Benefits of Safety Belts and Motorcycle Helmets

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

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Based on Data from
The Crash Outcome Data Evaluation System
(CODES)

NHTSA
People Saving People

ACKNOWLEDGMENT

The National Center for Statistics and Analysis of the National Highway Traffic Safety Administration wishes to acknowledge the outstanding collaborative effort by the many individuals and organizations in the 7 CODES states -- Hawaii, Maine, Missouri, New York, Pennsylvania, Utah, and Wisconsin -- in generating the data for and assisting in the preparation of this report.

EXECUTIVE SUMMARY

This study was undertaken in response to Section 1031(b) of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which required the National Highway Traffic Safety Administration (NHTSA) to conduct a study to determine the benefits of safety belt and motorcycle helmet use in crashes.

The study employed methods whereby statewide data from police crash reports, emergency medical services, hospital emergency departments, hospital discharge files, claims, and other sources were linked so that those people injured in motor vehicle crashes could be followed through the health care system. Information for both the injured and uninjured was then used to determine the benefits of protective devices in motor vehicle crashes. The available financial information included inpatient charges (acute care, rehabilitation, long-term care) and estimates of actual costs using a charge-to-cost ratio. Through the cooperation of the highway safety and medical communities, this was the first time these databases were linked using a probabilistic computer algorithm. Grants were awarded to entities in Hawaii, Maine, Missouri, New York, Pennsylvania, Utah, and Wisconsin to complete the linkage and perform the analyses upon which this report is based. All of the states were able to generate the linked data.

The Crash Outcome Data Evaluation System (CODES) study results revealed that safety belts are highly effective in reducing morbidity (the occurrence of any injury) and mortality. They also indicate that safety belts cause a downward shift in the severity of injuries.

The study results showed that the average inpatient charge for unbelted passenger vehicle drivers admitted to an inpatient facility as a result of a crash injury was more than 55 percent greater than the average charge for those that were belted, $13,937 and $9,004 respectively. If, in the CODES states, all unbelted passenger vehicle drivers had been wearing safety belts, it is estimated that inpatient charges would have been reduced by approximately $68 million and actual inpatient costs reduced by $47 million. Private insurance accounted for 69 percent of the inpatient charges compared to 16 percent for public and 15 percent for other sources. In all cases, the average inpatient charge was greater for drivers who were unbelted.

The study results also showed that motorcycle helmet effectiveness ranged from 9 percent in preventing any kind of injury to 35 percent in preventing a fatality. These results confirm previous NHTSA estimates. The average inpatient charge for motorcycle crash victims receiving inpatient care was $14,377 for those who used helmets, and $15,578 for those who did not, an 8 percent increase in charges for those electing to not wear a helmet. Private insurance sources accounted for 63 percent of inpatient charges compared to 23 percent for public and 14 percent for other sources. For the private and public sources, average inpatient charges for motorcycle crash victims were 15 percent and 5 percent higher, respectively, for the unhelmeted.

Helmets cannot protect the rider from most types of injuries. But further analysis of the CODES data, possible because of the linked medical outcome, showed that motorcycle helmets are 67 percent effective in preventing brain injuries. Thus, if all motorcyclists had been wearing helmets, 67 percent of those unhelmeted motorcyclists who received inpatient care for a brain injury would not have sustained the brain injury. In other words, unhelmeted motorcyclists were over three times as likely to suffer a

brain injury as were helmeted motorcyclists.

Examination of the average inpatient charges revealed that the average charge for inpatient care for a motorcyclist who sustained a brain injury is more than twice the average charge for motorcyclists receiving inpatient care for other injuries. On average, approximately $15,000 inpatient costs would be saved during the first 12 months for every injured motorcycle rider not sustaining a brain injury. Therefore, if all injured motorcycle riders wore helmets, fewer victims would incur the high cost of inpatient care associated with brain injury.

CODES demonstrated that linked, comparable data could be generated to evaluate the benefits of belts and helmets in terms of medical and financial outcome. Linkage enabled injury severity to be standardized among the CODES states. The linked data represent a permanent data file. Besides the belt and helmet study, these data were used to generate state-specific analyses and will continue to be used in the future. The CODES states learned new linkage skills that can be applied to the linkage of other types of records and also can be shared with other states interested in linkage. Of even more importance is the fact that linkage identified previously unknown problems with missing and inaccurate data. Correcting these problems for the study improved the quality of the data in the permanent files, making the state data (linked or unlinked) even more valuable for future uses.

INTRODUCTION

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), required the Department of Transportation and NHTSA to study the benefits of using safety belts and motorcycle helmets. This requirement appears in Section 1031, **USE OF SAFETY BELTS AND MOTORCYCLE HELMETS**, part (b) **STUDY**:

> "(1) **In general**. -- The Secretary shall conduct a study or studies to determine the benefits of safety belt use and motorcycle helmet use for individuals involved in motor vehicle crashes and motorcycle crashes, collecting and analyzing data from regional trauma systems regarding differences in the following: The severity of injuries; acute, rehabilitative and long-term medical costs, including the sources of reimbursement and the extent to which these sources cover actual costs; government, employer, and other costs; and mortality and morbidity outcomes. The study shall cover a representative period after January 1, 1990."

Funding was made available through the ISTEA, and the legislation called for a report to be submitted to Congress within "... 40 months after the funds for such a study were made available...." This report contains the results of that study.

STUDY DESIGN

Population Coverage

In designing the study, NHTSA considered the requirements specified in the legislation, the types of information which would comply with those specific analytic requirements, and the availability of such information. Consequently, the study results presented in this report are based on statewide databases in the participating states which include all persons involved in police-reported crashes -- those who were injured or who died ***and*** those who were not injured. In this manner, comparisons between those using and not using safety belts or motorcycle helmets could be made by identifying and contrasting the characteristics of the injured and uninjured occupants within each of the use groups. Exhibit 1, generated from previous research [1] (all footnotes are on page 35), shows the approximate distribution of persons involved in motor vehicle crashes by the severity of injury and emphasizes the fact that the majority of persons involved in crashes are not injured.

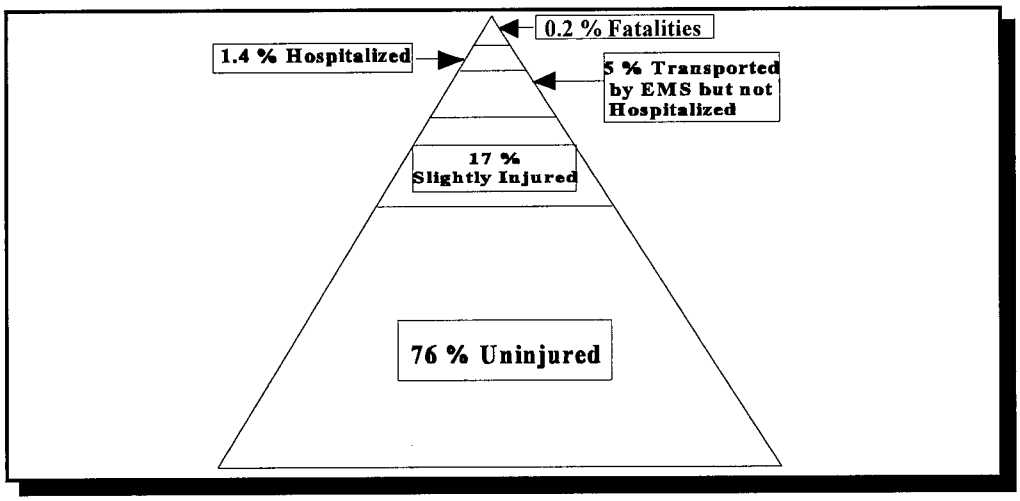

Exhibit 1. Distribution of Persons Involved in Motor Vehicle Crashes by Injury Outcome

In an individual state, the comprehensive source of information about all people involved in motor vehicle traffic crashes (including those involving passenger cars, vans, light trucks and motorcycles) is the statewide database created from crash reports filed by police agencies in the state. Police officers, who investigate the crash at the scene, complete a report which includes information about the crash, the vehicles, and the persons involved. Selected data from these reports are entered into an electronic database from which most states produce an annual report describing the crashes occurring in that state. The availability of these databases in electronic format make the data readily available for statistical analysis.

