167
3	0.0048	0.0319	0.0598	0.2861	0.0572
4	0.0004	0.0032	0.0027	0.0349	0.0029
5	0.0000	0.0010	0.0005	0.0259	0.0026
Fatal	0.0000	0.0000	0.0008	0.0132	0.0165
Total	1.0000	1.0000	1.0000	1.0000	1.0000

Appendix Table C-4. CISS Equivalent cases

MAIS	O No Injury	C Possible Injury	B Non-Incapacitating Injury	A Incapacitating Injury	Injured Severity Unk
0	0.8623	0.3391	0.1156	0.0559	0.4268
1	0.1325	0.5705	0.6956	0.3215	0.4684
2	0.0048	0.0668	0.1414	0.3082	0.0698
3	0.0004	0.0209	0.0402	0.2305	0.0292
4	0.0000	0.0022	0.0060	0.0507	0.0058
5	0.0000	0.0004	0.0003	0.0258	0.0000
Fatality	0.0000	0.0001	0.0010	0.0074	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000

Appendix Table C-5. All Crashes

MAIS	O No Injury	C Possible Injury	B Non-Incapacitating Injury	A Incapacitating Injury	Injured Severity Unk
0	0.9313	0.3905	0.1259	0.0612	0.4638
1	0.0662	0.5299	0.6918	0.3075	0.4471
2	0.0024	0.0590	0.1362	0.3015	0.0604
3	0.0001	0.0186	0.0394	0.2482	0.0244
4	0.0000	0.0016	0.0054	0.0477	0.0044
5	0.0000	0.0004	0.0002	0.0266	0.0000
Fatal	0.0000	0.0001	0.0011	0.0073	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000

Appendix D: KABCO Unit Costs

Police reports are generally coded using a generalized injury severity estimate commonly known as the KABCO scale. Within this scale, injuries are typically coded under one of the following categories:

K = Killed

A = incapacitating injury

B = non-incapacitating injury

C= complaint of pain

O = No injury

ISU = Injured, Severity Unknown

This very general scale is used by police officers on the scene and represents their judgment regarding injury severity. While police do their best to accurately judge each case, they do not have the training or diagnostic skills or equipment to determine more precise estimates of actual injury. As noted elsewhere in this report, translators developed from data systems that collected both KABCO and MAIS injury severities indicate that KABCO ratings are not very meaningful. Large numbers of crash victims are miscoded regarding their actual injury levels, with many people coded as A – incapacitating injury actually being uninjured and many coded as uninjured actually experiencing injuries. For this reason, we believe that analysis of motor vehicle injuries is more meaningful when injuries are first expressed, either directly or through a translator, using the AIS. Nonetheless, we recognize that in many cases police-reported data will be used directly with KABCO designations. For this reason, we have supplied a KABCO based unit cost table in this appendix. Note that there is a QALY value associated with O category KABCO injuries. This reflects the fact that many O injuries are actually injured based on the AIS rating.

Appendix Table D-1. KABCO INJURY UNIT COSTS

	O	**C**	**B**	**A**	**K**	**ISU**
Medical	$433	$3,754	$6,889	$36,946	$17,289	$4,654
EMS	$38	$90	$129	$280	$1,060	$90
Market	$502	$4,873	$9,292	$45,671	$1,010,970	$6,203
Household	$234	$1,998	$3,837	$19,799	$367,148	$2,620
Insurance	$584	$2,374	$3,886	$12,137	$36,245	$2,559
Workplace	$76	$163	$263	$1,367	$13,589	$210
Legal Costs	$155	$1,461	$2,757	$14,118	$138,025	$1,853
Subtotal	$2,021	$14,714	$27,053	$130,320	$1,584,326	$18,190
Congestion	$1,041	$1,148	$1,218	$1,381	$7,133	$1,136
Property Damage	$3,129	$6,797	$8,924	$11,652	$15,185	$6,169
Subtotal	$4,170	$7,945	$10,142	$13,033	$22,318	$7,306
Total	$6,191	$22,659	$37,195	$143,352	$1,606,644	$25,495

	O	C	B	A	K	ISU
QALYs	$8,922	$86,495	$162,619	$776,387	$9,651,851	$107,575
Total	$15,113	$109,154	$199,814	$919,740	$11,258,495	$133,071

Note that these KABCO unit costs were derived using the same set of translators and KABCO incidence counts used in this report. The results are thus reasonably consistent with this report's findings. However, should different translators be used for other specialized studies of crash type or vehicle type subsets, these cost estimates might not be consistent with the profile of injuries found in those subsets.

Appendix E: Estimating the Cost of Motor Vehicle Injuries in the United States From Health Care Files Data

The medical and work-loss costs of each injury were estimated for each crash injury patient in the 2013 and 2014 Healthcare Cost and Utilization Program National Inpatient Sample and Nationwide Emergency Department Sample. The 2013-14 NIS and NEDS also served as the basis for the estimation of lifetime work loss costs, supplemented by information from Finkelstein et al. (2006).

NIS and NEDS differ in their sample design. The NIS is drawn from all States participating in HCUP, covering more than 97 percent of the U.S. population. In 2018 NIS sampled one in five discharges from each of the 4,550 community hospitals (including trauma centers) in the District of Columbia and 47 States. That sampling added Alaska, Delaware, and Mississippi to the States NIS covered in 2014. The only States it did not cover were Alabama and Idaho, which do not have hospital discharge census systems, and New Hampshire. The NIS excludes Indian Health Service, Veterans Administration, rehabilitation, and long-term acute care hospitals. Although NEDS also provides about a 20 percent sample, its data on emergency department visits are a heavily stratified sample drawn just from 990 hospitals located in 36 States and the District of Columbia (Agency for Healthcare Research and Quality, 2022). To avoid double counting, incidence counts excluded fatal cases from NIS and NEDS, transfers from another hospital from NIS, and visits that result in inpatient admission from NEDS. Medical costs for fatalities were tabulated separated as explained below.

NIS records length of stay and acute care facility charges (except that Kaiser hospitals and Shriner's burn centers do not charge patients). NEDS provides a spottier record of facility charges. Neither dataset records medical professional fees associated with a visit. Because the relation between charges and costs varies widely between hospitals, HCUP provides hospital-specific cost-to-charge ratios that we used to convert its charge data to costs.

Data by detailed diagnosis from two CDC reports (Finkelstein et al., 2006; Lawrence & Miller, 2014) provided (1) multipliers that allowed addition of professional fees and post-discharge costs to the inpatient costs and (2) cost estimates for the ED cases. Those cost factors were developed for detailed diagnoses coded in the Clinical Modification of the 9th Edition of the International Classification of Diseases (ICD-9-CM) (CDC, 2022). Unfortunately, the United States stopped using that coding system partway through 2015. Hence our injury costs could only be computed or 2013-2014 or earlier incidents.

For incident counts, we instead relied on 2018 data coded in ICD-10-CM. A major advantage of ICD-10-CM is clear designation of which admissions represent first treatment visits. As described in Chapter 2, AIS-2008 scores were assigned to each HCUP diagnosis using a AAAM mapping supplemented by an artificial intelligence assignment of scores for traumatic brain injury. Software assignment based on diagnoses is less accurate than actual patent scoring or AIS assignment based on chart review, but chart-reviewed patient scores are neither performed on most patients nor recorded in nationally representative datasets if performed.

From the costed 2013-14 NIS and NEDS, we selected the acute injury cases that were cause-coded as unintentional motor vehicle traffic crashes.

Year of Dollars, Inflator Series, and Discount Rate

All costs are reported in 2019 dollars. Individual cost elements used in developing the cost module came from datasets belonging to different time periods and were inflated to 2019 dollars. Health care costs in earlier year's dollars were inflated using the medical care component of the

Consumer Price Index (CPI−Medical). Work loss costs were inflated using the index that DoT uses for inflating the value of a statistical life: $CPI \times ECI^{0.55}$, where CPI is the consumer price index, ECI is the employment cost index, and 0.55 is the estimated income elasticity. Work-loss costs more than one year post-injury were discounted to present value using the 3-percent discount rate recommended by the Panel on Cost- Effectiveness in Health and Medicine (Gold et al., 1996) and by Haddix et al. (2003). For sensitivity analysis, we also estimated costs using alternative discount rates of 0 percent, 2 percent, 4 percent and 7 percent.

Lifetime Medical Costs of Injuries

For some injuries, medical treatment and corresponding costs may persist for years or even decades after the initial injury. The medical costs presented in this study include costs associated with treatment for physical injuries only, as data required to estimate costs for mental health and psychological treatment were not available.