Statewide crash databases have some limitations, however. The individual data items collected by states vary widely. The training of the police officers in crash investigation and data collection, the data elements collected by police officers, and the actual data coded by each state onto its database, are different. Many states include information about all vehicle drivers and passengers, injured or uninjured, while others include information for passengers only if they are injured in the crash. Not all motor vehicle crashes are reported to the police. Every state has a minimum reporting threshold which excludes some or all of those crashes causing only minor property damage and no injuries. Thus, there may be even more successes resulting from the use of safety measures, currently undocumented and unavailable for analysis. Despite these shortcomings, statewide police-reported motor vehicle crash data are the only comprehensive source of data on a definable set of crashes within a given state.

Police-reported crash data also are limited in providing information about the medical and financial outcomes of crash victims. Police officers are not trained

diagnosticians and, in most states, do not code specific injuries to crash-involved occupants, nor are they able to obtain information on the financial consequences to the injured victims. Police crash reports typically contain a field for "injury severity". In most states the police use a standard scale similar to the "KABC0" scale, where:

- K = killed;
- A = severe or incapacitating injury;
- B = non-incapacitating injury;
- C = possible injury; and,
- 0 = not injured.

The application of this scale depends on a police officer's evaluation at the scene. Persons with different medical severities are often included within the same class. Frequently, transport by emergency medical services (EMS) of a crash victim for treatment is enough for the police officer to code "incapacitating injury." On the other hand, some injuries are not immediately evident at the scene of a crash, and a victim who is later diagnosed with a serious injury can be initially classified as not injured.

Therefore, police-reported crash data alone are not sufficient to satisfy the study requirement to examine the benefits of safety belts and motorcycle helmets with respect to "the severity of injuries," the "... medical costs, including the sources of reimbursement and the extent to which these sources cover actual costs," and "... government, employer, and other costs." Information to address these requirements must be found in other data sources.

Data relating to the type and cost of medical treatment provided to crash victims could come from several different medical service providers: emergency medical service (EMS) treatment and transport, hospital emergency department (ED) treatment, inpatient hospital treatment, nonhospital-based physician services, rehabilitative/long-term care, etc. Each one of these providers may have its own system for record keeping and billing. Some of these systems are statewide and some are limited to the facility or office where the treatment occurs. None of the data systems, however, are designed to be linked with other systems.

One statewide medical outcome database, a centralized database of inpatient hospital discharge information, is available in most states. This file usually includes diagnosis codes, procedure codes, and charges relating to the patient's hospital confinement. This last item, hospital charges, includes only the institutional component, not the professional fees, incurred at any of these facilities and does not represent actual costs.

The availability at the state level of other medical outcome information for motor vehicle crash victims is limited. Some states support statewide databases such as EMS run reports, hospital emergency department records, or rehabilitative and long-term care facility treatment summaries. Not all states collect or build statewide files from all these sources of information. But where they are available, these databases and the hospital discharge database are a valuable information source for highway safety research, particularly when an individual patient record can be associated with data on a police crash report.

NHTSA, therefore, elected to meet this study's data needs using police-reported crashes as the study population. The police reports were used to identify crashes, circumstances about the crashes, the vehicles, and the people involved. Patient information from the available data sources, usually EMS, ED, hospital discharge, and long-term and rehabilitative care databases, was used to identify injury outcomes and charges for those injured. The different databases were *linked* to obtain population-based occupant-specific outcome data for injured crash victims. Linking the databases enabled the information about the injury-causing event (the motor vehicle crash) to be directly related to specific medical and financial consequences for each person involved in the crash. This detailed information was used to evaluate the failures and *successes* resulting from the use or non-use of safety devices. Exhibit 2 shows schematically the linking of databases in a state where all such databases are available.

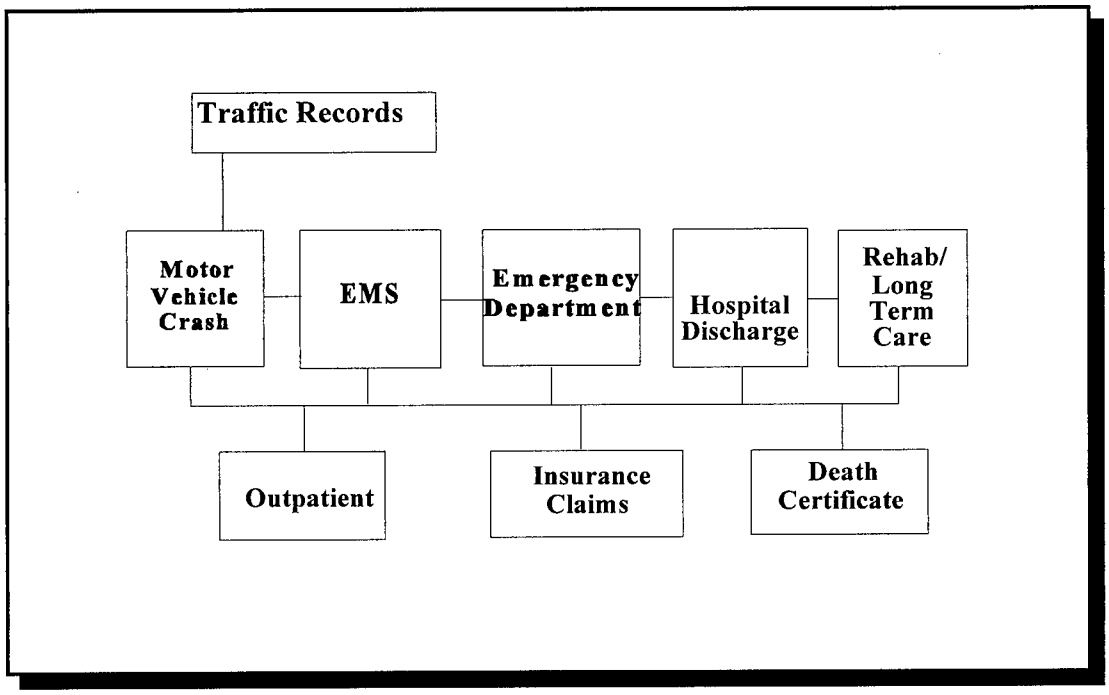

Exhibit 2. Crash and Injury Data Sources

Grants

NHTSA elected to fulfill the legislative mandate by providing grants to several states to link available databases and perform analyses using the linked data. Access to the needed databases would be obtained by the grantee from the owner agencies. The grantee would link the medical outcome databases to the police crash report file. NHTSA decided not to fund any states which would need to create new databases and instead focused on those that could guarantee delivery of the data for the analyses. Additionally, to promote cooperation between owners and users of the required databases, the grants would be made to a single applicant in a state who would be responsible for obtaining cooperation from the owners of the data.