Fatal Injuries

Fatal medical costs were calculated using costs per case by place of death from Finkelstein et al. (2006), expanded to include deaths in hospice. Costs were computed separately for six different places of death identified in the 2019 NVSS data.

On-scene/at home

Dead on arrival at a hospital (DOA)

In a hospital emergency department (ED).

In a hospital after inpatient admission

In a nursing home

In a hospice

The medical costs incurred, depending on the place of death, might include charges for coroner/medical examiner, emergency medical transport, ED visit, and stays in a hospital, nursing home, or hospice. Table E-1 summarizes the components included for each place of death.

Appendix Table E-1. Data and Methods for Estimating Medical Costs of Fatal Injuries

Place of Death	Cost Categories	Description, Unit Cost (2010 $)	Source of Data
On scene/at home	Coroner/ME (C/ME)	$50 admin, plus $1,742 if autopsy (C/ME)	Hickman et al. (2007) (C/ME)
Dead on arrival (DOA) at hospital	C/ME + Transport (T)	$50 +$1,742 (C/ME) + $550 (T)	Median cost of ambulance transport from 2012 GAO survey (T)
In ED	C/ME + T + ED	$50 +$1,742 (C/ME) + $550 (T) + $6,571 avg. cost for motor vehicle crash fatalities in ED (ED)	ED from Peterson et al. (2021), built from 2014-15 HCUP data.

Place of Death	Cost Categories	Description, Unit Cost (2010 $)	Source of Data
In hospital after admission	C/ME + T + Fatal inpatient total (FIT)	$50+$1,742 (C/ME) + $550 (T) + $50,295 avg. cost for or motor vehicle crash inpatient fatalities hospital (FIT)	FIT from ED from Peterson et al. (2021), built from 2014-15 HCUP data
In nursing home	C/ME + 2×T + Non-fatal inpatient total (NIT) + Cost of nursing home stay ending in death (NH)	$50+$1,742 (C/ME) + $1100 (2×T) + Avg. inpatient costs for discharges to NH by diagnosis and mechanism (NIT) + Avg. days in NH by body region × $231 cost/day (NH)	2008 HCUP-NIS and 1996– 97 MarketScan data (NIT), days in NH estimated from 2004 National Nursing Home Survey (NH),(Jones et al. 2009) cost/day from Mertropolitan Life (2012) Cost of Care Survey (LifePlans 2012)
In hospice	C/ME + 2×T + Non-fatal inpatient total (NIT) + Cost of hospice stay ending in death (HSP)	$50+$1,742 (C/ME) + $1100 (2×T) + Avg. inpatient costs for discharges to hospice by mechanism and body region (NIT) + $12,421 (HSP)	2008 HCUP-NIS and 1996– 97 MarketScan data (NIT), National Hospice and Palliative Care Organization, 2020 (HSP)

All fatalities were assigned coroner/medical examiner costs—a $50 administrative fee, plus an additional $1,742 if an autopsy was performed, as indicated by the NVSS autopsy variable. For cases where this variable was missing, we used autopsy probabilities by external cause group (46.0% for motor vehicle deaths) based on Hoyert.[33] We estimated the coroner costs from Hickman et al. (2007). This survey-based document provides the costs and workload of all U.S. medical examiner and coroner offices except in Louisiana. We calculated the $1,742 cost per accepted fatality under the arbitrary assumption that 5 percent of the office budget is used to determine which cases to accept, keep records about those determinations, and handle public relations and education requests unrelated to specific deaths.

DOAs and all deaths in the hospital, whether in the ED or as an inpatient, also received the cost of a one-way transport, which was based on average ambulance transport costs for injured patients in the 1999 Medicare 5 percent sample. Deaths in nursing homes or hospice were assigned the cost of two emergency transports—one from the scene to the hospital, and a second from the hospital to the facility where death eventually occurred. (This component is described in greater detail below, in the section on medical costs of hospital-admitted injuries.)

For deaths in the ED and as hospital inpatients, we used average medical payments per motor vehicle crash death in these setting from a 2021 CDC publication (Peterson, Xu, & Florence,

[33] Unpublished supplemental table accompanying Donna L. Hoyert's *The Changing Profile of Autopsied Deaths in the United States, 1972–2007*. (NCHS Data Brief No. 67). National Center for Health Statistics.

2021). Their costing started from the charges on the 10/2014-9/2015 HCUP NIS and NEDS for hospital inpatient admissions and ED visits where the patient died in the hospital. For each case, the facility cost was estimated by multiplying the hospital charge times a facility-specific cost-to-charge ratio. By service (inpatient versus ED), this product, in turn, was multiplied times another factor to account for non-facility services—i.e., professional services used while in the hospital yet not included in the admissions billing (e.g., surgeon, anesthesia, physical therapy). These non-facility factors were based on 2004-2012 Truven Health MarketScan data. The HCUP-NIS cost estimate for each admission was multiplied times the ratio for the corresponding body region to yield estimated total inpatient costs for each injury admission in the HCUP-NIS. The non-facility costs of nonfatal hospital admissions were estimated using this same approach (see below).

Deaths in a nursing home or hospice were assumed to be preceded by a stay in an acute care hospital. The method described in the previous paragraph was used to estimate hospital costs for each patient in the 2008 HCUP-NIS who was discharged to a hospice (3,336 cases) and each patient who was discharged to a nursing home following a severe (AIS≥4) injury (4,327 cases). Because of the small samples, fewer diagnosis/mechanism groups were used than for deaths in hospital, and there was no age breakdown. This cost was added to the usual coroner cost plus twice the usual emergency transport cost. Patients who died in a nursing home or hospice were assumed to have been transported by ambulance twice— first to the hospital, and then to the nursing home or hospice. The final component of medical costs for these deaths was the cost of the terminal stay in the nursing home or hospice.

For deaths in a nursing home, the cost of the nursing home stay was calculated as cost per day times the length of stay (LoS) in the nursing home. The average cost per day of nursing home care was taken from the Metropolitan Life Insurance 2012 Market Survey of Long Term Care Costs (LifePlans, Inc. 2012) and inflated to 2019 dollars. The average LoS in a nursing home was estimated by body region injured (head or neck, trunk, upper limb, hip, upper leg or knee, lower leg or foot, other) from 1,234 resident cases with an admitting diagnosis of injury from the 2004 National Nursing Home Survey (NNHS) (Jones et al., 2009). Since the NNHS is based on a survey of residents rather than discharge data, it did not allow us to identify patients whose stay ended in death. Moreover, it provided only the LoS as of the survey date, not the final LoS. To estimate the average complete LoS, we assumed that each surveyed resident represented a nursing home bed that was always filled with a patient identical to the survey respondent. We further assumed that each patient was surveyed at the midpoint of the nursing home stay, unless this would have resulted in a LoS of less than 13 days, which we imposed as a minimum, based on sensitivity analysis of the nursing home data. This allowed us to account for the many residents with a short LoS who would have passed through the nursing home before and after the survey date while residents with a longer LoS remained.

The cost of a terminal hospice stay came from the annual survey by the National Hospice and Palliative Care Organization (2020).

For all deaths involving medical treatment, based on payer distributions for injury deaths in the 2013 NIS and NEDS, we applied ratios of claims processing expenses to claims payments drawn from the 2013 National Health Expenditure Accounts (Centers for Medicare & Medicaid Services, 2021).

These costing methods were applied to the deaths in the 2008 NVSS data at the case level using the place of death variable, which specifies where the death occurred, to produce the fatal medical costs.

Hospitalized Injuries

The hospitalized injury costing methods in Finkelstein et al. (2006) were applied to 2008 acute care costs. An overview of the approach is presented in Table E-2. The details are provided in the following sections.