In a May 5, 1992, *Federal Register* announcement, NHTSA published a grant solicitation requesting applications from states. The announcement specified that applicants should have an available statewide crash report database, computerized EMS, ED, hospital discharge, and rehabilitative/long-term care databases, and further, be willing to collaborate with the owners of these databases, link the databases, perform analyses as specified by NHTSA, and provide NHTSA with the linked data and results of the analyses. Any state agency, nonprofit organization, or educational institution capable of setting up a coalition of data owners and users to perform the linkage was eligible to apply. Any representative period after January 1, 1990, was allowed, to obtain the most recent data each state had available without unnecessarily limiting the number of possible applicants. Twenty states responded to the solicitation. Selection of the grantee states was independent of safety belt and helmet use rates and current statutes mandating use. NHTSA titled the project "CODES".

On September 30, 1992, NHTSA awarded grants to conduct the study to entities in 7 states: the Departments of Health in Missouri, New York, and Pennsylvania; the Department of Public Safety in Maine, the Department of Transportation in Wisconsin; and state university systems in Hawaii and Utah. Besides having the needed data, the 7 states had other characteristics useful for this study. All of the states except Maine had enacted mandatory safety belt use laws. During the study period, helmet use laws, at various times adopted by all 7 states, were in force in 3 states: Missouri, New York, and Pennsylvania. Each state had a statewide police crash report database and a statewide hospital inpatient discharge file. All states except Wisconsin had a statewide EMS database. Wisconsin had date of birth and zip code of residence for drivers and injured passengers on its crash file, which facilitated linkage, in the absence of EMS data, to the hospital discharge and insurance claims files. Only Missouri and Utah had access to statewide emergency department data. New York obtained emergency department data for New York City. The other states attempted to obtain information for specific population groups from insurance claims databases. Hawaii and New York were no-fault insurance states. New York had access to statewide vehicle insurance claims information, and Hawaii had access to statewide health insurance claims information.

To promote collaboration, each grantee formed an advisory committee of the owners and users of the databases they intended to link. In most of the states, this was the first time these diverse groups collaborated on highway safety issues. These advisory committees addressed the problems of data accessibility, confidentiality, uniformity, and quality. They worked to define potential uses for the data and to set up

and review research projects whose results were included as part of the grantees' final reports to NHTSA. In short, these committees worked to coordinate the components which would promote the use of linked data for supporting injury control in the highway safety environment for the current study and in the future.

As discussed in the preceding section, states differ in the amount and type of data collected on police crash reports and coded onto their crash databases. Some of these differences affect the CODES analyses. Of the CODES states, Missouri and Wisconsin do not collect or code information about vehicle passengers who were not injured in the crash. Thus, the safety belt benefit analyses presented in this report were restricted to drivers. However, a comparison of the results for the belt analyses for drivers compared to all occupants in the 5 states which had the data found no significant differences. All of the states were able to generate the linked data.

Overview of Data Linkage

The CODES grantees linked their available databases using probabilistic linkage, a computer algorithm which makes use of a combination of indirect identifiers (age, date of birth, date of event, sex, etc.) and, when available, direct identifiers (name, unique number, etc.). After completing the linkage, each state had a database in which crash-involved occupants were linked to the available medical outcome databases (EMS, emergency department, hospital discharge, and/or rehabilitative/long-term care). Those occupants reported by the police as not injured were less likely to be linked to a medical outcome record, while those reported as having incapacitating injuries were more likely to be linked. Those in the middle (i.e.,

occupants who were reported with possible or non-incapacitating injuries) had varying linkage rates, since they were less likely than those with serious injuries to be transported or treated at an inpatient facility, but very likely to receive outpatient treatment. Thus, the final linkage rates varied according to the availability of outpatient or claims data.

The success of the linking process was influenced by 2 factors. First, although the probabilistic linkage algorithm increased the likelihood of accurate matches, some databases lacked sufficient information to discriminate among the events and persons involved. Because of privacy considerations, some of the data systems which collect a person's name do not code it on their electronic database, and, therefore, it is not available for linking. Having a victim's name or a common identifying number on each record enhanced the accuracy and helped to increase the number of matches obtained from the various files. Second, information about the external cause of injury (E-codes) was not uniformly collected and coded by the hospitals. Thus, injury records selected for linkage could not be restricted to only those with an E-code indicating cause of injury as a motor vehicle crash. E-codes documented in the inpatient record make it possible to exclude from the linkage those individuals not injured in motor vehicle crashes.

Outcome Measures

To estimate the benefits of safety belts and motorcycle helmets with respect to different categories of injury severity, outcome measures for crash-involved occupants were established. A precursor to the actual outcome measures was a combined scale

of "injury severity" and "treatment given" for each person in the linked files. This preliminary scale was based on information generated from the linked data and is shown in Exhibit 3 in increasing severity. Each crash-involved motor vehicle occupant or motorcycle rider was coded into one of the 5 mutually exclusive categories.

Exhibit 3.
Severity/Treatment Definitions Used in the CODES Analysis of Effectiveness of Safety Belts and Motorcycle Helmets

Severity/ Treatment	Definition
Not Injured	Reported by the police either as possible injury or not injured and did not link to a medical outcome record
Slightly Injured	Reported by the police as injured (except possible injury) but did not link to a medical outcome record or as possible injury and linked to an insurance claim record
Transported	Linked to an EMS and/or Emergency Department record but was not linked to a hospital inpatient record
Inpatient	Linked to medical outcome record indicating inpatient treatment (acute, rehabilitative and/or long-term care)
Died	Police-reported killed or linked to a medical outcome record indicating death within 30 days after the crash as a result of the crash

The actual outcome measures derived from this scale were:

(1) -- Died;

(2) -- Died or inpatient;

(3) -- Died, inpatient, or transported;

(4) -- Any injury (Died, inpatient, transported, or slightly injured).

These dichotomous measures permitted the grantees to use logistic regression models for the analysis.

The linking of the various databases in the grantee states produced a large number of crashes which contributed 879,670 passenger vehicle drivers and 10,353 motorcyclists for this study. Exhibit 4 shows the distribution of crash-involved passenger vehicle drivers and motorcycle riders by the severity/treatment levels listed in Exhibit 3. The distribution of motorcycle riders is different because motorcycle riders are more likely than passenger vehicle drivers to be injured in police-reported crashes.

Exhibit 4.
Number of Drivers and Motorcycle Riders Contributing to the CODES Analysis of Effectiveness of Safety Belts and Motorcycle Helmets, by Severity/Treatment Levels

Severity/Treatment Levels	Passenger Vehicle Drivers	Motorcycle Riders
Not Injured	703,319	2,892
Slightly Injured	81,353	3,128
Transported	78,054	2,378
Inpatient	14,599	1,604
Died	2,345	351
Total	879,670	10,353

Methodology

To evaluate whether safety belts and motorcycle helmets are beneficial in reducing mortality, morbidity and injury severity, NHTSA used a measure employed in many previous studies: effectiveness. Effectiveness is defined as the percentage reduction in injuries or deaths for people wearing safety belts or helmets compared to people not wearing safety belts or helmets. For example, if the effectiveness of some

device in reducing injuries is 35 percent, then 35 percent of those people who were injured while not using the device would not have been injured had they used it. In the CODES study, the group of crash victims (passenger vehicle drivers for belt effectiveness and all motorcycle riders for helmets) who died was compared with all other crash-involved victims to estimate effectiveness in reducing **mortality** (outcome measure 1). To assess the effectiveness in reducing **morbidity** (outcome measure 4), the group of crash victims experiencing any injury, i.e., slightly injured, transported, inpatient, or died, was compared with those not injured. Finally, to assess the benefits in reducing **injury severity,** the effectiveness for all outcome measures was analyzed.

To provide the input for computing effectiveness, each CODES grantee was required to perform a series of regression analyses on its linked data using the outcome measures listed above. The results of each of these analyses were provided to NHTSA by the grantees as part of their final project reports.

To estimate the effect of safety belt and motorcycle helmet use on **medical costs**, costs were limited to total inpatient charges found on hospital, rehabilitative, and long-term care patient records. Outpatient and non-medical charges were not available from the patient medical record nor uniformly available from other sources in the CODES states. Inpatient charges represent about 60 percent of the total direct medical expenses. The remaining 40 percent include 25 percent for physician charges, about 4 percent for emergency room charges, about 1 percent for EMS charges, and 10 percent for other charges.[2] In addition to the direct medical charges paid by the people who are injured in motor vehicle crashes, there are external costs which are paid, sometimes by the public, when someone fails to buckle up or wear a helmet.[3] Information on these costs are not readily available from the patient unit

record.

To provide the input for comparing average charges, each grantee computed average inpatient charges for passenger vehicle drivers and for motorcycle riders. Averages were calculated based on the victims' belt or helmet use and for various payers. The results of each of these analyses also were provided to NHTSA by the grantees as part of their final project reports.

The results presented in this report were statistically combined by NHTSA staff from the individual state data provided by the grantees. To obtain overall estimates of effectiveness, state estimates were weighted by the inverse of their standard errors. For overall estimates of average charges, each state estimate was weighted by the number of observations which contributed to it. Because these methods of computing averages are strongly influenced by the number of cases, data from the larger states (Missouri, New York, Pennsylvania, and Wisconsin) may disproportionately influence the overall weighted average. However, these methods made it possible to compare the association between injury level and safety belt/helmet use in each state. For individual state estimates the reader is referred to the *CODES Technical Report* which describes the linkage and analytical processes used in the CODES project.

The reader should note that the overall results presented in this report reflect only the 7 CODES states and the case selection criteria for the safety belt and motorcycle helmet analyses. They are not intended to be nationally representative. In addition, except as noted, the financial results were based only on data from the linked inpatient records. These linked records represent a sub-population of all occupants who were injured and required inpatient care as the result of a motor vehicle crash. Consequently, financial results generated from this population of linked records vary

from those results generated from a previous study based on all inpatient discharges with any E-code for a motor vehicle crash from 6 states, only one of which also participated in the CODES project. [4]

Contributing Risk Factors

Assessing whether or not safety belts and motorcycle helmets are effective in reducing the occurrences of occupant mortality and morbidity, and in reducing the severity of injury, is not a simple task. While it would be quite easy to compare the observed injury rates among drivers using safety belts, real differences in injury-reducing effectiveness can be masked by a multitude of factors, (e.g., driver age and sex) not directly related to safety belt or motorcycle helmet use themselves. To the extent possible, contributing risk factors need to be identified and included in the analysis. Exhibit 5 presents the risk factors which were available in all of the CODES states.

Exhibit 5.
Contributing Risk Factors Available for the CODES Safety Belt and Motorcycle Helmet Analyses

Factor	Analysis	
	Safety Belt	Motorcycle Helmet
Type of Crash	✔	Not Used
Rural/Urban	✔	✔
Age	✔	✔
Male/Female	✔	✔
Posted Speed Limit	✔	✔
Wet/Dry	✔	✔

Night/Day	✔	✔
Intersection Related	✔	✔
Vehicle Type	✔	Not Used
Seating Position	✔	Not Used

Failure to control for these risk factors might have led to incorrect estimates of safety belt or helmet effectiveness. Estimates of effectiveness without these factors incorporated were generated as part of the CODES analysis. These estimates of effectiveness with and without risk factors were not significantly different in most of the states.

RESULTS -- BENEFITS OF SAFETY BELT USE

Effectiveness

The results of the analyses for the effectiveness of safety belts in preventing death and injury are summarized in Exhibit 6.

Exhibit 6.
Safety Belt Effectiveness by Outcome
For Crash-Involved Drivers in the CODES States *

Outcome Measure	Effectiveness Estimates	
	Belt Use as Reported by Police	Adjusted for Overreporting of Belt Use
Died	89%	60%
Died or Inpatient	75%	45%
Died, Inpatient, or Transported	54%	30%

Any Injury	52%	20%

*Please read the discussion of the safety belt analyses on pages 21-23.

Given involvement in a crash, safety belts are effective both in preventing any injury and in reducing the likelihood of a fatality. This indicates that, in the 7 CODES states during the study years, many of those unbelted drivers injured or killed in police-reported crashes would **not** have been injured or killed had they been belted. However, because of the likelihood of crash involved vehicle occupants to over-report their safety belt use, it is believed that the study results using as-reported belt use are inflated. Consequently, estimates adjusted for expected over-reporting were developed (see the section beginning on page 21 for a discussion on over-reporting). Safety belts also are effective in reducing the severity of injuries, as evidenced by the effectiveness rates which increased as the severity of the outcome increases. The information in Exhibit 6 implies that safety belts cause a downward shift in the severity of injuries sustained by vehicle drivers injured in a crash; that is, wearing safety belts results in fewer injuries and less severe injuries on average than would be sustained if the drivers do not wear safety belts.

Cost of Crash Injuries

Average inpatient charges for passenger vehicle drivers are presented in Exhibit 7. The exhibit also shows the average charges adjusted for the likelihood of being admitted to an inpatient facility, that is, an average charge for all crash-involved belted and unbelted drivers.

Exhibit 7. Average Inpatient Charge by Safety Belt Use for Inpatient and All Crash-Involved Passenger Vehicle Drivers in the CODES States			
Group	Safety Belt Use		Increase for Not Using Belts
	Used	Not Used	
Inpatient Victims	$9,004	$13,937	55%
All Crash-Involved Drivers	$110	$562	408%

The difference in average charges (total charges hide the difference between the belted and unbelted when far more vehicle occupants use safety belts than do not) between the belted and unbelted groups indicates that unbelted inpatient drivers experienced higher charges reflecting more severe injuries and longer lengths of stays. The average inpatient charge is 55 percent higher for crash victims needing inpatient care who did not use their safety belt than for those who did, a savings of almost $5,000 for each belted inpatient. When total charges are distributed among all crash-involved drivers, the average charge, although smaller in magnitude, shows an even larger percentage increase for unbelted drivers due to the increased chance of inpatient care. The overall average inpatient charge for all crash-involved victims increased by 408 percent for unbelted drivers.