Appendix Table E-2. Data and Methods for Estimating Medical Costs of Nonfatal Injuries Requiring Hospitalization

Cost Category	Description, Unit Cost (2010 $)	Source/Notes
Facilities component of inpatient stay	Inpatient facility charges for the case multiplied by inpatient cost-to-charge ratio for the facility	2013-14 NIS for charges; cost-to-charge ratios from AHRQ
Non-facilities component of inpatient stay	Estimated by comparing ratio of total costs to facilities costs by Barell body part	2010-11 MarketScan commercial claims data
Hospital readmissions	Readmission rates by age group and Barell diagnosis group	2007 SID analysis, reported by Zaloshnja et al. (2011)
Short- to medium- term follow-up costs	Estimated as the ratio of total costs in months 1–18 (on average) to total inpatient costs by 16 diagnosis groups, excluding costs of readmission in the first 6 months	1996–99 MEPS
Follow-up costs beyond 18 months, up to 7 years	Estimated using ratios of total lifetime costs to 18-month costs for 17 diagnosis groups	1979–88 Detailed Claim Information (DCI) data from workers' compensation claims
Long-term costs beyond 7 years for SCI and TBI	SCI: All post-discharge costs were recomputed using the ratio of pre-to post-discharge costs TBI: Post-7-year costs estimated at 75 percent of SCI costs	1986 survey data reported in Berkowitz et al. (1990)
Hospital rehabilitation costs	Probabilities and average costs of rehabilitation estimated for 11 injury diagnosis groups	Probabilities from 1997 CA, MD, & PA hospital data; costs estimated using Prospective Payment System reimbursement amounts, as reported in Miller et al. (2006)
Nursing home costs	Cost/day in NH ($208) times estimated average length of stay by 7 body regions for patients discharged to NH	Cost/day from Metropolitan Life (2012) Cost of Care Survey (LifePlans,2012); length of stay estimated from 2004 National Nursing Home Survey (Jones et al., 2009)
Transport	Half of admissions assumed to have transport costs of $550	Median cost of ambulance transport from 2012 GAO survey

Cost Category	Description, Unit Cost (2010 $)	Source/Notes
Claims administration	Sum of all costs above is multiplied times payer-specific 2015 ratio of insurance and claims administration expenditures to personal health care expenditures	2015 National Health Expenditure Accounts (Centers for Medicare & Medicaid Services, 2021)

Total inpatient costs (facility and non-facility)

The 2013-14 NIS included the inpatient facility charge for each admission. For each record in the NIS, this charge was multiplied times the 2013-4 cost-to-charge ratios computed by AHRQ from Medicare's mandatory cost reporting. These ratios typically are hospital specific for almost two-thirds of the acute injury records in the NIS. For hospitals whose facility-specific ratio could not be calculated, a weighted group average ratio specific to the hospital's State, ownership, urban/rural location, and number of beds was used as recommended by AHRQ (Friedman et al., 2002). For Kaiser hospitals in California, which do not report charges, we computed the average facility cost by sampling stratum and diagnosis for hospitals in Census Division 9 in the 2013-14 NIS. These estimates of facility costs for each hospital admission were then multiplied times a ratio of total inpatient costs to facility costs to obtain the total cost of the admission, including non-facility costs, i.e., payments to professionals such as surgeons, anesthesiologists, and therapists who bill separately from the hospital itself. This factor is discussed in detail above, in the paragraph on medical costs of deaths in hospital.

In order to account for follow-up admissions, we used readmission rates based on HCUP's 2007 State Inpatient Databases (SID) from 13 States (Arizona, California, Florida, Missouri, Nebraska, New Hampshire, Nevada, New York, North Carolina, South Carolina, Tennessee, Utah, and Washington), as reported by Zaloshnja et al. (2011). The SID covers all inpatient stays in participating States. In 2007, AHRQ tracked revisits for inpatients in these 13 States, providing a rare look at follow-up hospitalizations. Zaloshnja et al. computed readmission rates by Barell nature of injury and body part and age group (0–14, 15–29, 30–74, 75+). Readmission rates averaged 4.3 percent but ranged as high as 21 percent (for hip fractures, ages 75+). We assumed that, on average, follow-up admissions have the same costs as initial admissions. (We were forced to make this assumption because the 2013-14 NIS did not allow us to distinguish initial from follow-up admissions with any precision.) We divided the total inpatient cost of each case by $(1-r)$, where r is the readmission rate, to factor up hospital costs for readmissions.

Short- to medium-term follow-up costs: To develop estimates of short- to medium-term costs for injuries requiring an inpatient admission, Finkelstein et al. (2006) multiplied total inpatient costs for each record in HCUP-NIS/Marketscan (as derived above) times the ratio of all costs in the first 18 months after injury, on average, (including costs for inpatient services, ED visits, ambulatory care, prescription drugs, home health care, vision aids, dental visits, and medical devices) to the total inpatient costs (including initial admissions and readmissions) for injury by diagnosis and mechanism of injury. These ratios were derived from 1996–99 MEPS data. MEPS is a nationally representative survey of the civilian non-institutionalized population that quantifies individuals' use of health services and corresponding medical expenditures for two consecutive years following enrollment. Because the MEPS analysis was limited to injuries of admitted patients with at least 12 months of follow-up and the MEPS data include costs for up to

24 months, the MEPS sample captures injuries with an average of 18 months of post-injury treatment.

Although MEPS is the best source of available data for capturing nationally representative injury costs across treatment settings (e.g., hospitals, physician's office, pharmacy), even after pooling four years of data the sample size for many injuries with low incidence rates was small. Therefore, to obtain robust direct cost estimates, injuries were collapsed into broad categories prior to quantifying average costs. Records were collapsed into ICD-9 diagnosis groupings based on the following guidelines (in priority order).

1. Groupings must be comprehensive, covering all injury diagnoses (including those for which MEPS lacks cases).
2. Groupings need to balance the goals of diagnosis-level detail and reasonable cell sizes. In some instances, cell samples as small as 5 were accepted in order to avoid combining radically dissimilar diagnoses into a single group.
3. Groupings should be similar, either in nature of injury (e.g., sprain, fracture) or in body region, if not in both.
4. Total injury costs (or the ratio of total injury costs to hospitalization costs for admitted injuries) should be similar in magnitude across diagnoses within each grouping.

Using the MEPS data grouped according to these criteria, we calculated the average ratio of 18-month costs to total inpatient costs (including inpatient facility and non-facility fees) for 15 injury-specific diagnosis groups, ranging in size from 5 to 61 unweighted cases. The ratios ranged from 1.02 to 2.12, with an overall average of 1.26 (see Supplement, Table A). The ratios were then multiplied times the corresponding inpatient cost estimates detailed in the preceding section to arrive at 18-month costs for injuries requiring an inpatient admission.

Long-term follow-up costs. While short- to medium-term costs capture the majority of costs for most injuries, some injuries continue to require treatment and costs beyond 18 months. Rice et al. (1989) estimated long-term medical costs from costs in the first six months using multipliers derived from longitudinal 1979–88 DCI data on 463,174 workers' compensation claims spread across 16 States. The DCI file was unique: nothing similar in size, geographic spread, and duration has become available subsequently. Because occupational injury includes a full spectrum of external causes (e.g., motor vehicle crash, violence, fall), the DCI data by diagnosis presumably captured the medical spending pattern for an injury to a working-age adult reasonably accurately. Their applicability to childhood injuries was questionable. To address this concern, Miller, Romano, and Spicer (2000) analyzed the 30-month cost patterns (long-term costs were not available) of adult versus child injury using 1987–89 MarketScan data on private health insurance claims. They found that the ratios of 30-month costs to initial hospitalization costs for children's episodes by diagnosis did not differ significantly from the comparable ratios for adults. By diagnosis, the ratios for children ranged from 95 percent to 105 percent of the ratios for adults. Thus, it is reasonable to apply the DCI estimates to childhood injury cases.

Costs beyond 18 months were not inconsequential for some injuries. For lack of a better alternative, following Finkelstein et al. (Finkelstein et al., 2006), we used ratios computed from the DCI expenditure patterns to adjust estimates of costs in the first 18 months to arrive at estimates of the total medical costs (including long-term) associated with injuries. This method implicitly assumed that while treatment costs varied over time, the ratio of lifetime costs to 18-month costs had remained constant between the time the DCI data were reported and 2009. The

18-month cost estimates from the previous section were multiplied times the ratio of lifetime costs to the costs in months 1–18 by Barell nature of injury (fracture, other) and body region. Although the DCI ratios varied by injury diagnosis, on average, at a 3-percent discount rate, 77 percent of the costs for admitted cases were incurred in months 1–18 (Miller et al., 2000a). The average long-term multiplier for admitted cases was 1.30.

Long-term costs of SCI and TBI: These estimates incorporate long-term SCI and TBI costs from Berkowitz et al. (1990). For several types of injuries, and especially for SCI and TBI, a substantial portion of the total medical costs occur more than 7 years after the injury is sustained. For severe SCI (i.e., quadriplegia or paraplegia), the ratio of lifetime costs to costs of the initial admission (including emergency transport) was used to factor up the cost of the initial admission. Ratios were computed separately for complete quadriplegia, partial quadriplegia, complete paraplegia, and partial paraplegia, as inferred from the primary injury diagnosis. (This special procedure for severe SCI cases bypasses the medium- and long-term cost methods described in previous sections.) This ratio was generated from data collected by Berkowitz et al. (1990), who surveyed a nationally representative sample of SCI survivors and their families in 1986 and collected data on 758 SCI victims, including those residing in institutions, those living at home, and those in independent living centers. The respondents (victims, families, or guardians) provided details of care payments during the past year, including payments for medical, hospital, prescription, vocational rehabilitation, durable medical equipment, environmental modification, personal assistant, and custodial care. The long-term cost estimates for SCI rely on the assumption that the now-dated Berkowitz data on medical costs by year post-injury mirror the expected lifetime costs for recent SCI victims.