Comparison of Charge to Cost

As mentioned earlier, this analysis of the benefits of safety belts was based on the charge information available from the hospital discharge and other (rehabilitative and long-term care) inpatient databases. Total charges reported in these databases are higher than the actual cost to the provider. They include a markup factor established by each health care provider to ensure the overall viability of the facility by covering bad debts, cost shifting among the payers, and profit/surplus revenue. The actual *cost* of care associated with a specific inpatient stay is very difficult to determine because actual costs are usually not patient-specific or routinely calculated.

To provide an order-of-magnitude estimate for costs incurred by motor vehicle crash victims requiring inpatient care, actual costs were estimated separately for each state using charge-to-cost ratios based on data that are obtained from statewide Medicare cost reports[5]. For the CODES states , the ratios for the CODES data collection year range from a low of 1.15 to a high of 1.71. Total charges in these states were $164.4 million. Using the charge-to-cost ratios results in an estimated total cost of $114.5 million. Estimated savings were then computed and are shown graphically in Exhibit 8. If all drivers involved in police-reported crashes had been wearing a safety belt, the savings could be represented as approximately $68 million in reduced inpatient charges or $47 million in reduced inpatient costs, both 41 percent reductions.

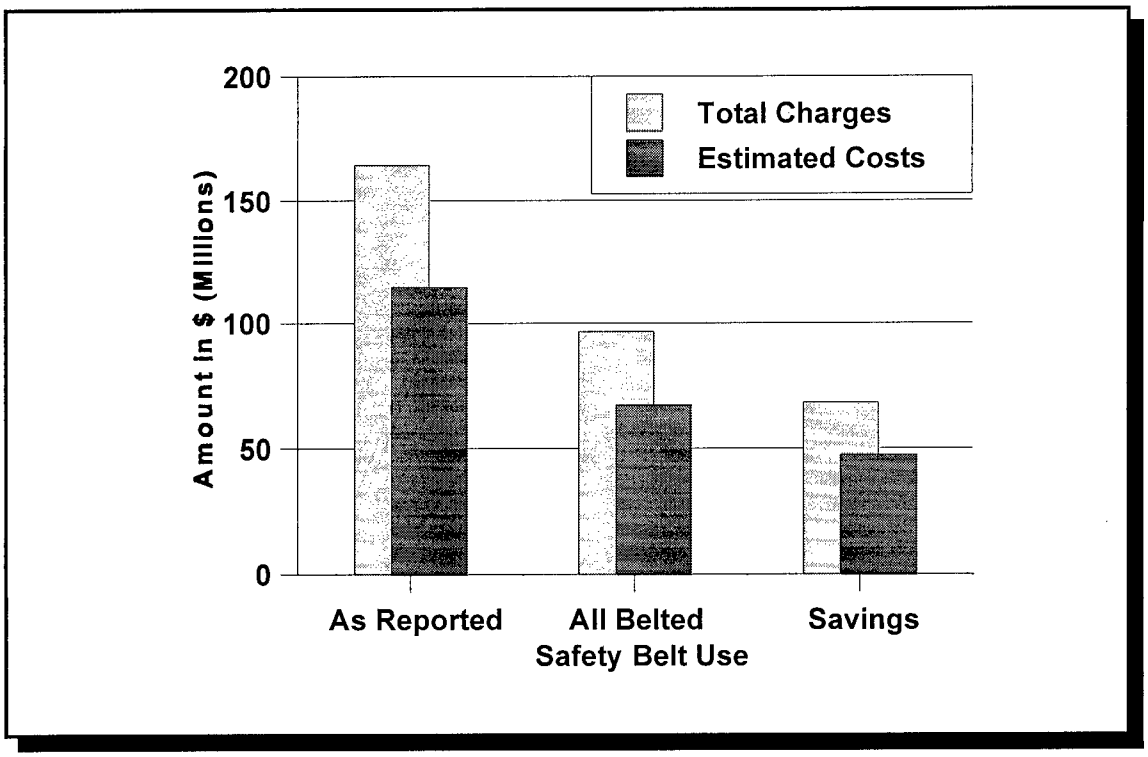

Exhibit 8. Estimated Total Inpatient Charges and Costs for All CODES States: (left) Given the Existing Mix of Belted and Unbelted Drivers As Reported; (center) If All Drivers Were Belted; and (right) Resulting Savings.

Charges by Payer Source

Hospitals and rehabilitative and long-term care facilities seek payment for charges from several sources. Private health insurance companies, including Worker's Compensation, are usually the primary source. The taxpayer is another source of payment through government programs such as Medicare and Medicaid. Victims without medical insurance are included in the other category. These "self-payers" often are unable to pay their bills, and the cost of providing this care is passed on through higher charges for those who do pay. Exhibit 9 shows the total amount of charges by each payer source and average inpatient charges by type of payer and safety belt use.

Exhibit 9. Average Inpatient Charge and Total Inpatient Charges by Source of Payment and Safety Belt Use for Crash-Involved Drivers in the CODES States				
Source of Payment	Average Inpatient Charge			Total Inpatient Charges
	Safety Belt Use		Difference	
	Used	Not Used		
Public[1]	$13,322	$18,922	$5,600	$26,498,675
Private Insurance[2]	$8,581	$14,058	$5,477	$113,156,421
Other[3]	$8,180	$10,534	$2,354	$24,788,922

[1]Includes all charges to Government Funded Sources including Medicaid, Medicare, etc.
[2]Private Insurance Companies including Worker's Compensation
[3]Usually Self Payment

At the time of discharge, private insurance, including Worker's Compensation, was the payer for 69 percent of all inpatient charges. Public sources, usually Medicare and Medicaid, and other government sources , accounted for 16 percent. The balance (15 percent) was in the other group. Regardless of pay source, the average charge for an inpatient who was not using a safety belt was higher than the charge for a belted inpatient. The average charge for unbelted drivers in the private insurance payer group was 64 percent higher than for those drivers using safety belts. For those not wearing safety belts in the public payer group the average charge was 42 percent higher than for the belted public payer group. For the other group, the difference was 29 percent. Note that the most severely injured people who become medically needy can apply for Medicaid as a result of their injuries. Therefore, the reader is cautioned not to draw any unwarranted inferences about higher charges to public payers, a subject that was not studied in this project.

Discussion of Safety Belt Analyses

NHTSA has completed many analyses of the effectiveness of safety belts. Based on these studies NHTSA believes that the effectiveness of safety belts is in the range of 40-50 percent for preventing mortality and in the range of 45-55 percent for preventing morbidity[6]. These estimates are not entirely consistent with those produced from the CODES analyses, and NHTSA believes that the CODES results may be inflated by over-reporting of belt use on the police crash reports. For most persons involved in crashes, belt use is self-reported. That is, the police do not observe it. During the past 10 years while safety belt laws have been put into force, there has been an increased tendency toward belt over-reporting, i.e., occupants tell the police officer they were belted when they were not. Over-reporting may be due to the presence of legal penalties for non-use of safety belts, to discounts offered by some automobile insurance companies for a signed commitment that the policy holder will always use his or her safety belt, or to other reasons. NHTSA's estimates of 40-50 percent for preventing mortality and 45-55 percent for preventing morbidity were based on data obtained prior to efforts to increase belt use through the passage of belt use laws and insurance incentives which are believed to have contributed to corresponding increases in observed belt use. Therefore, they are not as likely to be inflated by over-reporting.

Belt use rates are higher for drivers in police-reported crashes used in the CODES analysis than for drivers observed in the general motoring public. Exhibit 10 shows reported belt use, averaged from data for all of the CODES states, for the different levels of police-reported severity. These data were the most current at the time of the study: 1990 in Hawaii and Missouri, 1991 in Maine, Pennsylvania, Utah and Wisconsin, and 1992 in New York. For comparison, the estimated national use

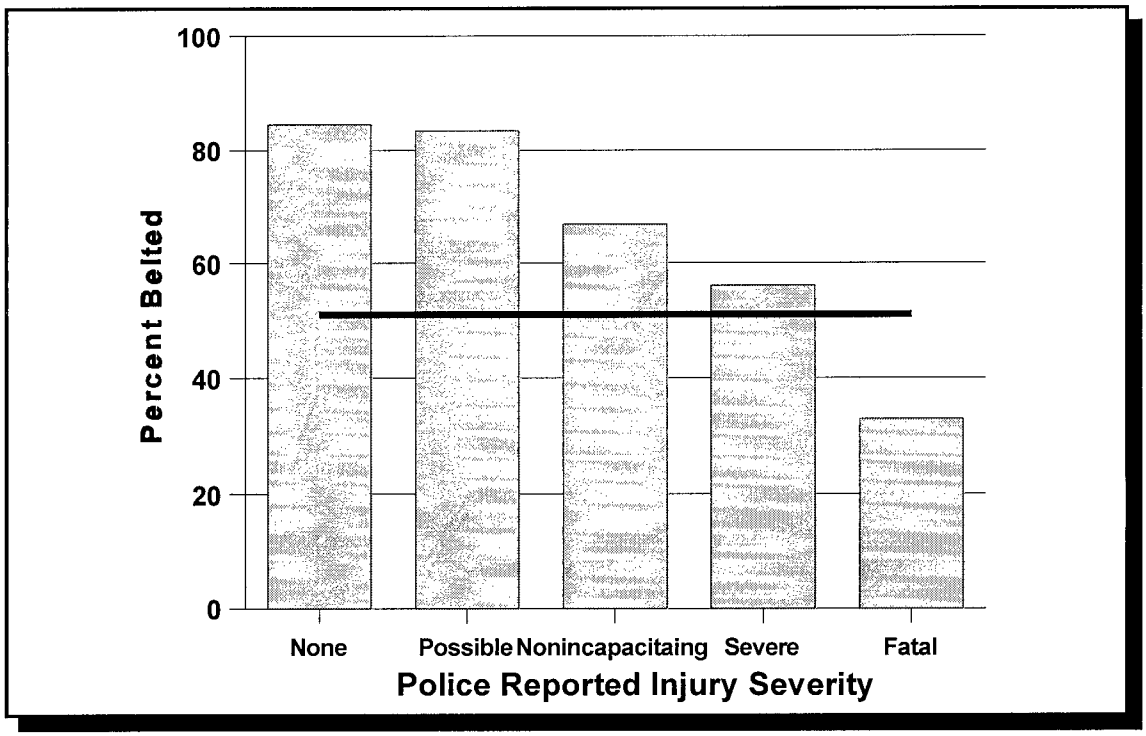

Exhibit 10. Police-Reported Belt Use, by Injury Severity for Crash-Involved Drivers in the CODES States. The horizontal line at 51 percent is the average from NHTSA's '19 Cities Survey.'

rate for 1991 based on observational data from NHTSA's 19 Cities Survey was 51 percent. It is unlikely that crash-involved drivers would have higher safety belt use rates than the general motoring public, since behavior that leads to increased risk of crash involvement is associated with risks such as driving after drinking or not wearing safety belts. The effect of higher reported safety belt use, especially among the less seriously injured and uninjured vehicle drivers, is to make safety belts appear more effective than they actually are.

Comparison of the observed and reported belt use rates for the CODES states suggests that 35 percent of the belted who are uninjured or slightly injured may have

misreported their belt use at the time of the crash. When this over-reporting rate is factored into the analyses, the effectiveness rates are closer to 60 percent for preventing mortality and 25 - 45 percent for preventing morbidity, estimates much closer to NHTSA's current estimates of belt effectiveness.

For the average inpatient charges reported in Exhibit 7, it is possible to assume that an injury severe enough to require inpatient care may be more likely to provide tangible evidence of belt use or non-use, thus discouraging the tendency to over-report. Therefore, the 55 percent figure would stay approximately the same.

For the average charges for the group of **all** crash-involved drivers, the situation is much more complicated, because all drivers were included. Assuming a 10 percent over-reporting by the inpatient drivers, and a 35 percent over-reporting by non-inpatient drivers, then the percent cost benefit of wearing a belt for crash-involved drivers approaches the same for drivers receiving inpatient care, or 60-70 percent.

RESULTS -- BENEFITS OF MOTORCYCLE HELMET USE

Effectiveness

In the analysis for helmet effectiveness, NHTSA used data from six of the 7 states for which data were available. Utah was excluded because there was no place on their police crash report to identify an unhelmeted motorcyclist -- all records were coded either "helmet worn" or "unknown." Also, all risk factors except helmet use were excluded to avoid reducing the sample size excessively due to missing data. In the

safety-belt analyses, dropping all the risk factors except safety-belt use had no significant effect on the results. In the helmet analyses, if only cases with no missing data for all risk factors were used, the results would have been extremely unstable due to the small number of cases. The combined results for motorcycle helmet effectiveness are summarized in Exhibit 11.

Exhibit 11.
Effectiveness of Motorcycle Helmets by Outcome Measure for Crash-Involved Motorcycle Riders in CODES States*

Outcome Measure	Effectiveness
Died	35%
Died or Inpatient	26%
Died, Inpatient, or Transported	26%
Any Injury	9%

*Excludes Utah.

Given involvement in a crash, CODES results show that motorcycle helmets are 35 percent effective in preventing fatality, but only 9 percent effective in preventing any injury. Effectiveness of motorcycle helmets was higher for more severe injuries, the same pattern that was found for safety belts. However, motorcycle helmets were not designed to prevent injuries other than head injuries.

Cost of Crash Injuries to Motorcycle Riders

An analysis similar to the one described previously for safety belts was done to determine the benefits of motorcycle helmets with respect to charges incurred by

those injured. Again, the analysis has been restricted to the charge information available from the inpatient databases. A summary of these results is presented in Exhibit 12.

Exhibit 12.
Average Inpatient Charge by Motorcycle Helmet Use For Inpatient Victims and All Crash-Involved Motorcycle Riders in CODES States*

Group	Motorcycle Helmet Use		Increase for Not Wearing Helmet
	Used	Not Used	
Inpatient Victims	$14,377	$15,578	8%
All Crash Involved Riders	$2,064	$2,808	36%

*Excludes Utah.