Quantifying long-term costs for TBI is more problematic. Most TBI programs do not have longitudinal data on TBI costs. However, Miller et al. (2004) estimated inpatient rehabilitation costs by diagnosis group, including SCI and TBI, finding that among patients receiving rehabilitation, the cost per case for TBI averaged 75 percent of the cost for SCI. TBI patients, however, were far less likely to receive inpatient rehabilitation (6% versus 31%). Finkelstein et al. (2006) assumed the TBI patients who received inpatient rehabilitation would follow the same cost pattern more than 7 years post-injury as the SCI patients, but with costs equal to 75 percent of SCI levels. Again using the Berkowitz data, we estimated that, at a 3-percent discount rate, 46.92 percent of the medical costs of TBI are incurred in the first 7 years. Therefore, we divided the seven-year costs by this percentage to arrive at lifetime medical costs of TBI. As with other long-term costs, we replicated this process for other discount rates to facilitate sensitivity analysis.

For very severe burns, amputations, and other non-SCI, non-TBI injuries requiring lifetime medical care, lack of available data will bias our lifetime cost estimates downwards.

Inpatient rehabilitation costs: Costs of inpatient rehabilitation were estimated using direct costs developed for 11 injury diagnosis groups by Miller et al. (2004). These costs came from the Health Care Financing Administration (HCFA, now the Center for Medicare and Medicaid Services) Prospective Payment System (PPS) reimbursement schedule that governs payments for all U.S. inpatient rehabilitation including professional fees. Miller et al. (2004) used PPS data on lengths of stay and cost per day to develop direct cost estimates of rehabilitative treatment. They used data from California, Maryland, and Pennsylvania hospital discharge systems to compute the probability of rehabilitation for each PPS diagnosis and mechanism group. The product of the probability of rehabilitation and the direct cost estimate of rehabilitation developed by Miller et al. (2004) were added to the HCUP- NIS/Marketscan-based cost estimates.

Transport costs: None of the data sets and analyses of nonfatal hospitalized injuries described above include transportation costs. To measure transportation costs to the hospital, we drew on a 2012 GAO survey of ambulance providers. GAO found that the median cost of ground ambulance providers in 2010 was $550 per transport (inflated to 2018 dollars). We used this cost for fatal, hospital-admitted, and ED-treated injuries. It should be conservative because (1) the distribution of ambulance costs is skewed, so the mean would be greater than the median; and (2) this "cost" estimate did not cover ambulance providers' full costs—it left them with an average loss of 1 percent, which Medicare alleviated by "add-on payments" of $35 per transport. Since there was no way to identify which inpatients were transported by ambulance, following Finkelstein et al. (2006), we assumed that half of hospital admissions involved ambulance transport and added half of the $550 median cost to every case.

The assumed 50 percent transport rate may be conservative. The National Pediatric Trauma Registry, which captures admitted serious injuries, showed that from April 1, 1994, to November 5, 2001, some 58.4 percent of 48,288 pediatric patients arrived by ambulance (National Pediatric Trauma Registry, 2002).

Claims administration: To estimate the claims processing expenses incurred by private insurers and government payers like Medicare and Medicaid, we drew on the 2015 National Health Expenditure Accounts (Centers for Medicare & Medicaid Services, 2021).) Using data from 2014 we computed the ratio of total administration and total net cost of health insurance expenditures to personal health care by source of payment: Medicare (6.52%), Medicaid (11.29%), private insurance (14.26%), self-pay (0%), and other (5.2%). The overall mean was 8.66 percent. While the NHEA would have permitted ratios to be calculated for additional payer categories, the uniform payer variable in the NIS has much less detail. Claims administration ratios of 0.00 percent were assigned to the payer categories "self-pay" and "no charge." The total of all preceding costs was multiplied times the payer-specific ratio to produce the estimate of claims administration expenditures.

Injuries Treated in an Emergency Department

Table E-3 summarizes the approach for quantifying costs of nonfatal injuries treated in EDs and released without inpatient admission.

Appendix Table E-3. Data and Methods for Estimating Medical Costs of Nonfatal, Non-Admitted Injuries Treated in Emergency Departments

Cost Category	**Description, Unit Cost (2018 $)**	**Source/Notes**
ED visit	Total ED payments, both facility and professional, by 3-digit ICD-9 diagnosis; differentiated by age, sex, and cause	Incidence, 2014 NEDS. Payments per nonfatal ED admission not admitted inpatient, 2010–11 MarketScan commercial outpatient services claims data

Cost Category	Description, Unit Cost (2018 $)	Source/Notes
Follow-up visits and medication, months 1–18	Estimated as the ratio of all costs in the first 18 months after injury to costs of the initial ED visit by diagnosis grouping	1996–99 MEPS
Follow-up costs beyond 18 months	Estimated using ratios of total lifetime costs to 18 month costs for 17 diagnosis groups	1979–88 DCI)data from workers' compensation claims; adjustment factor for youth from Miller et al. (2000a)
Emergency transport	An assumed 50 percent of ED visits have transport costs of $550	Median cost of ambulance transport from 2012 GAO survey
Claims administration	Sum of all costs above is multiplied times payer-specific 2015 ratio of insurance and claims administration expenditures to personal health care expenditures	2015 National Health Expenditure Accounts (Centers for Medicare & Medicaid Services, 2021)

The cost of the initial ED visit, based on claims for outpatient services in the 2010–11 MarketScan Commercial Claims and Encounters Database, was provided by CDC staff of SPEB/DARPI/NCIPC. ED visits were identified using the service category variable. The payments for all services rendered in the ED during a visit were summed, including services billed by departments other than the ED. These payments included both those for ED facility charges and those for professional fees billed separately by specialists. The mean total and facility payments per visit were computed by ICD-9-CM diagnosis. Overall, the average facility payment was $1,002 and the average total payment was $1,213. The MarketScan-based mean cost of the initial ED visit was merged onto an injury subset of the 2014 NEDS, a multi-state sample of patients treated in a hospital ED, by primary injury diagnosis. The NEDS subset was restricted to nonfatal injuries that did not result in a subsequent hospital admission.

Medical costs are known to vary by age and sex, and intentional and motor-vehicle injuries are known to result in higher medical costs than other injuries. The MarketScan- based cost estimates, however, were differentiated only by diagnosis. Therefore, we further differentiated them by age, sex, and cause of injury. For this purpose, we used ratios based on the previous generation of WISQARS medical costs for ED-treated injuries. For a given diagnosis, for each age-sex-cause cell, the old ED visit cost assigned to that cell was divided by the mean old ED visit cost for the diagnosis to produce a ratio, which was then multiplied times the MarketScan-based mean cost to produce a cost estimate tailored to the patient's age, sex, and cause of injury.

As with costs for hospitalized injuries, the cost of the initial visit was multiplied times medium-term and long-term factors to obtain lifetime costs. To account for follow-up visits and medication in the first 18 months post-injury, ratios based on 1996–99 MEPS data for 51 ICD-9-CM diagnosis groups were used. The ratios ranged from 1.02 to 5.44, with an overall average of 1.78. For follow-up costs beyond 18 months, 1979–88 DCI ratios were used. At a 3 percent discount rate, 88 percent of the costs for non-admitted cases occurred in months 1 to 18 and the average multiplier was 1.14 (Miller et al., 2000a). (More detail on these MEPS and DCI ratios can be found above, where the parallel ratios for inpatients, which come from the same sources, are described.) As with hospital costs, half of patients were assumed to receive emergency transport, so half of the $550 median cost of a one-way emergency transport was added to the medical cost of each case (see Section 3.2.7 above for details). Finally, we added payer-specific claims administration costs (see Section 3.2.8 above for details).

Lifetime Work Losses Due to Injuries

Injuries can result in both temporary and permanent disability. When this occurs, injury victims may lose part or all of their productivity potential. Work losses due to injury may include lost earnings and accompanying fringe benefits, plus the lost ability to perform one's normal household responsibilities. For nonfatal injuries, work losses represent the value of goods and services not produced because of injury-related illness and disability. To the degree that injuries prevent or deter individuals from producing goods and services in the marketplace, the public sector, or the household, the value of these losses is a cost borne by society.

Fatal work losses represent the value of goods and services never produced because of injury-related premature death. These work loss costs were estimated by applying expected lifetime earnings by age and sex to the all deaths from injury sustained in 2008, including an imputed value for lost household services.

Consistent with the human capital approach for quantifying the burden of injuries (Rice et al., 1989), estimates of nonfatal work losses involve applying average earnings to work-years lost and the value of housekeeping services to time lost in home production. Nonfatal injuries may result in both short-term work losses and in lifetime work losses. The latter includes the value (in 2019 $) of output lost by people disabled in later years as a result of injury sustained in 2019.

All short-term work loss estimates were inflated from Finkelstein et al. (2006). Nonfatal work losses were stratified into two categories: short-term losses, which represent lost earnings and accompanying fringe benefits and household services occurring in the first six months after an injury, and long-term losses, which represent the respective earnings and household loss occurring after six months from the time of the injury. The decision to use six months as the transition point between short-term and long-term work losses was driven by the availability of data on duration of work loss.

Because men earn higher earnings than women, even in the same job (Bureau of Labor Statistics, 2001) or for injuries with the same prevalence between men and women, the work loss estimates were greater for men. Finkelstein et al. (2006) view this as more of a shortcoming of the labor market than an inherent problem with the human capital approach. Regardless, this undervaluation of women's labor is reflected in the estimates.

Fatal Injuries

For someone of a given sex and age who sustained a fatal injury, Finkelstein et al. (2006) summed the sex-specific probability of surviving to each subsequent year of age times sex-specific expected earnings for someone of that age. We followed this method using an updated life table (Arias & Xu, 2019). We used this formula with money earnings data by sex and year of age derived from the March Supplement of the Current Population Survey, averaged across a full business cycle from 2007 through 2018. We inflated all earnings figures to 2019 dollars using the Employment Cost Index–Wages & Salaries, All Civilian. We added fringe benefits of 23.588 percent of wages based on the average ratio of wage supplements to wages for 2007–18 from the national income accounts (Economic Report of the President, 2021, Table B-16). Earnings, including salary and the value of fringe benefits, at future ages were adjusted upwards to account for a historical 1 percent work growth rate (Haddix et al., 2003; Bureau of Labor Statistics, 2021) and then discounted to present value using a 3-percent discount rate. (For sensitivity analysis, parallel estimates were constructed using discount rates of 0 percent, 2 percent, 4 percent, and 7%).

Parallel calculations valued lost household work. Estimates of the value of household work came from Krueger and Ward (2020), which used data from the American Time Use Survey to estimate time spent on household services and the earnings of workers who perform various services that are equivalent to household production. Historically, productivity growth in household production has been negligible, so following Finkelstein et al. (2006), we did not adjust for it. We also accepted their assumption that no further productivity is lost if some survives past the age of 102.

In equation form, lifetime earnings for someone of age a and sex b (Earna,b) is computed as

$$Earn_{a,b} = \sum_{k=a}^{102} \left\{ P_{a,b}(k) \times Y_{k,b} \times \left(\frac{1+g}{1+d} \right)^{k-a} \right\}$$

where $P_{a,b}(k)$ = the probability that someone of age a and sex b will live until age k; $Y_{k,b}$ = the average value of annual earnings (including fringe benefits) or of annual household production at age k for someone of sex b; g = the productivity growth rate (0.01 for earnings, 0.00 for household production); and d is the discount rate (usually 0.03, but allowed to vary for sensitivity analysis).

These costing methods were applied to each case in the 2019 NVSS data to produce the fatal work loss costs used in our estimates.

Nonfatal Injuries

For nonfatal injuries, work loss estimates included the sum of the value of wage and household work lost due to short-term disability in the acute recovery phase and of the value of wage and household work lost due to permanent or long-term disability for the subset of injuries that cause lasting impairments that restrict work choices or preclude return to work.

Short-term work losses. Finkelstein et al. (2006) quantified temporary or short-term work loss for non- fatal injuries using the approach presented in Lawrence et al. (2000). Lawrence et al. combined the probability of an injury resulting in lost workdays from 1987–96 National Health Interview Survey (NHIS) data with the mean work days lost (conditional on having missed at least one day) per injury estimated from the 1993 Annual Survey of Occupational Injury and Illness reported by the BLS. These data were sent to the bureau by employers through a mandatory reporting system. Employers reported work loss from date of occupational injury to the end of the calendar year for a sample of approximately 600,000 injury victims. All cases reported involved at least one day of work loss beyond the date of the injury. Moreover, if a worker still was out of work at the time the employer report was due to BLS, the report would undercount work days lost. On average, BLS work-loss reports cover six months post injury. Lawrence et al. (2000) used a Weibull regression model to estimate the total duration of work loss for cases still open at the end of the survey reporting period. These results were combined with those of the closed cases to estimate average work loss, conditional on having missed at least one day of work. These BLS-based estimates were then combined with the pooled 1987–1996 NHIS data on probability of work loss to compute mean work loss including cases without work loss. Although BLS uses a detailed two-column coding system (body part, nature of injury), Finkelstein et al. (2006) were able to map their codes to the ICD-9-CM codes.

Although the BLS data are limited to injuries that occur on the job, Finkelstein et al.'s (2006) separate analysis of 1996–99 MEPS data (based on a much smaller sample) found that the duration of work loss did not differ significantly by whether or not the injury occurred on the job. This suggested that the BLS- NHIS work loss estimates could credibly be applied to estimate work loss associated with non-work- related injuries.

Analysis of the MEPS data revealed that work loss was roughly five times longer for hospitalized injuries than for non-hospitalized injuries with work loss. Using this ratio, Finkelstein et al. (2006) decomposed work-loss durations into separate estimates for admitted and non-admitted injuries.

Averaged across all injuries (including those with no work loss), the estimated temporary work loss was 11.1 days per injury. Consistent with this estimate, Peterson, Xu, and Barnett (2021) estimate first-year work loss averaged 11.3 days in 2014-16. That estimate came from MarketScan Health and Productivity Management data on 349,785 commercially insured patients aged 18-64 treated for injury in an emergency department.

To place a monetary value on temporary wage work loss, the estimated days of work lost were multiplied times average earnings per day of work, given the victim's age and sex, from the Current Population Survey, as described above in the section on fatal injuries.

Household workdays lost were estimated as 90 percent of wage workdays lost, based on findings from an unpublished nationally representative survey on household work losses following injury (S. Marquis, the Rand Corporation, personal communication, 1992). This ratio and the value of household work by age group and sex from Krueger and Ward (2020).

Long-term work losses. Finkelstein et al. (2006) considered permanent total disability and permanent partial disability separately. For permanent total disability, the present value of age-and-sex-specific lifetime earnings and household production from the fatality analysis were multiplied times the probability of permanent total disability for each type of injury. For permanent partial disability, the earnings estimate times the probability of permanent partial disability was multiplied times an additional factor identifying the extent of disability resulting from that type of injury. The total and partial disability costs were then summed to compute the net loss of work associated with permanent disability.

The probabilities of permanent total and partial disability by diagnosis and admission status came from Miller, Pindus, et al. (1995) and were based on pooled multi-State workers' compensation data from the 1979–88 Detailed Claims Information (DCI) database of the National Council on Compensation Insurance (NCCI). The disability percentage (i.e., the average extent of disability) by diagnosis came from Lawrence et al. (2000) and was based on 1992–96 DCI data. DCI records the disability status for each sampled case. Following Rice et al.

(1989), Finkelstein et al. (2006) assumed that these probabilities do not vary according to whether the injury occurred on the job and that these probabilities have not changed significantly over time. This method also assumes that the probability that an injury (e.g., a skull fracture) will cause someone never to do wage or household work again is the same for children, adults, and the elderly (though the years of work lost obviously will vary with the age of onset) and that people will experience the same percentage reduction in household work ability that they experience in wage work ability.

To verify that the DCI data produce reasonable estimates, Finkelstein et al. (2006) conducted a literature review to compare their estimates to those from other sources. Because of the paucity of data on this subject, they identified only a few sources of published disability estimates, and these were generally dated and limited to specific populations. Based on the limited information available, the DCI data suggested similar probabilities of permanent disability to the other studies of long-term work loss. Although dated and restricted to occupational injury, the DCI data have several advantages that outweigh their disadvantages. As a result of their large sample, the DCI data can be used to compute probabilities for a far wider range of specific diagnoses than all the disability studies in the literature combined. Despite its restriction to occupational injury, the DCI sample also is more representative of the mix of injuries admitted to hospitals than the few studies in the literature, notably those which are restricted to patients triaged to trauma centers. The DCI data also are virtually the only source of information about permanent disability due to injuries not admitted to the hospital. The sample includes 318,885 medically treated, non-admitted patients with valid lost work claims in workers' compensation. Averaged across all injuries, the estimated percentage of lifetime productivity potential lost due to permanent injury-related disability was 0.26 percent per injury.