The average inpatient charge for motorcycle crash victims receiving inpatient care was $14,377 for those who used helmets, and $15,578 for those who did not, an 8 percent increase ($1,201) in charges for those electing to not wear a helmet. When adjusted for all crash-involved motorcycle riders, the difference in the average inpatient charge, $744, is 36 percent higher for those not wearing a helmet. These differences are not as dramatic as those seen for safety belts. This is likely to be an effect of both the smaller sample sizes involved and the likelihood that motorcycle riders will be injured in a crash, regardless of whether or not they are wearing a helmet, in large part because there is little or no protective vehicle structure.

Comparison of Charge to Cost

The same charge-to-cost ratios by state as used in the safety belt analysis were applied to the data from the 6 states which contributed to the motorcycle helmet analysis. If all motorcycle riders involved in police-reported motorcycle crashes had been wearing a motorcycle helmet, about 3 percent of total inpatient charges or 7 percent of actual costs would have been saved. This result is shown graphically in Exhibit 13.

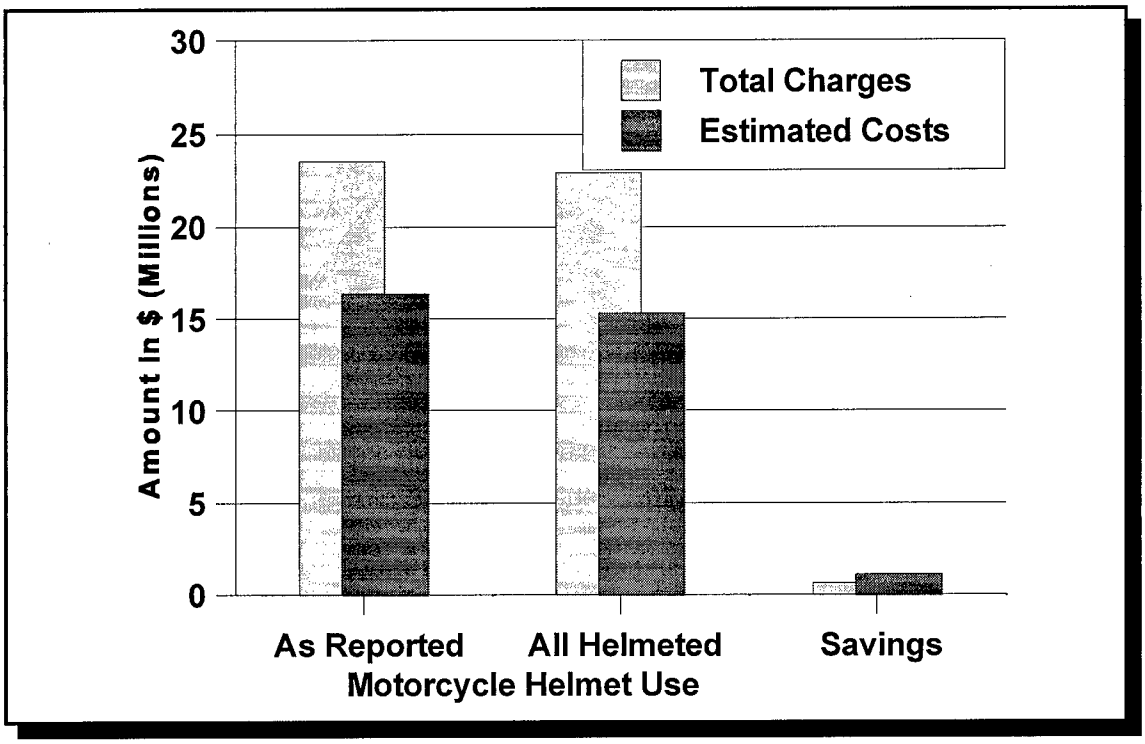

Exhibit 13. Estimated Total Inpatient Charges and Costs for 6 CODES States (Excluding Utah): (left) Given the Existing Mix of Helmeted and Unhelmeted Riders As Reported; (center) If All Riders Were Helmeted; and (right) Resulting Savings.

Charges by Payer Source

Exhibit 14 presents the average inpatient charge by type of payer and motorcycle helmet use for inpatient motorcycle crash victims.

Exhibit 14. Average Inpatient Charge and Total Inpatient Charges by Source of Payment and Motorcycle Helmet Use for Crash-Involved Motorcycle Riders in CODES States*				
Source of Payment	Average Inpatient Charge			Total Inpatient Charges
	Motorcycle Helmet Use		Difference	
	Used	Not Used		
Public[1]	$23,793	$24,925	$1,132	$5,364,759
Private Insurance[2]	$13,617	$15,687	$2,070	$14,764,706
Other[3]	$10,565	$8,913	($1,653)	$3,403,183

*Excludes Utah.
[1]Includes All Charges to Government Funded Sources including Medicaid, Medicare, etc.
[2]Private Insurance Companies and Worker's Compensation
[3]Usually Self Payment

The motorcycle helmet results are similar to those shown for the safety belt analysis except for the other category. At the time of discharge, the expected pay source for a majority of charges was a private insurance company. Billings to private insurance companies covered 63 percent of all charges, and the average charge for an unhelmeted motorcyclist was almost 15 percent higher than the charge for a helmeted rider in this group. On the other hand, the average charge for an unhelmeted motorcycle occupant in the other payer group was lower than for helmeted riders. Public sector sources covered about 23 percent of the inpatient charges for motorcycle crash victims in the 6 states in this analysis. The average inpatient charge for those injured motorcyclists who used a public payer source was more than 5 percent higher for motorcyclists who did not wear a helmet than for those who did.

Prevention of Brain Injury

Helmets were not designed to protect the rider from most types of injuries which could affect a motorcycle rider. Their main function is to reduce injuries to the head and, especially, the brain. Brain injury is more likely to result in expensive and long-lasting treatment, sometimes resulting in lifelong disability, whereas other head injuries, concussions and skull fractures (without damage to the brain itself), are more likely to result in full recovery. To examine whether motorcycle helmets would be more effective in reducing the injuries they were designed to prevent, NHTSA performed a separate analysis restricting the outcome measure to whether or not the motorcyclist received inpatient care for a brain injury. One state, Wisconsin, had subdivided its inpatients with head injuries into brain injury, concussion, and simple skull fracture groups. The inpatient files from 5 other states were added to Wisconsin's data following the definitions used by Wisconsin. Again, Utah was not used since the crash report did not include a code for not wearing a helmet. The model was revised to include only helmet use as a risk factor to maximize the number of cases which could be included in the analysis.

The resulting analysis of effectiveness revealed that motorcycle helmets are 67 percent effective in preventing brain injuries. Thus, if all motorcyclists had been wearing helmets, 67 percent of those unhelmeted motorcyclists who received inpatient care for a brain injury would not have sustained the brain injury. In other words, unhelmeted motorcyclists were over three times as likely to suffer a brain injury as were helmeted motorcyclists.

Average charges for inpatient motorcycle riders by brain injury status and helmet use are shown in Exhibit 15.

Exhibit 15. Average Inpatient Charge by Motorcycle Helmet Use and Brain Injury Status For Inpatient Motorcycle Riders in CODES States*				
Group/ Payer Source	Motorcycle Helmet Use			
	Used		Not Used	
	Brain Injured	Not Brain Injured	Brain Injured	Not Brain Injured
All Inpatient Victims	$26,985	$12,736	$26,805	$11,730
Public	$33,764	$22,066	$46,347	$11,596
Private	$29,610	$11,834	$24,461	$12,807
Other	$16,664	$9,585	$10,238	$8,593

*Excludes Utah.

Regardless of helmet use and payer source, the average charge for inpatient care for a motorcyclist who sustained a brain injury is more than twice the average charge for motorcyclists receiving inpatient care for other injuries. Inpatient charges for unhelmeted motorcyclists receiving care for a brain injury ($26,805) are 2¼ times greater than the average charge for care for unhelmeted inpatient motorcyclists not sustaining a brain injury ($11,730). Therefore, if all motorcyclists wore helmets, approximately $15,000 in inpatient charges would be saved during the first 12 months for every motorcycle rider who, due to wearing the helmet, did not sustain a brain injury. Additional savings would accrue from avoiding the continual costs for care over a lifetime.

Discussion of Motorcycle Helmet Analysis

Regarding the effectiveness of motorcycle helmets in reducing fatalities and

injuries, the results are also consistent with previous analyses NHTSA has conducted. The 34 percent figure in Exhibit 11 is very close to a 1989 NHTSA analysis [7] which estimated that motorcycle helmets were 29 percent effective against fatal injury. The minimal effectiveness of helmets when lesser injuries are added to the analysis should not be surprising. Helmets prevent head injury, not all injuries.

This makes the analysis of brain injury all the more important, because it shows that helmets are effective in reducing the types of injury they were designed to reduce. They were 67 percent effective in the 6 selected states, which is more than twice the fatality effectiveness. Helmets also reduce the cost where it counts. In these 6 states, cases with brain injury were more than twice as costly as non-brain injury during the first 12 months.

With motorcycle helmets, the over-reporting problem does not exist, because it is easier to see "helmet use" than "belt use." There is no substantial group of motorcyclists claiming they were wearing helmets when they were not. No adjustments need be contemplated as in the safety-belt analysis. However, there is a problem with missing data on motorcycle helmet use. New York, with a helmet-use law, showed "unknown helmet use" on 38 percent of its motorcyclist records. Wisconsin, without a helmet-use law, showed only 9 percent. In general, states with laws are more likely to have missing data. Police may be reluctant to give a ticket for not wearing a helmet to a motorcyclist who has just suffered a crash.

CONCLUSIONS

Study Results

The CODES study results confirm earlier NHTSA analyses that safety belts are highly effective in preventing injury and fatality in motor vehicle traffic crashes, and that they cause a downward shift in the severity of injuries. The earlier NHTSA studies estimated that safety belts are 40 - 50 percent effective in preventing mortality and 45 - 55 percent effective in preventing morbidity.

The CODES results also show that the average inpatient charge for a driver admitted to an inpatient facility as a result of a motor vehicle injury is 55 percent higher if that person was unbelted. For the 7 states contributing data for this study, the average charge for a belted crash-involved driver receiving inpatient care was $9,004, while the average charge for an unbelted driver was $13,937. If, in these states, all unbelted passenger vehicle drivers had been wearing safety belts, it is estimated that the reduction in inpatient charges would have been approximately $68 million, or an estimated $47 million in actual inpatient costs. Private insurance accounted for 69 percent of the inpatient charges compared to 16 percent for public and 15 percent for other sources. In all cases, the average inpatient charge was greater for drivers who were unbelted.

The study results confirmed NHTSA's estimate of motorcycle helmet effectiveness (29 percent) in preventing fatalities. CODES results showed that helmets were 35 percent effective in preventing a fatality. The average inpatient charge for motorcycle crash victims was $14,377 for those who used helmets, and $15,578 for those who did not, an 8 percent increase for those electing not to wear a

helmet. Seven percent in actual inpatient costs, and more in lifetime care, would be saved if unhelmeted motorcyclists wore helmets. Private insurance sources accounted for 63 percent of inpatient charges compared to 23 percent for public and 14 percent for other sources. For both the private and public sources, average inpatient charges for motorcycle crash victims were greater for the unhelmeted.

Helmets cannot protect the rider from most types of injuries. However, further analysis revealed that motorcycle helmets are 67 percent effective in preventing brain injuries. In other words, unhelmeted motorcyclists were over three times as likely to suffer a brain injury as were helmeted motorcyclists.

Examination of the average inpatient charges revealed that the average charge for inpatient care for a motorcyclist who sustained a brain injury is more than twice the average charge for motorcyclists receiving inpatient care for other injuries. On average, approximately $15,000 in inpatient costs would be saved during the first 12 months for every injured motorcycle rider who did not also sustain a brain injury. Therefore, if all motorcycle riders wore helmets, fewer victims would incur the high cost of inpatient care associated with brain injury.

Significance of CODES

The linked data provide unique insights into the **financial outcome** of highway crashes. Police crash reports provide information about the crash environment and driver/occupants; EMS reports and hospital discharge data add medical information about injury type and severity; and hospital discharge and insurance claims data reveal the financial consequences. Taken together, these linked data generated greater

value than when considered alone.

Hundreds of thousands of police-reported crashes were included in the statewide linked data. This large volume of **vehicle-related information** increases the available statistical power to discriminate among specific vehicle attributes while controlling for nonvehicle-related factors making it possible to generate cost benefit analyses of vehicle safety performance standards.

An important concern of the public health community relates to the **availability of medical services** and their impact on outcome. The availability of linked injury and crash information supports collaboration between the nonmedical and medical communities. These data can be used to demonstrate the effectiveness of the emergency response by police, EMS, and the acute care system, and to predict the need for an aggressive medical response when specific crash, vehicle, and behavioral characteristics exist.

NHTSA often examines state data to evaluate the benefits of specific traffic safety countermeasures. CODES linked data allow the agency to examine not only a more accurate description of injury consequences, but also the public health cost savings associated with highway safety initiatives. Since a high percentage of these costs are funded by citizens through increased taxes to cover the expenses of uninsured and underinsured crash victims, documentation of the costs is important to motivate public and legislative support for stricter laws and enforcement actions. CODES provides documentation, generated from a state's own linked data, that is more credible among local decision makers who may be tempted to repeal the safety mandates, such as helmet legislation. CODES information has the capability to

demonstrate the increased costs associated with head injuries for unhelmeted riders, to identify the health care costs for specific vehicles, crashes, and behaviors (e.g., alcohol involvement, unsafe driving actions), to generate community-based information to support community-based traffic safety programs, and to target specific populations at risk at the local, regional, or state levels. All of this information identifies and supports outcome-based injury control activities that have the most potential for reducing health care costs.

FOOTNOTES

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5. *Almanac of Hospital Financial and Operating Indicators.* Cleverley, William O. Center for Health Care Industry Studies, Ohio State University (published annually).

6. *Final Regulatory Analysis*, Amendment to FMVSS No.208, Passenger Car Front Seat Occupant Protection. DOT, NHTSA, Office of Plans and Policy, July, 1984.

7. *The Effectiveness of Motorcycle Helmets in Preventing Fatalities.* Wilson, D. DOT HS 807 416, NHTSA Technical Report, March, 1989.