For hospital-admitted cases of traumatic brain injury (TBI), we computed modified disability probabilities using a logistic regression model developed by Selassie et al. (2008). The model took account of the severity of TBI (as per the Barell matrix, which distinguishes three types of TBI), the presence of comorbid conditions, whether the patient was transferred from the initial acute care hospital to another medical facility, and the patient's age and sex. This new disability probability was then decomposed into separate probabilities of total and partial disability according to the total/partial ratio of the old disability probabilities. In cases where the TBI diagnosis was a secondary diagnosis, the new probability was kept only if it exceeded the old probability based on the non-TBI primary injury diagnosis.

Calculating total work loss costs. The work loss costs were computed as described for all nonfatal acute injury cases in the 2013-14 NIS and NEDS. Short- and long-term costs were summed to compute total work loss costs.

Limitations Methods for Medical and Work Loss Estimates

These cost estimates are subject to several limitations. First, the estimates focus exclusively on medical costs and work loss costs. They do not include costs due to psychological treatment, e.g., for post-traumatic stress disorder.

Second, a major limitation was the requirement to use data from a multitude of sources. Although these were the best available data at the time of the analysis, some sources are old, others are based on non- representative samples, and all are subject to reporting and measurement error. These factors may have incorporated significant bias into the cost estimates.

The costing approach was designed to minimize the potential bias. More current and nationally representative data would have been preferable but were not available.

Third, combining factors from data sets (typically with only published mean estimates available) and unavoidable assumptions about data sets being representative make it impossible to estimate definitive confidence intervals around the cost estimates. The variance we calculated around the medical costs, market wage loss, household work loss, quality-of-life, and QALYs captured only a portion of the variation. The costs or losses for a given injured person came from an economic formula that uses mean values of cost components to calculate the cost estimate for the injured person. For example, work loss for a person's broken finger is calculated as mean daily earnings for someone of their age and sex times mean days of work lost to a broken finger. Although each of those means has a variance, we do not have access to that variance information. Thus, we were unable to carry the variance around each item in the cost calculation for an individual into the calculation of variance for mean costs. The variance information we present captures only the variability among the costs of a class of injuries (e.g., hospital-admitted MAIS1 injuries) across a variety of detailed diagnoses and age group/sex categories.

The methods for estimating work loss costs had many additional limitations. Because women, the elderly, and children have lower average earnings, the human capital approach probably undervalued injuries to these groups relative to working-age males. The approach also placed lower values on the work of full-time homemakers than the work of people participating in the labor market, which further depressed the value placed on women's losses relative to men's losses. It also undervalued disability among those of retirement age, and did not value temporary disability among children, as they had not yet entered the labor force. Discounting future work losses to present value meant that the loss of a lifetime of work by a 2-year-old was considered equivalent to loss of a lifetime of work by a 43-year-old. Although the child loses many more years of work, those years are far in the future and heavily discounted. The work loss cost calculations were also based on a year 2018 life table, which essentially assumed that life expectancy would have remained constant over each person's expected lifespan absent injury. Moreover, victims of serious and fatal injury may tend to be risk-takers (for example, thrill-seekers, heavy drinkers, or drug abusers) whose life expectancy may be shorter than for the average population, which would overestimate the losses. As noted above, some of the estimates are computed using fairly dated data that are based on a working population. Additionally, the estimates excluded some work losses by people other than the injured person, notably by family and friends caring for the injured. All these limitations suggest that the costs and especially the available standard error information should be interpreted with caution.

Adjustment to MAIS1 Costs to Account for Injuries Not Treated at Hospitals

The methods above explain how the costs of nonfatal injuries treated in hospitals were calculated. Not surprisingly. subtracting the hospital-based crash injury counts from the overall incident counts including injuries in unreported crashes reveals that many people with only MAIS1 injuries are not treated in hospital ED or inpatient settings. This section analyzes the incidence of those injuries and adjusts the costs per MAIS1 injury to account for them.

Incidence. An estimated 3,875,265 people suffered crash injuries of MAIS1 in 2019. The MAIS scored HCUP data indicate that 20,985 of those injured were admitted as hospital inpatients and 2,637,032 were treated in the ED and released or left against medical advice. Until 2000, the

National Ambulatory Medical Care Survey (NAMCS) counted injury patients treated only in doctors' offices or clinics and recorded what caused their injury. Using data underlying CDC's study of injury incidence and cost in 2000 (Finkelstein et al., 2006), the ratio of crash Injuries treated in doctors' offices or clinics from NAMCS to ones treated in the ED from HCUP is 0.132. Applying that ratio to the MAIS1 ED count indicates that an estimated 400,368 MAIS1 crash-injury patients were treated in other medical settings rather than hospitals in 2010. Subtracting all the treated injuries from the total reveals that 816,880 people with MAIS1 injuries did not get professional medical treatment.

Costs. The data underlying Finkelstein et al. also yielded ratios of cost per MAIS1 injury patient treated in non-hospital versus hospital settings of 0.83347 (1021/1225) for medical care, 0.83455 (2316/2775.15) for wage work, 0.83292 (849/1019.31) for household work, and 0.67914 (889/1309) for quality-of-life. We assigned a $0 cost to cases that were not treated by medical professionals. Combining the incidence and cost ratios with the HCUP counts and costs let us calculate revised costs for MAIS1 injury cases that accounted for the cases not treated at hospitals.

Short-term Follow-up Cost Factors

The 16 diagnosis groups and associated multipliers that were used for estimating short-term follow up costs for admitted patients were as follows:

Appendix Table E-4. Multipliers by Diagnosis Code for Hospital-Admitted Patients

Group No.	ICD-9-CM Diagnosis Codes	Average ratio of all costs in the first 18 months after injury to total inpatient costs
1	802, 830	1.02
2	800, 801,803, 804, 850–854	1.38
3	806, 952	2.12
4	805, 807–809, 839	1.10
5	810–819, 831–834	1.26
6	820, 835	1.35
7	821–829, 836–838	1.43
8	840–848	1.67
9	860–869	1.12
10	870–904	1.12
11	910–929	1.24
12	930–939, 950–958, 990–995	1.97
13	940–949	1.13
14	959	1.16

Group No.	ICD-9-CM Diagnosis Codes	Average ratio of all costs in the first 18 months after injury to total inpatient costs
15	960–989	1.02
16	Other	1.03
	All	1.26

Multipliers for Short-Term Follow-Up Costs for ED-Treated Patients

The 51 diagnosis groups and associated multipliers that were used for estimating short-term follow-up costs for injuries treated in emergency departments and released were as follows:

Appendix Table E-5. Multipliers by Diagnosis Code for Emergency Room Treated Patients

Group No.	ICD-9-CM Diagnosis Codes	Average ratio of all costs in the first 18 months after injury to total ED visit costs		Group No.	ICD-9-CM Diagnosis Codes	Average ratio of all costs in the first 18 months after injury to total ED visit costs
1	802, 830	2.47		27	851–854	1.38
2	800, 801, 803, 804	1.19		28	860–869	1.04
3	805–809	1.40		29	870–874	1.15
4	810–811	3.40		30	875–879	1.09
5	812	3.95		31	880–881	1.82
6	813	1.43		32	882	1.28
7	814	2.83		33	883	1.28
8	815–817	1.75		34	884–887	1.45
9	818–819	1.77		35	890–891, 894–897	1.35
10	820–822	2.01		36	892–893	1.18
11	823	2.31		37	900–904	2.73
12	824	2.19		38	910–919	1.29
13	825	1.77		39	920	1.02
14	826	1.69		40	921	1.33
15	827–829	1.38		41	922	1.32
16	831	2.44		42	923	1.28
17	832–833	3.96		43	924	1.49
18	834	1.36		44	925–929	1.53
19	835–839	1.27		45	930–934	1.11
20	840	5.44		46	935–939	1.74
21	841–842	1.22		47	940–949	1.93
22	843–844	2.25		48	950–958, 990–995	1.11
23	845	1.34		49	959	2.00

Group No.	ICD-9-CM Diagnosis Codes	Average ratio of all costs in the first 18 months after injury to total ED visit costs		Group No.	ICD-9-CM Diagnosis Codes	Average ratio of all costs in the first 18 months after injury to total ED visit costs
24	846–847	1.83		50	960–988	1.11
25	848	1.62		51	989	1.12
26	850	1.16			All	1.78

Appendix F: Unit Costs and Standard Errors at Different Discount Rates

Appendix Table F-1. Selected 2019 Crash costs per fatal Victim at Different Discount rates (2019 $)

Cost component	3%	0%	2%	4%	7%
Medical	17,289	17,289	17,289	17,289	17,289
Market Work	1,010,970	1,758,237	1,193,482	869,909	598,303
Household Work	367,148	680,257	439,197	313,449	214,594
Quality-of-life	9,651,851	8,687,542	9,420,753	9,828,476	10,164,020
Total Selected Costs	11,047,258	11,143,325	11,070,721	11,029,123	10,994,206

Appendix Table F-2. 2007–2008 HCUP-Based Unit Earnings loss at Different Discount Rates
AIS-2008 (2019 $)

Fracture	MAIS	Discount- 0%		Discount- 2%		Discount- 3%		Discount- 4%		Discount- 7%	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Traumatic Brain Injury											
N/A	1	9,974	4.6	6,586	3.12	5,115	2.65	4,726	2.30	3247	1.63
N/A	2	74,994	15.28	50,884	9.62	43,025	7.93	37,449	6.72	26467	4.46
N/A	3	384,261	26.46	256,078	16.07	215,530	13.2	184,207	11.21	126597	7.66
N/A	4	461,165	56.05	310,716	33.92	263,011	27.58	225,673	22.97	157228	15.08
N/A	5	783,003	47.78	513,453	27.75	428,770	22.4	360,670	18.77	243851	12.61
Spinal Cord											
N/A	1										
N/A	2										
N/A	3	611,745		405,252		340,005		290,294		196743	
N/A	4	469,597		358,514		319,887		288,719		223664	
N/A	5	973,212	14.51	653,076	8.82	550,891	7.15	472,477	5.94	323289	3.81
Other Head/Neck											
No	1	7,525	0.92	5,104	0.57	4,174	0.47	3,822	0.4	2816	0.29
No	2	17,312	11.5	11,954	7.49	10,070	6.26	8,942	5.37	6500	3.69
No	3	81,537	120.5	55,244	79.07	46,763	66.41	40,707.0	56.89	28516	39.18
No	4										
No	5	479,892	712.1	325,732	369.6	276,038	273.31	237748.0	205.63	164574	98.02
Yes	1	12,295	13.53	8,142	7.95	6,708	6.4	5,917.0	5.30	4140	3.48
Yes	2	39,110	30.45	26,696	19.46	22,643	16.13	19,679.0	13.64	14047	9.17
Yes	3	107,787	48.66	73,145	31.03	61,993	25.77	53,482.0	22.00	37454	14.82
Yes	4	252,462		157,055		128,336		107,139.0		69056	
Yes	5	471,936	284.3	307,681	170.2	255,737	139.53	216,199.0	118.32	142307	83.77
Trunk											
No	1	5,725	0.76	4,759	0.54	4,317	0.48	4,262	0.44	3767	0.37
No	2	25,306	4.98	18,956	3.28	16,898	2.77	15,600	2.49	12590	1.74

Fracture	MAIS	Discount- 0%		Discount- 2%		Discount- 3%		Discount- 4%		Discount- 7%	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
No	3	60,919	11.37	44,687	7.57	39,416	6.42	35,332	5.59	27642	3.99
No	4	123,913	194.2	84,740	123.7	72,218	102.16	61,836	84.14	44481	57.05
No	5	173,197	6.54	114,495	3.95	96,344	3.21	83,041	2.67	57527	1.73
Yes	1	6,883	4.29	5,668	3.21	5,065	2.87	4,955	2.61	4246	2.14
Yes	2	44,995	4.85	33,286	3.19	29,362	2.71	26,653	2.41	21016	1.74
Yes	3	58,593	7.52	45,666	5.16	41,310	4.44	37,944	3.88	31255	2.88
Yes	4	162,337	214.7	117,638	143.7	103,008	122	91,700	105.69	69695	75.66
Yes	5	251,426	30.31	178,656	19.7	155,102	16.67	136,632	14.37	101562	10.6
Upper Extremity											
No	1	12,276	9.12	8,589	5.53	7,093	4.63	6,557	4.04	4924	3.19
No	2	30,897	1.35	22,583	0.89	19,509	0.77	17,912	0.71	14055	0.56
No	3	141,286	27.51	104,320	17.74	92,301	14.95	82,874	12.96	65315	9.54
No	4	224,824	128.4	164,057	78.41	144,208	64.24	128,784	54.23	98847	37.86
No	5										
Yes	1	12,276	9.12	8,589	5.53	7,093	4.63	6,557	4.04	4924	3.19
Yes	2	30,897	1.35	22,583	0.89	19,509	0.77	17,912	0.71	14055	0.56
Yes	3	141,286	27.51	104,320	17.74	92,301	14.95	82,874	12.96	65315	9.54
Yes	4	224,824		164,057		144,208		128,784		98847	
Yes	5	268,688	79.4	181,867	50.06	154,934	41.86	134,600	36.00	96888	25.91
Lower Extremity											
No	1	3,576	1.65	2,914	1.11	2,635	0.96	2,565	0.85	2259	0.67
No	2	11,694	2.59	8,795	1.82	7,827	1.61	7,153	1.46	5802	1.2
No	3	133,538	162.7	102,184	119.4	91,907	107.4	83,783	99.49	68633	85.82
No	4	321,687		241,062		214,631		195,205		157402	
No	5	400,095	12.75	272,923	44.09	232,845	52.11	202,393	57.30	145628	63.9
Yes	1	5,572	9.34	4,462	5.34	3,998	4.23	3,844	3.49	3293	2.46
Yes	2	54,160	1.62	41,526	1.11	37,099	0.97	34,143	0.89	27992	0.75
Yes	3	105,502	4.33	77,502	2.94	68,550	2.56	61,747	2.32	48758	1.86
Yes	4	163,817		116,233		101,028		89,382		67313	

Fracture	MAIS	Discount- 0%		Discount- 2%		Discount- 3%		Discount- 4%		Discount- 7%	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Yes	5	216,947	19.35	159,630	13.03	140,854	11.24	126,209	9.95	97519	7.64
Burns											
N/A	1	6,770	8.37	4,610	4.86	3,664	3.95	3,428	3.47	2465	2.8
N/A	2	13,151	14.52	9,018	8.37	7,469	7.15	6,734	6.57	4906	5.69
N/A	3	70,797	759.8	45,632	417.2	37,907	319.87	32,312	250.94	22078	138.5
N/A	4										
N/A	5	86,933	72.02	58,220	42.97	49,372	34.34	42,729	28.08	30552	17.51
Minor Injuries											
N/A	1	1	1312	0.06	1072	0.04	984	0.03	949	0.03	840

Appendix Table F-3. 2013–20148 HCUP-Based unit household production loss at Different Discount rates, AIS 2008 (2019 $)

Fracture	MAIS	Discount- 0%		Discount- 2%		Discount- 3%		Discount- 4%		Discount- 7%	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Traumatic Brain Injury											
N/A	1	4,115	1.55	2,556	1.02	1,805	0.87	1826	0.76	1221	0.55
N/A	2	29,627	5.21	19,298	3.14	16,090	2.57	14067	2.18	9931	1.46
N/A	3	169,872	8.04	108,708	4.65	90,671	3.81	77245	3.27	53275	2.26
N/A	4	238,785	14.33	158,368	7.52	134,149	5.94	115614	5.03	82035	3.43
N/A	5 or 6	356,211	14.31	220,965	7.64	181,937	6.03	152666	5.04	102428	3.25
Spinal Cord											
N/A	1										
N/A	2										
N/A	3	256,239		162,165		134,678		114476		77975	
N/A	4	272,977		195,718		170,126		150051		109989	
N/A	5 or 6	397,119	4.01	252,054	2.28	209,305	1.83	177714	1.52	120411	0.99
Other Head/Neck											
No	1	2,765	0.27	1,796	0.15	1,382	0.12	1389	0.11	982	0.08
No	2	6,410	3.57	4,204	2.19	3,430	1.81	3136	1.55	2239	1.09

Fracture	MAIS	Discount- 0%		Discount- 2%		Discount- 3%		Discount- 4%		Discount- 7%	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
No	3	33,412	41.14	21,360	24.72	17,730	20.29	15342	17.13	10571	11.68
No	4										
No	5 or 6	197,093	148.45	126,106	68.81	104,975	50.7	89302	39.51	60779	24.56
Yes	1	4,409	4	2,783	2.37	2,212	1.94	2029	1.63	1412	1.11
Yes	2	14,862	10.32	9,593	6.21	7,987	5.09	6959	4.30	4946	2.91
Yes	3	42,921	16.95	27,537	10.29	22,955	8.48	19681	7.23	13639	4.93
Yes	4	119,936		71,548		57,959		48264		31430	
Yes	5 or 6	206,746	81.08	125,933	45.9	102,714	37.59	85838	32.02	56101	22.72
Trunk											
No	1	2,375	0.24	1,881	0.15	1,629	0.13	1818	0.12	1431	0.1
No	2	10,460	1.93	7,529	1.21	6,632	1	6160	0.87	4930	0.6
No	3	29,232	5.35	20,419	3.53	17,723	2.99	15732	2.60	12015	1.85
No	4	64,892	90.38	42,218	57.17	35,507	47.65	30391	40.38	21540	28.03
No	5 or 6	89,954	2.94	57,482	1.8	48,062	1.49	41337	1.26	28737	0.86
Yes	1	3,099	1.01	2,432	0.59	2,070	0.49	2162	0.42	1745	0.31
Yes	2	20,456	1.79	14,658	1.07	12,807	0.88	11760	0.77	9282	0.52
Yes	3	29,140	3.31	21,687	2.17	19,312	1.84	17611	1.58	14152	1.14
Yes	4	80,027	115.62	54,023	70.88	46,255	58.28	40543	49.17	30029	33.17
Yes	5 or 6	142,895	15.16	97,171	10.19	83,269	8.77	72901	7.71	53204	5.71
Upper Extremity											
No	1	4,849	2.16	3,223	1.09	2,496	0.86	2491	0.71	1796	0.54
No	2	12,386	0.35	8,702	0.21	7,298	0.18	6950	0.18	5348	0.14
No	3	60,715	11.11	42,766	7.18	37,296	6.08	33263	5.29	25736	3.87
No	4	93,456	42.81	63,993	26.5	55,036	22.13	48312	19.04	35835	13.72
No	5 or 6										
Yes	1	4,849	2.16	3,223	1.09	2,496	0.86	2491	0.71	1796	0.54
Yes	2	12,386	0.35	8,702	0.21	7,298	0.18	6950	0.18	5348	0.14
Yes	3	60,715	11.11	42,766	7.18	37,296	6.08	33263	5.29	25736	3.87
Yes	4	93,456		63,993		55,036		48312		35835	

Fracture	MAIS	Discount- 0%		Discount- 2%		Discount- 3%		Discount- 4%		Discount- 7%	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Yes	5 or 6	161,149	37.32	107,525	21.43	91,657	17.27	79879	14.42	58282	9.85
Lower Extremity											
No	1	1,397	0.44	1,087	0.28	944	0.24	1046	0.22	817	0.18
No	2	4,379	0.87	3,154	0.58	2,763	0.5	2590	0.45	2045	0.35
No	3	55,074	68.43	39,082	43.7	34,241	36.92	30668	32.68	24129	24.96
No	4	118,834		81,241		69,864		62348		48067	
No	5 or 6										
Yes	1	2,187	2.49	1,645	1.59	1,404	1.41	1470	1.31	1144	1.16
Yes	2	22,178	0.43	16,185	0.26	14,145	0.22	13130	0.20	10517	0.17
Yes	3	43,985	2.03	30,984	1.35	27,102	1.16	24304	1.02	19018	0.76
Yes	4	91,913		60,566		51,391		44643		32473	
Yes	5 or 6	136,724	8.45	94,826	5.62	81,849	4.85	71985	4.28	53277	3.25
Burns											
N/A	1	2,916	1.52	1,871	0.82	1,373	0.6	1399	0.58	972	0.45
N/A	2	5,134	4.11	3,298	2.42	2,586	2.03	2431	1.90	1720	1.6
N/A	3	29,883	282.87	19,092	169.9	15,931	139.2	13743	117.32#####	9702	79.32
N/A	4										
N/A	5 or 6	43,464	31.22	27,540	17.43	23,000	13.73	19698	11.16	13830	6.9
Minor Injuries											
N/A	1	558	0.02	444	0.01	400	0.01	431	0.01	344	0.01

Appendix G: Definitions Cost Factors

Congestion Costs: The value of travel time delay for people who are not involved in traffic crashes, but who are delayed in the resulting traffic congestion from these crashes, as well as the value of excess fuel consumed, greenhouse gases, and criteria pollutants emitted as a result of traffic congestion caused by the crash.

Emergency Services: Police and fire department response costs.

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

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

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

Market Productivity: The present discounted value (using a 3% discount rate in our base case) of lost wages and benefits over the victim's remaining life span.

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

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

QALY: Lost quality-of-life due to death or injury. Includes both physical and emotional pain, suffering and limitation of life activities. Typically derived from willingness-to-pay studies that examine implicit valuation of life based on consumers valuation of products or services that reduce risk.

Vocational Rehabilitation: The cost of job or career retraining required as a result of disability caused by motor vehicle injuries. These costs are grouped with medical costs in this report.

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

Appendix H: Supporting Tables for QALY Values

The following tables represent the results of the process described in detail in Chapter 5 of this report to produce QALY values. Table H-1, representing QALYs lost per person injured and Table H-2, representing the cost per QALY, were derived from this process. Table H-3, representing the monetized QALY loss per person injured, was derived as the product of each corresponding cell in Tables H-1 and H-2. Table H-4 shows the percentage of QALYs lost to the average crash fatality that are lost per person injured in a crash by MAIS of the crash survivor. This percentage was derived as the quotient from dividing each nonfatal injury cell in Table H-3 by the corresponding fatality value in Table H-3. Table 5-2 in Chapter 5 reproduces Table H-4. Table H-5 represents the age/sex adjusted lifetime QALYs absent the crash for the people whose QALY losses are reported in Table H-1. Table H-6, representing the percentage of remaining lifetime QALYs lost to crash injuries, is the quotient from dividing total QALYs lost in Table H-1 by remaining lifetime QALYs in Table H-5.

Appendix Table H-1. QALYs Lost per Person Injured by Discount Rate and MAIS

MAIS	**QALY- 0%**	**QALY- 2%**	**QALY- 3%**	**QALY- 4%**	**QALY- 7%**
1	0.128	0.095	0.08481	0.083	0.064
2	1.401	0.969	0.830	0.742	0.533
3	6.094	4.303	3.639	3.173	2.215
4	8.268	7.185	6.061	5.199	3.633
5 & 6	19.96	12.627	10.457	8.814	5.927
Fatal	36.30	23.70	19.91	17.08	11.83

Note: QALY losses were computed from HCUP unit record data and life expectancies that were age-and-sex specific.

Appendix Table H-2. Cost per QALY by Discount Rate

$/QALY	$239,325	$397,528	$484,756	$575,438	$859,170

Appendix Table H-3. Monetized QALY Loss per Person Injured by Discount Rate and MAIS

MAIS	**QALY- 0%**	**QALY- 2%**	**QALY- 3%**	**QALY- 4%**	**QALY- 7%**
1	$30,634	$37,765	$41,112	$47,761	$54,987
2	$335,294	$385,205	$402,341	$426,975	$457,938
3	$1,458,447	$1,710,563	$1,763,881	$1,825,865	$1,903,062
4	$1,978,739	$2,856,239	$2,938,008	$2,991,702	$3,121,365
5 & 6	$4,776,927	$5,019,586	$5,068,923	$5,071,911	$5,092,301
Fatal	8,687,542	9,420,753	9,651,851	9,828,476	10,164,020

Appendix Table H-4. Percentage of QALY Loss Per Fatality Lost per Person Injured by Discount Rate and MAIS

MAIS	QALY- 0%	QALY- 2%	QALY- 3%	QALY- 4%	QALY- 7%
1	0.35%	0.40%	0.43%	0.49%	0.54%
2	3.86%	4.09%	4.17%	4.34%	4.51%
3	16.79%	18.16%	18.28%	18.58%	18.72%
4	22.78%	30.32%	30.44%	30.44%	30.71%
5 & 6	54.99%	53.28%	52.52%	51.60%	50.10%

Appendix Table H-5. QALYs Remaining in the Injured Person's Expected Lifespan Absent the

MAIS	QALY- 0%	QALY- 2%	QALY- 3%	QALY- 4%	QALY- 7%
1	49.44	29.50	23.97	20.01	13.11
2	47.83	28.78	23.47	19.66	12.98
3	44.93	27.51	22.58	19.01	12.69
4	43.11	26.57	21.88	18.48	12.42
5 & 6	47.68	28.71	23.41	19.60	12.92

Appendix Table H-6. Percentage of Lifetime QALYs Lost to the Crash Injuries by Discount Rate and MAIS

MAIS	QALY- 0%	QALY- 2%	QALY- 3%	QALY- 4%	QALY- 7%
1	0.26%	0.32%	0.35%	0.41%	0.49%
2	2.93%	3.37%	3.54%	3.78%	4.11%
3	13.56%	15.64%	16.11%	16.69%	17.46%
4	19.18%	27.04%	27.70%	28.14%	29.26%
5 & 6	41.86%	43.98%	44.67%	44.97%	45.86%

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DOT HS 813 403
February 2023

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15814-021023-v11